BSc. Physical Sciences

Multidisciplinary

DISCIPLINE SPECIFIC CORE COURSE – 1 (PHYSICS DSC - 1)
MECHANICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Mechanics Physics DSC 1	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with dynamics of a system of particles and ends with the special theory of relativity. Students will appreciate the concept of rotational motion, gravitation and oscillations. The students will be able to apply the concepts learnt to several real world problems.

Learning outcomes:

Upon completion of this course, students are expected to understand the following concepts.

- Laws of motion and their application to various dynamical situations.
- Conservation of momentum, angular momentum and energy. Their application to basic problems.
- Particle collision (elastic and in-elastic collisions)
- Motion of simple pendulum
- Postulates of special theory of relativity, inertial and non-inertial frame of reference and their transformation, relativistic effects on the mass and energy of a moving body.

In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier calliper and travelling microscope) student shall embark on verifying various principles and associated measurable quantities.

SYLLABUS OF PHYSICS DSC – 1

THEORY COMPONENT

Unit 1: Review of vectors and ordinary differential equation **(4 Hours)**

Gradient of a scalar field, divergence and curl of vectors field, polar and axial vectors Second order homogeneous ordinary differential equations with constant coefficients (Operator Method Only).

Unit 2: Fundamentals of Dynamics **(7 Hours)**

Dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry

Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy. Particle collision (Elastic and in-elastic collisions)

Unit 3: Rotational Dynamics and Oscillatory Motion **(8 Hours)**

Angular momentum, torque, conservation of angular momentum, Moment of inertia, Theorem of parallel and perpendicular axes (statements only). Calculation of moment of inertia of discrete and continuous objects (1-D and 2-D).

Idea of simple harmonic motion, differential equation of simple harmonic motion and its solution, Motion of simple pendulum, damped harmonic oscillator

Unit 4: Gravitation **(3 Hours)**

Newton's Law of Gravitation, Motion of a particle in a central force field, Kepler's Laws (statements only)

Unit 5: Special Theory of Relativity **(8 Hours)**

Frames of reference, Galilean transformations, inertial and non-inertial frames, Michelson Morley's Experiment, postulates of special theory of relativity, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass.

References:

Essential Readings:

1) Vector Analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2nd Edn., 2009, McGraw- Hill Education.

2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.

3) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education

4) Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.

5) Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.

Additional Readings:

1) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.

2) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

3) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.

4) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.

5) Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.

6) Physics for Scientists and Engineers, Randall D Knight, 3/e, 2016, Pearson Education.

PRACTICAL COMPONENT (60 Hours)

The teacher is expected to give basic idea and working of various apparatus and instruments related to different experiments. Students should also be given knowledge of recording and analysing experimental data.

Every student should perform at least 06 experiments from the following list.

1) Measurement of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
2) Study the random error in observations.
3) Determination of height of a building using a sextant.
4) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity
5) Determination of moment of inertia of a flywheel.
6) Determination of g and velocity for a freely falling body using digital timing technique.
7) Determination of modulus of rigidity of a wire using Maxwell's needle.
8) Determination of elastic constants of a wire by Searle's method.
9) Determination of value of g using bar pendulum.
10) Determination of value of g using Kater's pendulum.

References (for Laboratory Work):

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3) Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4) A Textbook of Practical Physics, I. Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
5) B. Sc. Practical Physics, Geeta Sanon, R. Chand and Co., 2016.

BSc. Physical Sciences with Electronics

Multidisciplinary

DISCIPLINE SPECIFIC CORE COURSE – 1 (PHYSICS DSC - 1)
MECHANICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Mechanics Physics DSC 1	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives
This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with dynamics of a system of particles and ends with the special theory of relativity. Students will appreciate the concept of rotational motion, gravitation and oscillations. The students will be able to apply the concepts learnt to several real world problems.

Learning Outcomes
Upon completion of this course, students are expected to understand the following concepts.

- Laws of motion and their application to various dynamical situations.
- Conservation of momentum, angular momentum and energy. Their application to basic problems.
- Particle collision (elastic and in-elastic collisions)
- Motion of simple pendulum
- Postulates of special theory of relativity, inertial and non-inertial frame of reference and their transformation, relativistic effects on the mass and energy of a moving body.

In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier calliper and travelling microscope) student shall embark on verifying various principles and associated measurable quantities.

SYLLABUS OF PHYSICS DSC-1

THEORY COMPONENT

Unit 1: Review of vectors and ordinary differential equation (04 Hours)

Gradient of a scalar field, divergence and curl of vectors field, polar and axial vectors Second order homogeneous ordinary differential equations with constant coefficients (Operator Method Only).

Unit 2: Fundamentals of Dynamics (07 Hours)

Dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry

Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy. Particle collision (Elastic and in-elastic collisions)

Unit 3: Rotational Dynamics and Oscillatory Motion (08 Hours)

Angular momentum, torque, conservation of angular momentum, Moment of inertia, Theorem of parallel and perpendicular axes (statements only). Calculation of moment of inertia of discrete and continuous objects (1-D and 2-D).

Idea of simple harmonic motion, differential equation of simple harmonic motion and its solution, Motion of simple pendulum, damped harmonic oscillator

Unit 4: Gravitation (03 Hours)

Newton's Law of Gravitation, Motion of a particle in a central force field, Kepler's Laws (statements only)

Unit 5: Special Theory of Relativity (08 Hours)

Frames of reference, Galilean transformations, inertial and non-inertial frames, Michelson Morley's Experiment, postulates of special theory of relativity, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass.

References:

Essential Readings:

1) Vector Analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2nd Edn., 2009, McGraw- Hill Education.

2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.

3) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education

4) Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.

5) Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.

Additional Readings:

1) Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.

2) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

3) University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.

4) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.

5) Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.

6) Physics for Scientists and Engineers, Randall D Knight, 3/e, 2016, Pearson Education.

PRACTICAL COMPONENT (60 Hours)

The teacher is expected to give basic idea and working of various apparatus and instruments related to different experiments. Students should also be given knowledge of recording and analysing experimental data.

Every student should perform at least 06 experiments from the following list.

1) Measurement of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
2) Study the random error in observations.
3) Determination of height of a building using a sextant.
4) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity
5) Determination of moment of inertia of a flywheel.
6) Determination of g and velocity for a freely falling body using digital timing technique.
7) Determination of modulus of rigidity of a wire using Maxwell's needle.
8) Determination of elastic constants of a wire by Searle's method.
9) Determination of value of g using bar pendulum.
10) Determination of value of g using Kater's pendulum.

References (for Laboratory Work):

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3) Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4) A Textbook of Practical Physics, I. Prakash and Ramakrishna, 11/e, 2011, Kitab Mahal.
5) B. Sc. Practical Physics, Geeta Sanon, R. Chand and Co., 2016.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC CORE COURSE – 2 (DSC - 2)
Network Analysis and Analog Electronics

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Network Analysis and Analog Electronics Physics DSC 2	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Physics and Mathematics syllabus of class XII

Learning Objectives
This course offers the basic knowledge to students to design and analyse the network circuit analysis and analog electronics. It gives the concept of voltage, current sources and various electrical network theorems, physics of semiconductor devices including junction diode, bipolar junction transistors, unipolar devices and their applications are discussed in detail. This also develops the understanding of amplifier and its applications.

Learning Outcomes
At the end of this course, students will be able to achieve the following learning outcomes.

- To understand the concept of voltage and current sources, Network theorems, Mesh Analysis.
- To develop an understanding of the basic operation and characteristics of different type of diodes and familiarity with its working and applications.
- Become familiar with Half-wave, Full-wave centre tapped and bridge rectifiers. To be able to calculate ripple factor and efficiency.
- To be able to recognize and explain the characteristics of a PNP or NPN transistor.
- Become familiar with the load-line analysis of the BJT configurations and understand the hybrid model (h- parameters) of the BJT transistors.
- To be able to perform small signal analysis of Amplifier and understand its classification.
- To be able to perform analysis of two stage R-C coupled Amplifier.
- To understand the concept of positive and negative feedback along with applications in case of oscillators.
- To become familiar with construction, working and characteristics of JFET and UJT.

SYLLABUS OF PHYSICS DSC – 2

THEORY COMPONENT

Unit 1: (8 Hours)
Circuit Analysis: Concept of Voltage and Current Sources (ideal and practical). Kirchhoff's Laws. Mesh Analysis, Node Analysis. Star and Delta networks and their Conversion Superposition Theorem. Thevenin's Theorem. Norton's Theorem. Reciprocity Theorem. Maximum Power Transfer Theorem.

Unit 2: (5 Hours)
Semiconductor Diode: PN junction diode (Ideal and practical), Diode equation (Qualitative only) and I-V characteristics. Idea of static and dynamic resistance, Zener diode working. Rectifiers: Half wave rectifier (Qualitative only), Full wave rectifiers (center tapped and bridge): circuit diagrams, working and waveforms, ripple factor and efficiency.
Filter circuits: Shunt capacitance and series Inductance filter (no derivation).
Regulation: Zener diode as voltage regulator for load and line regulation.

Unit 3: (7 Hours)
Bipolar Junction Transistor: Review of the characteristics of transistor in CE and CB configurations, Regions of operation (active, cut off and saturation), Current gains α and β. Relations between α and β. dc load line and Q point.

Amplifiers: Transistor biasing and Stabilization circuits - Voltage Divider Bias. Thermal runaway, stability (Qualitative only). Transistor as a two-port network, h-parameter equivalent circuit. Small signal analysis of single stage CE amplifier. Input and Output impedance, Current and Voltage gains. Class A, B and C Amplifiers.

Unit 4: (10 Hours)

Cascaded Amplifiers: Two stage RC Coupled Amplifier and its frequency response.
Sinusoidal Oscillators: Concept of feedback (negative and positive feedback), Barkhausen criterion for sustained oscillations. Phase shift and Colpitt's oscillator. Determination of frequency and condition of oscillation
Unipolar Devices: JFET. Construction, working and I-V characteristics (output and transfer), Pinch-off voltage. UJT, basic construction, working, equivalent circuit and I-V characteristics. UJT Oscillator.

References:

Essential Readings:

1) Network, Lines and Fields, J. D. Ryder, Prentice Hall of India
2) Integrated Electronics, J. Millman and C.C. Halkias, Tata Mcgraw Hill (2001)
3) Electric Circuits , S. A. Nasar, Schaum Outline Series, Tata McGraw Hill (2004)
4) Electric Circuits, K.A. Smith and R. E. Alley, Cambridge University Press(2014)
5) 2000 Solved Problems in Electronics, J. J. Cathey, Schaum Outline Series, Tata McGraw Hill (1991)

Additional Readings:

1) Microelectronic Circuit, A. S. Sedra, K.C. Smith, A. N. Chandorkar, 6th Edition (2014), Oxford University Press
2) Electronic Circuits: Discreet and Integrated, D. L. Schilling and C. Belove, Tata McGraw Hill.
3) Electronic Devices and Circuits, David A. Bell, 5th Edition 2015, Oxford University Press.
4) Electrical Circuits, M. Nahvi and J. Edminister, Schaum Outline Series, Tata McGraw Hill (2005)

PRACTICAL COMPONENT (60 Hours)

At least 06 experiments from the following.

1) To familiarize with basic electronic components (R, L, C, diodes, transistors), digital Multimeter, Function Generator and Oscilloscope
2) Verification of
    a. Thevenin's theorem and
    b. Norton's theorem.
3) Verification of
    a. Superposition Theorem and
    b. Reciprocity Theorem
4) Verification of the Maximum Power Transfer Theorem.
5) Study of the I-V Characteristics of
    a. p-n junction Diode, and
    b. Zener diode.

6) Study of
    a. Half wave rectifier and
    b. Full wave rectifier (FWR).
7) Study the effect of
    a. C- filter and L- filter and
    b. Zener regulator.
8) Study of the I-V Characteristics of UJT and design relaxation oscillator.
9) Study of the output and transfer I-V characteristics of common source JFET.
10) Study of Voltage divider bias configuration for CE transistor.
11) Design of a Single Stage CE amplifier of given gain.
12) Study of the RC Phase Shift Oscillator.

References (For Laboratory Work):

1) Electronic Devices and Circuits, Allen Mottershead, Goodyear Publishing Corporation.
2) Electrical Circuits, M. Nahvi and J. Edminister, Schaum Outline Series, Tata McGraw Hill (2005)
3) Network, Lines and Fields, J. D. Ryder, Prentice Hall of India
4) Integrated Electronics, J. Millman and C.C. Halkias, Tata Mcgraw Hill (2001)

BSc. Physical Sciences

DISCIPLINE SPECIFIC CORE COURSE (DSC-1): Basic Concepts of Organic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course t itle & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Concepts of Organic Chemistry	04	02	-	02	**12th Pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of the concept of visualizing the organic molecules in a three-dimensional space.
- To establish the applications of these concepts, a study of diverse reactions through mechanisms is included.
- The constitution of the course strongly aids in the paramount learning of the basic concepts and their applications

Learning outcomes

The Learning Outcomes of this course are as follows:

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learned.
- Understand the fundamental concepts of stereochemistry.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Learn and identify many organic reactions and their mechanisms including electrophilic addition, nucleophilic addition, nucleophilic substitution, electrophilic substitution and rearrangement reactions.

SYLLABUS OF DSC-1

UNIT – I Fundamentals of organic chemistry (6 Hours)

Types of Electronic displacements: Inductive effect, Resonance effect, Hyperconjugation, Electromeric Effect. Reactive intermediates and their stability: carbocations, free radicals, carbanions, benzyne, carbenes.

Acidity and basicity in organic compounds (comparison of carboxylic acids, alcohols, phenols, primary, secondary and tertiary aliphatic amines, aniline and its derivatives)

UNIT – II Stereochemistry (6 Hours)

Types of projection formulae: Flying Wedge Formula, Newmann, Sawhorse and Fischer representations and their interconversion.

Stereoisomerism: Concept of chirality (upto two carbon atoms). Configurational isomerism: geometrical and optical isomerism; enantiomerism, diastereomerism and meso compounds). Threo and erythro; D and L; *Cis-trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and *E*/*Z* nomenclature (for upto two C=C systems).

Conformational isomerism with respect to ethane, butane and cyclohexane.

UNIT – III Types of Organic Reactions (Including reactions of alkenes, alkyl and aryl halides, alcohols, aldehydes, ketones) (18 Hours)

Electrophilic addition reactions

Electrophilic addition reaction (with respect to propene, propyne, 3,3-dimethyl-1-butene): Hydration, Addition of HX in the absence and presence of peroxide, Hydroboration oxidation, Addition of bromine (with stereochemistry).

Nucleophilic addition reactions

Nucleophilic addition reaction of carbonyl compounds: Addition of HCN, ammonia derivatives (Hydroxylamine, Hydrazine, Semicarbazide and 2,4-DNP), the addition of carbanion (Aldol condensation, Claisen Schmidt, Benzoin condensation, Perkin reaction, reactions involving Grignard reagent).

Elimination and Nucleophilic substitution reactions

Nucleophilic substitution reaction (S_N1 and S_N2) in alkyl halides (mechanisms with stereochemical aspect), alcohols (with nucleophiles like ammonia, halides, thiols, ambident nucleophiles (cyanide and nitrite ion)), ethers (Williamson ether synthesis), Elimination reaction (E1 & E2), elimination *vs* substitution (*w.r.t.* potassium t-butoxide and KOH); Nucleophilic aromatic substitution in aryl halides-elimination addition reaction *w.r.t.* chlorobenzene, including the effect of nitro group (on the ring) on the reaction. relative reactivity and strength of C-X bond in alkyl, allyl, benzyl, vinyl and aryl halides towards substitution reactions

Electrophilic substitution reactions

Electrophilic Aromatic substitution with mechanism (benzene)- sulphonation, nitration, halogenation, Friedel craft acylation :*o*-, *m*- and *p*- directive influence giving examples of toluene/nitrobenzene/ phenol/ aniline/ chlorobenzene.

Reactive intermediates and Rearrangement Reactions

Free radicals (Birch Reduction); *Carbocations* (Pinacol-Pinacolone, Wagner-Meerwein, Rearrangement, and Beckmann rearrangement); *Carbanions (*Michael Addition); *Carbenes* (Reimer-Tiemann).

Practical component (60 Hours)

1. Purification of an organic compound by crystallization (from water and alcohol) and distillation, Criteria of purity: Determination of M.P.
2. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
3. Detection of extra element
4. Preparations: (Mechanism of various reactions involved to be discussed).
    a. Bromination of phenol/aniline.
    b. 2,4-Dinitrophenylhydrazone of aldehydes and ketones
    c. Semicarbazone of aldehydes/ ketones
    d. Aldol condensation reaction using green method.
    e. Bromination of Stilbene.
    f. Acetanilide to p-Bromoacetanilide.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

Essential/recommended readings
Theory:

1. Sykes, P.(2003), **A Guide Book to Mechanism in Organic Chemistry,** 6th Edition Pearson Education.
2. Eliel, E. L. (2001), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Pearson Education.

Practical:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Dhingra, S; Ahluwalia V.K., (2017), **Advanced Experimental Organic Chemistry**, Manakin Press.

Suggestive readings
Theory:

1. Bahl, A; Bahl, B. S. (2019), **Advanced Organic Chemistry**, 22nd Edition, S. Chand.

Practical:

1. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category II

B. Sc. Physical Science with Physics as one of the Core Discipline

DISCIPLINE SPECIFIC CORE COURSE (PHYSICS DSC - 2): ELECTRICITY AND MAGNETISM

Course Title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Electricity and Magnetism Physics DSC 2	4	2	0	2	Class XII pass	----

LEARNING OBJECTIVES

This course reviews the concepts of electricity and magnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real world problems.

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Understand Gauss' law, Coulomb's law for the electric field, and apply them to systems of point charges as well as line, surface, and volume distributions of charges. Also to use the knowledge to solve some simple problems
- Express electric current and capacitance in terms of electric field and electric potential.
- Calculate the force experienced by a moving charge in a magnetic field
- Determine the magnetic force generated by a current carrying conductor
- Have brief idea of magnetic materials, understand the concept of electromagnetic induction, solve problems using Faraday's and Lenz's laws

In the laboratory course, students will be able to measure resistance (high and low), voltage, current, self and mutual inductance, capacitor, strength of magnetic field and its variation, study different electric circuits.

SYLLABUS OF PHYSICS DSC – 2

THEORY COMPONENT

Unit 1: (10 Hours)

Electrostatics: Electric field, electric flux, Gauss' theorem in electrostatics, applications of Gauss' theorem (linear, plane and spherical charge distribution), line integral of electric field, electric potential due to a point charge, electric potential and electric field of a dipole and charged disc, capacitance due to parallel plates and spherical condenser. Electrostatic energy of system of charge (charged sphere), dielectric medium, dielectric polarization, displacement vector, Gauss' theorem in dielectrics, parallel plate capacitor filled with dielectric.

Unit 2: (8 Hours)

Magnetostatics: Magnetic force between current elements and definition of magnetic field **B**, Biot-Savart's law and its applications (current carrying straight conductor, current carrying circular coil, current carrying solenoid), divergence and curl of magnetic field, Ampere's circuital law, magnetic properties of materials (magnetic intensity, magnetic induction, permeability, magnetic susceptibility), brief introduction of dia-, para- and ferro magnetic materials

Unit 3: (7 Hours)

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self-inductance of single coil, mutual inductance of two coils, energy stored in magnetic field. Maxwell`s equations and equation of continuity of current, displacement current

Unit 4: (5 Hours)

DC Circuits: Review of Kirchhoff's Voltage and Current Laws, Thevenin theorem, Norton theorem, Superposition theorem, Maximum Power Transfer theorem.

References:

Essential Readings:

1) Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill.
2) Electricity and Magnetism, J. H. Fewkes and J. Yarwood. Vol. I, 1991, Oxford Univ. Press
3) Electricity and Magnetism, D. C. Tayal, 1988, Himalaya Publishing House.
4) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
5) Introduction to Electrodynamics, D. J. Griffiths, 3rd Edn, 1998, Benjamin Cummings.

Additional Readings:

1) Electricity and Magnetism, Berkeley Physics Course, Edward M. Purcell, 1986, McGraw-Hill Education.
2) Problems and Solutions in Electromagnetics, Ajoy Ghatak, K Thyagarajan and Ravi Varshney.
3) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

4) Schaum's Outline of Electric Circuits, J. Edminister and M. Nahvi, 3rd Edn., 1995, McGraw Hill.

PRACTICAL COMPONENT – 60 Hours

The teacher is expected to give basic idea and working of various instruments and circuits related to different experiments. Students should also be given knowledge of recording and analyzing experimental data.
Every student should perform at least 06 experiments from the following list of experiments.

1) To use a multimeter for measuring resistances, a.c and d.c voltages, d.c. current, capacitance and for checking electrical fuses.
2) Ballistic Galvanometer:
    a) Measurement of charge and current sensitivity
    b) Measurement of critical damping resistance
    c) Determine a high resistance by leakage method
    d) Determine self-inductance of a coil by Rayleigh's Method.
3) To compare capacitances using de Sauty's bridge.
4) Measurement of field strength B and its variation in a Solenoid
5) To study the Characteristics of a Series RC Circuit.
6) To study a series LCR circuit and determine its resonant frequency and quality factor.
7) To study a parallel LCR circuit and determine its anti-resonant frequency and quality factor
8) To determine a low resistance by Carey Foster bridge.
9) To verify the Thevenin, superposition and maximum power transfer theorems
10) To verify Norton theorem

References (for Laboratory Work):

1) Advanced Practical Physics for Students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3) A Textbook of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4) Practical Physics, G. L. Squires, 2015, 4th Edition, Cambridge University Press
5) Advanced Level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category II

(Physical Science Courses (with Electronics) for Undergraduate Programme of study with Physics and Electronics discipline as Core Disciplines)

DISCIPLINE SPECIFIC CORE COURSE (PHYSICS DSC - 3): ELECTRICITY AND MAGNETISM

Course Title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Electricity and Magnetism Physics DSC 3	4	2	0	2	Class XII pass	----

LEARNING OBJECTIVES

This course reviews the concepts of electricity and magnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real world problems.

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Understand Gauss' law, Coulomb's law for the electric field, and apply them to systems of point charges as well as line, surface, and volume distributions of charges. Also to use the knowledge to solve some simple problems
- Express electric current and capacitance in terms of electric field and electric potential.
- Calculate the force experienced by a moving charge in a magnetic field
- Determine the magnetic force generated by a current carrying conductor
- Have brief idea of magnetic materials, understand the concept of electromagnetic induction, solve problems using Faraday's and Lenz's laws

In the laboratory course, students will be able to measure resistance (high and low), voltage, current, self and mutual inductance, capacitor, strength of magnetic field and its variation, study different electric circuits.

<u>SYLLABUS OF PHYSICS DSC – 3</u>

<u>THEORY COMPONENT</u>

Unit 1: (10 Hours)

Electrostatics: Electric field, electric flux, Gauss' theorem in electrostatics, applications of Gauss' theorem (linear, plane and spherical charge distribution), line integral of electric field, electric potential due to a point charge, electric potential and electric field of a dipole and charged disc, capacitance due to parallel plates and spherical condenser. Electrostatic energy of system of charge (charged sphere), dielectric medium, dielectric polarization, displacement vector, Gauss' theorem in dielectrics, parallel plate capacitor filled with dielectric.

Unit 2: (8 Hours)

Magnetostatics: Magnetic force between current elements and definition of magnetic field **B**, Biot-Savart's law and its applications (current carrying straight conductor, current carrying circular coil, current carrying solenoid), divergence and curl of magnetic field, Ampere's circuital law, magnetic properties of materials (magnetic intensity, magnetic induction, permeability, magnetic susceptibility), brief introduction of dia-, para- and ferro magnetic materials

Unit 3: (7 Hours)

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self-inductance of single coil, mutual inductance of two coils, energy stored in magnetic field. Maxwell`s equations and equation of continuity of current, displacement current

Unit 4: (5 Hours)

DC Circuits: Review of Kirchhoff's Voltage and Current Laws, Thevenin theorem, Norton theorem, Superposition theorem, Maximum Power Transfer theorem.

References:

Essential Readings:

1) Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill.
2) Electricity and Magnetism, J. H. Fewkes and J. Yarwood, Vol. I, 1991, Oxford Univ. Press
3) Electricity and Magnetism, D. C. Tayal, 1988, Himalaya Publishing House.
4) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
5) Introduction to Electrodynamics, D. J. Griffiths, 3rd Edn, 1998, Benjamin Cummings.

Additional Readings:

1) Electricity and Magnetism, Berkeley Physics Course, Edward M. Purcell, 1986, McGraw-Hill Education.
2) Problems and Solutions in Electromagnetics, Ajoy Ghatak, K Thyagarajan and Ravi Varshney

3) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
4) Schaum's Outline of Electric Circuits, J. Edminister and M. Nahvi, 3rd Edn., 1995, McGraw Hill.

PRACTICAL COMPONENT – 60 Hours

The teacher is expected to give basic idea and working of various instruments and circuits related to different experiments. Students should also be given knowledge of recording and analyzing experimental data.
Every student should perform at least 06 experiments from the following list of experiments.

1) To use a multimeter for measuring resistances, a.c and d.c voltages, d.c. current, capacitance and for checking electrical fuses.
2) Ballistic Galvanometer:
    e) Measurement of charge and current sensitivity
    f) Measurement of critical damping resistance
    g) Determine a high resistance by leakage method
    h) Determine self-inductance of a coil by Rayleigh's Method.
3) To compare capacitances using de Sauty's bridge.
4) Measurement of field strength B and its variation in a Solenoid
5) To study the Characteristics of a Series RC Circuit.
6) To study a series LCR circuit and determine its resonant frequency and quality factor.
7) To study a parallel LCR circuit and determine its anti-resonant frequency and quality factor
8) To determine a low resistance by Carey Foster bridge.
9) To verify the Thevenin, superposition and maximum power transfer theorems
10) To verify Norton theorem

References (for Laboratory Work):

1) Advanced Practical Physics for Students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3) A Textbook of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4) Practical Physics, G. L. Squires, 2015, 4th Edition, Cambridge University Press
5) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Category II

BSc. Physical Science with Chemistry as one of the Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – 4:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Periodic Properties and Chemical Bonding DSC-4 Chemistry-II	4	2	0	2	Class 12th Pass	----

Learning Objectives

The Learning Objectives of this course are as follows:

- The course discusses the periodicity in properties with reference to the s, p and d block, which is necessary in understanding their group chemistry.
- It provides basic knowledge about ionic, covalent and metallic bonding underlining the fact that chemical bonding is best regarded as a continuum between the three cases.
- It provides an overview of hydrogen bonding and van derWaal's forces which influence the melting points, boiling points, solubility and energetics of dissolution of compounds

Learning outcomes

By the end of the course, the students will be able to:

- Understand periodicity in ionization enthalpy, electron gain enthalpy, electronegativity and enthalpy of atomization.
- Understand variability in oxidation state, colour, metallic character, magnetic and catalytic properties and ability to form complexes
- Understand the concept of lattice energy using Born-Landé expression.
- Draw Born Haber Cycle and analyse reaction energies.
- Draw the plausible structures and geometries of molecules using VSEPR theory.
- Understand and draw MO diagrams (homo- & hetero-nuclear diatomic molecules). Understand the importance and applications of hydrogen and van der Wall bonding

SYLLABUS OF DSC-4

Unit I: Periodic Properties (12 Hours)

Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy, inert pair effect.
General group trends of s, p and d block elements with special reference to Ionization Enthalpy, Electron Gain Enthalpy, Electronegativity, Enthalpy of Atomization, oxidation state, colour, metallic character, magnetic and catalytic properties, ability to form complexes

UNIT II: Chemical Bonding (18 Hours)

Ionic Bonding: General characteristics of ionic bonding, Lattice Enthalpy and Solvation Enthalpy and their relation to stability and solubility of ionic compounds, Born-Lande equation for calculation of Lattice Enthalpy (no derivation), Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.
Covalent Bonding: Valence Bond Approach, Hybridization and VSEPR Theory with suitable examples, Concept of resonance and resonating structures in various inorganic and organic compounds, Molecular Orbital Approach: Rules for the LCAO method, bonding, nonbonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+.
Brief introduction to Metallic Bonding, Hydrogen Bonding, van der Waal's Forces

PRACTICALS: 60 Hours

1. Preparation of standard solutions.
2. Estimation of Sodium carbonate with HCl
3. Estimation of oxalic acid by titrating it with $KMnO_4$.
4. Estimation of Mohr's salt by titrating it with $KMnO_4$.
5. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
6. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal and external indicators.
7. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
8. Chromatographic separation of mixture of metal ions Cu^{2+}, Cd^{2+} or Ni^{2+}, Co^{2+}.
9. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using
   a). internal indicator
   b). external indicator
10. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
11. Paper Chromatographic separation of mixture of metal ions
    a). Cu^{2+} , Cd^{2+}
    b). Ni^{2+} , Co^{2+}
12. Any suitable experiment (other than the listed ones) based upon neutralisation/redox reactions.

References:

Theory:

1. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education
2. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic Chemistry**, 5th Edition, W. H. Freeman and Company.
4. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India
5. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994),**Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
6. Wulfsberg, G (2002), **Inorganic Chemistry**, Viva Books Private Limited.
7. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition, Pearson.

Practical:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Sciences (Physical Sciences)

Category II

BSc (Physical Sciences) with Chemistry as one of the Core Discipline

DISCIPLINE SPECIFIC CORE COURSE -7: Chemistry -III Chemical Energetics and Equilibria

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemical Energetics and Equilibria (DSC-7: Chemistry 03:	04	02	0	02	Passed Class 12^{th} with Physics, Chemistry, Mathematics	NIL

Learning objectives

The objectives of this course are as follows:

- To develop basic understanding of the chemical energetics, laws of thermodynamics and ionic equilibrium.
- to provides basic understanding of the behaviour of electrolytes and their solutions.
- To make students learn about the properties of ideal and real gases and deviation from ideal behavior

Learning outcomes

By studying this course, students will be able to:

- Explain the laws of thermodynamics, thermochemistry and equilibria.
- Use the concept of pH and its effect on the various physical and chemical properties of the compounds.
- Use the concepts learnt to predict feasibility of chemical reactions and to study the behaviour of reactions in equilibrium

SYLLABUS

UNIT-1: Chemical Energetics **(16 Hours)**

Recapitulation of Intensive and extensive variables; state and path functions; Isolated, closed and open systems

First law

Concept of heat (Q), work (W), internal energy (U), and statement of first law; enthalpy (H), relation between heat capacities for ideal gas, Joule's experiment, calculations of Q, W, ΔU and ΔH for reversible expansion of ideal gases under isothermal conditions.

Thermochemistry

Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of ionization enthalpy of hydration, enthalpy of formation and enthalpy of combustion, Integral enthalpy of solution, bond dissociation energy and bond enthalpy; Hess's law, Born Haber's cycle (NaCl/ KCl).

Second Law

Concept of entropy; statements of the second law of thermodynamics (Kelvin and Clausius). Calculation of entropy change for reversible processes (for ideal gases). Free Energy Functions: Gibbs and Helmholtz energy (Non-PV work and the work function); Free energy change and concept of spontaneity (for ideal gases).

Third Law

Statement of third law, qualitative treatment of absolute entropy of molecules (examples of NO, CO), concept of residual entropy

UNIT-2: Chemical Equilibrium (4 Hours)

Criteria of thermodynamic equilibrium. Free energy change in a chemical reaction and equilibrium constant, exergenic and endergenic reactions with examples such conversion of ATP to ADP or vice verca,, Le Chatelier's principle, relationship between Kp, Kc and Kx for reactions involving ideal gases.

UNIT-3: Ionic Equilibria (10 Hours)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, Ostwald's dilution law, ionization constant and ionic product of water, ionization of weak acids and bases, Degree of ionization, pH scale, common ion effect, Buffer solutions, Henderson-Hasselbach equation. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle

Practical Component: 60 Hours

(Laboratory periods: 15 classes of 4 hours each)

Chemical Energetics:

1. Determination of heat capacity ofcalorimeter.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodiumhydroxide.
3. Determination of the enthalpy of ionization of acetic acid.

4. Determination of enthalpy of neutralization of acetic acid and ammonium hydroxide using Hess's law.
5. Determination of integral enthalpy of solution (both endothermic and exothermic) of salts.
6. Determination of enthalpy of hydration of Copper sulphate.

Ionic equilibria:

7. Preparation of buffer solutions: (i) Sodium acetate-acetic acid or (ii) Ammonium chloride-ammonium acetate. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.
8. Study the effect of addition of HCl/NaOH on pH of the buffer solutions (acetic acid, and sodium acetate).
9. pH metric titration of strong acid with strong base,
10. pH metric titration of weak acid with strong base

References:

Theory:

1. Castellan, G. W. (2004),**Physical Chemistry**,Narosa.
2. Kapoor, K. L. (2015),**A Textbook of Physical Chemistry**,Vol 1, 6th Edition, McGraw Hill Education.
3. Kapoor, K. L. (2015), **A Textbook of Physical Chemistry**, Vol 2, 6thEdition, McGraw Hill Education.
4. Puri, B. R., Sharma, L. R. and Pathania M. S. (2020), **Principles of Physical Chemistry**, Vishal PublishingCo.

Practical:

1. Khosla,B. D.;Garg,V. C.; Gulati,A.(2015), **SeniorPracticalPhysicalChemistry**,R.Chand&Co.
2. Kapoor, K. L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGraw Hill Education.
3. Batra, S. K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry,** Book Age series.

Additional Resources:

1. Mahan, B. H.(2013), **University Chemistry**,Narosa.
2. Barrow, G. M. (2006), **Physical Chemistry**, 5thEdition, McGrawHill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Pool of DISCIPLINE SPECIFIC ELECTIVES (DSEs) for BSC (Physical Science)

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -1:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-1: Main Group Chemistry	**04**	**02**	**0**	**02**	**Passed Class XII with Science**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide basic understanding of the fundamental principles of metallurgy through study of the different methods of extraction and refining of metals.
- To illustrate the diversity and fascination of inorganic chemistry through the study of structure, properties and utilities of s- and p-block elements and their compounds.

Learning outcomes

By studying this course, students will be able to:

- Understand the basis of occurrence of metals in nature and the methods that can be applied on minerals to extract the metals from them.
- Explain the importance of free energy of formation of oxides with the choice of reducing agent for extracting the metals.
- Understand and explain the importance of refining of metals and the choice of a refining procedure
- Explain the group trends observed for different properties of s and p block elements
- Explain the structures and the bonding basis of compounds of s- and p- block elements
- Explain the uniqueness observed in alkali metals and some other main group elements
- Understand and explain the polymerization of inorganic ions to generate inorganic polymers and the difference between organic and inorganic polymers.

Syllabus

Unit 1: General Principles of Metallurgy **(6 Hours)**

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining.

Unit 2: General Properties **(4 Hours)**

General group trends of s- and p-block elements with special reference to melting and boiling points, flame colour, metallic character and complex formation tendency, diagonal relationship and anomalous behaviour of first member of each group, Alkali metal solutions in liquid ammonia

Unit 3: Structure, Bonding, Properties and Applications **(16 Hours)**

Structure, bonding, properties (Acidic/Basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, thermal stability) and applications of the following:

Crown Ethers and cryptates of Alkali metals

Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.

Oxides: Oxides of nitrogen, phosphorus and sulphur.

Oxoacids: oxoacids of phosphorus, sulphur and chlorine

Halides of phosphorus

Unit 4: Inorganic Polymers **(4 Hours)**

Preparation, properties, structure and uses of the following:

Borazine, Silicates and Silicones

Practicals **(60 Hours)**

(Laboratory periods:60)

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations (preferably 7-8 mixtures). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-},

NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}

The mixtures may contain combination of anions/one interfering anion.

Spot tests should be preferred wherever applicable.

References:

Theory:

1. Lee, J.D.; (2010), Concise Inorganic Chemistry, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), Concepts and Models of Inorganic Chemistry, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
5. Housecraft, E. H.; Sharpe, A.G. (2018), Inorganic Chemistry, 5th Edition, Pearson.
6. F.A. Cotton & G. Wilkinson (1999), Advanced Inorganic Chemistry, 6th Edition, John Wiley & Sons.

Practicals:

1. Vogel, A.I. (1972), Qualitative Inorganic Analysis, Longman.
2. Svehla, G. (1996), Vogel's Qualitative Inorganic Analysis, Prentice Hall.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -2:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-2: Polynuclear Hydrocarbons, Pharmaceutical Compounds, UV- Visible & IR Spectroscopy	**04**	**02**	**0**	**02**	**Passed Class XII with Science**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the chemistry and applications of polynuclear hydrocarbons and heterocyclic compounds.
- Introduction to spectroscopy, an important analytical tool which allows identification of organic compounds by correlating their spectra to structure.

Learning outcomes

By studying this course, students will be able to:

- Understand the fundamentals of polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques.
- Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules.

SYLLABUS OF CHEM-DSE-2

UNIT-1: Polynuclear Hydrocarbons (6 Hours)

Introduction, classification, uses, aromaticity of polynuclear compounds, Structure elucidation of naphthalene, preparation and properties of naphthalene and anthracene.

UNIT-2: Pharmaceutical Compounds **(12 Hours)**

Introduction, classification, general mode of action of antipyretics and analgesics, aspirin; Synthesis, uses and side effects of the following drugs:
Antipyretics - Paracetamol (with synthesis and mode of action); Analgesics- Ibuprofen (with synthesis and overview of the mode of action); Antimalarials - Chloroquine (synthesis and mode of action).
An elementary treatment of Antibiotics and detailed study of chloramphenicol including mode of action. Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

UNIT-3: UV-Visible and IR Spectroscopy **(12 Hours)**

UV-Visible and IR Spectroscopy and their application to simple organic molecules. Electromagnetic radiations and their properties; double bond equivalence and hydrogen deficiency. UV-Visible spectroscopy (electronic spectroscopy): General electronic transitions, λ_{max} & ε_{max}, chromophores &auxochromes, bathochromic & hypsochromic shifts. Application of Woodward rules for the calculation of λ_{max} for the following systems: conjugated dienes - alicyclic, homoannular and heteroannular; α, β-unsaturated aldehydes and ketones, charge transfer complex.

Infrared (IR) Spectroscopy: Infrared radiation and types of molecular vibrations, the significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Practical component 60 Hours
(Laboratory periods: 15 classes of 4 hours each)

1. Isolation and estimation of the amount of aspirin in a commercial tablet.
2. Preparation of Aspirin.
3. Synthesis of ibuprofen.
4. Systematic qualitative identification and derivative preparation of organic compounds (Aromatic hydrocarbons, Aryl halides)
5. Detection of simple functional groups through examination of IR spectra (spectra to be provided). IR spectra of simple compounds like phenols, aldehydes, ketones, carboxylic acids may be given.
6. Differentiation between of o-/p-hydroxybenzaldehyde by IR spectroscopy (Spectra to be provided).
7. Differentiation between benzoic acid and cinnamic acid by UV spectroscopy.
8. Diel’s Alder reaction using Anthracene and Maleic anhydride.
9. Partial Reduction of m-dinitrobenzene to m-nitroaniline and then analysing the IR spectra of reactant and Product.
10. Laboratory preparation of Paraacetamol.

References:

Theory:

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd.

(Pearson Education).
2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry,** Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.
4. Pavia, D.L. **Introduction to Spectroscopy**, Cengage learning (India) Pvt. Ltd.
3. Kemp, W. (1991), **Organic Spectroscopy**, Palgrave Macmillan.

Practicals:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry,** University Press (India) Ltd.
2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 3:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 3: Computer Applications in Chemistry	**04**	**02**	**0**	**02**	**Passed Class XII with Science**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to basic computer skills that will help them in solving chemistry problems using spreadsheets and BASIC language.
- To acquaint the students with different software for data tabulation, calculation, graph plotting, data analysis and document preparation.
- To expose the students to the concept of molecular modelling, its applications to various molecular systems, energy minimization techniques, analysis of Mulliken Charge and ESP Plots.

Learning outcomes

By studying this course, students will be able to:

- Have knowledge of most commonly used commands and library functions used in programming in C language.
- Develop algorithm to solve problems and write corresponding programs in C language for performing calculations involved in laboratory experiments.
- Use various spreadsheet software to perform theoretical calculations and plot graphs

SYLLABUS OF CHEM-DSE-3

UNIT-1: Programming using BASIC **(20 Hours)**

Programming Language – Elements of BASIC language, Numeric and string Constants and Variables, arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the various QBASIC commands: REM, CLS, INPUT, PRINT, GOTO, IF, IF…THEN, IF..THEN..ELSE, IF and END IF, FOR and NEXT etc., DIM, READ, DATA, GOSUB, RETURN, RESTORE, DEF FNR and Library Functions, Simple programs based on usage of the commands mentioned above.

Statistical analysis using BASIC: Mean, Least square fit - Linear regression, variance, standard deviation.

UNIT-2: Handling of Numerical Data (4 Hours)

Spreadsheet software: MS Excel. Creating a spreadsheet, entering and formatting information, applying basic functions and formulae to the data, drawing charts, tables and graphs, displaying the equation of graph along with the R^2 value, incorporating tables and graphs in Word files, graphical solution of equations, plotting pressure-volume curves of van der Waals gases, Maxwell-Boltzmann distribution, concentration versus time graphs, spectral data, titration curves, etc.

UNIT-3: Molecular Modelling (6 Hours)

Introduction to molecular modelling, overview of classical and quantum mechanical methods (molecular mechanics, semi empirical, ab initio and DFT), general considerations and comparison of these methods.

Practical component 60 Hours

(Laboratory periods: 15 classes of 4 hours each)

Exercises of Programing

1. Calculate pressure of a real gas using Van der Waal's Equation.
2. Calculate the most probable speed, average speed and root men square velocity of an ideal gas.
3. Roots of quadratic equations
4. Binomial coefficient using GOSUB statement.
5. Mean, standard deviation
6. Least square curve fitting method for linear equation.

Plotting graphs using a spreadsheet

1. van der Waals isotherms
2. Maxwell-Boltzmann distribution curves as function of temperature and molecular weight
3. Plot the conductometric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base
4. Plot the pH metric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base and determine the pK_a of the weak acid
5. Plot the graphs for the kinetics of first order reaction and determine the rate constant
6. Plot the UV-vis absorbance spectra and determine the molar absorption coefficient.

Molecular Modelling

1. Optimize and compare the geometry parameters of H_2O and H_2S using Argus Lab.
2. Compare the basicities of N atom in ammonia, methylamine, dimethylamine and trimethylamine using Argus Lab by comparing Mulliken charges and ESP map in Argus Lab.
3. Compare C-C bond lengths and bond order in ethane, ethene and ethyne using Argus Lab.
4. Determine enthalpy of isomerization of cis and trans-2-butene in Argus Lab.
5. Compare the HAH bond angles for the second row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory.

References:

Theory:

1. Levie, R. de. (2001), **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press.
2. Venit, S.M. (1996),**Programming in BASIC: Problem solving with structure and style**. Jaico Publishing House.
3. Lewars, E. (2003), **Computational Chemistry,** Kluwer academic Publisher.
4. Cramer, C.J.(2004), **Essentials of Computational Chemistry,** John Wiley & Sons.
5. Hinchcliffe, A. (1996), **Modelling Molecular Structures,** John Wiley & Sons.
6. Leach, A.R.(2001), **Molecular Modelling,** Prentice-Hall.

Practicals:

1. Lewars, E. **(2003), Computational Chemistry,** Kluwer academic Publisher.
2. Cramer, C.J. **(2004), Essentials of Computational Chemistry,** John Wiley & Sons.
3. Hinchcliffe, A. **(1996), Modelling Molecular Structures,** John Wiley & Sons.

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Category II

Physical Science Courses
with Physics discipline as one of the Core Disciplines

(B. Sc. Physical Science with Physics as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 3: HEAT AND THERMODYNAMICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
HEAT AND THERMODYNAMICS PHYSICS DSC – 3	4	2	0	2	Passed 12th Class	NIL

LEARNING OBJECTIVES

This course will review the basic concepts of thermodynamics, kinetic theory of gases with a brief introduction to statistical mechanics. The primary goal is to make the student understand the applications of fundamental laws of thermodynamics to various systems and processes. This coursework will enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecule through a brief knowledge of statistical mechanics. The lab course deals with providing the knowledge of the concepts of thermodynamics along with Planck's law and Stefan Boltzmann laws related to black body radiation.

LEARNING OUTCOMES

At the end of this course, students will be able to,

- gain an essence of the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations along with Maxwell's thermodynamic relations.
- Know the fundamentals of the kinetic theory of gases, Maxwell-Boltzmann distribution law, mean free path of molecular collisions, viscosity, thermal conductivity and diffusion.
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significances.
- gain the basic knowledge about quantum statistics: the Bose-Einstein statistics and the Fermi-Dirac statistics.
- In the laboratory course, the students are expected to: Measure of Planck's constant using black body radiation, determine Stefan's Constant, coefficient of thermal conductivity of a bad conductor and a good conductor, determine the temperature coefficient of

resistance, study variation of thermo-e.m.f. across two junctions of a thermocouple with temperature etc.

SYLLABUS OF PHYSICS DSC – 3

THEORY COMPONENT

Unit – I - Laws of Thermodynamics (10 Hours)

Fundamental basics of Thermodynamic system and variables, Zeroth Law of Thermodynamics and temperature, First law and internal energy, various thermodynamical processes, Applications of First Law: general relation between C_P and C_V, work done during various processes, Compressibility and Expansion Coefficient, reversible and irreversible processes, Second law: Kelvin-Planck and Clausius statements, Carnot engine, Carnot cycle and theorem, basic concept of Entropy, Entropy changes in reversible and irreversible processes, Clausius inequality, Entropy-temperature diagrams.

Unit – II - Thermodynamic Potentials and Maxwell's Relations (5 Hours)

Basic concept of Thermodynamic Potentials, Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, derivation of Maxwell's Thermodynamic Relations and their applications in Clausius Clapeyron Equation, value of $C_P - C_v$, TdS Equations, Energy equations for ideal gases, evaluation of C_P / C_v

Unit – III - Kinetic Theory of Gases and Molecular Collisions (6 Hours)

Maxwell-Boltzmann Law of Distribution of Velocities in an ideal gas and its experimental verification, Mean, Root Mean Square and Most Probable Speeds, Mean Free Path (Zeroth order), Transport Phenomena in ideal gases: Viscosity, Thermal Conductivity and Diffusion (for vertical case)

Unit – IV - Theory of Radiation (5 Hours)

Blackbody radiation, Spectral distribution, Derivation of Planck's law, Deduction of Wien's law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law

Unit – V - Statistical Mechanics (4 Hours)

Macrostate and Microstate, phase space, Entropy and thermodynamic probability, Maxwell-Boltzmann law, qualitative description of Quantum statistics – Bose Einstein and Fermi Dirac, comparison of three statistics.

References:

Essential Readings:

1) Heat and Thermodynamics: M. W. Zemansky and R. Dittman, Tata McGraw-Hill, 1981
2) Thermal Physics: S. C. Garg, R. M. Bansal and C. K. Ghosh, 2nd Edition, Tata McGraw-Hill.
3) Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Sears and Salinger, Narosa, 1988
4) Concepts in Thermal Physics: Blundell and Blundell, 2nd Edition, Oxford University Press, 2009
5) Thermal Physics, A. Kumar and S. P. Taneja, R. Chand Publications, 2014
6) A Text Book of Heat and Thermodynamics for Degree Students, J. B. Rajam, S. Chand, 1981

Additional Readings:

1) An Introduction to Thermal Physics: D. Schroeder, Oxford University Press (earlier published by Pearsons), 2021
2) Thermal Physics: C. Kittel and H. Kroemer, 2nd Edition, W. H. Freeman, 1980
3) Heat, Thermodynamics and Statistical Physics, Brij Lal, N. Subrahmanyam and P. S. Hemne, S. Chand and Company

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be done from the following:

1) To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2) To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3) To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method using steam or electrical heating.
4) Measurement of Planck's constant using black body radiation.
5) To determine the temperature coefficient of resistance by Platinum Resistance Thermometer using Carey Foster's bridge.
6) To study the variation of thermo-e.m.f. across two junctions of a thermocouple with temperature.
7) To determine Stefan's Constant.
8) To determine the Temperature Coefficient of Resistance using Platinum Resistance Thermometer (PRT) by Callender-Griffith Bridge

References for laboratory work:

1) Advanced Practical Physics for students: B. L. Flint and H. T. Worsnop, Asia Publishing House, 1971
2) A Text Book of Practical Physics: Indu Prakash and Ramakrishna, 11th Edition, Kitab Mahal
3) Advanced level Practical Physics: Nelkon and Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4) An Advanced Course in Practical Physics: D. Chattopadhyay and P. C. Rakshit, 1990, New Central Book Agency.
5) Practical Physics: G. L. Squires, Cambridge University Press, 1985
6) B.Sc. Practical Physics: Harnam Singh, P. S. Hemne, revised edition 2011, S. Chand and Co.
7) B. Sc. Practical Physics: C. L. Arora, S. Chand and Co.
8) B. Sc. Practical Physics: Geeta Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 13a: BIOPHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Biophysics PHYSICS DSE 13a	4	3	0	1	Passed 12^{th} Class	NIL

LEARNING OBJECTIVES

This course familiarizes the students with the basic facts and ideas of biology from a quantitative perspective. It shows them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales. The course also gives them a flavour of the interface between biology, chemistry, physics and mathematics.

LEARNING OUTCOMES

After completing this course, students will

- Know basic facts about biological systems, including single cells, multicellular organisms and ecosystems from a quantitative perspective.
- Gain familiarity with various biological processes at different length and time scales, including molecular processes, organism level processes and evolution.
- Be able to apply the principles of physics from areas such as mechanics, electricity and magnetism, thermodynamics, statistical mechanics, and dynamical systems to understand certain living processes.
- Get exposure to complexity of life at i) the level of cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere.
- Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behaviour.
- Perform mathematical and computational modelling of certain aspects of living systems.
- Get exposure to models of evolution.
- Be able to perform experiments demonstrating certain physical processes that occur in living systems.

SYLLABUS OF PHYSICS DSE – 13a

THEORY COMPONENT

Unit – I **(4 Hours)**

Overview: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales.

Unit - II **(12 Hours)**

Molecules of life: Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation.

Unit - III **(12 Hours)**

Molecular motion in cells: Random walks and applications to biology: Diffusion; models of macromolecules. Mechanical, entropic and chemical forces: Osmosis, cell assembly, molecular motors, bacterial chemotaxis.

Unit - IV **(12 Hours)**

The complexity of life: At the level of a cell: Intracellular biochemical networks. Dynamics of metabolic networks; the stoichiometric matrix. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cellular differentiation and development. Brain structure: neurons and neural networks. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems. Allometric scaling laws.

Unit - V **(5 Hours)**

Evolution: The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

List of experiments

1) Demonstration of diffusion, effect of medium, temperature, molecular weight and size on the rate of diffusion.
2) Demonstration of osmosis in a living system.
3) Demonstration of the relationship between viscosity and density.
4) Demonstration of how microscopic particles travel in air through aerosols.
5) Graphic visualization and demonstrations of 3D structure of biomolecules using in-silico visualization tools.
6) Estimation of serum protein using BSA as the standard. (Optional).

References:

Essential Readings:

1) Biological Physics: Energy, Information, Life; Philip Nelson (W. H. Freeman & Co, NY, 2004)
2) Cell Biology by the Numbers; Ron Milo and Rob Phillips (Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2016)
3) Physical Biology of the Cell (2nd Edition); Rob Phillips et al (Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2013)
4) Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd Edition).

Additional Readings:

1) Physics in Molecular Biology; Kim Sneppen and Giovanni Zocchi (Cambridge University Press, Cambridge UK, 2005)
2) Biophysics: Searching for Principles; William Bialek (Princeton University Press, Princeton USA, 2012).

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 13b: MATHEMATICAL PHYSICS I

<table>
<tr><th rowspan="2">Course Title & Code</th><th rowspan="2">Credits</th><th colspan="3">Credit distribution of the course</th><th rowspan="2">Eligibility Criteria</th><th rowspan="2">Pre-requisite of the course</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>MATHEMATICAL PHYSICS I

PHYSICS DSE – 13b</td><td>4</td><td>3</td><td>1</td><td>0</td><td>Passed 12th Class</td><td>NIL</td></tr>
</table>

LEARNING OBJECTIVES

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. The mathematical tools might be building blocks to understand the fundamental computational physics skills and hence enable them to solve a wide range of physics problems. Overall, to help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers

LEARNING OUTCOMES

After completing this course, student will be able to,

- Learn the functions more than one variable using the concepts of calculus.
- Solve first order differential equations and apply it to physical problems.
- Represent a periodic function by a sum of harmonics using Fourier series.
- Obtain power series solution of differential equation of 2^{nd} order with variable coefficients using Frobenius mehod.
- Learn beta and gamma functions

SYLLABUS OF PHYSICS DSE 13b

THEORY COMPONENT

Unit – I **(18 Hours)**

Calculus of functions of more than one variable: Partial derivatives, chain rule for partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions. Application to Summing of Infinite Series.

Unit – II **(12 Hours)**

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre Differential Equations and its solution. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations.

Unit – III **(15 Hours)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of 1D wave equation.

References:

Essential Readings:

1) An introduction to ordinary differential equations, E.A. Coddington, PHI learning, 2009
2) Differential Equations, George F. Simmons, McGraw Hill, 2007
3) Mathematical methods for Scientists and Engineers, D. A. McQuarrie, Viva Book, 2003
4) Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, 5th Edition, Jones and Bartlett Learning, 2012
5) Advanced Engineering Mathematics, Erwin Kreyszig, Wiley India, 2008
6) Fourier Analysis: With Applications to Boundary Value Problems, Murray Spiegel, McGraw Hill Education, 2017
7) Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, F. E. Harris, 7th Edition, Elsevier, 2013
8) Essential Mathematical Methods, K. F. Riley and M. P. Hobson, Cambridge Univ. Press, 2011

Additional Readings:

1) Introduction to Electrodynamics, Chapter 1, David J. Griffiths, 4th Edition, Cambridge University Press, 2017
2) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, Narosa Publishing House, 2008
3) Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, 5th Edition, Jones and Bartlett Learning, 2012
4) Mathematical Tools for Physics, James Nearing, Dover Publications, 2010
5) Mathematical Physics, A. K. Ghatak, I. C. Goyal and S. J. Chua, Laxmi Publications Private Limited, 2017

Category II

Physical Science Courses (with Electronics)
with Physics and Electronics discipline as Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 5: HEAT AND THERMODYNAMICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
HEAT AND THERMODYNAMICS PHYSICS DSC 5	4	2	0	2	Passed 12th Class	NIL

LEARNING OBJECTIVES

This course will review the basic concepts of Thermodynamics, Kinetic Theory of gases with a brief introduction to Statistical Mechanics. The primary goal is to make the student understand the applications of fundamental laws of thermodynamics to various systems and processes. This coursework will enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecule through a brief knowledge of statistical mechanics. The lab course deals with providing the knowledge of the concepts of Thermodynamics along with Planck's Law and Stefan Boltzmann laws related to black body radiation.

LEARNING OUTCOMES

At the end of this course, students will be able to

- gain an essence of the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations along with Maxwell's thermodynamic relations.
- Know the fundamentals of the kinetic theory of gases, Maxwell-Boltzmann distribution law, mean free path of molecular collisions, viscosity, thermal conductivity and diffusion.
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significances.
- gain the basic knowledge about quantum statistics: the Bose-Einstein statistics and the Fermi-Dirac statistics.
- In the laboratory course, the students are expected to: Measure of Planck's constant using black body radiation, determine Stefan's Constant, coefficient of thermal conductivity of a bad conductor and a good conductor, determine the temperature coefficient of resistance, study variation of thermo-e.m.f. across two junctions of a thermocouple with temperature etc.

SYLLABUS OF PHYSICS DSC – 5

THEORY COMPONENT

Unit – I - Laws of Thermodynamics (10 Hours)

Fundamental basics of Thermodynamic system and variables, Zeroth Law of Thermodynamics and temperature, First law and internal energy, various thermodynamical processes, Applications of First Law: general relation between C_P and C_V, work done during various processes, Compressibility and Expansion Coefficient, reversible and irreversible processes, Second law: Kelvin-Planck and Clausius statements, Carnot engine, Carnot cycle and theorem, basic concept of Entropy, Entropy changes in reversible and irreversible processes, Clausius inequality, Entropy-temperature diagrams.

Unit – II - Thermodynamic Potentials and Maxwell's Relations (5 Hours)

Basic concept of Thermodynamic Potentials, Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy, derivation of Maxwell's Thermodynamic Relations and their applications in Clausius Clapeyron Equation, value of $C_P - C_v$, TdS Equations, Energy equations for ideal gases, evaluation of C_P / C_v

Unit – III - Kinetic Theory of Gases and Molecular Collisions (6 Hours)

Maxwell-Boltzmann Law of Distribution of Velocities in an ideal gas and its experimental verification, Mean, Root Mean Square and Most Probable Speeds, Mean Free Path (Zeroth order), Transport Phenomena in ideal gases: Viscosity, Thermal Conductivity and Diffusion (for vertical case)

Unit – IV - Theory of Radiation (5 Hours)

Blackbody radiation, Spectral distribution, Derivation of Planck's law, Deduction of Wien's law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law

Unit – V - Statistical Mechanics (4 Hours)

Macrostate and Microstate, phase space, Entropy and thermodynamic probability, Maxwell-Boltzmann law, qualitative description of Quantum statistics – Bose Einstein and Fermi Dirac, comparison of three statistics.

References:

Essential Readings:

1) Heat and Thermodynamics: M. W. Zemansky and R. Dittman, Tata McGraw-Hill, 1981
2) Thermal Physics: S. C. Garg, R. M. Bansal and C. K. Ghosh, 2nd Edition, Tata McGraw-Hill.
3) Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Sears and Salinger, Narosa, 1988
4) Concepts in Thermal Physics: Blundell and Blundell, 2nd Edition, Oxford University Press, 2009
5) Thermal Physics, A. Kumar and S. P. Taneja, R. Chand Publications, 2014
6) A Text Book of Heat and Thermodynamics for Degree Students, J. B. Rajam, S. Chand, 1981

Additional Readings:

1) An Introduction to Thermal Physics: D. Schroeder, Oxford University Press (earlier published by Pearsons), 2021
2) Thermal Physics: C. Kittel and H. Kroemer, 2nd Edition, W. H. Freeman, 1980
3) Heat, Thermodynamics and Statistical Physics, Brij Lal, N. Subrahmanyam and P. S. Hemne, S. Chand and Company

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be done from the following:

1) To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2) To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3) To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method using steam or electrical heating.
4) Measurement of Planck's constant using black body radiation.
5) To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer using Carey Foster's bridge.
6) To study the variation of thermo-e.m.f across two junctions of a thermocouple with temperature.
7) To determine Stefan's Constant.
8) To determine the Temperature Coefficient of Resistance using Platinum Resistance Thermometer (PRT) by Callender-Griffith Bridge

References for laboratory work:

1) Advanced Practical Physics for students: B. L. Flint and H. T. Worsnop, Asia Publishing House, 1971
2) A Text Book of Practical Physics: Indu Prakash and Ramakrishna, 11th Edition, Kitab Mahal
3) Advanced level Practical Physics: Nelkon and Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4) An Advanced Course in Practical Physics: D. Chattopadhyay and P. C. Rakshit, New Central Book Agency, 1990
5) Practical Physics: G. L. Squires, Cambridge University Press, 1985
6) B.Sc. Practical Physics: Harnam Singh, Dr P. S. Hemne, revised edition 2011, S. Chand and Co.
7) B. Sc. Practical Physics: C. L. Arora, S. Chand and Co.
8) B. Sc. Practical Physics: Geeta Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 6: COMMUNICATION ELECTRONICS

<table>
<tr><th rowspan="2">Course Title & Code</th><th rowspan="2">Credits</th><th colspan="3">Credit distribution of the course</th><th rowspan="2">Eligibility Criteria</th><th rowspan="2">Pre-requisite of the course</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>COMMUNICATION ELECTRONICS

PHYSICS DSC – 6</td><td>4</td><td>2</td><td>0</td><td>2</td><td>Passed 12^{th} Class</td><td>NIL</td></tr>
</table>

LEARNING OBJECTIVES

This paper aims to describe the concepts of electronics in communication. Communication techniques based on analog modulation, analog and digital pulse modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail. Communication and Navigation systems such as GPS, satellite and mobile telephony systems are introduced.

LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes:

- This paper aims to describe the concepts of electronics in communication. In this course, students will receive an introduction to the principle, performance and applications of communication systems.
- Students will learn the various means and modes of communication. They will gain an understanding of fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- They will gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Students will be able to analyse different parameters of analog communication techniques.
- They will learn the need of sampling and different sampling techniques where they can sample analog signal
- Students will learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- They will gain an in-depth understanding of different concepts used in a satellite communication system.
- This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

SYLLABUS OF PHYSICS DSC 6

THEORY COMPONENT

Unit – I **(10 Hours)**

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals.

Analog Modulation: Amplitude Modulation: Frequency spectrum of AM waves, average power, average voltage, modulation index, AM-modulator circuits (collector modulation), AM-demodulator (diode detector), single side band generation and detection.

Angle Modulation: Frequency and phase modulation, frequency spectrum of FM waves, intersystem comparisons (FM and AM), FM generation using VCO, FM detector (slope detector)

Unit – II **(5 Hours)**

Analog Pulse Modulation: Channel capacity, Sampling Theorem and Nyquist Criterion, Basic Principles – Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM), modulation and detection technique for PAM only, Multiplexing – Time Division Multiplexing (TDM) and Frequency Division Multiplexing (FDM).

Unit – III **(6 Hours)**

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation (PCM), Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK) and Phase Shift Keying (PSK)

Unit – IV **(6 Hours)**

Satellite Communication: Introduction, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of the earth station.

Unit – V **(3 Hours)**

Mobile Telephony System: Basic concept of mobile communication, frequency bands used in mobile communication, the concept of cell sectoring and cell splitting, SIM number, IMEI number, GPS navigation system (qualitative idea only).

References:

Essential Readings:

1) Communication Electronics, Principles and Applications, L. E. Frenzel, Tata McGraw-Hill.
2) Communication Systems: Analog and Digital, R. P. Singh and S. D. Sapre, Tata McGraw-Hill.
3) Analog and Digital Communications, H. Hsu, Schaum's Outline Series, Tata McGraw-Hill.
4) Electronic Communications Systems: Fundamentals Through Advanced, Wayne Tomasi, Fifth Edition, Pearson.

5) Communication Systems, S. Haykin, Wiley India

Additional Readings:

1) Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
2) Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
3) Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Every student must perform at least 06 experiments.

1) To study AM – Generation and Detection circuit
2) To study FM – Generation and Detection circuit
3) To study Time Division Multiplexing (TDM)
4) To study Pulse Amplitude Modulation (PAM)
5) To study Pulse Width Modulation (PWM)
6) To study Pulse Position Modulation (PPM)
7) To study Amplitude Shift Keying (ASK)
8) To study Frequency Shift Keying (FSK)
9) To study Phase Shift Keying (PSK)

References (for Laboratory Work):

1) Introduction to Analog and Digital Communication – by M. A. Bhagyaveni, R. Kalidoss and K. S. Vishvaksenan, River Publishers Series in Communications
2) Communication Systems – by Michael Moher Simon Haykin, Wiley
3) Wireless Communication – by Goldsmith Andrea, Cambridge University Press
4) Digital Communications: Fundamentals and Applications – Bernard Sklar and Pabitra Kumar Ray, Pearson Education India

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 1: BIOPHYSICS

<table>
<tr><th rowspan="2">Course Title & Code</th><th rowspan="2">Credits</th><th colspan="3">Credit distribution of the course</th><th rowspan="2">Eligibility Criteria</th><th rowspan="2">Pre-requisite of the course</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>Biophysics

PHYSICS DSE 1</td><td>4</td><td>3</td><td>0</td><td>1</td><td>Passed 12th Class</td><td>NIL</td></tr>
</table>

LEARNING OBJECTIVES

This course familiarizes the students with the basic facts and ideas of biology from a quantitative perspective. It shows them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales. The course also gives them a flavour of the interface between biology, chemistry, physics and mathematics.

LEARNING OUTCOMES

After completing this course, students will

- Know basic facts about biological systems, including single cells, multicellular organisms and ecosystems from a quantitative perspective.
- Gain familiarity with various biological processes at different length and time scales, including molecular processes, organism level processes and evolution.
- Be able to apply the principles of physics from areas such as mechanics, electricity and magnetism, thermodynamics, statistical mechanics, and dynamical systems to understand certain living processes.
- Get exposure to complexity of life at i) the level of cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere.
- Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behaviour.
- Perform mathematical and computational modelling of certain aspects of living systems.
- Get exposure to models of evolution.
- Be able to perform experiments demonstrating certain physical processes that occur in living systems.

SYLLABUS OF PHYSICS DSE – 1

THEORY COMPONENT

Unit – I **(4 Hours)**

Overview: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales.

Unit - II **(12 Hours)**

Molecules of life: Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation.

Unit - III **(12 Hours)**

Molecular motion in cells: Random walks and applications to biology: Diffusion; models of macromolecules. Mechanical, entropic and chemical forces: Osmosis, cell assembly, molecular motors, bacterial chemotaxis.

Unit - IV **(12 Hours)**

The complexity of life: At the level of a cell: Intracellular biochemical networks. Dynamics of metabolic networks; the stoichiometric matrix. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cellular differentiation and development. Brain structure: neurons and neural networks. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems. Allometric scaling laws.

Unit - V **(5 Hours)**

Evolution: The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution.

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

List of experiments

1) Demonstration of diffusion, effect of medium, temperature, molecular weight and size on the rate of diffusion.
2) Demonstration of osmosis in a living system.
3) Demonstration of the relationship between viscosity and density.
4) Demonstration of how microscopic particles travel in air through aerosols.
5) Graphic visualization and demonstrations of 3D structure of biomolecules using in-silico visualization tools.
6) Estimation of serum protein using BSA as the standard. (Optional).

References:

Essential Readings:

1) Biological Physics: Energy, Information, Life, P. Nelson, W. H. Freeman & Co, NY, 2004
2) Cell Biology by the Numbers, R. Milo and R. Phillips, Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2016
3) Physical Biology of the Cell, R. Phillips et al, 2nd edition, Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2013
4) Evolution, M. Ridley, Blackwell Publishers, 2009, 3rd edition

Additional Readings:

1) Physics in Molecular Biology, K. Sneppen and G. Zocchi, Cambridge University Press, Cambridge UK, 2005
2) Biophysics: Searching for Principles, W. Bialek, Princeton University Press, Princeton USA, 2012

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 2: MATHEMATICAL PHYSICS I

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
MATHEMATICAL PHYSICS I Physics DSE 2	**4**	**3**	**1**	**0**	Passed 12th Class	NIL

LEARNING OBJECTIVES

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. The mathematical tools might be building blocks to understand the fundamental computational physics skills and hence enable them to solve a wide range of physics problems. Overall, to help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers

LEARNING OUTCOMES

After completing this course, student will be able to,

- Learn the functions more than one variable using the concepts of calculus.
- Solve first order differential equations and apply it to physical problems.
- Represent a periodic function by a sum of harmonics using Fourier series.
- Obtain power series solution of differential equation of 2nd order with variable coefficients using Frobenius mehod.
- Learn beta and gamma functions

SYLLABUS OF PHYSICS DSE 2

THEORY COMPONENT

Unit – I **(18 Hours)**

Calculus of functions of more than one variable: Partial derivatives, chain rule for partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions. Application to Summing of Infinite Series.

Unit – II **(12 Hours)**

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre Differential Equations and its solution. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations.

Unit – III **(15 Hours)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of 1D wave equation.

References:

Essential Readings:

1) An introduction to ordinary differential equations, E. A. Coddington, PHI learning, 2009
2) Differential Equations, George F. Simmons, McGraw Hill, 2007
3) Mathematical methods for Scientists and Engineers, D. A. McQuarrie, Viva Book, 2003
4) Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5th Edition, Jones and Bartlett Learning, 2012
5) Advanced Engineering Mathematics, Erwin Kreyszig, Wiley India, 2008
6) Fourier Analysis: With Applications to Boundary Value Problems, Murray Spiegel, McGraw Hill Education, 2017
7) Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, F.E. Harris, 7th Edition, Elsevier, 2013
8) Essential Mathematical Methods, K. F. Riley and M. P. Hobson, Cambridge University Press, 2011

Additional Readings:

1) Introduction to Electrodynamics, Chapter 1, David J. Griffiths, 4th Edition, Cambridge University Press, 2017
2) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, Narosa Publishing House, 2008
3) Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, 5th Edition, Jones and Bartlett Learning, 2012
4) Mathematical Tools for Physics, James Nearing, Dover Publications, 2010
5) Mathematical Physics, A. K. Ghatak, I. C. Goyal and S. J. Chua, Laxmi Publications Private Limited, 2017

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

GENERIC ELECTIVE (GE – 4): INTRODUCTION TO ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisites
		Lecture	Tutorial	Practical		
INTRODUCTION TO ELECTRONICS GE – 4	4	2	0	2	Passed 12th Class	NIL

LEARNING OBJECTIVES

This paper aims to introduce fundamentals of electronics to students not majoring in physics. Basics of Analog and Digital Electronics are envisioned to be introduced with emphasis on applications of diodes, transistor (BJT), operational amplifier, 555 timer, number systems, basic gates and digital circuits.

LEARNING OUTCOMES

At the end of this course, students will be able to imbibe the following learning outcomes:

- This paper aims to describe the concepts of basic electronics in real-life. In this course, students will receive an introduction to the principle, performance and applications of basic electronic components.
- The students will gain an insight on the existence of analog and digital signals and their necessity. Specifically they would know the difference between active and passive electronic components including filters.
- Students will learn about diodes and its uses in rectification (analog) and switching properties thereof (digital). They will gain an insight into working principle of Photodiodes, Solar Cells, LED and Zener Diode as Voltage Regulator.
- They will gain an understanding of construction and working principle of bipolar junction transistors (BJTs). Specifically, they would understand the fundamentals of amplification.
- Students will be able to seamlessly understand and work on different numbers systems including binary, octal, hexadecimal besides decimal.
- They will learn about the existence of digital gates besides their need in electronic decision making thus laying the foundation for basic artificial intelligence.
- Students will learn the fundamentals of operation amplifier and their regular application including those used to sum, subtract and compare two or more signals.
- They will gain an in-depth understanding of working of Cathode Ray Oscilloscope which effectively acts as an electronic stethoscope for analysis of electronic signal in any laboratory.
- This paper will essentially connect the text book knowledge with the most common electronic components available that influence design of technology in a real world.
- The project component included in the practical section is envisaged to impart much

needed hands-on skill sets to the student. Therein he/she gets an experience in correctly choosing components required to build an electronic circuit, identifying the procurement source (online/offline) besides gaining valuable experience in trouble-shooting

SYLLABUS OF GE - 4

THEORY COMPONENT

Unit – I **(4 Hours)**

Analog and digital signals, Active and passive electronic components, RC integrator and differentiator (use as low pass and high pass filter): Qualitative analysis and frequency response.

Unit – II **(6 Hours)**

I-V characteristics of a diode and it's applications as rectifier (Half and full wave rectifier configurations), Clipper and Clamper circuits (Qualitative Analysis only). Principle and working of Photodiodes, Solar Cells, LED and Zener Diode as Voltage Regulator.

Unit – III **(4 Hours)**

Input and output characteristics of a bipolar junction transistor (BJT) in CB and CE configurations, identifying active, cut-off and saturation regions. Transistor parameters alpha and beta, and relation between them. Application of BJT as a switch and an amplifier in CE configuration (Graphical Analysis)

Unit – IV **(6 Hours)**

Review of basic and Universal Logic Gates, Binary to decimal and Decimal to binary conversion, binary addition and subtraction using 2's complement, Half and Full Adder, Half and Full Subtractor using NAND Gates.

Unit – V **(6 Hours)**

Operational Amplifier (Black Box Approach): Pinout diagram of IC 741; Characteristics of Op-amp (Voltage Gain, offset voltage, slew rate, CMRR, Bandwidth, Input Impedance and Output Impedance). Open loop configuration and its application as a comparator and zero crossing detector. Closed Loop Configuration and its Applications as Inverting and Non-inverting Amplifier (Voltage gain using concept of virtual ground), Summing Amplifier and Subtractor

Unit – VI **(4 Hours)**

Block diagram of CRO, Voltage and frequency measurement. Pin-out diagram of IC 555 and its application as Astable Multivibrator

References:

Essential Readings:

1) Electronic Devices, Thomas L Floyd; Pearsons Education
2) Op Amps and Linear Integrated Circuits, Ramakant A Gaekwad, Pearson Education
3) Microelectronic circuits, A. S. Sedra, K. C. Smith, A. N. Chandorkar, Oxford University Press
4) Electronic Principles, A. Malvino, D. J. Bates, 7th Edition, Tata Mc-Graw Hill Education, 2018

5) Electronic Devices and circuit theory, R. L. Boylestad and L. D. Nashelsky, Pearson Learning
6) Digital Principles and Applications, Donald P Leach, Albert Paul Malvino and Goutam Saha, Pearson Education, Tata Mc-Graw Hill.

Additional Readings:

1) Electronic Fundamental and Applications, John D Ryder; PHI Learning
2) Electronic Devices and Circuits, J. Millman and C. C. Halkias, Tata Mc-Graw Hill.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Every student must perform either "04 Experiments and 01 Project" or "At least six experiments"

1) Voltage and frequency measurement using CRO
2) Study of RC circuits as an Integrator and Differentiator
3) IV characteristics for pn junction diode and Zener diode
4) Study of Zener diode as voltage regulator circuit
5) Study of transistor characteristics in CE configuration
6) Half Adder and Full Adder using NAND gates
7) Half Subtractor and Full Subtractor using NAND gates
8) Design Astable Multivibrator using IC 555
9) Study the Frequency Response of Op Amp in Inverting and Non Inverting configurations.
10) Study of zero crossing detector using Op amp IC 741
11) Addition of two dc voltages using OP Amp in inverting and non-inverting configurations.

References (for Laboratory Work):

1) An Analog Electronics Companion: Basic Circuit Design for Engineers and Scientists – by Scott Hamilton, Cambridge University Press
2) Practical Electronics – by Ralph Morrison, Wiley
3) Practical Electronic Design for Experimenters (ELECTRONICS) – by Louis E. Frenzel, McGraw Hill Education
4) Practical Electronics for Inventors – by Paul Scherz and Simon Monk, McGraw Hill
5) Analog Electronics with Op-amps: A Source Book of Practical Circuits (Electronics Texts for Engineers and Scientists) – by Anthony Peyton and Vincent Walsh, Cambridge University Press

GENERIC ELECTIVE (GE – 5): SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
SOLID STATE PHYSICS GE – 5	4	3	1	0	Passed 12th Class	NIL

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society. Emphasis should be given on the applications and uses of solids.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, basis and symmetry in crystals. Learn to appreciate structure and symmetry of solids.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Describe the main features of the physics of electrons in solids: origin of energy bands.
- Introduction to dia-, para-, ferri and ferro-magnetic properties of solids and their applications.
- Introduction to dielectric properties exhibited by solids and the concept of polarizability.
- Introduction to superconductivity.

SYLLABUS OF GE - 5

THEORY COMPONENT

UNIT – I **(21 Hours)**

Review of Atomic Structure and bonding in solids: Classification of matter as solid, liquid and gas: salient features and properties, Qualitative discussion on Rutherford Model and Bohr model of atom, qualitative idea about discrete energy levels, wave-mechanical concept of the atom, forces between atoms, Ionic bonding, covalent bonding, metallic bonding, Hydrogen bonding and Van der Waals bonding, Properties of solids exhibiting different bonding.

Crystal structure: Periodicity in crystals: lattice points and space lattice, translational, rotational and reflection symmetry elements, lattice with a basis and crystal structure, unit cells and lattice parameters, Bravais lattices (in 2D and 3D) and crystal systems SC, BCC and FCC lattices, conventional and primitive unit cell, Wigner Seitz unit cell, amorphous and crystalline materials. Planes, Miller Indices, directions, density of atoms in different planes, inter-planar spacing, concept of Reciprocal Lattice, Brillouin zones (2 D lattice)

Atomic Packing and Imperfections in crystals: Packing of spheres in 2D and 3D, hexagonal close packing, packing fraction of SC, FCC, and BCC. Point defects and line defects and their consequences on the crystal properties
X-rays: Their generation and properties, Bragg's law and Laue Condition, single crystal method and powder diffraction method, simple problems related to X-Ray diffraction in SC, BCC, FCC

UNIT – II **(4 Hours)**
Elementary Lattice Dynamics: Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustic and optical phonons, qualitative description of the phonon spectrum in solids.

UNIT – III **(10 Hours)**
Electrical properties of metals: Free electron theory of metals (Drude model), its success and drawbacks, concept of relaxation time, collision time and mean free path, electrical conductivity, mobility and Ohm's law, thermal conductivity of metals, Wiedemann-Franz-Lorentz law.
Band Theory: The Kronig-Penney model (Qualitative idea), Band Gap, direct and indirect bandgap, concept of effective mass, Hall Effect (Metal and Semiconductor).
Optical properties of solids: (Qualitative) Absorption process, transmission and reflectance in solids. Discussion on photoconductivity, photoluminescence.

UNIT – IV **(3 Hours)**
Magnetic Properties of solids: Dia-, Para-, Ferri- and Ferro- magnetic Materials, definition in terms of susceptibility.Weiss's Theory of FerromagnetismandFerromagnetic Domains (qualitative treatment only),B-H curve, soft and hard material and their applications(discussion only) as cores in generators, transformers and electromagnets, energy lossin Hysteresis curve.

UNIT – V **(4 Hours)**
Dielectric Properties of solids: Dipole moment, polarization,local electric field in solids. Depolarization field, electric susceptibility, various sources of polarizability,piezo-, pyro- and ferroelectric materials and their applications(discussion only) as transducers, pickups, sensors, actuators, delay lines.

UNIT – VI **(3 Hours)**
Superconductivity: (Qualitative treatment only) Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, applications of superconductors. Discussion on applications in MRI, particle collider, power transmission, magnetic levitation etc.

References:
Essential Readings:
1) Solid State Physics, M. A. Wahab, 3rd Edition, Narosa Publications, 2015
2) Solid State Physics, S. O. Pillai, New Age International Publishers
3) Introduction to Solid State Physics, Charles Kittel, 8th Edition, Wiley India Pvt. Ltd, 2004
4) Elements of Solid State Physics, J. P. Srivastava, 2nd Edition, Prentice-Hall of India, 2006
5) Solid State Physics, A. J. Dekker, Macmillan Education, 2008

Additional Readings:

1) Introduction to Solids, Leonid V. Azaroff, Tata Mc-Graw Hill, 2004
2) Solid State Physics, N. W. Ashcroft and N. D. Mermin, Cengage Learning, 1976
3) Elementary Solid State Physics, M. Ali Omar, Pearson, 2006
4) Solid State Physics, Rita John, McGraw Hill, 2014
5) Superconductivity: A Very short Introduction – Stephen J Blundell – Audiobook
6) Crystallography applied to solid state physics, A. R. Verma and O. N. Srivastava, New Age International Publishers, 2005

GENERIC ELECTIVE (GE – 7): BIOLOGICAL PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
BIOLOGICAL PHYSICS GE – 7	4	3	1	0	Passed 12th Class	NIL

LEARNING OBJECTIVES

This course familiarizes the students with the basic facts and ideas of biology from a quantitative perspective. It shows them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales. The course also gives them a flavour of the interface between biology, chemistry, physics and mathematics.

LEARNING OUTCOMES

After completing this course, students will

- Know basic facts about biological systems, including single cells, multicellular organisms and ecosystems from a quantitative perspective.
- Gain familiarity with various biological processes at different length and time scales, including molecular processes, organism level processes and evolution.
- Appreciate how fundamental principles of physics can be applied to gain an understanding of biological systems.
- Get exposure to complexity of life at i) the level of cell, ii) level of multi cellular organism and iii) at macroscopic system – ecosystem and biosphere.
- Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behaviour.
- Perform mathematical modelling of certain aspects of living systems.
- Get exposure to models of evolution.

SYLLABUS OF GE 7

THEORY COMPONENT

Unit – I **(4 Hours)**

Overview: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales.

Unit - II **(12 Hours)**

Molecules of life: Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation.

Unit - III **(12 Hours)**

Molecular motion in cells: Random walks and applications to biology: Diffusion; models of macromolecules. Molecular motors: Transport along microtubules. Flagellar motion: bacterial chemotaxis.

Unit - IV **(12 Hours)**

The complexity of life: At the level of a cell: Intracellular biochemical networks. Dynamics of metabolic networks; the stoichiometric matrix. The implausibility of life based on a simplified probability estimate, and the origin of life problem. At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cellular differentiation and development. Brain structure: neurons and neural networks. At the level of an ecosystem and the biosphere: Foodwebs. Feedback cycles and self-sustaining ecosystems. Allometric scaling laws.

Unit - V **(5 Hours)**

Evolution: The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution.

References:

Essential Readings:

1) Biological Physics: Energy, Information, Life, P. Nelson, W H Freeman & Co, NY, 2004
2) Cell Biology by the Numbers, R. Milo and R. Phillips, Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2016
3) Physical Biology of the Cell, R. Phillips et al, 2nd edition, Garland Science, Taylor & Francis Group, NY USA and Abingdon UK, 2013
4) Evolution, M. Ridley, Blackwell Publishers, 2009, 3rd edition

Additional Readings:

1) Physics in Molecular Biology, K. Sneppen and G. Zocchi, Cambridge University Press, Cambridge UK, 2005
2) Biophysics: Searching for Principles, W. Bialek, Princeton University Press, Princeton USA, 2012

GENERIC ELECTIVE (GE – 8):

NUMERICAL ANALYSIS AND COMPUTATIONAL PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
NUMERICAL ANALYSIS AND COMPUTATIONAL PHYSICS GE – 8	4	2	0	2	Passed 12th Class	Differential calculus, integration and ordinary differential calculus at the class 12 level.

LEARNING OBJECTIVES

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Develop numerical methods to understand errors and solution of Algebraic and Transcendental equations.
- Understand interpolation, least square fitting, Numerical differentiation, Numerical integration and solution of ordinary differential equations.

In the laboratory course, the students will learn to,

- apply appropriate numerical method to solve selected physics problems using user defined and inbuilt functions
- solve non-linear equations
- perform least square fitting of the data taken in physics lab by user defined functions
- Interpolate a data by polynomial approximations
- numerically integrate a function and
- solve first order initial value problems numerically

SYLLABUS OF GE - 8

THEORY COMPONENT

Unit – I **(8 Hours)**

Errors and iterative Methods: Truncation and Round-off Errors. Floating Point Computation, Overflow and underflow. Single and Double Precision Arithmetic, Iterative Methods. Review of Taylor's Theorem and Mean value Theorem (No proofs).

Solutions of Algebraic and Transcendental Equations: Bisection method, Secant Method, Newton Raphson method. Comparison and error estimation

Unit – II **(10 Hours)**

Interpolation: Concept of Interpolation, Lagrange Form of interpolating polynomial, Newton's Forward and Backward Differences, Newton's Forward and Backward Interpolation Formulas.

Regression: Algorithm for Least square fitting of a straight line, Fitting a Power function, and Exponential Function using conversion to linear relation by transforming the variables.

Unit – III **(7 Hours)**

Numerical Differentiation: Approximating the derivative of a function given in the form of discrete data, Numerical Computation of First and second order derivative of a function given in closed form (using Taylor's expansion) , errors in Numerical Differentiation.

Numerical Integration: Newton Cotes Quadrature methods for evaluation of definite integrals numerically, Trapezoidal Rule, Simpson's 1/3 and 3/8 Rules. Derivation of composite formulae for these methods and discussion of error estimation

Unit – IV **(5 Hours)**

Solution of Ordinary Differential Equations: First Order ODE's: solution of Initial Value problems: (1) Euler's Method and (2) Runge Kutta methods

References:

Essential Readings:

1) Elementary Numerical Analysis, K. E. Atkinson, 3rd Edition, Wiley India Edition, 2007
2) Introduction to Numerical Analysis, S. S. Sastry, 5th Edition, PHI Learning Pvt. Ltd, 2012
3) Computational Physics, Darren Walker, 1st Edition, Scientific International Pvt. Ltd, 2015
4) Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, 2007

Additional Readings:

1) An Introduction to Computational Physics, T. Pang, Cambridge University Press, 2010
2) Numerical Recipes: The art of scientific computing, William H. Press, Saul A. Teukolsky and William Vetterling, Cambridge University Press, 3rd Edition, 2007
3) Computational Problems for Physics, R. H. Landau and M. J. Páez, CRC Press, 2018

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

The aim of this lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- The course will consist of practical sessions and lectures on Python.
- Assessment is to be done not only on the programming but also on the basis of formulating the problem.
- The list of recommended programs is suggestive only. Students should be encouraged to do more physics applications. Emphasis should be given to formulate a physics problem as mathematical one and solve by computational methods.
- At least 6 programs must be attempted (taking at least one from each unit).

Unit I

Basic Elements of Python: The Python interpreter, the print statement, comments, Python as simple calculator, objects and expressions, variables (numeric, character and sequence types) and assignments, mathematical operators. Strings, Lists, Tuples and Dictionaries, type conversions, input statement, list methods. List mutability, formatting in the print statement

Control Structures: Conditional operations, i*f, if-else, if-elif-else, while* and *for* Loops, indentation, break and continue, List comprehension. Simple programs for practice like solving quadratic equations, temperature conversion etc.

Functions: Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules. Writing functions to perform simple operations like finding largest of three numbers, listing prime numbers, etc. Generating pseudo random numbers

Recommended List of Programs

(a) Make a function that takes a number *N* as input and returns the value of factorial of *N*. Use this function to print the number of ways a set of *m* red and *n* blue balls can be arranged.

(b) Generate random numbers (integers and floats) in a given range and calculate area and volume of regular shapes with random dimensions.

(c) Generate data for coordinates of a projectile and plot the trajectory. Determine the range, maximum height and time of flight for a projectile motion.

Unit II

NumPy Fundamentals: Importing *Numpy*, Difference between List and NumPy array, Adding, removing and sorting elements, creating arrays using *ones(), zeros(), random(), arange(), linspace()*. Basic array operations (*sum, max, min, mean, variance*), 2-d arrays, matrix operations, reshaping and transposing arrays, savetxt() and loadtxt().

Plotting with Matplotlib: *matplotlib.pyplot* functions, Plotting of functions given in closed form as well as in the form of discrete data and making histograms.

Recommended List of Programs

(a) Given a function in closed form y=f(x), generate numpy arrays for x and y and plot y as a function of x with appropriate scale and legend.

(b) Generate data for coordinates of a projectile and plot the trajectory.

(c) Given the expressions in closed form, plot the displacement-time and velocity-time graph for the un-damped, under damped critically damped and over damped oscillator.

Unit III

Root Finding

a) Determine the depth up to which a spherical homogeneous object of given radius and density will sink into a fluid of given density.

b) Solve transcendental equations like α = tan(α).

c) To approximate nth root of a number up to a given number of significant digits.

Unit IV

Least Square fitting

Make function for least square fitting, use it for fitting given data (*x,y*) and estimate the parameters *a, b* as well as uncertainties in the parameters for the following cases:

a) Linear ($y = ax + b$)

b) Power law ($y = ax^b$)

c) Exponential ($y = ae^{bx}$)

Interpolation:

(a) Write program to determine the unique polynomial of a degree n that agrees with a given set of (n+1) data points (x_i, y_i) and use this polynomial to find the value of y at a value of x not included in the data.

(b) Generate a tabulated data containing a given number of values (x_i, $f(x_i)$) of a function f(x) and use it to interpolate at a value of x not used in table.

Unit V

Numerical Differentiation

a) Given displacement at equidistant time values, calculate velocity and acceleration and plot them.

b) Compute the left, right and central approximations for derivative of a function given in closed form. Plot both the function and derivative (forward, backward and central derivatives) on the same graph. Plot the error as a function of step size on a log-log graph, study the behaviour of the plot as step size decreases and hence discuss the effect of round off error.

Numerical Integration:

a) Given acceleration at equidistant time values, calculate position and velocity and plot them.

b) Use integral definition of ln(x) to compute and plot ln(x) in a given range. Use trapezoidal and Simpson methods and compare the results.

c) Verify the rate of convergence of the composite Trapezoidal and Simpson methods by approximating the value of a given definite integral.

References

1) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).

2) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/

3) Computational Physics, Darren Walker, 1st Edition, Scientific International Pvt. Ltd, 2015

4) Introduction to Numerical Analysis, S. S. Sastry, 5th Edition, PHI Learning Pvt. Ltd, 2012

5) Elementary Numerical Analysis, K. E. Atkinson, 3rd Edition, Wiley India Edition, 2007

6) Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, 2007

GENERIC ELECTIVE (GE – 9): APPLIED DYNAMICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
APPLIED DYNAMICS GE – 9	4	3	1	0	Passed 12th Class	NIL

LEARNING OBJECTIVES

This course introduces the main topics of low-dimensional nonlinear systems, with applications to a wide variety of disciplines, including physics, engineering, mathematics, chemistry, and biology. This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. The nature of the subject demands that the tutorials should include only computational problems.

LEARNING OUTCOMES

Upon successful course completion, a student will be able to:

- Demonstrate understanding of the concepts that underlay the study of dynamical systems.
- Learn various forms of dynamics and different routes to chaos.
- Understand basic Physics of fluids and its dynamics

SYLLABUS OF GE 9

THEORY COMPONENT

Unit – I **(22 Hours)**

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Concept of stability and un-stability. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems. Examples of dynamical systems – Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics.

Unit – II **(16 Hours)**

Introduction to Chaos: Bifurcations: Saddle-Node bifurcation, Transcritical bifurcation, Pitchfork bifurcation and Hopf bifurcation. Chaos in nonlinear equations: Logistic map and Lorenz equations. Sensitivity to initial states. Parameter dependence: steady, periodic and chaotic states. Cobweb iteration. Simple examples from physics, chemistry, engineering and lifesciences.

Unit – III **(7 Hours)**

Elementary Fluid Dynamics: Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity and equation of state.

References:

Essential Readings:

1) Nonlinear Dynamics and Chaos, S. H. Strogatz, Westview Press, 2nd Edition, 2014
2) Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer New York, 1995
3) Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003
4) An Introduction to Fluid Dynamics, G. K. Batchelor, Cambridge University Press, 2002
5) Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987

REGISTRAR

UNIVERSITY OF DELHI

CNC-II/093/1(28)/2023-24/45

Dated: 18.01.2024

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/-(14-1-6/-) dated 09.06.2023 and 27-1-1/ dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-IV of the following programmes in respect of Department of Physics & Astrophysics under Faculty of Science based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23:

SEMESTER-IV: BSc. (H) Physics/ Pool of Discipline Specific Electives/ BSc. Physical Science with Physics as one of the Core Disciplines/ BSc. Physical Science with Physics & Electronics as one of the Core Disciplines/ Common Pool of Generic Electives (GEs) ***(As per Annexure-1)***

18/1/24

REGISTRAR

ANNEXURE-1

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DEPARTMENT OF PHYSICS AND ASTROPHYSICS
Semester-IV

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B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC - 10: MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Modern Physics DSC – 10	4	3	0	1	Class XII Pass with PCM	Studied 'DSC-Light and Matter' & Mathematical Physics-I, II & III

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation and its applications to step potential and rectangular potential problems. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. This paper covers the in-depth knowledge of lasers, its principle and working. It also introduces concepts of nuclear physics and accelerators.

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering.
- The Schrodinger equation in 1-dimension, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values, Commutator of position and momentum operators.
- Time independent Schrodinger equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels. Reflection and transmission across a step and rectangular potential barrier.
- Modification in Bohr's quantum model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Lasers and their working principle, spontaneous and stimulated emissions and absorption, Einstein's A and B coefficients, Metastable states, components of a laser and lasing action in He-Ne lasers and free electron laser.
- Basic properties of nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory. Radioactivity.
- Types of Accelerators, Van-de Graaff generator linear accelerator, cyclotron.

SYLLABUS OF DSC – 10

THEORY COMPONENT

Unit – I **(9 Hours)**

Origin of Quantum Theory: Black body radiation and failure of classical theory, Planck's quantum hypothesis, Planck's radiation law, quantitative treatment of photo-electric effect and Compton scattering, Heisenberg's uncertainty principle, Gamma ray microscope thought experiment, position - momentum uncertainty, consequences of uncertainty principle.

Unit – II **(9 Hours)**

The Schrodinger Equation: The Schrodinger equation in one dimension, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values. Commutator of position and momentum operators

Unit – III **(9 Hours)**

Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem. Reflection and transmission across a step and rectangular potential barrier

Unit - IV **(9 Hours)**

Atomic Physics: Beyond the Bohr's Quantum Model: Sommerfeld theory of elliptical orbits; Hydrogen atom energy levels and spectra, emission and absorption spectra; Correspondence principle; X-rays: Method of production, Continuous and Characteristic X-rays, Moseley's law.

Lasers: Lifetime of excited states, natural and Doppler width of spectral lines, emission (spontaneous and stimulated) and absorption processes, Einstein's A and B coefficients, principle of detailed balancing, metastable states, components of a laser and lasing action, working principle of a 4 level laser, e.g. He-Ne lasers; qualitative idea of X-ray free electron lasers.

Unit - V **(9 Hours)**

Basic Properties of Nuclei: Introduction (notation, a basic idea about nuclear size, mass, angular momentum, spin, parity, isospin), N-Z graph, nuclear binding energy, semi-empirical mass formula, and basic idea about the nuclear force and meson theory.

Radioactivity: Law of radioactivity and secular equilibrium.

Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages), discovery of new elements of the periodic table

References:

Essential Readings:

1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage.
3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC

4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning.
5) Introduction to Modern Physics, F. K. Richtmyer, E. H. Kennard and J. N. Cooper, 2002, Tata McGraw Hill.
6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
8) Modern Physics, R. Murugeshan, S Chand & Co. Ltd.
9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited.
13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education.
14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education.
15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House.
16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, (S. Chand & Co.
17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers.
18) Physics of Atoms and Molecules, B. H. Bransden and C. J. Jochain, 2nd edition, Pearson
19) Atomic and Molecular Physics, Rajkumar, RBSA Publishers.
20) Atoms, Molecules and Photons, W. Demtroder, 2nd edition, 2010, Springer.
21) Introducing Nuclear Physics, K. S. Krane, 2008, Wiley India.

Additional Readings:

1) Basic Atomic & Molecular Spectroscopy, J. M. Hollas (Royal Society of Chemistry)
2) Molecular Spectra and Molecular Structure, G. Herzberg.
3) Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach (Series in Fundamental and Applied Nuclear Physics), K. Heyde (Institute of Physics Publishing Third Edition.
4) Nuclear Physics: Principles and applications, J. Lilley, 2006, Wiley.
5) Schaum's Outline of Modern Physics, 1999, McGraw-Hill Education.
6) Atomic and molecular Physics, R. Kumar, 2013, Campus Book Int.
7) The Fundamentals of Atomic and Molecular Physics (Undergraduate Lecture Notes in Physics), 2013, Springer.
8) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
9) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster`s focusing; determination of angle of prism.

<u>At least five experiments to be performed from the following list</u>

1) Measurement of Planck's constant using black body radiation and photo-detector
2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
3) To determine the work function of material of filament of directly heated vacuum diode.
4) To determine the Planck's constant using LEDs of at least 4 different colours.
5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
6) To determine the ionization potential of mercury.
7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8) To show the tunneling effect in tunnel diodes using I-V characteristics.
9) One innovative experiment designed by the teacher relevant to the syllabus.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11^{th} edition, 2011, Kitab Mahal.
3) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4^{th} edition, reprinted, 1985, Heinemann Educational Publishers.
4) A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publisher.
5) B.Sc. Practical Physics, H. Singh, S. Chand & Co Ltd.
6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC CORE COURSE – DSC - 11: SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Solid State Physics DSC – 11	**4**	**3**	**0**	**1**	Class XII Pass with PCM	Studied 'Thermal Physics, Electricity & Magnetism' and Mathematical Physics-I,II & III

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon the arrangement of its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. It also communicates the importance of solid- state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and symmetry operations
- Understand elementary lattice dynamics and its influence on the properties of materials
- Describe the origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- Understand the basics of superconductivity
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor

SYLLABUS OF DSC - 11

THEORY COMPONENT

Unit – I - Crystal Structure **(10 Hours)**

Classification of solids as amorphous and crystalline materials, basic understanding of bonding in crystals, closed packed structure and packing fractions, lattice translation vectors, lattice with a basis, types of lattices, unit cell, symmetry elements, crystal planes and Miller indices, reciprocal lattice and Ewald's construction (geometrical), Brillouin Zones, Diffraction of X-rays: single crystal and powder method. Bragg's Law

Unit – II - Elementary band theory **(6 Hours)**

Brief discussion on free electron model, success and failure of free electron model, Kronig-Penney model, band gap, direct and indirect band gap, effective mass, concept of mobility, Hall effect (Semiconductor).

Unit – III - Elementary Lattice Dynamics **(10 Hours)**
Lattice Vibrations and Phonons: Linear monoatomic and diatomic chains, acoustic and optical phonons, Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law

Unit – IV - Magnetic Properties of Matter **(9 Hours)**
Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevin Theory of dia– and para-magnetism, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains, Curie's law, B-H Curve, hysteresis and energy loss, soft and hard material

Unit – V - Dielectric Properties of Materials **(7 Hours)**
Polarization, local electric field in solids, depolarization field, electric susceptibility, polarizability, Clausius Mossotti equation, classical theory of electronic polarizability, AC electronic polarizability, normal and anomalous dispersion, complex dielectric constant, basic idea of ferroelectricity and PE Hysteresis loop.

Unit – VI – Superconductivity **(3 Hours)**
Experimental results, critical temperature, critical magnetic field, Meissner effect, Type I and type II superconductors

References:
Essential Readings:

1) Introduction to Solid State Physics, Charles Kittel, 8th edition, 2004, Wiley India Pvt. Ltd.
2) Elements of Solid State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India.
3) Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning.
5) Solid-state Physics, H. Ibach and H. Luth, 2009, Springer

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)
- Sessions on the construction and use of specific measurement instruments and experimental apparatus used in the solid state physics laboratory, including necessary precautions.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the laboratory.

At least four experiments to be performed from the following list

1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method).
2) To measure the magnetic susceptibility of solids.
3) To study the dielectric constant of a material/s (solid/liquid) as a function of temperature and frequency.
4) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
5) To determine the refractive index of a dielectric material using SPR technique.
6) To study the PE Hysteresis loop of a ferroelectric crystal.
7) To draw the BH curve of iron (Fe) using solenoid and determine the energy loss from hysteresis loop.
8) To measure the resistivity of a semiconductor (Ge) with temperature (up to 150^{o}C) by four-probe method and determine its band gap.
9) To determine the Hall coefficient of a semiconductor sample.
10) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size.
11) To study magnetoresistance in a semiconductor with magnetic field

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
3) Elements of Solid State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press.
5) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand

DISCIPLINE SPECIFIC CORE COURSE – DSC - 12: ANALOG ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Analog Electronics DSC – 12	4	2	0	2	Class XII Pass with PCM	Studied 'Electrical Circuit Analysis'

LEARNING OBJECTIVES

This course introduces the concept of semiconductor devices and their analog applications. It also emphasizes on understanding of amplifiers, oscillators, operational amplifier and their applications.

LEARNING OUTCOMES

At the end of this course, the following concepts will be learnt.

- To learn about diodes and its uses in rectification
- To gain an insight into working principle of photodiodes, solar cells, LED and zener diode as voltage regulator
- To gain an understanding of construction and working principle of bipolar junction transistors (BJTs), characteristics of different configurations, biasing and analysis of transistor amplifier
- To be able to design and understand use of different types of oscillators
- To learn the fundamentals of operation amplifiers and understand their operations to compare, add, or subtract two or more signals and to differentiate or integrate signals etc.

In the laboratory course, the students will be able to study characteristics of various diodes and BJT. They will be able to design amplifiers, and oscillators. Also different applications using Op-Amp will be designed.

SYLLABUS OF DSC - 12

THEORY COMPONENT

Unit – I - Two-terminal devices and their applications (5 Hours)

IV characteristics of a diode and its application as rectifier (half-wave and full wave rectifier), IV characteristics of a zener diode and its use as voltage regulator, principle, structure and characteristics of (1) LED, (2) Photodiode and (3) Solar Cell

Unit – II - Bipolar junction transistors (4 Hours)

n-p-n and p-n-p transistors, IV characteristics of CB and CE configurations, active, cut-off and saturation regions, current gains α and β, relations between α and β, physical mechanism of current flow

Unit – III – Amplifiers and sinusoidal oscillators (11 Hours)

Load line analysis of transistor, DC load line and Q-point, fixed bias and voltage divider bias,

transistor as 2-port network, h-parameter equivalent circuit of a transistor, analysis of a single-stage CE amplifier using hybrid model (input and output impedance, current and voltage gain)
Sinusoidal Oscillators: General idea of positive and negative feedback, Barkhausen's criterion for self-sustained oscillations, RC phase shift oscillator, determination of frequency, Hartley and Colpitts oscillators

Unit – IV - Operational Amplifiers (Black Box approach) (10 Hours)
Characteristics of an ideal and practical Op-Amp (IC 741), open-loop and closed-loop gain, frequency response, CMRR, slew rate and concept of virtual ground
Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Comparator and Zero crossing detector (7) Wein bridge oscillator

References:
Essential Readings:

1) Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill
2) Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall
3) Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
4) Microelectronic circuits, A. S. Sedra, K. C. Smith and A. N. Chandorkar, 6th edition, 2014, Oxford University Press.
5) Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd edition, 2002, Wiley India
6) Electronic Principles, A. Malvino, D. J. Bates, 7th edition, 2018, Tata Mc-Graw Hill Education.
7) Electronic Devices and circuit Theory, R. L. Boylestad and L. D. Nashelsky, 2009, Pearson

Additional Readings:

1) Learning Electronic Devices and circuits, S. Salivahanan and N. S. Kumar, 3rd edition, 2012, Tata Mc-Graw Hill
2) Microelectronic Circuits, M. H. Rashid, 2nd edition, Cengage Learning
3) Microelectronic Devices and Circuits, D. A. Bell, 5th edition, 2015, Oxford University Press
4) Basic Electronics: Principles and Applications, C. Saha, A. Halder and D. Ganguli, 1st edition, 2018, Cambridge University Press
5) Solid State Electronic Devices, B. G.Streetman and S. K. Banerjee, 6th edition, 2009, PHI

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Session on the construction and use of specific analogue devices and experimental apparatuses used in the lab, including necessary precautions
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

1) To study the V-I characteristics of a Zener diode and its use as voltage regulator.
2) Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
3) To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4) To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
5) To design a Wien bridge oscillator for given frequency using an op-amp.
6) To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain
7) To design inverting amplifier using Op-amp (741, 351) and study its frequency response
8) To design non-inverting amplifier using Op-amp (741, 351) and study frequency response
9) To add two dc voltages using Op-amp in inverting and non-inverting mode
10) To study the zero-crossing detector and comparator
11) To investigate the use of an op-amp as an integrator
12) To investigate the use of an op-amp as a differentiator.

References for laboratory work:

1) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino and M. A. Miller, 1994, Mc- Graw Hill
2) Student Manual for The Art of Electronics, T. C. Hayes and P. Horowitz

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 3: ADVANCED MATHEMATICAL PHYSICS I

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Advanced Mathematical Physics I DSE – 3	**4**	**3**	**1**	**0**	Class XII Pass with PCM	Studied DSC 'Mathematical Physics I, II & Physics III'

LEARNING OBJECTIVES

The objective of the course is to impart the concept of generalized mathematical constructs in terms of algebraic structures mainly vector spaces. Linear algebra studies linear vector spaces, linear transformations, and the matrices and is an important mathematical tool with applications in physics, engineering, machine learning, economics and even life sciences and social sciences. This course is intended to provide a solid foundation in linear algebra as used by physicists and has direct applications in classical and quantum mechanics.

LEARNING OUTCOMES

After completing this course, students will be able to,

- Understand algebraic structures in n-dimension and basic properties of the linear vector spaces.
- Understand the concept of dual spaces and inner product spaces.
- Represent linear transformations as matrices and understand basic properties of matrices.
- Determine the eigenvalues and eigenvectors of matrices and diagonalise the matrices.
- Determine orthogonal basis for a vector space using Gram-Schmidt procedure.

SYLLABUS OF DSE - 3

THEORY COMPONENT

Unit – I **(13 Hours)**

Vector Spaces as Algebraic Structures: Definition and examples of groups, rings, fields and vector spaces. Real and Complex fields, Use of ket notation $|\alpha>$ for vectors. Subspaces, Linear combination of vectors, Linear dependence and independence of vectors, span of a subset of vectors, Bases and dimension of vector space, direct sum of spaces, representation of vectors as column vectors with R^n as example.

Inner Product Spaces: Inner product of vectors $(<\alpha|\beta>)$ and norm of a vector, euclidean spaces and unitary spaces. Cauchy-Schwartz inequality, concept of length and distance, metric spaces. Hilbert Space (definition only). Linear functional, dual space, dual basis ($<\alpha|$ notation); Orthogonality of vectors, orthonormal basis, Gram-Schmidt procedure to construct an orthonormal basis.

Unit – II **(8 Hours)**
Linear Transformation: Linear Mappings and Examples, Homomorphism and Isomorphism of vector space, rank and nullity of a linear mapping, Range space and Kernel (null space) of a linear mapping, non-singular transformations, Nilpotent and Idempotent Transformations.

Unit – III **(10 Hours)**
Matrices as Representations: Matrix Representation of a Linear transformations, composition of linear transformations and matrix multiplication, linear algebra. Algebra of matrices, determinant and trace of matrix and their properties. Non-singular matrices. Rank of a matrix and invertibility of matrices. Direct sum and direct product of matrices.
Change of basis transformation, similar matrices, trace and determinant as invariants of basis change. Transpose and adjoint of a linear transformation, self-adjoint operators. Symmetric and hermitian matrices. Preservation of norms by orthogonal and unitary transformations.

Unit – IV **(14 Hours)**
Eigen-values and Eigenvectors: Eigen-values and eigen vectors of a transformation and corresponding matrix representation. Cayley- Hamilton Theorem (Statement only), its applications like inverse and powers of a matrix. Eigensystems of hermitian and unitary matrices. Diagonalization of matrices. Normal matrices. Simultaneous diagonalizability of two matrices.
Use of Matrices in Solving Coupled Linear first order ordinary differential equations with constant coefficients. Minimal Polynomial, Functions of a Matrix.

References:
Essential Readings:

1) Mathematical Methods for Physicists, G. Arfken, H. Weber and F. E. Harris, 7th edition, 2012, Elsevier
2) Introduction to Matrices and Linear Transformations, D. T. Finkbeiner, 2011, Dover Publications
3) Schaum's Outline of Theory and Problems of Linear Algebra, S. Lipschutz and M. Lipson, 2017, McGraw Hill Education
4) Linear Algebra, S. H. Friedberg, A. J. Insel, and L. E. Spence, 2022, Pearson Education
5) Linear Algebra and Applications, D. C. Lay, 2002, Pearson Education India.

Additional Readings:

1) Elementary Linear Algebra with Supplemental Applications, H. Anton and C. Rorres, 2016, Wiley Student Edition
2) A Physicist's Introduction to Algebraic Structures: Vector Spaces, Groups, Topological Spaces and More, P. B. Pal, 2019, Cambridge University Press
3) Matrices and Tensors in Physics: A.W. Joshi, 2017, New Age International Pvt. Ltd.
4) An Introduction to Linear Algebra and Tensors, M. A. Akivis, V. V. Goldberg, Richard and Silverman, 2012, Dover Publications
5) Vector Spaces and Matrices in Physics, M. C. Jain, 2000, Narosa
6) Mathematical Methods for Physics and Engineering, K. F. Riley and M. P. Hobson, 2018, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 4: PHYSICS OF DEVICES

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Physics of Devices DSE – 4	**4**	**2**	**0**	**2**	Class XII Pass with PCM	'Mathematical Physics-I', 'Mechanics' and 'Electrical Circuit Analysis'.

LEARNING OBJECTIVES

This paper is based on advanced electronics which covers the devices such as UJT, JFET, MOSFET, CMOS etc. Process of IC fabrication is discussed in detail.

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Develop the basic knowledge of semiconductor device physics and electronic circuits along with the practical technological considerations and applications.
- Understand the operation of devices such as UJT, JFET, MOS, various bias circuits of MOSFET, basics of CMOS and charge coupled devices.
- Learn to analyse MOSFET circuits and develop an understanding of MOSFET I-V characteristics and the allowed frequency limits.
- Learn the IC fabrication technology involving the process of diffusion, implantation, oxidation and etching with an emphasis on photolithography and electron-lithography
- Apply concepts for the regulation of power supply by developing an understanding of various kinds of RC filters classified on the basis of allowed range of frequencies.
- Learn to use semiconductor diode as a clipper and clamper circuit

SYLLABUS OF DSE - 4

THEORY COMPONENT

Unit – I **(7 Hours)**

Semiconductors (P and N type), Energy band diagram, Barrier formation in pn junction diode, Derivation of barrier potential and barrier width, storage and depletion capacitances, current flow mechanism in forward and reverse bias junction, current components in a transistor, tunnel diode, metal-semiconductor contacts, Schottky junction and Ohmic junction

Unit – II **(6 Hours)**

Diode as clipper and clamper circuits, RC Filters: Passive-Low pass and High pass filters, Active (1st order Butterworth)-Low Pass, High Pass, Band Pass, and band reject Filters.

Unit – III **(11 Hours)**

Characteristic and small-signal equivalent circuits of UJT and JFET, introduction to metal oxide semiconductor (MOS) device/MOSFET, MOSFET - their frequency limits, enhancement and depletion mode MOSFETS, basic idea of CMOS and charge coupled devices, importance of power devices: power diode, SCR. Construction and I-V characteristics of DIAC and TRIAC.

Unit – IV **(4 Hours)**
(Basic idea) Basic process flow for IC fabrication, diffusion and implantation of dopants, passivation/oxidation technique for Si, contacts and metallization technique, basic idea of thermal evaporation and sputtering techniques, basic idea of photolithography, electron-lithography, SSI, MSI, LSI, VLSI and USI.

Unit – V **(2 Hours)**
Basic idea about sensors (gas/fire) and piezoelectric transducer

References:
Essential Readings:

1) Physics of Semiconductor Devices, S. M. Sze and K. K. Ng, 3rd edition 2008, John Wiley and Sons
2) Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
3) Electronic communication systems, G. Kennedy, 1999, Tata McGraw Hill.
4) Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill.
5) Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall.
6) Solid State Electronic Devices, B. G. Streetman and S. K. Banerjee, 7th edition
7) Power Electronics, M. D. Singh and K. B. Khanchandani, 2006, Tata Mc-Graw Hill

Additional Readings:

1) Op-Amps and Linear Integrated Circuits, R. A. Gayakwad, 4th edition, 2000, PHI Learning Pvt. Ltd
2) Introduction to Measurements and Instrumentation, A. K. Ghosh, 4th edition, 2017, PHI Learning
3) Semiconductor Physics and Devices, D. A. Neamen, 4th edition, 2011, Tata McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To design the active low pass and high pass filters of given specification.
2) To design the active filter (wide band pass and band reject) of given specification.
3) To study the output and transfer characteristics of a JFET.
4) To design a common source JFET amplifier and study its frequency response.
5) To study the output characteristics of a MOSFET.
6) To study the characteristics of a UJT and design a simple relaxation oscillator.
7) To study diode as clipper circuit.
8) To study diode as a clamper circuit.
9) Pattern the given structure on silicon wafer by wet chemical etching.

Suggested extra experiment:

1) Deposition of metallic thin films using thermal evaporation technique.
2) Preparation of a pn junction and study its IV characteristics.

References for laboratory work:

1) Advanced PC based instrumentation; Concepts and Practice, N. Mathivanan, 2007, Prentice-Hall of India
2) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, M. A. Miller,1994, Mc-Graw Hill
3) Introduction to PSPICE using ORCAD for circuits and Electronics, M. H. Rashid, 2003, PHI Learning.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 5: PHYSICS OF EARTH

<table>
<tr><th rowspan="2">Course Title & Code</th><th rowspan="2">Credits</th><th colspan="3">Credit distribution of the course</th><th rowspan="2">Eligibility Criteria</th><th rowspan="2">Pre-requisite of the course</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>Physics of Earth

DSE – 5</td><td>4</td><td>3</td><td>1</td><td>0</td><td>Class XII Pass with PCM</td><td>NIL</td></tr>
</table>

LEARNING OBJECTIVES

This course familiarizes the students with the origin of earth in the solar system and various processes occurring in atmosphere, oceans and earth's internal structure.

LEARNING OUTCOMES

At the end of this course student will be able to,

- Have an overview of structure of the earth as well as various dynamical processes occurring on it.
- Develop an understanding of evolution of the earth.
- Apply physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure.
- Understand the origin of magnetic field, Geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection.
- Explore various roles played by water cycle, carbon cycle, nitrogen cycles in maintaining steady state of earth leading to better understanding of the contemporary dilemmas (climate change, bio diversity loss, population growth, etc.) disturbing the Earth.
- Develop the problem solving skills by adding numerical and simulations to clarify the fundamental concepts.

SYLLABUS OF DSE - 5

THEORY COMPONENT

Unit – I **(10 Hours)**

The Earth and the Universe:

a) General characteristics and origin of the Universe. The Big Bang Theory. Estimation of age of the Universe and Hubble constant. Formation of Galaxies. Types of galaxies, Milky Way galaxy, Nebular hypothesis, Solar system, The Terrestrial and Jovian planets (Sizes, Acceleration due to gravity, Obliquity, Flatness, Eccentricity, Density, Temperature, Pressure, Atmosphere, Moons, Exceptions in trends). Titius-Bode law. Asteroid belt. Asteroids: origin types and examples, Meteorites.

b) Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. Earth's orbit and spin, the Moon's orbit and spin.

c) Energy and particle fluxes incident on the Earth.

Unit – II **(8 Hours)**

Structure of Earth:

a) Internal structure of Earth: Core, mental, magnetic field. Origin of the Magnetic field. Convection in Earth's core and production of its magnetic field. Dynamo Theory, calculation of magnetic fields, Causes of variation of Magnetic Field and Palaeomagnetism.
b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. Ocean circulations. Oceanic current system and effect of Coriolis forces.
c) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

Unit – III **(8 Hours)**

Dynamical Processes:

a) The Solid Earth: Concept of plate tectonics; types of plate movements, hotspots; sea-floor spreading and continental drift.
b) Earthquake and earthquake belts. Types and properties of Seismic waves, Richter scale, geophones.
c) Volcanoes: types, products and distribution.
d) Concepts of eustasy, air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.

Unit – IV **(10 Hours)**

The Atmosphere

a) The Atmosphere: Features of different layers, variation of temperature with altitude; Dry, moist and environmental lapse rate, variation of density and pressure with altitude, Types of clouds and formation.
b) The Atmosphere: Atmospheric circulation. Causes of Atmospheric circulation, Formation of three cells, Easterlies and Westerlies, and ICTZ, Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones, tropical storms, hurricanes and tornadoes.
c) Climate: Earth's temperature and greenhouse effect. Paleoclimate and recent climate changes. The Indian monsoon system.

Unit – V **(9 Hours)**

Disturbing the Earth – Contemporary dilemmas

a) Hydrosphere: Fresh water depletion.
b) Geosphere: Chemical effluents, nuclear waste.
c) Biosphere: Biodiversity loss. Deforestation. Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.
d) Air Pollution: Types of air pollutants, Effects on atmosphere and living organisms. Ozone Hole.

References:

Essential Readings:

1) Planetary Surface Processes, H. J. Melosh, 2011, Cambridge University Press.
2) Holme's Principles of Physical Geology, 1992, Chapman & Hall.
3) Planet Earth, Cosmology, Geology and the Evolution of Life and Environment, C. Emiliani, 1992, Cambridge University Press.
4) Physics of the Earth, F. D. Stacey, P. M. Davis, 2008, Cambridge University Press.
5) Environmental Physics: Sustainable Energy and Climate Change, E. Boecker and R.V. Grondelle, 3rd edition, 2011, Wiley, UK
6) Atmospheric Remote Sensing (Principles and Applications, Editors – S. Tiwari and A. K.

Singh, Chapter-1 (Composition and thermal structure of the Earth's atmosphere, by S. K. Dhaka and V. Kumar), 1st edition, Elsevier

Additional Readings:

1) The Blue Planet: An Introduction to Earth System Science, B. J. Skinner, S. C. Portere, 1994, John Wiley & Sons.
2) Consider a Spherical Cow: A course in environmental problem solving, J. Harte, University Science Books.
3) Fundamentals of Geophysics, W. Lowrie, 1997, Cambridge University Press.
4) The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
5) Climate Change: A Very Short Introduction, M. Maslin, 3rd edition, 2014, Oxford University Press.
6) The Atmosphere: A Very Short Introduction, P. I. Palmer, 2017, Oxford University Press.
7) IGNOU Study material: PHE 15 Astronomy and Astrophysics Block 2

Category II

Physical Science Courses
with Physics discipline as one of the Core Disciplines

(B. Sc. Physical Science with Physics as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 4: WAVES AND OPTICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Waves and Optics PHYSICS DSC – 4	4	2	0	2	Class XII Pass with Science	Studied Mathematical Physics-I, Mechanics

LEARNING OBJECTIVES

This is a core course in Physics curriculum that begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

LEARNING OUTCOMES

On successfully completing the requirements of this course, the students will have the skill and knowledge to,

- Understand simple harmonic oscillation and superposition principle.
- Understand superposition of a range of collinear and mutually perpendicular simple harmonic motions and their applications.
- Understand concept of normal modes in stationary waves: their frequencies and configurations.
- Understand interference as superposition of waves from coherent sources derived from same parent source.
- Demonstrate understanding of interference experiments: Young's double slit, Fresnel's biprism, Llyod's mirror, Newton's rings
- Demonstrate basic concepts of diffraction: Superposition of wavelets diffracted from apertures
- Understand Fraunhoffer diffraction from apertures: single slit, double slit, grating
- Demonstrate fundamental understanding of Fresnel diffraction: Half period zones, diffraction of different apertures
- Laboratory course is designed to understand the principles of measurement and skills in experimental designs.

SYLLABUS OF PHYSICS DSC – 4

THEORY COMPONENT

Unit – I **(11 Hours)**

Superposition of collinear harmonic oscillations: Simple harmonic motion (SHM); linearity and superposition principle; superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (beats).

Superposition of two perpendicular harmonic oscillations: Graphical and analytical methods.

Lissajous figures with equal and unequal frequencies and their uses
Superposition of two harmonic Waves: Standing (stationary) waves in a string; normal modes of stretched strings

Unit – II **(8 Hours)**
Interference: Division of amplitude and division of wavefront; Young's double slit experiment: width and shape of fringes; Fresnel's biprism; Lloyd's mirror; Phase change on reflection: Stokes' treatment; Interference in thin films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger fringes); Fringes of equal thickness (Fizeau Fringes); Newton's rings: Measurement of wavelength and refractive index

Unit – III **(11 Hours)**
Diffraction:
Fraunhofer diffraction: Single slit, double slit, diffraction grating
Fresnel diffraction: Fresnel's assumptions. Fresnel's half-period zones for plane wave. Explanation of rectilinear propagation of light; Fresnel's diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis

References:
Essential Readings:

1) Vibrations and Waves, A. P. French, 1st edition, 2003, CRC press.
2) The Physics of Waves and Oscillations, N. K. Bajaj, 1998, Tata McGraw Hill.
3) Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
4) Fundamental of Optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand Publications.
5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi
6) The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

Additional Readings:

1) Principles of Optics, M. Born and E. Wolf, 7th edition, 1999, Pergamon Press.
2) Optics, E. Hecht, 4th edition, 2014, Pearson Education.
3) Fundamentals of Optics, F. A. Jenkins and H. E. White, 1981, McGraw-Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least 7 experiments to be performed from the following list

1) To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2) To study Lissajous figures.
3) Familiarization with Schuster`s focusing and determination of angle of prism.
4) To determine refractive index of the material of a prism using sodium light.
5) To determine the dispersive power and Cauchy's constants of the material of a prism using mercury light.
6) To determine wavelength of sodium light using Fresnel biprism.
7) To determine wavelength of sodium light using Newton's rings.
8) To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped film.

9) To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
10) To determine dispersive power and resolving power of a plane diffraction grating.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11^{th} edition, 2011, Kitab Mahal
3) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4^{th} edition, reprinted 1985, Heinemann Educational Publishers
4) A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.
5) B.Sc. Practical Physics, G. Sanon, 2019, R. Chand & Co

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 14a: INTRODUCTION TO NUMERICAL METHODS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Introduction to Numerical Methods PHYSICS DSE 14a	4	2	0	2	Class XII Pass with Science	Elementary calculus

LEARNING OBJECTIVES

The main objective of this course is to introduce the students to the field of numerical analysis enabling them to solve a wide range of physics problems. The skills developed during the course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Analyse a physics problem, establish the mathematical model and determine the appropriate numerical techniques to solve it.
- Derive numerical methods for various mathematical tasks such as root finding, interpolation, least squares fitting, numerical differentiation, numerical integration, and solution of initial value problems.
- Analyse and evaluate the accuracy of the numerical methods learned.

In the laboratory course, the students will learn to implement these numerical methods in Python and develop codes to solve various physics problems and interpret the results.

SYLLABUS OF PHYSICS DSE – 14a
THEORY COMPONENT

Unit – I **(7 Hours)**

Approximation and errors in computing: Introduction to numerical computation, Taylor's expansion and mean value theorem; Floating point computation, overflow and underflow; IEEE single and double precision format; Rounding and truncation error, absolute and relative error, error propagation.

Solutions of algebraic and transcendental equations: Basic idea of iteration method, Bisection method, Secant method, Newton Raphson method; comparison of order of convergence.

Unit – II **(7 hours)**

Interpolation: Interpolation and Lagrange polynomial, divided differences, Newton divided-difference form of the interpolating polynomial with equally spaced nodes. Theoretical error in interpolation.

Least Squares Approximation: Least squares linear regression, Least squares regression for exponential and power functions by taking logarithm.

Unit - III **(8 Hours)**

Numerical Differentiation: Using finite difference to approximate derivatives of first and second order using Taylor series and error in this approximation.

Numerical Integration: Newton Cotes quadrature methods; derivation of Trapezoidal and Simpson (1/3 and 3/8) rules from Lagrange interpolating polynomial; error and degree of precision of a quadrature formula; composite formulae for trapezoidal and Simpson methods; Gauss Legendre quadrature method.

Unit - IV **(8 Hours)**

Initial Value Problems: Solution of initial value problems by Euler, modified Euler and Runge Kutta (RK2, RK4) methods; local and global errors, comparison of errors in the Euler and RK methods, system of first order differential equations. Solving higher order initial value problems by converting them into a system of first order equations.

References:

Essential Readings:

1) Introduction to Numerical Analysis, S. S. Sastry, 5th edition, 2012, PHI Learning Pvt. Ltd.
2) Elementary Numerical Analysis, K. E. Atkinson, 3rd edition, 2007, Wiley India Edition.
3) Numerical methods for scientific and engineering computation, M. K. Jain, S. R. K. Iyenger and R. K. Jain, 2012, New Age Publishers
4) A Friendly Introduction to Numerical Analysis, B. Bradie, 2007, Pearson India

Additional Readings:

1) Numerical Recipes: The art of scientific computing, W. H. Press, S. A. Teukolsky and W. Vetterling, 3rd edition, 2007, Cambridge University Press
2) Numerical Methods for Scientists and Engineers, R. W. Hamming, 1987, Dover Publications
3) Applied numerical analysis, C. F. Gerald and P. O. Wheatley, 2007, Pearson Education
4) Numerical Analysis, R. L. Burden and J. D. Faires, 2011, Brooks/Cole, Cengage Learning
5) Numerical Methods, V. N. Vedamurthy and N. Ch. S.N. Iyengar, 2011, Vikas Publishing House

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- Assessment is to be done not only on the programming but also on the basis of formulating the problem.
- The list of recommended programs is suggestive only. Students should be encouraged to do more physics applications. Emphasis should be given to formulate a physics problem as mathematical one and solve by computational methods.
- The students should be encouraged to develop and present an independent project.
- **At least 12 programs must be attempted (taking two from each unit). The implementation is to be done in Python. Use of scipy inbuilt functions may be encouraged**

Unit 1

Basic Elements of Python: The Python interpreter, the print statement, comments, Python as simple calculator, objects and expressions, variables (numeric, character and sequence types) and assignments, mathematical operators. Strings, Lists, Tuples and Dictionaries, type conversions, input statement, list methods. List mutability, formatting in the print statement.

Control Structures: Conditional operations, ***if, if-else, if-elif-else, while*** and ***for*** Loops, indentation, break and continue, List comprehension. Simple programs for practice like solving quadratic equations, temperature conversion etc.

Functions: Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules. Writing functions to perform simple operations like finding largest of three numbers, listing prime numbers, etc. Use of inbuilt functions to generate pseudo random numbers.

Recommended List of Programs

a) Make a function that takes a number *N* as input and returns the value of factorial of *N*. Use this function to print the number of ways a set of *m* red and *n* blue balls can be arranged.
b) Generate random numbers (integers and floats) in a given range and calculate area and volume of regular shapes with random dimensions.
c) Write functions to convert Cartesian coordinates of a given point to cylindrical and spherical polar coordinates or vice versa.
d) Solve quadratic equations for the three cases of distinct real, double real and complex conjugate roots.

Unit 2

NumPy Fundamentals: Importing *Numpy*, Difference between List and NumPy array, Adding, removing and sorting elements, creating arrays using *ones(), zeros(), random(), arange(), linspace()*. Basic array operations (*sum, max, min, mean, variance*), 2-d arrays, matrix operations, reshaping and transposing arrays, savetxt() and loadtxt().

Plotting with Matplotlib: *matplotlib.pyplot* functions, plotting of functions given in closed form as well as in the form of discrete data and making histograms

Recommended List of Programs

(a) To generate data for coordinates of a projectile and plot the trajectory. Determine the range, maximum height and time of flight for a projectile motion.
(b) To plot the displacement-time and velocity-time graph for the undamped, under damped critically damped and over damped oscillator using *matplotlib* (using given formulae).
(c) To generate array of N random numbers drawn from a given distribution (uniform, binomial, poisson and gaussian) and draw histogram using *matplotlib* for increasing N to verify the distribution.
(d) To approximate the elementary functions (e.g. exp(x), sin(x), cos(x), ln(1+x), etc.) by a finite number of terms of Taylor's series and discuss the truncation error. To plot the function as well the nth partial sum of its series for various values of *n* on the same graph and visualise the convergence of series.

Unit 3

Root Finding: Implement the algorithms for Bisection, Secant and Newton Raphson methods or their combinations to,

(a) Determine the depth up to which a spherical homogeneous object of given radius and density will sink into a fluid of given density.

(b) Solve transcendental equations like $\alpha = \tan(\alpha)$.
(c) Approximate nth root of a number up to a given number of significant digits.

Unit 4
Interpolation and Least Square Fitting:

a) Given a dataset (x, y) with equidistant x values, prepare the Newton's divided difference table. Generate a tabulated data for an elementary function, approximate it by a polynomial and compare with the true function.
b) Given a dataset (x, y) corresponding to a physics problem, use Lagrange and Newton's forms of interpolating polynomials and compare. Determine the value of y at an intermediate value of x not included in the data set. This may be done with equally spaced and non-equally spaced x-values.
c) Make Python function for least square fitting, use it for fitting given data (*x, y*) and estimate the parameters *a, b* as well as uncertainties in the parameters for the following cases :
i. Linear ($y = ax + b$)
ii. Power law ($y = ax^b$) and
iii. Exponential ($y = ae^{bx}$)
The real data taken in physics lab may be used here.
d) Compare the interpolating polynomial for a given dataset (following a known form e.g. exponential) with the approximation obtained by least square fitting.

Unit 5
Differentiation and Integration:

a) To compute the left, right and central approximations for derivative of a function given in closed form. Plot both the function and derivative on the same graph. Plot (using *matplotlib)* the error as a function of step size on a log-log graph, study the behaviour of the plot as step size decreases and hence discuss the effect of round off error.
b) Use integral definition of error function to compute and plot erf(x) in a given range. Use Trapezoidal, Simpson and Gauss Legendre methods and compare the results for small and large values of x.
c) Verify the degree of precision of each quadrature rule.
d) Approximate the value of π by evaluating the integral $\int_0^\infty \frac{1}{x^2+1}dx$ using Simpson and Gauss Legendre method. More integrals may be evaluated.

Unit 6
Initial Value Problems (IVP):

a) Compare the errors in Euler, RK2 and RK4 by solving a first order IVP with known solution. Reduce the step size to a point where the round off errors takes over.
b) Radioactive decay: With a given number of initial nuclei and decay constant plot the number of nuclei left as a function of time and determine the half life
c) Solve a system of two first order differential equations by Euler, RK2 and RK4 methods. Use it to solve an nth order IVP. Solve a damped free and forced harmonic oscillator problem using this.
d) Solve a physics problem like free fall with air drag or parachute problem using RK method.
e) Obtain the current flowing in a series LCR circuit with constant voltage for a given set of initial conditions.

References for laboratory work:

1) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
3) Computational Physics, D. Walker, 1st edition, 2015, Scientific International Pvt. Ltd
4) An Introduction to Computational Physics, T. Pang, 2010, Cambridge University Press
5) Python Programming and Numerical Methods - A Guide for Engineers and Scientists, Q. Kong, T. Siauw, A. M. Bayen, 2021, Academic Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 14b: ANALOG ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Analog Electronics PHYSICS DSE – 14b	4	2	0	2	Class XII Pass with Science	NIL

LEARNING OBJECTIVES

This course introduces the concept of semiconductor devices and their analog applications. It also emphasizes on understanding of amplifiers, oscillators, operational amplifier and their applications.

LEARNING OUTCOMES

At the end of this course, the following concepts will be learnt.

- To learn about diodes and its uses in rectification
- To gain an insight into working principle of photodiodes, solar cells, LED and zener diode as voltage regulator
- To gain an understanding of construction and working principle of bipolar junction transistors (BJTs), characteristics of different configurations, biasing and analysis of transistor amplifier
- To be able to design and understand use of different types of oscillators
- To learn the fundamentals of operation amplifiers and understand their operations to compare, add, or subtract two or more signals and to differentiate or integrate signals etc.

In the laboratory course, the students will be able to study characteristics of various diodes and BJT. They will be able to design amplifiers, and oscillators. Also different applications using Op-Amp will be designed.

SYLLABUS OF Physics DSE – 14b

THEORY COMPONENT

Unit – I - Two-terminal devices and their applications (5 Hours)

IV characteristics of a diode and its application as rectifier (half-wave and full wave rectifier), IV characteristics of a zener diode and its use as voltage regulator, principle, structure and characteristics of (1) LED, (2) Photodiode and (3) Solar Cell

Unit – II - Bipolar junction transistors (4 Hours)

n-p-n and p-n-p transistors, IV characteristics of CB and CE configurations, active, cut-off and saturation regions, current gains α and β, relations between α and β, physical mechanism of current flow

Unit – III – Amplifiers and sinusoidal oscillators (11 Hours)

Load line analysis of transistor, DC load line and Q-point, fixed bias and voltage divider bias, transistor as 2-port network, h-parameter equivalent circuit of a transistor, analysis of a

single-stage CE amplifier using hybrid model (input and output impedance, current and voltage gain)
Sinusoidal Oscillators: General idea of positive and negative feedback, Barkhausen's criterion for self-sustained oscillations, RC phase shift oscillator, determination of frequency, Hartley and Colpitts oscillators

Unit – IV - Operational Amplifiers (Black Box approach) (10 Hours)
Characteristics of an ideal and practical Op-Amp (IC 741), open-loop and closed-loop gain, frequency response, CMRR, slew rate and concept of virtual ground
Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Comparator and Zero crossing detector (7) Wein bridge oscillator

References:
Essential Readings:

1) Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill
2) Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall
3) Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
4) Microelectronic circuits, A. S. Sedra, K. C. Smith and A. N. Chandorkar, 6th edition, 2014, Oxford University Press.
5) Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd edition, 2002, Wiley India
6) Electronic Principles, A. Malvino, D. J. Bates, 7th edition, 2018, Tata Mc-Graw Hill Education.
7) Electronic Devices and circuit Theory, R. L. Boylestad and L. D. Nashelsky, 2009, Pearson

Additional Readings:

1) Learning Electronic Devices and circuits, S. Salivahanan and N. S. Kumar, 3rd edition, 2012, Tata Mc-Graw Hill
2) Microelectronic Circuits, M. H. Rashid, 2nd edition, Cengage Learning
3) Microelectronic Devices and Circuits, D. A. Bell, 5th edition, 2015, Oxford University Press
4) Basic Electronics: Principles and Applications, C. Saha, A. Halder and D. Ganguli, 1st edition, 2018, Cambridge University Press
5) Solid State Electronic Devices, B. G.Streetman and S. K. Banerjee, 6th edition, 2009, PHI

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Session on the construction and use of specific analogue devices and experimental apparatuses used in the lab, including necessary precautions
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

1) To study the V-I characteristics of a Zener diode and its use as voltage regulator.

2) Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
3) To study the characteristics of a Bipolar Junction Transistor in CE configuration.
4) To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
5) To design a Wien bridge oscillator for given frequency using an op-amp.
6) To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain
7) To design inverting amplifier using Op-amp (741, 351) and study its frequency response
8) To design non-inverting amplifier using Op-amp (741, 351) and study frequency response
9) To add two dc voltages using Op-amp in inverting and non-inverting mode
10) To study the zero-crossing detector and comparator
11) To investigate the use of an op-amp as an integrator
12) To investigate the use of an op-amp as a differentiator.

References for laboratory work:

1) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino and M. A. Miller, 1994, Mc- Graw Hill
2) Student Manual for The Art of Electronics, T. C. Hayes and P. Horowitz

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 14c: PHYSICS OF EARTH

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Physics of Earth PHYSICS DSE – 14c	**4**	**3**	**1**	**0**	Class XII Pass with Science	NIL

LEARNING OBJECTIVES

This course familiarizes the students with the origin of earth in the solar system and various processes occurring in atmosphere, oceans and earth's internal structure.

LEARNING OUTCOMES

At the end of this course student will be able to,

- Have an overview of structure of the earth as well as various dynamical processes occurring on it.
- Develop an understanding of evolution of the earth.
- Apply physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure.
- Understand the origin of magnetic field, geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behaviour of the upper mantle and its top.
- Explore various roles played by water cycle, carbon cycle, nitrogen cycles in maintaining steady state of earth leading to better understanding of the contemporary dilemmas (climate change, bio diversity loss, population growth, etc.) disturbing the Earth
- Develop the problem solving skills by adding numerical and simulations to clarify the fundamental concepts.

SYLLABUS OF DSE – 14c

THEORY COMPONENT

Unit – I **(10 Hours)**

The Earth and the Universe:

a) General characteristics and origin of the Universe. The Big Bang Theory. Estimation of age of the Universe and Hubble constant. Formation of Galaxies. Types of galaxies, Milky Way galaxy, Nebular hypothesis, Solar system, The Terrestrial and Jovian planets (Sizes, Acceleration due to gravity, Obliquity, Flatness, Eccentricity, Density, Temperature, Pressure, Atmosphere, Moons, Exceptions in trends). Titius-Bode law. Asteroid belt. Asteroids: origin types and examples, Meteorites.

b) Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. Earth's orbit and spin, the Moon's orbit and spin.

c) Energy and particle fluxes incident on the Earth.

Unit – II **(8 Hours)**

Structure of Earth:

a) Internal structure of Earth: Core, mental, magnetic field. Origin of the Magnetic field. Convection in Earth's core and production of its magnetic field. Dynamo Theory, calculation of magnetic fields, Causes of variation of Magnetic Field and Palaeomagnetism.
b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. Ocean circulations. Oceanic current system and effect of Coriolis forces.
c) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

Unit – III **(8 Hours)**

Dynamical Processes:

a) The Solid Earth: Concept of plate tectonics; types of plate movements, hotspots; sea-floor spreading and continental drift.
b) Earthquake and earthquake belts. Types and properties of Seismic waves, Richter scale, geophones.
c) Volcanoes: types, products and distribution.
d) Concepts of eustasy, air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.

Unit – IV **(10 Hours)**

The Atmosphere

a) The Atmosphere: Features of different layers, variation of temperature with altitude; Dry, moist and environmental lapse rate, variation of density and pressure with altitude, Types of clouds and formation.
b) The Atmosphere: Atmospheric circulation. Causes of Atmospheric circulation, Formation of three cells, Easterlies and Westerlies, and ICTZ, Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones, tropical storms, hurricanes and tornadoes.
c) Climate: Earth's temperature and greenhouse effect. Paleoclimate and recent climate changes. The Indian monsoon system.

Unit – V **(9 Hours)**

Disturbing the Earth – Contemporary dilemmas

a) Hydrosphere: Fresh water depletion.
b) Geosphere: Chemical effluents, nuclear waste.
c) Biosphere: Biodiversity loss. Deforestation. Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.
d) Air Pollution: Types of air pollutants, Effects on atmosphere and living organisms. Ozone Hole.

References:

Essential Readings:

1) Planetary Surface Processes, H. J. Melosh, 2011, Cambridge University Press.
2) Holme's Principles of Physical Geology, 1992, Chapman & Hall.
3) Planet Earth, Cosmology, Geology and the Evolution of Life and Environment, C. Emiliani, 1992, Cambridge University Press.
4) Physics of the Earth, F. D. Stacey, P. M. Davis, 2008, Cambridge University Press.
5) Environmental Physics: Sustainable Energy and Climate Change, E. Boecker and R.V. Grondelle, 3rd edition, 2011, Wiley, UK
6) Atmospheric Remote Sensing (Principles and Applications, Editors – S. Tiwari and A. K.

Singh, Chapter-1 (Composition and thermal structure of the Earth's atmosphere, by S. K. Dhaka and V. Kumar), 1st edition, Elsevier

Additional Readings:

1) The Blue Planet: An Introduction to Earth System Science, B. J. Skinner, S. C. Portere, 1994, John Wiley & Sons.
2) Consider a Spherical Cow: A course in environmental problem solving, J. Harte, University Science Books.
3) Fundamentals of Geophysics, W. Lowrie, 1997, Cambridge University Press.
4) The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
5) Climate Change: A Very Short Introduction, M. Maslin, 3rd edition, 2014, Oxford University Press.
6) The Atmosphere: A Very Short Introduction, P. I. Palmer, 2017, Oxford University Press.
7) IGNOU Study material: PHE 15 Astronomy and Astrophysics Block

Category II

Physical Science Courses (with Electronics) with Physics and Electronics discipline as Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 7: WAVES AND OPTICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Waves and Optics PHYSICS DSC 7	4	2	0	2	Class XII Pass with Science	--

LEARNING OBJECTIVES

This is a core course in Physics curriculum that begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

LEARNING OUTCOMES

On successfully completing the requirements of this course, the students will have the skill and knowledge to,

- Understand simple harmonic oscillation and superposition principle.
- Understand superposition of a range of collinear and mutually perpendicular simple harmonic motions and their applications.
- Understand concept of normal modes in stationary waves: their frequencies and configurations.
- Understand interference as superposition of waves from coherent sources derived from same parent source.
- Demonstrate understanding of interference experiments: Young's double slit, Fresnel's biprism, Llyod's mirror, Newton's rings
- Demonstrate basic concepts of diffraction: Superposition of wavelets diffracted from apertures
- Understand Fraunhoffer diffraction from apertures: single slit, double Slit, grating
- Demonstrate fundamental understanding of Fresnel diffraction: Half period zones, diffraction of different apertures
- Laboratory course is designed to understand the principles of measurement and skills in experimental designs.

SYLLABUS OF PHYSICS DSC – 7

THEORY COMPONENT

Unit – I **(11 Hours)**

Superposition of collinear harmonic oscillations: Simple harmonic motion (SHM); linearity and superposition principle; superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (beats).

Superposition of two perpendicular harmonic oscillations: Graphical and analytical methods. Lissajous figures with equal and unequal frequencies and their uses

Superposition of two harmonic Waves: Standing (stationary) waves in a string; normal modes of stretched strings

Unit – II **(8 Hours)**

Interference: Division of amplitude and division of wavefront; Young's double slit experiment: width and shape of fringes; Fresnel's biprism; Lloyd's mirror; Phase change on reflection: Stokes' treatment; Interference in thin films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger fringes); Fringes of equal thickness (Fizeau Fringes); Newton's rings: Measurement of wavelength and refractive index

Unit – III **(11 Hours)**

Diffraction:
Fraunhofer diffraction: Single slit, double slit, diffraction grating
Fresnel diffraction: Fresnel's assumptions. Fresnel's half-period zones for plane wave. Explanation of rectilinear propagation of light; Fresnel's diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis

References:

Essential Readings:

1) Vibrations and Waves, A. P. French, 1st edition, 2003, CRC press.
2) The Physics of Waves and Oscillations, N. K. Bajaj, 1998, Tata McGraw Hill.
3) Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
4) Fundamental of Optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand Publications.
5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi
6) The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

Additional Readings:

1) Principles of Optics, M. Born and E. Wolf, 7th edition, 1999, Pergamon Press.
2) Optics, E. Hecht, 4th edition, 2014, Pearson Education.
3) Fundamentals of Optics, F. A. Jenkins and H. E. White, 1981, McGraw-Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least 7 experiments to be performed from the following list

1) To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2–T law.
2) To study Lissajous figures.
3) Familiarization with Schuster`s focusing and determination of angle of prism.
4) To determine refractive index of the material of a prism using sodium light.
5) To determine the dispersive power and Cauchy's constants of the material of a prism using mercury light.
6) To determine wavelength of sodium light using Fresnel biprism.
7) To determine wavelength of sodium light using Newton's rings.
8) To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.

9) To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
10) To determine dispersive power and resolving power of a plane diffraction grating.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11^{th} edition, 2011, Kitab Mahal
3) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4^{th} edition, reprinted 1985, Heinemann Educational Publishers
4) A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.
5) B.Sc. Practical Physics, G. Sanon, 2019, R. Chand & Co

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 8: MICROPROCESSOR AND MICROCONTROLLER

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Microprocessor and Microcontroller PHYSICS DSC – 8	4	2	0	2	Class XII Pass with Science	Basic Electronics

LEARNING OBJECTIVES

This paper introduces the basic concepts of microprocessor and microcontrollers to the undergraduate students. Basic architecture and buildings blocks of a microprocessor and microcontrollers will be discussed in detail. Pin out diagram and the assembly language programming is discussed for both of them. The course is supported by a lab where students will apply the learned concepts and write simple programs to strengthen their classroom learning.

LEARNING OUTCOMES

Upon completion of this course, students will be able to,

- Describe the basic difference between a microprocessor and microcontroller and a general computing system.
- Explain the basic architecture and pin out diagram of 8085 microprocessor and 8051 microcontroller.
- Explain the difference between machine code, mnemonics, assembly language (low level) and high level language.
- Explain the concept of memory, different types of memory available in a system. The concept of memory map and how addresses are assigned to each memory element and peripherals.
- Classify instructions 1-, 2- or 3-byte instructions and into arithmetic, logical types etc.
- Describe the different addressing modes available to perform the same task.
- Write simple programs for 8085 microprocessor and 8051 microcontroller.

SYLLABUS OF PHYSICS DSC - 8

THEORY COMPONENT

Unit – I - Microcomputer organization (4 Hours)

Basic organization of a microcomputer/ microprocessor based system, computer memory, memory classification (RAM and ROM), memory organization and addressing, memory interfacing, memory map

Unit – II - 8085 Microprocessor architecture (4 Hours)

Main features of 8085, pin-out diagram of 8085, data and address buses, registers, ALU, stack pointer, program counter

Unit – III - 8085 Programming **(7 Hours)**
Instruction classification (data transfer, arithmetic, logical, branch, and control instructions), general discussion on 1 byte, 2 bytes and 3 bytes instructions, subroutines, instruction cycle, timing diagram of MOV and MVI, hardware and software interrupts (general discussion).

Unit – IV - 8051 microcontroller **(8 Hours)**
Microcontroller vs microprocessor, block diagram of 8051 microcontroller, 8051 assembly language programming, program counter and ROM memory map, data types and directives, flag bits and program status word (PSW) register, register banks and stack, jump, loop and call instructions

Unit – V - 8051 I/O port programming **(3 Hours)**
Pin out diagram of 8051 microcontroller, introduction of I/O port and their general features, I/O port programming in 8051 (using assembly language)

Unit – VI - 8051 Programming **(4 Hours)**
8051 addressing modes and accessing memory locations using various addressing modes, arithmetic and logic instructions

References:
Essential Readings:

1) Microprocessor Architecture Programming and applications with 8085, R. S. Goankar, 2002, Prentice Hall.
2) Microprocessors and Microcontrollers, K. Kant, 2nd edition, 2016. PHI learning Pvt. Ltd.
3) The 8051 Microcontroller, Ayala, Cengage learning, 3rd edition.
4) The 8051 Microcontroller and Embedded Systems Using Assembly and C, M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, 2nd edition, 2007, Pearson Education India.
5) Microprocessor and Microcontrollers, N. Senthil Kumar, 2010, Oxford University Press.
6) 8051 Microcontroller, S. Shah, 2010, Oxford University Press.

Additional Readings:

1) Embedded Systems: Design and Applications, S. F. Barrett, 2008, Pearson Education India.
2) Introduction to embedded system, K. V. Shibu, 1st edition, 2009, McGraw Hill.
3) Embedded Microcomputer systems: Real time interfacing, J. W. Valvano, 2011, Cengage Learning.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

There are two options here:
A. Every Student must perform at least 06 experiments each from Section-A and Section-B
Or
B. Every Student must perform at least 04 experiments each from Section-A and Section-B and a suitable project based on Arduino.

Section-A: Programs using 8085 Microprocessor

1) Addition and subtraction of two 8 bits numbers using direct addressing mode

2) Addition and subtraction of two 8 bits numbers using indirect addressing mode
3) Addition and subtraction of two 16 bits numbers using direct addressing mode
4) Addition and subtraction of two 16 bits numbers using indirect addressing mode
5) Multiplication by repeated addition.
6) Division by repeated subtraction.
7) Handling of 16-bit Numbers.
8) Use of CALL and RETURN Instruction.
9) Block data handling.
10) Parity checking in an 8-bit and 16 bit number.

Section-B: Experiments using 8051 microcontroller:

1) To find that the given numbers is prime or not.
2) To find the factorial of a number.
3) Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4) Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's.
5) Program to glow the first four LEDs then next four using TIMER application.
6) Program to rotate the contents of the accumulator first right and then left.
7) Program to run a countdown from 9-0 in the seven segment LED display.
8) To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9) To toggle '1234' as '1324' in the seven segments LED display.
10) Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11) Application of embedded systems: Temperature measurement & display on LCD

References for laboratory work:

1) Microprocessor Architecture Programming and applications with 8085, R. S. Goankar, 2002, Prentice Hall.
2) Embedded Systems: Architecture, Programming and Design, R. Kamal, 2008, Tata McGraw Hill.
3) The 8051 Microcontroller and Embedded Systems Using Assembly and C, M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, 2nd edition, 2007, Pearson Education India.
4) 8051 microcontrollers, S. Shah, 2010, Oxford University Press.
5) Embedded Microcomputer systems: Real time interfacing, J. W. Valvano, 2011, Cengage Learning

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 11: INTRODUCTION TO NUMERICAL METHODS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Introduction to Numerical Methods PHYSICS DSE 11	4	2	0	2	Class XII Pass with Science	Elementary calculus

LEARNING OBJECTIVES

The main objective of this course is to introduce the students to the field of numerical analysis enabling them to solve a wide range of physics problems. The skills developed during the course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Analyse a physics problem, establish the mathematical model and determine the appropriate numerical techniques to solve it.
- Derive numerical methods for various mathematical tasks such as root finding, interpolation, least squares fitting, numerical differentiation, numerical integration, and solution of initial value problems.
- Analyse and evaluate the accuracy of the numerical methods learned.

In the laboratory course, the students will learn to implement these numerical methods in Python and develop codes to solve various physics problems and interpret the results.

SYLLABUS OF PHYSICS DSE – 11

THEORY COMPONENT

Unit – I **(7 Hours)**

Approximation and errors in computing: Introduction to numerical computation, Taylor's expansion and mean value theorem; Floating point computation, overflow and underflow; IEEE single and double precision format; Rounding and truncation error, absolute and relative error, error propagation.

Solutions of algebraic and transcendental equations: Basic idea of iteration method, Bisection method, Secant method, Newton Raphson method; comparison of order of convergence.

Unit – II **(7 hours)**

Interpolation: Interpolation and Lagrange polynomial, divided differences, Newton divided-difference form of the interpolating polynomial with equally spaced nodes. Theoretical error in interpolation.

Least Squares Approximation: Least squares linear regression, Least squares regression for exponential and power functions by taking logarithm.

Unit - III **(8 Hours)**

Numerical Differentiation: Using finite difference to approximate derivatives of first and second order using Taylor series and error in this approximation.

Numerical Integration: Newton Cotes quadrature methods; derivation of Trapezoidal and Simpson (1/3 and 3/8) rules from Lagrange interpolating polynomial; error and degree of precision of a quadrature formula; composite formulae for trapezoidal and Simpson methods; Gauss Legendre quadrature method.

Unit - IV **(8 Hours)**

Initial Value Problems: Solution of initial value problems by Euler, modified Euler and Runge Kutta (RK2, RK4) methods; local and global errors, comparison of errors in the Euler and RK methods, system of first order differential equations. Solving higher order initial value problems by converting them into a system of first order equations.

References:

Essential Readings:

1) Introduction to Numerical Analysis, S. S. Sastry, 5th edition, 2012, PHI Learning Pvt. Ltd.
2) Elementary Numerical Analysis, K. E. Atkinson, 3rd edition, 2007, Wiley India Edition.
3) Numerical methods for scientific and engineering computation, M. K. Jain, S. R. K. Iyenger and R. K. Jain, 2012, New Age Publishers
4) A Friendly Introduction to Numerical Analysis, B. Bradie, 2007, Pearson India

Additional Readings:

1) Numerical Recipes: The art of scientific computing, W. H. Press, S. A. Teukolsky and W. Vetterling, 3rd edition, 2007, Cambridge University Press
2) Numerical Methods for Scientists and Engineers, R. W. Hamming, 1987, Dover Publications
3) Applied numerical analysis, C. F. Gerald and P. O. Wheatley, 2007, Pearson Education
4) Numerical Analysis, R. L. Burden and J. D. Faires, 2011, Brooks/Cole, Cengage Learning
5) Numerical Methods, V. N. Vedamurthy and N. Ch. S.N. Iyengar, 2011, Vikas Publishing House

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- Assessment is to be done not only on the programming but also on the basis of formulating the problem.
- The list of recommended programs is suggestive only. Students should be encouraged to do more physics applications. Emphasis should be given to formulate a physics problem as mathematical one and solve by computational methods.
- The students should be encouraged to develop and present an independent project.
- **At least 12 programs must be attempted (taking two from each unit). The implementation is to be done in Python. Use of scipy inbuilt functions may be encouraged.**

Unit 1

Basic Elements of Python: The Python interpreter, the print statement, comments, Python as simple calculator, objects and expressions, variables (numeric, character and sequence types) and assignments, mathematical operators. Strings, Lists, Tuples and Dictionaries, type conversions, input statement, list methods. List mutability, formatting in the print statement.

Control Structures: Conditional operations, ***if, if-else, if-elif-else, while*** and ***for*** Loops, indentation, break and continue, List comprehension. Simple programs for practice like solving quadratic equations, temperature conversion etc.

Functions: Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules. Writing functions to perform simple operations like finding largest of three numbers, listing prime numbers, etc. Use of inbuilt functions to generate pseudo random numbers.

Recommended List of Programs

a) Make a function that takes a number *N* as input and returns the value of factorial of *N*. Use this function to print the number of ways a set of *m* red and *n* blue balls can be arranged.
b) Generate random numbers (integers and floats) in a given range and calculate area and volume of regular shapes with random dimensions.
c) Write functions to convert Cartesian coordinates of a given point to cylindrical and spherical polar coordinates or vice versa.
d) Solve quadratic equations for the three cases of distinct real, double real and complex conjugate roots.

Unit 2

NumPy Fundamentals: Importing *Numpy*, Difference between List and NumPy array, Adding, removing and sorting elements, creating arrays using *ones(), zeros(), random(), arange(), linspace()*. Basic array operations (*sum, max, min, mean, variance*), 2-d arrays, matrix operations, reshaping and transposing arrays, savetxt() and loadtxt().

Plotting with Matplotlib: *matplotlib.pyplot* functions, plotting of functions given in closed form as well as in the form of discrete data and making histograms

Recommended List of Programs

(a) To generate data for coordinates of a projectile and plot the trajectory. Determine the range, maximum height and time of flight for a projectile motion.
(b) To plot the displacement-time and velocity-time graph for the undamped, under damped critically damped and over damped oscillator using *matplotlib* (using given formulae).
(c) To generate array of N random numbers drawn from a given distribution (uniform, binomial, poisson and gaussian) and draw histogram using *matplotlib* for increasing N to verify the distribution.
(d) To approximate the elementary functions (e.g. exp(x), sin(x), cos(x), ln($1+x$), etc.) by a finite number of terms of Taylor's series and discuss the truncation error. To plot the function as well the nth partial sum of its series for various values of *n* on the same graph and visualise the convergence of series.

Unit 3

Root Finding: Implement the algorithms for Bisection, Secant and Newton Raphson methods or their combinations to,

(a) Determine the depth up to which a spherical homogeneous object of given radius and density will sink into a fluid of given density.

(b) Solve transcendental equations like $\alpha = \tan(\alpha)$.
(c) Approximate nth root of a number up to a given number of significant digits.

Unit 4
Interpolation and Least Square Fitting:

a) Given a dataset (x, y) with equidistant x values, prepare the Newton's divided difference table. Generate a tabulated data for an elementary function, approximate it by a polynomial and compare with the true function.
b) Given a dataset (x, y) corresponding to a physics problem, use Lagrange and Newton's forms of interpolating polynomials and compare. Determine the value of y at an intermediate value of x not included in the data set. This may be done with equally spaced and non-equally spaced x-values.
c) Make Python function for least square fitting, use it for fitting given data (*x, y*) and estimate the parameters *a, b* as well as uncertainties in the parameters for the following cases :
   i. Linear $(y = ax + b)$
   ii. Power law $(y = ax^b)$ and
   iii. Exponential $(y = ae^{bx})$
   The real data taken in physics lab may be used here.
d) Compare the interpolating polynomial for a given dataset (following a known form e.g. exponential) with the approximation obtained by least square fitting.

Unit 5
Differentiation and Integration:

a) To compute the left, right and central approximations for derivative of a function given in closed form. Plot both the function and derivative on the same graph. Plot (using *matplotlib)* the error as a function of step size on a log-log graph, study the behaviour of the plot as step size decreases and hence discuss the effect of round off error.
b) Use integral definition of error function to compute and plot erf(x) in a given range. Use Trapezoidal, Simpson and Gauss Legendre methods and compare the results for small and large values of x.
c) Verify the degree of precision of each quadrature rule.
d) Approximate the value of π by evaluating the integral $\int_0^\infty \frac{1}{x^2+1} dx$ using Simpson and Gauss Legendre method. More integrals may be evaluated.

Unit 6
Initial Value Problems (IVP):

a) Compare the errors in Euler, RK2 and RK4 by solving a first order IVP with known solution. Reduce the step size to a point where the round off errors takes over.
b) Radioactive decay: With a given number of initial nuclei and decay constant plot the number of nuclei left as a function of time and determine the half life
c) Solve a system of two first order differential equations by Euler, RK2 and RK4 methods. Use it to solve an nth order IVP. Solve a damped free and forced harmonic oscillator problem using this.
d) Solve a physics problem like free fall with air drag or parachute problem using RK method.
e) Obtain the current flowing in a series LCR circuit with constant voltage for a given set of initial conditions.

References for laboratory work:

1) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
2) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
3) Computational Physics, D. Walker, 1st edition, 2015, Scientific International Pvt. Ltd
4) An Introduction to Computational Physics, T. Pang, 2010, Cambridge University Press
5) Python Programming and Numerical Methods - A Guide for Engineers and Scientists, Q. Kong, T. Siauw, A. M. Bayen, 2021, Academic Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 12: PHYSICS OF EARTH

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Physics of Earth Physics DSE 12	**4**	**3**	**1**	**0**	Class XII Pass with Science	--

LEARNING OBJECTIVES
This course familiarizes the students with the origin of earth in the solar system and various processes occurring in atmosphere, oceans and earth's internal structure.

LEARNING OUTCOMES
At the end of this course student will be able to,
- Have an overview of structure of the earth as well as various dynamical processes occurring on it.
- Develop an understanding of evolution of the earth.
- Apply physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure.
- Understand the origin of magnetic field, geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behaviour of the upper mantle and its top.
- Explore various roles played by water cycle, carbon cycle, nitrogen cycles in maintaining steady state of earth leading to better understanding of the contemporary dilemmas (climate change, bio diversity loss, population growth, etc.) disturbing the Earth
- Develop the problem solving skills by adding numerical and simulations to clarify the fundamental concepts.

SYLLABUS OF DSE – 12

THEORY COMPONENT

Unit – I **(10 Hours)**

The Earth and the Universe:

a) General characteristics and origin of the Universe. The Big Bang Theory. Estimation of age of the Universe and Hubble constant. Formation of Galaxies. Types of galaxies, Milky Way galaxy, Nebular hypothesis, Solar system, The Terrestrial and Jovian planets (Sizes, Acceleration due to gravity, Obliquity, Flatness, Eccentricity, Density, Temperature, Pressure, Atmosphere, Moons, Exceptions in trends). Titius-Bode law. Asteroid belt. Asteroids: origin types and examples, Meteorites.

b) Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age. Earth's orbit and spin, the Moon's orbit and spin.

c) Energy and particle fluxes incident on the Earth.

Unit – II **(8 Hours)**

Structure of Earth:

a) Internal structure of Earth: Core, mental, magnetic field. Origin of the Magnetic field. Convection in Earth's core and production of its magnetic field. Dynamo Theory, calculation of magnetic fields, Causes of variation of Magnetic Field and Palaeomagnetism.
b) The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. Ocean circulations. Oceanic current system and effect of Coriolis forces.
c) The Cryosphere: Polar caps and ice sheets. Mountain glaciers, permafrost.

Unit – III **(8 Hours)**

Dynamical Processes:

a) The Solid Earth: Concept of plate tectonics; types of plate movements, hotspots; sea-floor spreading and continental drift.
b) Earthquake and earthquake belts. Types and properties of Seismic waves, Richter scale, geophones.
c) Volcanoes: types, products and distribution.
d) Concepts of eustasy, air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.

Unit – IV **(10 Hours)**

The Atmosphere

a) The Atmosphere: Features of different layers, variation of temperature with altitude; Dry, moist and environmental lapse rate, variation of density and pressure with altitude, Types of clouds and formation.
b) The Atmosphere: Atmospheric circulation. Causes of Atmospheric circulation, Formation of three cells, Easterlies and Westerlies, and ICTZ, Weather and climatic changes. Earth's heat budget. Cyclones and anti-cyclones, tropical storms, hurricanes and tornadoes.
c) Climate: Earth's temperature and greenhouse effect. Paleoclimate and recent climate changes. The Indian monsoon system.

Unit – V **(9 Hours)**

Disturbing the Earth – Contemporary dilemmas

a) Hydrosphere: Fresh water depletion.
b) Geosphere: Chemical effluents, nuclear waste.
c) Biosphere: Biodiversity loss. Deforestation. Water cycle, Carbon cycle. The role of cycles in maintaining a steady state.
d) Air Pollution: Types of air pollutants, Effects on atmosphere and living organisms. Ozone Hole.

References:

Essential Readings:

1) Planetary Surface Processes, H. J. Melosh, 2011, Cambridge University Press.
2) Holme's Principles of Physical Geology, 1992, Chapman & Hall.
3) Planet Earth, Cosmology, Geology and the Evolution of Life and Environment, C. Emiliani, 1992, Cambridge University Press.
4) Physics of the Earth, F. D. Stacey, P. M. Davis, 2008, Cambridge University Press.
5) Environmental Physics: Sustainable Energy and Climate Change, E. Boecker and R.V. Grondelle, 3rd edition, 2011, Wiley, UK
6) Atmospheric Remote Sensing (Principles and Applications, Editors – S. Tiwari and A. K.

Singh, Chapter-1 (Composition and thermal structure of the Earth's atmosphere, by S. K. Dhaka and V. Kumar), 1st edition, Elsevier

Additional Readings:

1) The Blue Planet: An Introduction to Earth System Science, B. J. Skinner, S. C. Portere, 1994, John Wiley & Sons.
2) Consider a Spherical Cow: A course in environmental problem solving, J. Harte, University Science Books.
3) Fundamentals of Geophysics, W. Lowrie, 1997, Cambridge University Press.
4) The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
5) Climate Change: A Very Short Introduction, M. Maslin, 3rd edition, 2014, Oxford University Press.
6) The Atmosphere: A Very Short Introduction, P. I. Palmer, 2017, Oxford University Press.
7) IGNOU Study material: PHE 15 Astronomy and Astrophysics Block

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

GENERIC ELECTIVE (GE – 15): QUANTUM MECHANICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Quantum Mechanics GE – 15	4	3	1	0	Class XII Pass with Science	GE Modern Physics of this course or its equivalent

LEARNING OBJECTIVES

The development of quantum mechanics has revolutionized the human life. In this course, the students will be exposed to the probabilistic concepts of basic non-relativistic quantum mechanics and its applications to understand the sub atomic world.

LEARNING OUTCOMES

After completing this course, the students will be able to,

- Learn the methods to solve time-dependent and time-independent Schrödinger equation.
- Characteristics of an acceptable wave function for any sub atomic particle in various potentials.
- Applications of the Schrodinger equation to different cases of potentials namely infinite and finite potential well, step potential, rectangular potential barrier, harmonic oscillator potential.
- Solve the Schrodinger equation in 3-D.
- Understand the spectrum and eigen functions for hydrogen atom

SYLLABUS OF GE - 15

THEORY COMPONENT

Unit – I **(10 Hours)**

Review of Schrodinger wave equation, applicability of operator, eigenvalues, eigenfunction, normalisation, expectation value to various kinds of potential, Superposition Principle, linearity of Schrodinger equation, General solution as a linear combination of discrete stationary states, Observables as operators, Commutator of position and momentum operators, Ehrenfest’s theorem. Applicability to various kinds of wave functions

Unit – II **(15 Hours)**

General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary conditions and emergence of discrete energy levels. Application to energy eigen states for a particle in a finite square potential well, reflection and transmission across step potential and rectangular potential barrier. Fourier transforms and momentum space wave function, time evolution of Gaussian wave packets, Uncertainty principle

Unit – III **(10 Hours)**

Harmonic oscillator: Energy eigen values and eigen states of a 1-D harmonic oscillator using algebraic method (ladder operators) and using Hermite polynomials. Zero point energy and uncertainty principle. Applications to various kinds of wave functions

Unit – IV **(10 Hours)**

Schrödinger Equation in three dimensions: Probability and probability densities in 3D. Schrödinger equation in spherical polar coordinates, its solution for Hydrogen atom solution using separation of angular and radial variables, Angular momentum operator, quantum numbers and spherical harmonics. Radial wave functions from Frobenius method, Orbital angular momentum quantum numbers l and ml, s, p, d shells

References:

Essential Readings:

1) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 6th edition, 2019, Laxmi Publications, New Delhi.
2) Introduction to Quantum Mechanics, D. J. Griffith, 2nd edition, 2005, Pearson Education.
3) A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd edition, 2010, McGraw Hill.
4) Quantum Mechanics, B. H. Bransden and C. J. Joachain, 2nd edition, 2000, Prentice Hall
5) Quantum Mechanics: Concepts and Applications, 2nd edition, N. Zettili, A John Wiley and Sons, Ltd., Publication
6) Atomic Physics, S. N. Ghoshal, 2010, S. Chand and Company

Additional Readings:

1) Quantum Mechanics for Scientists & Engineers, D. A. B. Miller, 2008, Cambridge University Press.
2) Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, 1966, Addison-Wesley Publications
3) Quantum Mechanics, L. I. Schiff, 3rd edition, 2010, Tata McGraw Hill.
4) Quantum Mechanics, R. Eisberg and R. Resnick, 2nd edition, 2002, Wiley
5) Quantum Mechanics, B. C. Reed, 2008, Jones and Bartlett Learning.
6) Quantum Mechanics, W. Greiner, 4th edition, 2001, Springer.
7) Introductory Quantum Mechanics, R. L. Liboff, 4th edition, 2003, Addison Wesley

GENERIC ELECTIVE (GE – 16) INTRODUCTION TO EMBEDDED SYSTEM DESIGN

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Introduction to Embedded System Design GE – 16	4	2	0	2	Class XII Pass with Science	NIL

LEARNING OBJECTIVES

This paper aims to introduce the basic concepts or fundamentals of embedded system design to students not majoring in physics. The course covers the comprehensive introduction to embedded systems, their role and application areas in our daily life. Basic elements needed to design a typical embedded system are discussed to provide the students a broader perspective. Specific applications of embedded systems which are a part of our daily life were discussed. In the end Arduino Uno is introduced.

LEARNING OUTCOMES

Upon completion of this course, students will be able to,

- Learn about an embedded system and how it is different than a general purpose computing system like computer or laptop etc.
- The student should be able to identify various embedded systems available around us in our daily life.
- Classify embedded systems based on generation, complexity and performance, major applications areas etc.
- Explain the domains and areas of applications of embedded systems. The students should be able to get a broader perspective of different embedded systems available in industry, telecom, photography, homes, automobile, aviation and ship industry etc.
- Explain the roles and uses of various components like microcontroller, memory, sensors and actuators, interface types etc. of embedded systems.
- Know the basic characteristics and quality attributes that any typical embedded system must possess.
- This paper is designed in such a way that the students will be able to connect the textbook knowledge with basic design and working of the various embedded systems present in our daily life. By the end of this course the student will have a fairly good idea of embedded systems and the gained knowledge will be helpful in predicting the possible design and working of an unknown system. Arduino Uno is introduced so that students can learn how to use different sensors to control different processes.

SYLLABUS OF GE - 16

THEORY COMPONENT

UNIT – I - Introduction to Embedded Systems (3 Hours)
Embedded systems, historical background, difference between an embedded systems and general computing systems, classification of embedded systems based on generation, complexity and performance, major applications areas, purpose of embedded systems like in data collection/storage/representation, data communication, data/signal processing, monitoring, control, application specific user interface.

Unit – II - Elements of Embedded System (6 Hours)
Core of the embedded system: General purpose and domain specific processors like microprocessors, microcontrollers and digital signal processors, application specific integrated circuits (ASICs), programmable logic devices (PLDs), commercial off-the-shelf components (COTS), reduced instruction set computing (RISC) and complex instruction set computing (CISC), Harvard vs Von-Neumann architecture, different types of memory (RAM, ROM, Storage etc) their classification and different versions, reset circuit, oscillator unit

Unit – III - Peripheral devices, sensors and actuators (6 Hours)
General discussion on light emitting dodes (LEDs), 7-segment LED display, piezo buzzer, push button switch, keypad or keyboard (discuss design using push button switches), relay (single pole single throw), LDR, thermistor, IR sensor, ultrasonic sensor, opto-coupler, DC motors, servo motor, stepper motor (unipolar and bipolar)

Unit – IV - Communication Interface (2 Hours)
Serial and parallel interface, universal serial bus (USB), Infra-red data transfer, bluetooth (BT), Wi-Fi, general packet radio Service (GPRS), 3G, 4G, LTE

Unit – V - Characteristics and quality attributes of an embedded systems (3 Hours)
Characteristics: Application and domain specific, reactive and real time, operation under harsh environments, distributed or stand alone, size and weight, power consumption
Operational and non-operational attributes: response time, throughput, reliability, maintainability, security, safety, testability and debug-ability, evolvability, portability, cost and revenue

Unit – VI - Applications of Embedded Systems (4 Hours)
General discussion on the design and working of washing machine, refrigerator, microwave oven, automobiles, mobile phones, hearing aid device, electrocardiogram (ECG), AC or TV remote control system, smart watch, digital camera and laser printers etc.

Unit – VII - Introduction to Arduino (6 Hours)
Pin diagram and description of Arduino UNO, basic programming and applications

References:
Essential Readings:

1) Introduction to embedded system, K. V. Shibu, 1st edition, 2009, McGraw Hill
2) Embedded Systems: Architecture, Programming and Design, R. Kamal, 2008, Tata McGraw Hill
3) Embedded Systems and Robots, S. Ghoshal, 2009, Cengage Learning.
4) Embedded Microcomputer systems: Real time interfacing, J. W. Valvano, 2011, Cengage Learning
5) Embedded System, B. K. Rao, 2011, PHI Learning Pvt. Ltd.
6) Programming Arduino: Getting Started with Sketches, S. Monk, 2nd edition, McGraw Hill

7) Arduino: Getting Started With Arduino and Basic Programming with Projects by E. Leclerc

Additional Readings:

1) The 8051 Microcontroller and Embedded Systems Using Assembly and C, M. A. Mazidi, J. G. Mazidi and R. D. McKinlay, 2nd edition, 2007, Pearson Education
2) Microprocessors and Microcontrollers, K. Kant, 2nd edition, 2016, PHI learning Pvt. Ltd.
3) The 8051 Microcontroller, Ayala, 3rd edition, Cengage learning

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Every student must perform at least six experiments from the following list
- Mandatory exercise for all students: Familiarization with power supply, function generator, CRO/DSO, multimeter, bread board etc. Measure the frequency and amplitude (pp or rms) of a given signal using CRO/DSO. (The purpose is to acquaint the students with these instruments so that they can have a basic understanding of these instruments).

ARDUINO based Experiments:

1) Flashing LEDs ON/OFF after a given delay.
2) Design a simple transmitter and receiver circuit using IR LED and a detector and use it for obstacle detection.
3) Interface a simple relay circuit to switch ON and OFF a dc motor/LED.
4) Interface DC motor to Arduin Uno and rotate it clockwise and anticlockwise.
5) Interface Servo motor to Arduin Uno and rotate it clockwise and anticlockwise for a given angle.
6) Interface an ADC and read the output of the LDR sensor. Display the value on the serial monitor.
7) To design an alarm system using an Ultrasonic sensor.
8) To design a counter/Motion sensor alarm using IR Led and Detector
9) To design a circuit to control ON/OFF of LED light using LDR.
10) To design a circuit to control ON/OFF of a process using a thermistor.
11) To design a thermistor based thermometer.
12) Control the speed of the DC motor using LDR.

References for laboratory work:

1) Arduino Programming: 3 books in 1 - The Ultimate Beginners, Intermediate and Expert Guide to Master Arduino Programming, R. Turner
2) Arduino: Getting Started With Arduino and Basic Programming with Projects, E. Leclerc
3) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, M. A. Miller, 1994, McGraw Hill.
4) Electronic Devices and circuit theory, R. L. Boylestad and L. D. Nashelsky, 2009, Pearson
5) Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall.
6) Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning.

GENERIC ELECTIVE (GE - 17) NANO PHYSICS

<table>
<tr><th rowspan="2">Course Title & Code</th><th rowspan="2">Credits</th><th colspan="3">Credit distribution of the course</th><th rowspan="2">Eligibility Criteria</th><th rowspan="2">Pre-requisite of the course</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>Nano Physics

GE – 17</td><td>4</td><td>2</td><td>0</td><td>2</td><td>Class XII Pass with Science</td><td>NIL</td></tr>
</table>

LEARNING OBJECTIVES

The syllabus introduces the basic concepts of nanomaterials, their synthesis, properties exhibited by them and finally few applications. Various nanomaterial synthesis/growth methods and characterizations techniques are discussed to explore the field in detail. The effect of dimensional confinement of charge carries on the electrical, optical and structural properties will be discussed. Interesting experiments which shape this filed like conductance quantization in 2DEG (Integer Quantum Hall Effect) and coulomb blockade are introduced. The concept of micro- and nano-electro mechanical systems (MEMS and NEMS) and important applications areas of nanomaterials are discussed.

LEARNING OUTCOMES

On successful completion of the course students should be able to,

- Explain the difference between nanomaterials and bulk materials and their property difference.
- Explain various methods for the synthesis/growth of nanomaterials.
- Explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.
- Explain the concept of quasi-particles such as excitons and how they influence the optical properties.
- Explain the direct and indirect band gap semiconductors, radiative and non-radiative processes and the concept of luminescence.
- Explain the structure of 2DEG system and its importance in quantum transport experiments, like integer quantum Hall effect and conductance quantization.
- Explain the conductance quantization in 1D structure and its difference from the 2DEG system.
- Explain the necessary and sufficient conditions required to observe coulomb blockade, single electron transistor and the scope of these devices.
- Explain how MEMS and NEMS devices are produced and their applications.

SYLLABUS OF GE - 17

THEORY COMPONENT

Unit – I – Introduction **(3 Hours)**

Basic introduction to nano-science and technology - Implications on nanoscience on fields like Physics, Chemistry, Biology and Engineering, Classifications of nanostructured materials as quantum dots (0D), nanowires (1D), Thin films (2D) and Multilayered materials or super lattices; introduction to properties like mechanical, electronic, optical, magnetic and thermal properties and how they change at nano scale dimensions to motivate students (qualitative only).

Unit – II - Nanoscale Systems (8 Hours)

Brief review of Schrodinger equation and its applications in- Infinite potential well, potential step and potential box problems, band structure and density of states of 3D and 2D systems in detail and qualitatively for 1D and 0D, confinement of charges in nanostructures their consequences on electronic and optical properties.

Unit – III - Properties of Nano Scale systems (10 Hours)

Time and length scales (diffusion, elastic and inelastic lengths etc.) of electrons in nanostructured materials, Carrier transport in nanostructures: diffusive and ballistic transport

2D naomaterials: Conductance quantization in 2DEG in GaAs and integer quantum hall effect (semi-classical treatment)

1D nanomaterials: Conductance quantization in 1D structures using split gate in 2DEG system (Qualitative)

0D nanomaterials: Charging effect, Coulomb Blockade effect, Single Electron Transfer (SET) device

Basic understanding of excitons in semiconductors and their consequence on optical properties of the material

Unit – IV - Synthesis of Nanomaterials (Qualitative) (5 Hours)

Top down and Bottom up approach, Ball milling, Spin Coating

Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Chemical vapor deposition (CVD).

Preparation of colloidal solutions of Metals, Metal Oxide nanoparticles

Unit – V - Applications (Qualitative) (4 Hours)

Micro Electromechanical Systems (MEMS), Nano-electromechanical Systems (NEMS), Applications of nanomaterials as probes in medical diagnostics and targeted drug delivery, sunscreen, lotions, and paints and other examples to give broader perspective of applications of nanomaterials

References:

Essential Readings:

1) Introduction to Nanotechnology, C. P. Poole and Jr. Frank J. Owens, 1st edition, 2003, Wiley India Pvt. Ltd.
2) Nanotechnology: Principles and Practices, S. K. Kulkarni, 2nd edition, 2011, Capital Publishing Company
3) Introduction to Nanoscience and Technology, K. K. Chattopadhyay and A. N. Banerjee, 2009, PHI Learning Private Limited
4) Introduction to Nanoelectronics, V. V. Mitin, V. A. Kochelap and M. A. Stroscio, 2011, Cambridge University Press
5) Nanotechnology for Dummies, R. Booker and E. Boysen, 2005, Wiley Publishing Inc.
6) Introductory Nanoscience, M. Kuno, 2012, Garland science Taylor and Francis Group
7) Electronic transport in mesoscopic systems, S. Datta, 1997, Cambridge University Press.
8) Fundamentals of molecular spectroscopy, C. N. Banwell and E. M. McCash, 4th edition, McGrawHill

Additional Readings:

1) Quantum Transport in semiconductor nanostructures, C. Beenakker and H. Van Houten, 1991, available at arXiv: cond-mat/0412664) Open Source
2) Ph.D. thesis, S. Cronewett, 2001, Available as Arxiv
3) Solid State Physics, J. R. Hall and H. E. Hall, 2nd edition, 2014, Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Synthesis of metal (e.g. Au/Ag) nanoparticles by chemical route and study its optical absorption properties.
2) Synthesis of semiconductor ($CdS/ZnO/TiO_2/Fe_2O_3$ etc) nanoparticles and study its XRD and optical absorption properties as a function of ageing time.
3) Surface Plasmon study of metal nanoparticles as a function of size by UV-Visible spectrophotometer.
4) Analysis of XRD pattern of given nanomaterial and estimate lattice parameters and particle size.
5) To study the effect of the size nanoparticles on its color.
6) To prepare composite of CNTs with other materials and study their optical absorption/Transmission properties.
7) Growth of metallic thin films using thermal evaporation technique.
8) Prepare a ceramic disc of a given compound and study its XRD/I-V characteristics/ measure its dielectric constant or any other property.
9) Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study its XRD and transmittance spectra in UV-Visible region.
10) Prepare thin film capacitor and measure capacitance as a function of temperature or frequency.
11) Fabricate a pn junction diode by diffusing Al over the surface of N-type Si/Ge and study its V-I characteristic.
12) Fabricate thin films (polymer, metal oxide) using electro-deposition
13) To study variation of resistivity or sheet resistance with temperature of the fabricated thin films using four probe method.

References for laboratory work:

1) Introduction to Nanotechnology, C. P. Poole and Jr. Frank J. Owens, 1st edition, 2003, Wiley India Pvt. Ltd.
2) Nanotechnology: Principles and Practices, S. K. Kulkarni, 2nd edition, 2011, Capital Publishing Company
3) Introduction to Nanoscience and Technology, K. K. Chattopadhyay and A. N. Banerjee, 2009, PHI Learning Private Limited
4) Nanotechnology for Dummies, R. Booker and E. Boysen, 2005, Wiley Publishing Inc.

GENERIC ELECTIVE (GE – 18): PHYSICS OF DETECTORS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Physics of Detectors GE – 18	4	3	1	0	Class XII Pass with Science	GE Modern Physics of this course or its equivalent

LEARNING OBJECTIVES

A detector is necessary for every physical measurement, and experimental physicists must be proficient in detector physics. The course will provide an overview of radiation and particle detectors, as well as how to use them in various experimental physics settings and application fields. The course covers the theory of detectors, their design and operation including electronic readout systems and signal processing. The fundamental physics processes for detecting radiation and particles are covered in the course, which include the photoelectric effect, Compton scattering, pair creation, excitation, ionization, bremsstrahlung, Cherenkov radiation, nuclear reactions, and secondary emissions.

LEARNING OUTCOMES

After completion of this course, students are expected to be able to,

- Understand the different types underlying fundamental physical processes for the detection of radiation and particles
- Acquire knowledge of design principles and characteristics of different types of detector
- Acquire knowledge of electronic readout systems and signal processing
- Assess the applicability of different types of detectors and detector systems in various fields of physics and applied sciences.

SYLLABUS OF GE - 18

THEORY COMPONENT

Unit – I **(12 Hours)**

Interaction of Radiation with matter: Interaction of radiation with matter (e.m. charged particles); detection of charged particles in magnetic field and measurement of charge to mass ratio; energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation; gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production); Dependence of electron and photon energy spectrum on materials (increasing Z); neutron interaction with matter

Unit – II **(8 Hours)**

Introduction to detectors: Basic principle of detector operation and its modes of operation, pulse height spectra, various detector performance parameters: response time, energy resolution, fano factor, efficiency: intrinsic and extrinsic, dead time.

Unit – III **(16 Hours)**

Detectors:

Gas detectors: Detector gases, gas detector characteristics, different types of detectors: gas filled ionization detectors (ionization chamber), bubble and cloud chambers, proportional counters, multi wire proportional counters (MWPC), Geiger Mueller (GM) counters and avalanche counters, gaseous multiplication detector.

Scintillation detectors: General characteristics, organic scintillators (anthracene and plastic), inorganic crystals (NaI(Tl), CsI(Tl)), Charge Coupled Devices (CCD)

Photomultipliers: Basic construction and operation, time response and resolution, noise, gain stability; scintillation counter operation

Semiconductor detectors: Doped semiconductors, np semiconductor junction, depletion depth, detector characteristics of semiconductors. silicon and germanium detectors

Neutron detectors (gas-filled, scintillation, and semiconducting): slow and fast neutron detectors

Bolometric detectors: Working principle, characteristics and use of infrared detectors

Unit - IV **(5 Hours)**

Electronics, signal processing and techniques for data acquisition and analysis: Basic idea of analog and digital signal processing, noise and its types; instrumentation standards for nuclear instruments: NIM, ECL; TTL standards

Data acquisition system: VME and Digital pulse processing system.

Unit - V **(4 Hours)**

Application of detectors: for particle physics experiments, for nuclear physics, for astrophysics and cosmology, medical physics and imaging, by giving two examples each.

References:

Essential Readings:

1) Radiation detection and measurement, G. F. Knoll, 2010, John Wiley and Sons
2) Principles of radiation interaction in matter and detection, C. Leroy and P. G. Rancoita, 3rd edition, 2011, World Scientific
3) Techniques for Nuclear and Particle Physics experiments, W. R. Leo, 1994, Springer
4) Nuclear Radiation Detectors, S. S. Kapoor and V. S. Ramamurthy, 1st edition, John Wiley and Sons.
5) Physics and Engineering of Radiation Detection, S. N. Ahmed, 2007, Academic Press Elsevier
6) Semiconductor detectors: New developments, E. Gatti and P. Rehak, 2002, Springer

Additional Readings:

1) Radiation Detection for Nuclear Physics Methods and industrial applications, D. Jenkins
2) Advanced Nuclear Radiation Detectors Materials, processing, properties and applications, A. K. Batra, IOP Publishing
3) Measurement and Detection of Radiation, N. Tsoulfanidis et al., 4th edition, T and F CRC
4) Principles of nuclear radiation detection, G. G. Eichholz and J. W. Poston, CRC
5) Introduction to Nuclear Radiation Detectors: 2, Laboratory Instrumentation and Techniques, P. Ouseph, Springer
6) Detectors for Particle Radiation, K. Kleinknecht, Cambridge
7) Particle Detectors, C. Grupen, Cambridge
8) Handbook of Particle Detection and Imaging, C. Grupen and I. Buvat

GENERIC ELECTIVE (GE - 19): NUCLEAR AND PARTICLE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Nuclear and Particle Physics GE – 19	4	3	1	0	Class XII Pass with Science	NIL	Physics and Astrophysics

LEARNING OBJECTIVES

This course imparts the understanding of the sub atomic particles and their properties; introduces various nuclear phenomena and their applications, interactions of basic building blocks of matter through fundamental forces, the inherent discrete symmetries of particles and complements each and every topic with applications and problems.

LEARNING OUTCOMES

After completion of this course, students are expected to have an understanding of,

- Nuclear charge and mass density, size, magnetic and electric moments
- Theoretical principles and experimental evidences towards modelling the nucleus
- Kinematics of nuclear reactions and decays
- Energy loss of radiation during propagation in medium
- Principles of nuclear detection technique
- Classification of fundamental forces based on their range, time-scale and mediator mass.
- Scattering cross-sections of 2 to 2 processes and their inherent symmetries.
- Angular and energy distributions for three body decay process.
- Discrete symmetries of nature and associated conservation laws
- Colour triplet quarks and anti-quarks as constituents of observed colour singlet baryons and mesons.

SYLLABUS OF GE 19

THEORY COMPONENT

Unit – I **(5 Hours)**

General properties of nuclei: Constituents of nucleus and their Intrinsic properties: quantitative facts about mass, radii, charge density, matter density, binding energy, N/Z plot, angular momentum, parity, magnetic moment, electric moments.

Unit – II **(5 Hours)**

Nuclear models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, evidence for nuclear shell structure and the basic assumptions of shell model, magic numbers.

Unit – III **(7 Hours)**

Radioactivity decay: Decay rate and equilibrium (secular and transient)
(a) Alpha decay: basics of α-decay processes, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains.
(b) β-decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis.
(c) Gamma decay: Gamma ray emission from the excited state of the nucleus and kinematics, internal conversion.

Unit – IV **(5 Hours)**
Nuclear reactions: Kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, Coulomb scattering (Rutherford scattering).

Unit – V **(8 Hours)**
Interaction of nuclear radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation; Gamma ray interaction through matter
Detector for nuclear radiations: Basics of types of detectors: gas detectors, scintillation detector, semiconductor detector (principle, schematics of construction and working)

Unit – VI **(15 Hours)**
Particle Physics: Overview of particle spectrum and their interactions in the Standard Model; range, time-scale and relative strength of interactions; interactions at a distance mediated by virtual particles (Exchange Force)
Kinematics for 2 -> 2 scattering processes and crossing symmetries of scattering amplitudes; angular and energy distributions of decaying particles in 1 -> 3 decay processes (muon decay/beta decay); identification of invisibles (neutrinos) from energy and transverse momentum distributions
Lepton and Baryon quantum numbers; isospin, strangeness and hypercharge; Gell-Mann-Nishijima formula; parity and charge conjugation of a particle state; time reversal and general CPT theorem
Valence quark model of Murray Gell-Mann and Yuval Ne'eman, current and constituent masses of quarks, flavor symmetry isospin triplets, baryon octet, decuplet and meson octet; existence of Δ^{++} baryon as a clue for necessity of colour quantum number; evidence for colour triplet quarks from e^+e^- annihilation experiment; confinement of quarks, antiquarks and gluons in hadrons
High energy scattering experiments at linear and circular colliders, inelastic collisions at hadron colliders; elastic and inelastic neutrino-nucleus scattering experiments

References:
Essential Readings:
(A) For Nuclear Physics
1) Basic ideas and concepts in nuclear physics: An introductory approach, K. Heyde, 3rd edition, 1999, IOP Publication
2) Introductory Nuclear Physics, K. S. Krane, 2008, Wiley-India Publication
3) Nuclear Physics, S. N. Ghoshal, 1st edition, 2010, S. Chand Publication
4) Nuclear Physics: Principles and applications, J. Lilley, 2006, Wiley Publication
5) Concepts of Nuclear Physics, B. L. Cohen, 1974, Tata McGraw Hill Publication
6) Radiation detection and measurement, G. F. Knoll, 2010, John Wiley and Sons

(B) For Particle Physics
1) Modern Particle Physics, M. Thompson, 2013, Cambridge University Press

2) Particles and Nuclei: An Introduction to the Physical Concepts, B. Povh, K. Rith, C. Scholz, F. Zetsche and W. Rodejohann, 2015, Springer-Verlag
3) An Introductory Course of Particle Physics, P. B. Pal, 2015, CRC Press
4) Introduction to High Energy Physics, D. H. Perkins, 4th edition, 2000, Cambridge University Press
5) Introduction to elementary particles, D. J. Griffiths, 2008, Wiley
6) Quarks and Leptons, F. Halzen and A. D. Martin, 1984, John Wiley

Additional Readings:

References for Tutorial

1) Problems and Solutions in Nuclear and Particle Physics, S. Petreta, 2019, Springer
2) Schaum's Outline of Modern Physics, 1999, McGraw-Hill
3) Schaum's Outline of College Physics, E. Hecht, 11th edition, 2009, McGraw Hill
4) Problems and Solutions on Atomic, Nuclear and Particle Physics, Yung-Kuo Lim, 2000, World Scientific
5) Nuclear Physics "Problem-based Approach" including MATLAB, H. M. Aggarwal, 2016, PHI Learning Pvt. Ltd

GENERIC ELECTIVE (GE – 20): ATOMIC AND MOLECULAR PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Atomic and Molecular Physics GE – 20	4	3	1	0	Class XII Pass with Science	GE Modern Physics and GE Quantum Mechanics of this course or their equivalent

LEARNING OBJECTIVES

This course introduces the basic concepts of atomic, molecular and nuclear physics to an undergraduate student. Advanced mathematics is avoided and the results of quantum mechanics are attempts to explain, or even to predict, the experimental observations of spectroscopy. The student will be able to visualize an atom or molecule as a physical entity rather than a series of mathematical equations.

LEARNING OUTCOMES

On successful completion of the module students should be able to elucidate the following main features.

- Stern-Gerlach experiment, electron spin, spin magnetic moments
- Space quantization and Zeeman effect
- Spectral notations for atomic and molecular states and corresponding term symbols
- Understanding of atomic spectra and molecular spectra
- Basic principle of Raman spectroscopy and Franck Condon principle
- To complete scientific potential lies on the way we are able to interpret the fundamental astrophysical and nuclear data. This acquired knowledge will be a common base for the areas of astrophysics, nuclear, medical, geology and other inter-disciplinary fields of Physics, Chemistry and Biology. Special skills required for the different fields will be enhanced.

SYLLABUS OF GE 20

THEORY COMPONENT

Unit – I – Atomic Physics (23 Hours)

One-electron atoms: Degeneracy of energy levels and selection rules, modes of relaxation of an excited atomic state, line intensities and the lifetimes of excited states, line shapes and widths

Fine structure of hydrogenic atoms: Shifting of energy levels, splitting of spectral lines, relativistic correction to kinetic energy, spin-orbit term, Darwin term, fine structure spectral lines, Lamb shift (qualitative idea)

Atoms in external magnetic fields: Larmor's theorem, Stern-Gerlach experiment, normal Zeeman effect, Paschen Back effect, and anomalous Zeeman effect, g-factors

Two and multi-electron systems: Spin multiplicity, singlet and triplet states and selection rules in helium atom, central field approximation, Aufbau and Pauli exclusion principle,

Slater determinant, LS and JJ coupling scheme (equivalent and non-equivalent electrons), term symbols and Hund's rule, Lande' interval rule
Qualitative Discussion of: Lamb shift and Auger effect.

Unit – II - Molecular Physics (22 Hours)

Electronic states of diatomic molecules: Linear combination of atomic orbitals (LCAO), bonding and antibonding orbitals; 'gerade', 'ungerade', molecular orbitals and the ground state electronic configurations for homo and hetero-nuclear diatomic molecules, classification of molecular excited states of diatomic molecule, Vector representation of Orbital and electron spin angular momenta in a diatomic molecule, The Born-Oppenheimer approximation, Concept of Potential energy curve for a diatomic molecule, Morse potential. The Franck-Condon principle

Molecular Spectra of diatomic molecule: Rotational Spectra (rigid and non-rigid rotor), Vibrational Spectra (harmonic and anharmonic), Vibration-Rotation Spectrum of a diatomic molecule, Isotope effect, Intensity of spectral lines

Raman Effect: Classical Theory (with derivation) of Raman effect, pure rotational Raman Lines, Stoke's and Anti-Stoke's Lines, comparison with Rayleigh scattering

Idea of spin resonance spectroscopy (Nuclear Magnetic Resonance, Electron Spin Resonance) with few examples, estimation of magnetic field of the Sun.

References:

Essential Readings:

1) Physics of Atoms and Molecules, B. H. Bransden and C. J. Jochain, 2nd edition, Pearson
2) Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 1994, Tata McGraw – Hill
3) Atomic physics, J. B. Rajam and foreword by Louis De Broglie, 2010, S. Chand and Co.
4) Atoms, Molecules and Photons, W. Demtroder, 2nd edition, 2010, Springer
5) Atomic, Nuclear and. Particle Physics. Compiled by. The Physics Coaching Class. University of science and Technology of China, edited By Yung-Kuo Lim. World scientific.
6) Atomic Physics, S. N. Ghoshal, 2019, S. Chand Publication
7) Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. A. Kriz and J. R. Vyvyan, 5th edition, 2014, Brookes/Cole

Additional Readings:

1) Basic Atomic and Molecular Spectroscopy, J. M. Hollas, Royal Society of Chemistry
2) Molecular Spectra and Molecular Structure, G. Herzberg
3) Introduction to elementary particles, D. J Griffiths, 2008, Wiley
4) Atomic and molecular Physics, R. Kumar, 2013, Campus Book Int.
5) The Fundamentals of Atomic and Molecular Physics, Undergraduate Lecture Notes in Physics, 2013, Springer

UNIVERSITY OF DELHI

CNC-II/093/1(28)/2024-25/

Dated: 15.05.2024

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/-(14-1-6/-) dated 09.06.2023 and 27-1-1/ dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester- V and VI in respect of Department of Physics & Astrophysics under Faculty of Science based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23:

(i) **SEMESTER-V**: BSc. (H) Physics/ Pool of DSEs/ BSc. Physical Science with Physics as one of the Core Disciplines/ BSc. Physical Science with Physics & Electronics as one of the Core Disciplines/ Common Pool of GEs ***(As per Annexure-1)***

(ii) **SEMESTER-VI**: BSc. (H) Physics/ Pool of DSEs/ BSc. Physical Science with Physics as one of the Core Disciplines/ BSc. Physical Science with Physics & Electronics as one of the Core Disciplines/ Common Pool of GEs ***(As per Annexure-2)***

REGISTRAR

ANNEXURE-1

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DEPARTMENT OF PHYSICS AND ASTROPHYSICS
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B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC - 13: ELECTROMAGNETIC THEORY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Electromagnetic Theory DSC – 13	4	3	0	1	Class XII pass with Physics and Mathematics as main subjects	Mathematical Physics I, II; Waves and Oscillation; Electricity and Magnetism papers of this course or their equivalents

LEARNING OBJECTIVES

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

LEARNING OUTCOMES

At the end of this course the student will be able to,

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media
- Understand polarization of electromagnetic waves: Linear, circular and elliptical polarization. Production as well as detection of waves in laboratory
- Learn the features of planar optical wave guide
- In the laboratory course, the students will get an opportunity to perform experiments with polarimeter, Babinet compensator, ultrasonic grating and simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization

SYLLABUS OF DSC – 13

THEORY COMPONENT

Unit - I **(6 Hours)**

Review of Maxwell's equations; Coulomb gauge and Lorentz gauge; Poynting's theorem and Poynting's vector; electromagnetic (em) energy density; physical concept of electromagnetic field energy density

Unit – II **(10 Hours)**

EM wave propagation in unbounded media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation constant;

Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.

Unit – III **(9 Hours)**

EM waves in bounded media: Boundary conditions at a plane interface between two media; reflection and refraction of plane em waves at plane interface between two dielectric media - Laws of reflection and refraction; Fresnel's formulae for perpendicular and parallel polarization, Brewster's law; reflection and transmission coefficients; total internal reflection, evanescent waves; metallic reflection (normal incidence)

Unit – IV **(13 Hours)**

Polarization of EM waves: Propagation of em waves in an anisotropic media; symmetric nature of dielectric tensor; Fresnel's formula; uniaxial and biaxial crystals; light propagation in uniaxial crystal; double refraction; polarization by double refraction; Nicol prism; ordinary and extraordinary refractive indices; production and detection of plane, circular and elliptically polarized light; phase retardation plates: quarter wave and half wave plates

Optical rotation; Biot's laws for rotatory polarization; Fresnel's theory of optical rotation; specific rotation

Unit – V **(7 Hours)**

Wave guides: Planar optical wave guides; planar dielectric wave guide ($-d/2 < x < d/2$); condition of continuity at interface; phase shift on total reflection; Eigenvalue equations; phase and group velocity of guided waves; field energy and power transmission (TE mode only)

References:

Essential Readings:

1) Introduction to Electrodynamics, D. J. Griffiths, 3rd edition, 1998, Benjamin Cummings.
2) Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd edition, 2003, CBS Publisher
3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2010, Wiley
4) Principle of Optics, M. Born and E. Wolf, 6th edition, 1980, Pergamon Press
5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi

Additional Readings:

1) Electricity, Magnetism and Electromagnetic Theory, S. Mahajan, and S. R. Choudhary, 2017, TMH
2) Principles of Electromagnetic Theory, C. Jain, 2017, Narosa Publishing House
3) Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
4) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
5) Problems and solution in Electromagnetics, A. Ghatak, K. Thyagarajan and Ravi Varshney, 2015
6) Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
7) Engineering Electromagnetic, W. H. Hayt, 8th edition, 2012, McGraw Hill.
8) Electromagnetics, J. A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
9) 2008+ Solved Problems in Electromagnetics, S. A. Nasar, 2001, SciTech

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

- Mandatory sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Mandatory sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

1) To verify the law of Malus for plane polarized light.
2) To determine the specific rotation of sugar solution using polarimeter.
3) To analyse elliptically polarized light by using a Babinet's compensator.
4) To study the elliptical polarized light using Fresnel rhomb.
5) To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6) To study the reflection and refraction of microwaves
7) To study polarization and double slit interference in microwaves.
8) To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9) To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10) To verify the Stefan's law of radiation and to determine Stefan's constant.
11) To determine Boltzmann constant using V-I characteristics of PN junction diode.
12) To find numerical aperture of an optical fibre.
13) To use a prism shaped double refracting crystal to determine the refractive indices of the quartz/ calcite corresponding to ordinary and extra-ordinary rays.
14) To measure birefringence of Mica
15) To determine the dielectric constant of solids using microwaves

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publisher
3) Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press
5) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd

DISCIPLINE SPECIFIC CORE COURSE – DSC - 14: QUANTUM MECHANICS – I

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Quantum Mechanics – I DSC – 14	4	3	0	1	Class XII pass with Physics and Mathematics as main subjects	Light and Matter, and Elements of Modern Physics papers of this course or their equivalents

LEARNING OBJECTIVES

The development of quantum mechanics has revolutionized the human life. In this course, the students will be exposed to the probabilistic concepts of basic non-relativistic quantum mechanics and its applications to understand the sub atomic world.

LEARNING OUTCOMES

After completing this course, the students will be able to,

- Understand the applications of the Schrodinger equation to different cases of potentials namely finite square potential well, harmonic oscillator potential.
- Solve the Schrodinger equation in 3-D.
- Understand the spectrum and eigen functions for hydrogen atom
- Understand the angular momentum operators in position space, their commutators, eigenvalues and eigen functions.
- In the laboratory course, the students will be able to use computational methods to
    - Solve Schrödinger equation for ground state energy and wave functions of various simple quantum mechanical one- dimensional potentials
    - Solve Schrödinger equation for ground state energy and radial wave functions of some central potentials

SYLLABUS OF DSC - 14

THEORY COMPONENT

Unit – I **(10 Hours)**

General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary conditions and emergence of discrete energy levels. Application to energy eigen states for a particle in a finite square potential well, Momentum space wavefunction, Time evolution of Gaussian Wave packet, Superposition Principle, linearity of Schrodinger Equation, General solution as a linear combination of discrete stationary states, Observables as operators, Commutator of position and momentum operators, Ehrenfest's theorem.

Unit – II **(8 Hours)**

Harmonic oscillator: Energy eigen values and eigen states of a 1-D harmonic oscillator using algebraic method (ladder operators) and using Hermite polynomials. Zero point energy and uncertainty principle.

Unit – III **(15 Hours)**

Schrödinger Equation in three dimensions: Probability and probability densities in 3D. Schrödinger equation in spherical polar coordinates, its solution for Hydrogen atom solution using separation of angular and radial variables, Angular momentum operator, quantum numbers and spherical harmonics. Radial wave functions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m_l, s, p, d shells.

Unit – IV **(12 Hours)**

Angular momentum: Commutation relations of angular momentum operators; concept of spin and total angular momentum; ladder operators, eigenvalues, eigenvectors; Pauli matrices; addition of angular momenta

References:

Essential Readings:

1) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 6th edition, 2019, Laxmi Publications, New Delhi.
2) Introduction to Quantum Mechanics, D. J. Griffith, 2nd edition, 2005, Pearson Education.
3) A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd edition, 2010, McGraw Hill.
4) Quantum Mechanics, B. H. Bransden and C. J. Joachain, 2nd edition, 2000, Prentice Hall
5) Quantum Mechanics: Concepts and Applications, 2nd edition, N. Zettili, A John Wiley and Sons, Ltd., Publication
6) Atomic Physics, S. N. Ghoshal, 2010, S. Chand and Company

Additional Readings:

1) Quantum Mechanics for Scientists & Engineers, D. A. B. Miller, 2008, Cambridge University Press.
2) Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, 1966, Addison-Wesley Publications
3) Quantum Mechanics, L. I. Schiff, 3rd edition, 2010, Tata McGraw Hill.
4) Quantum Mechanics, R. Eisberg and R. Resnick, 2nd edition, 2002, Wiley
5) Quantum Mechanics, B. C. Reed, 2008, Jones and Bartlett Learning.
6) Quantum Mechanics, W. Greiner, 4th edition, 2001, Springer.
7) Introductory Quantum Mechanics, R. L. Liboff, 4th edition, 2003, Addison Wesley

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

At least 4 programs must be attempted. The implementation may be done in C++/Scilab /Python. Use of available library functions may be encouraged. Similar programs may be added.

Unit 1

1) Visualize the spherical harmonics by plotting the probability density for various values of the quantum numbers (*l, m*)

2) Use the analytical solution for a particle in finite potential well. Numerically solve the transcendental equation one gets after putting the continuity and boundary conditions to determine the energy eigenvalues for various values of the potential width and depth. Plot the corresponding normalised eigen functions.

Unit 2

Solve the Schrödinger equation using shooting/finite difference or any other method for the following simple 1-D potentials and compare with the analytical solutions:

1) Particle in a box
2) Particle in a finite potential well
3) Harmonic Potential

Unit 3

Solve the s-wave Schrodinger equation for the following cases.

$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E],$$

1) Ground state and the first excited state of the hydrogen atom:

$$V(r) = \frac{-e^2}{r}$$

Here *m* is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511×10^6 eV/c^2.

2) For an atom in the screened coulamb potential

$$V(r) = \frac{-e^2}{r}e^{\frac{-r}{a}}$$

Here *m* is the reduced mass of the system (which can be chosen to be the mass of an electron). Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, $m = 0.511 \times 10^6$ eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

Unit 4

Solve the s-wave Schrodinger equation $\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$, for a particle of mass *m* for the following cases

1) Anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b= 0, 10, 30 MeV fm^{-3}. In these units, $c\hbar$ = 197.3 MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

2) For the vibrations of hydrogen molecule with Morse potential

$$V(r) = D(e^{-2ar'} - e^{-ar'}), r' = \frac{r - r_0}{r}$$

Here m is the reduced mass of the two-atom system for the Morse potential
Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take: $m = 940 \times 10^6$ eV/c^2, $D = 0.755501$ eV, $\alpha = 1.44$, $r_0 = 0.131349$ Å

References for laboratory work:

1) Schaum's Outline of Programming with C++, J. Hubbard, 2000, McGraw-Hill Education.
2) C++ How to Program, P. J. Deitel and Harvey Deitel, 2016, Pearson
3) Scilab (A Free Software to Matlab): H. Ramchandran, A. S. Nair, 2011, S. Chand and Co
4) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
5) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
6) Computational Physics, Darren Walker, 1st edition, 2015, Scientific International Pvt. Ltd
7) An Introduction to Computational Physics, T. Pang, 2010, Cambridge University Press
8) A Guide to MATLAB, B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, 3rd edition, 2014, Cambridge University Press

DISCIPLINE SPECIFIC CORE COURSE – DSC - 15: DIGITAL ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Digital Electronics DSC – 15	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

The objective of the course is to introduce digital electronics and its simple applications to physics Honours students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilised in designing counters and registers.

LEARNING OUTCOMES

This paper is one of the core papers in the Physics curriculum. After studying this paper students will become familiar with,

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits.
- Understand the working principle of data processing circuits, arithmetic circuits, sequential logic circuits, registers, counters based on flip flops

SYLLABUS OF DSC - 15

THEORY COMPONENT

Unit – I - Integrated circuits (2 Hours)

Integrated Circuits (Qualitative treatment only), active and passive components, discrete components, wafer, chip, advantages and drawbacks of ICs, scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only), classification of ICs, examples of linear and digital lCs

Unit – II - Digital circuits and Boolean algebra (14 Hours)

Difference between analog and digital circuits, binary number, decimal to binary and binary to decimal conversion, BCD, octal and hexadecimal numbers, AND, OR and NOT gates (realization using diodes and transistor), NAND and NOR gates as universal gates, XOR and XNOR gates and application as parity checkers

De Morgan’s theorems, Boolean laws, simplification of logic circuit using Boolean algebra, fundamental products, idea of minterms and maxterms, conversion of truth table into equivalent logic circuit by (1) Sum of Products method and (2) Karnaugh map simplification (upto four variables).

Unit – III - Combinational Logic Circuits **(9 Hours)**
Data processing circuits: Multiplexers and its applications, de-multiplexers, decoders, encoders Arithmetic logic circuits: Express binary number in signed and unsigned form, 1's and 2's complement representation, binary addition, binary subtraction using 2's complement, half and full Adders, half and full subtractors, 4-bit binary adder/subtractor using 2's complement method.

Unit – IV - Sequential Logic Circuits **(8 Hours)**
Flip Flops SR, D, and JK clocked (level and edge triggered) flip-flops, preset and clear operations, race-around conditions in JK flip-flop, master-slave JK flip-flop, conversion of one flip flop to another using an excitation table

Unit – V - Application of Sequential Logic Circuits **(9 Hours)**
Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).
Counters: Asynchronous counters, MOD-N synchronous counter designing using excitation table.

Unit – VI – Timers **(3 Hours)**
IC 555: Pin -out diagram, block diagram and its applications as astable multivibrator and monostable multivibrator

References:
Essential Readings:

1) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw
2) Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
3) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
4) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
5) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
6) Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
7) Digital Electronics G. K. Kharate, 2010, Oxford University Press

Additional Readings:

1) Logic circuit design, S. P. Vingron, 2012, Springer
2) Digital Principles, R. L. Tokheim, 1994, Schaum's Outline Series, Tata McGraw-Hill
3) Solved Problems in Digital Electronics, S. P. Bali, 2005, Sigma Series, Tata McGraw-Hill
4) Digital Electronics: An Introduction To Theory And Practice, W. H. Gothmann, 2000, Prentice Hall of India
5) Modern Digital Electronics, R. P. Jain, 2003, Tata McGraw-Hill
6) Digital Electronics, S. Ghoshal, 2012, Cengage Learning
7) Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

At least five experiments should be performed from the following list.
All designing should be done on the bread boards.

1) (a) To design a combinational logic system for a specified truth table.
   (b) To convert Boolean expression into logic circuit and design it using basic logic gate ICs
2) To minimize a given logic circuit using K-map and design using NAND gates.
3) Designing of Half Adder and Half Subtractor using NAND gates
4) Designing of 4-bit binary adder using adder IC.
5) To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
6) To build Flip-Flop (D-type and JK) circuits using NAND gate
7) To build a 3-bit Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
8) To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
9) To design an astable multivibrator of given specifications using 555 Timer.

References for laboratory work:
1) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
2) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
3) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
4) Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 6: ASTRONOMY AND ASTROPHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Astronomy and Astrophysics DSE – 6	4	3	1	0	Class XII pass with Physics and Mathematics as main subjects	Mechanics; Waves and Oscillation; Electricity & Magnetism; Mathematical Physics papers of this course or their equivalents

LEARNING OBJECTIVES

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics. They will also be introduced to the Indian contribution to astronomy in the modern times, techniques to measure astronomical parameters, the different layers of the Sun and an overview of our Milky Way galaxy.

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LEARNING OUTCOMES

After completing this course, student will gain an understanding of,

- Basic concepts of positional astronomy and astronomical coordinate systems
- Astronomical instruments and the modern telescopes
- Measurement of astronomical parameters such as distance, stellar brightness, stellar mass, radii, temperature and spectra
- The different layers of solar atmosphere and basic results of solar magneto-hydrodynamics
- Basic structure of different galaxies and rotation of the Milky Way galaxy

It is advised that the tutorial sessions should involve discussion on problems meant to help students develop the ability to apply the theory they learn in lectures to diverse astrophysical phenomenon.

SYLLABUS OF DSE - 6

THEORY COMPONENT

Unit – I - Introduction to Astronomy (12 Hours)

Overview of the night sky; diurnal and yearly motions of the Sun; basic concepts of positional astronomy: celestial sphere, astronomical coordinate systems (Horizon and Equatorial systems of coordinates), circumpolar stars

Unit – II - Basic Parameters of Stars (12 Hours)

Measurement of astronomical distances (stellar parallax, aberration, proper motion), measurement of brightness, radiant flux and luminosity (apparent and absolute magnitude scales; distance modulus); determination of stellar mass (visual binaries, eclipsing binaries, spectroscopic binaries); measurement of stellar temperature and radius; stellar spectra, dependence of spectral types on temperature; Stellar classification (Harvard classification scheme), H-R diagram

Unit – III - Sun **(9 Hours)**

Solar parameters, Sun's internal structure, solar photosphere, solar atmosphere, chromosphere, corona, solar activity, basics of solar magneto-hydrodynamics

Unit – IV - Physics of galaxies **(12 Hours)**

Nature of rotation of the Milky Way: Differential rotation of the Galaxy and Oort constants, rotation curve of the Galaxy and the dark matter, virial theorem
Cosmology: Standard Candles (Cepheids and SNe Type1a); cosmic distance ladder; expansion of the Universe, Cosmological principle, Newtonian cosmology and Friedmann models

References:
Essential Readings:

1) Fundamental Astronomy, H. Karttunen et al., Springer Berlin, Heidelberg
2) Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.
3) Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
4) Astronomy in India: A Historical Perspective, T. Padmanabhan, Springer
5) Foundation of Astrophysics, B. Ryden and B. M. Peterson, Cambridge University Press
6) Astronomy: A Physical Perspective, M. Kutner, Cambridge University Press

Additional Readings:

1) Seven Wonders of the Cosmos, J. V. Narlikar, Cambridge University Press
2) Explorations: Introduction to Astronomy, T. Arny and S. Schneider, McGraw Hill
3) Astrophysics Stars and Galaxies, K. D. Abhyankar, Universities Press
4) An introduction to astrophysics, B. Basu, Prentice Hall of India Private Limited.
5) The Physical Universe: An Introduction to Astronomy, F. H. Shu, University Science Books
6) Telescopes and techniques, C. R. Kitchin, Springer New York, NY
7) Fundamentals of solar astronomy, A. Bhatnagar and W. C. Livingston, World Scientific
8) Astrophysics for Physicists, A. R. Choudhuri, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7: PHYSICS OF MATERIALS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Physics of Materials DSE – 7	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Solid state physics paper of this course or its equivalent

LEARNING OBJECTIVES

This course intends to provide knowledge of emerging topics in condensed matter physics. In addition, this course aims to provide a general introduction to advanced topics by covering polymers, liquid crystals, carbon-based materials, and Diluted Magnetic Semiconductors. More importantly, the students will be exposed to different characterization techniques used in experimental condensed matter physics.

LEARNING OUTCOMES

After completion of this course the students should be able to,

- Identify different materials of technological importance in appliances and objects around us
- Explain the importance of concepts like density of states and its role in determining device characteristics
- Elucidate the ferroelectric, piezoelectric and pyroelectric materials and their applications.
- Explain the properties of liquid crystals and their application.
- Differentiate between different form of carbon based materials and their applications
- Introduce the importance of dilute magnetic semiconductors as a new technologically advance material for electronic devices
- Explain various characterization techniques used in understanding properties of different material

SYLLABUS OF DSE - 7

THEORY COMPONENT

Unit – I – Semiconductors (4 Hours)

Basic concept of mobility and conductivity, density of states, determination of electron and hole concentration in doped semiconductor, Fermi level, Fermi energy, Fermi temperature, Fermi wavelength, Fermi surface.

Unit – II - Dielectric and magnetic materials (9 Hours)

Dielectrics, Ferroelectric, Piezoelectric and Pyroelectric materials, applications of ferroelectrics in capacitors and memory device, Piezoelectrics in micro positioner and actuator, Pyroelectrics in radiation detectors and thermometry

Classification and applications of soft and hard magnetic materials, application in transformers, memory device, introduction of spintronics based systems (spin transport)

Unit – III - Polymers **(3 Hours)**

Chemical structure of polymers of few thermoplastic (polyethylene, PVC, PTFE, PMMA, Polyester, Nylons) and thermosetting (Epoxy resin) polymers, conducting polymers-application in organic electronics

Unit – IV – Liquid crystals **(3 Hours)**

Classification of liquid crystals, structural and orientational ordering (isotropic to Nematic), thermotropic liquid crystals, Phases and phase transitions; anisotropic; Birefringence and display devices

Unit – V – Carbon based materials **(3 Hours)**

Structure and properties of Fullerenes, C_{60}, single walled and multi walled CNTs, Graphene and their energy band diagram.

Unit – VI – Synthesis of materials **(8 Hours)**

Ceramic (Calcination, Sintering, Grain), thin films (general idea of vacuum, thermal evaporation, molecular beam epitaxy, pulsed laser deposition), Crystals (qualitative idea of zone refining and Czochralski method), Polymers (Polymerization mechanism)

References:

Essential Readings:

1) Solid State Physics, M. A. Wahab, 2011, Narosa Publishing House
2) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
3) Semiconductor Devices: Physics and Technology, S. M. Sze, 2^{nd} edition, 2002, Wiley India
4) Introduction to Polymer Physics, U. Eisele and S. D. Pask, 1990, Springer-Verlag
5) The physics of liquid crystals, Pierre-Gilles de Gennes, 2^{nd} edition, 2003, Oxford University Press
6) Introduction to Liquid Crystals, P. J. Wojtowicz, E. Priestly and P. Sheng, 1975, Plenum Press
7) Dielectric Phenomenon in solids with Emphasis on Physical Concepts of Electronic Processes, K. C. Kao, Elsevier.
8) Physics of Ferroelectrics A Modern Perspective, K. M. Rabe Charles H. Ahn Jean-Marc Triscone, Springer
9) Carbon Nanotubes: Properties and Applications, M. J. O'Connell, 2006, CRC Press
10) Dilute Magnetic Semiconductors, M. Jain, World Scientific.

Additional Readings:

1) Encyclopaedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann
2) Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, (2nd Ed., CRC Press, 2015).
3) Dilute magnetic semiconducting materials, Br. R. Saravanan, MRF

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Study phase transition in a ferroelectric sample by measuring its dielectric constant as a function of frequency and temperature.
2) Study dielectric properties of given polymer sample as a function of frequency and temperature.
3) Study dielectric properties of given piezoelectric sample as a function of frequency and temperature.
4) Determine the coupling coefficient of a given piezoelectric crystal.
5) BH Hysteresis of different ferromagnetic materials (Loop Tracer).
6) Analyse the XRD spectra of a given ferroelectric ceramic sample and determine its lattice parameter.
7) Analyse the XRD spectra of a given ferromagnetic sample (basically ferrites, Fe_3O_4, $CoFe_2O_3$) and determine its lattice parameter.
8) Analyse the XRD spectra of a given compound semiconductor (ZnO, TiO_2, etc) thin film/ceramic sample and determine its lattice parameter.
9) Analyse the UV-Vis spectra of a given wide band gap semiconductor and determine its bandgap.
10) Study the IV characteristics of a polymer material by depositing/painting Aluminum electrodes.
11) To determine the g-factor of a sample by ESR Spectrometer.
12) Analyse the given SEM/TEM/AFM micrographs of the deposited thin film or nanostructure of any material and determine surface roughness, crystallinity, particle size etc.
13) Deposition of any kind of thin film by any technique available in the lab.
14) Liquid crystals (reading project)

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
3) Elements of Solid State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) Elements of X-Ray Diffraction, B. D. Cullity and S. R. Stock
5) Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, 2nd edition, 2015, CRC Press
6) Encyclopedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8: COMMUNICATION SYSTEM

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Communication System DSE – 8	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of Digital Electronics and Analog Electronics

LEARNING OBJECTIVES

This paper aims to describe the fundamental concepts of communication systems and communication techniques based on Analog Modulation, Analog and digital Pulse Modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Understand fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- In the laboratory course, students will apply the theoretical concepts to gain hands-on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

SYLLABUS OF DSE - 8

THEORY COMPONENT

Unit – I - Electronic communication and analog modulation (8 Hours)

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system, channels and base-band signals

Analog Modulation: Amplitude modulation, modulation index and frequency spectrum. Generation of AM (emitter modulation), amplitude demodulation (diode detector), Single sideband (SSB) systems, advantages of SSB transmission, frequency modulation (FM) and phase modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

Unit – II - Analog Pulse Modulation **(4 Hours)**
Sampling theorem, basic principles - PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing)

Unit – III - Digital Pulse Modulation **(10 Hours)**
Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding, concept of amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), and binary phase shift keying (BPSK)

Unit – IV - Satellite Communication and Mobile Telephony system **(8 Hours)**
Satellite communication: Need for satellite communication, geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), uplink and downlink, Ground and earth stations
Mobile Telephony System: Concept of cell sectoring and cell splitting, SIM number, IMEI number, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset.

References:
Essential Readings:
1) Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2) Advanced Electronics Communication Systems, Tomasi, 6th edition, Prentice Hall.
3) Electronic Communication systems, G. Kennedy, 3rd edition, 1999, Tata McGraw Hill.
4) Principles of Electronic communication systems, Frenzel, 3rd edition, McGraw Hill
5) Modern Digital and Analog Communication Systems, B. P. Lathi, 4th edition, 2011, Oxford University Press.
6) Communication Systems, S. Haykin, 2006, Wiley India
7) Wireless communications, A. Goldsmith, 2015, Cambridge University Press

Additional Readings:
1) Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
2) Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
3) Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To design an amplitude modulator using transistor
2) To design envelope detector for demodulation of AM signal
3) To study FM - generator and detector circuit
4) To study AM transmitter and receiver
5) To study FM transmitter and receiver
6) To study time division multiplexing (TDM)
7) To design pulse amplitude modulator using transistor.

8) To design pulse width modulator using 555 timer IC.
9) To design pulse position modulator using 555 timer IC
10) To study ASK, PSK and FSK modulators and demodulators

References for laboratory work:

1) Electronic Communication system, Blake, 5th edition, Cengage
2) Introduction to Communication systems, U. Madhow, 1st edition, 2018, Cambridge University Press

Category II

Physical Science Courses
with Physics discipline as one of the Core Disciplines

(B. Sc. Physical Science with Physics as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 5: ELEMENTS OF MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Elements of Modern Physics PHYSICS DSC – 5	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values. Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

SYLLABUS OF PHYSICS DSC – 5

THEORY COMPONENT

Unit - I **(8 Hours)**

Origin of Quantum Theory: Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

Unit - II **(7 Hours)**

The Schrodinger Equation: The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators

Unit – III **(5 Hours)**

Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

Unit – IV **(5 Hours)**

Atomic Physics: Beyond the Bohr's Quantum model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra
Correspondence principle
X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley Law.

Unit – V **(5 Hours)**

Basic Properties of Nuclei: Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.
Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages), discovery of new elements of the periodic table

References:

Essential Readings:

1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning
5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
8) Modern Physics, R. Murugeshan, S Chand & Co. Ltd
9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.

17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers
18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

Additional Readings:

1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster`s focusing; determination of angle of prism.

At least six experiments to be performed from the following list

1) Measurement of Planck's constant using black body radiation and photo-detector
2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
3) To determine the work function of material of filament of directly heated vacuum diode.
4) To determine the Planck's constant using LEDs of at least 4 different colours.
5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
6) To determine the ionization potential of mercury.
7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8) To show the tunneling effect in tunnel diodes using I-V characteristics.
9) To determine the wavelength of a laser source using diffraction of a single slit.
10) 10. To determine the wavelength of a laser source using diffraction of double slits.
11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
12) One innovative experiment designed by the teacher relevant to the syllabus.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal.
3) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted, 1985, Heinemann Educational Publishers.
4) A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publisher.
5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15a: FOUNDATION OF ASTROPHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Foundation of Astrophysics PHYSICS DSE 15a	4	3	1	0	Class XII pass with Physics and Mathematics as main subjects	Mechanics; Electricity & Magnetism; Waves and Optics papers of this course or their equivalents

LEARNING OBJECTIVES

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics. They will also be introduced to the Indian contribution to astronomy in the modern times, techniques to measure astronomical parameters, the different layers of the Sun, the characteristics of planets in the solar system, an overview of our Milky Way galaxy and astrobiology.

LEARNING OUTCOMES

After completing this course, student will gain an understanding of,

- Basic concepts of positional astronomy and astronomical coordinate systems
- Astronomical instruments and modern telescopes
- Measurement of basic astronomical parameters such as distance, stellar brightness, stellar mass, radii, temperature and spectra
- Different layers of the Sun's atmosphere
- The difference between the terrestrial planets and the Jovian planets
- Basic structure of different galaxies and rotation of the Milky Way galaxy
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life

It is advised that the tutorial sessions should involve discussion on problems meant to help students develop the ability to apply the theory they learn in lectures to diverse astrophysical phenomenon.

SYLLABUS OF PHYSICS DSE – 15a

THEORY COMPONENT

Unit – I - Introduction to Astronomy (12 Hours)

Overview of the night sky; diurnal and yearly motions of the Sun; basic concepts of positional astronomy: celestial sphere, astronomical coordinate systems (Horizon and Equatorial systems of coordinates), circumpolar stars

Unit – II - Basic Parameters of Stars (15 Hours)

Measurement of astronomical distances (stellar parallax, aberration, proper motion), measurement of brightness, radiant flux and luminosity (apparent and absolute magnitude scales; distance modulus); determination of stellar mass by Kepler's law; measurement of stellar temperature and radius; stellar spectra, dependence of spectral types on temperature; Stellar classification (Harvard classification scheme), H-R diagram

Unit – III - Sun and the solar system (9 Hours)
Solar parameters; Sun's internal structure; solar photosphere; solar atmosphere; chromosphere; corona; solar activity; solar system (characteristics of terrestrial and Jovian planets)

Unit – IV- Physics of galaxies, Cosmology, Astrobiology (9 Hours)
Physics of galaxies: Nature of rotation of the Milky Way: Differential rotation of the Galaxy, dark matter
Cosmology: Standard Candles (Cepheids and SNe Type1a); cosmic distance ladder; expansion of the Universe
Astrobiology: History of the Universe; chemistry of life; origin of life; chances of life in the solar system

References:
Essential Readings:

1) Seven Wonders of the Cosmos, J. V. Narlikar, Cambridge University Press
2) Fundamental Astronomy, H. Karttunen et al., Springer Berlin, Heidelberg
3) Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.
4) Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
5) Astronomy in India: A Historical Perspective, T. Padmanabhan, Springer
6) Foundation of Astrophysics, B. Ryden and B. M. Peterson, Cambridge University Press
7) Astronomy: A Physical Perspective, M. Kutner, Cambridge University Press

Additional Readings:

1) Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, McGraw Hill
2) Astrophysics Stars and Galaxies, K. D. Abhyankar, Universities Press
3) An introduction to astrophysics, B. Basu, Prentice Hall of India Private Limited.
4) The Physical Universe: An Introduction to Astronomy, F. H. Shu, University Science Books
5) Telescopes and techniques, C. R. Kitchin, Springer New York, NY
6) Fundamentals of solar astronomy, A. Bhatnagar and W. C. Livingston, World Scientific
7) Astrophysics for Physicists, A. R. Choudhuri, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15b: DIGITAL ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Digital Electronics PHYSICS DSE – 15b	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

The objective of the course is to introduce digital electronics and its simple applications to physics program students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilised in designing counters and registers.

LEARNING OUTCOMES

After studying this paper students will become familiar with,

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits
- Understand the working mechanism of data processing circuits, arithmetic circuits, sequential logic circuits, register and their applications.

SYLLABUS OF PHYSICS DSE 15b

THEORY COMPONENT

Unit – I - Integrated Circuits (qualitative treatment only) (2 Hours)

Advantages and drawbacks of ICs, scale of integration, SSI, MSI, LSI and VLSI (basic idea and definitions only), classification of ICs, examples of linear and digital lCs

Unit – II - Digital circuits and Boolean Aalgebra (13 Hours)

Binary numbers, decimal to binary and binary to decimal conversion, octal and hexadecimal numbers, NAND and NOR gates as universal gates, XOR and XNOR gates and their application as parity checkers

Boolean algebra: De Morgan's theorems, Boolean laws, idea of minterms, simplification of logic circuit using Boolean algebra and Karnaugh map

Unit – III - Combinational logic Circuits (7 Hours)

Data processing circuits: Multiplexers and its applications, de-multiplexers, decoders, encoders

Arithmetic circuits: Binary addition, binary subtraction using 2's complement, half and full adders, half and full subtractor

Unit – IV - Sequential Circuits (8 Hours)

Flip Flops: SR, D, and JK, clocked (edge triggered) flip-flops, race-around conditions in JK flip-flop, application of flip flops in designing shift register (serial -in- parallel out) and 2- bit (MOD-4) up-down asynchronous counter

References:

Essential Readings:

1) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw
2) Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
3) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
4) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
5) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
6) Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
7) Digital Electronics, G. K. Kharate, 2010, Oxford University Press

Additional Readings:

1) Logic circuit design, S. P. Vingron, 2012, Springer
2) Digital Principles, Schaum's Outline Series, R. L. Tokheim, 1994, Tata McGraw-Hill
3) Solved Problems in Digital Electronics, S. P. Bali, 2005, Sigma Series, Tata McGraw-Hill
4) Digital Electronics: An Introduction To Theory And Practice, W. H. Gothmann, 2000, Prentice Hall of India
5) Modern Digital Electronics, R. P. Jain, 2003, Tata McGraw-Hill
6) Digital Electronics, S. Ghoshal, 2012, Cengage Learning.
7) Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Either (1) At least 6 experiments or (II) 4 experiments and one project equivalent to two experiments and all designing should be done on the bread boards.

1) Study of truth tables of basic logic gates, universal logic gates XOR and XNOR logic gates
2) (a)To design a combinational logic system for a specified truth table.
   (b) To convert Boolean expression into logic circuit and design it using basic logic gate ICs
3) To minimize a given logic circuit using K-map and design using NAND gates.
4) Designing of Half Adder and Half Subtractor using NAND gates.
5) Designing of Full adder/Full Subtractor using NAND gates
6) Designing of 4-bit binary adder using adder IC.
7) To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
8) To build Flip-Flop (D-type and JK) circuits using NAND gate
9) To build a 2-bit Asynchronous Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
10) To make a 3-bit Shift Register (serial in- and parallel out) using D-type/JK Flip-Flop ICs.

References for laboratory work:

1) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
2) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw

Hill
3) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
4) Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15c: RADIATION AND ITS APPLICATIONS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Radiation and its Applications PHYSICS DSE – 15c	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows.

- To focus on the applications of nuclear techniques and radiation protection.
- To not only enhance the skills towards the basic understanding of the radiation but also provide the knowledge about the protective measures against radiation exposure.
- To impart all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, jobs dealing with nuclear medicine: chemotherapists, operators of PET, MRI, CT scan, gamma camera etc.

LEARNING OUTCOMES

After studying this course, the student will be able to,

- Understand and use the applications of nuclear techniques and radiation protection to guard against nuclear radiation hazards.
- Understand and use the units of radiations and their safety limits, the devices to detect and measure radiation.
- Understand and use radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards,
- Use the devices which apply radiations in medical sciences, such as X - ray, MRI, PET, CT-scan with the required safety measures.
- Understand and perform experiments like study the background radiation levels using Radiation detectors, Determination of gamma ray linear and mass absorption coefficient of a given material for radiation shielding application.
- Use graphical software to plot the simulations done through SRIM or similar software.

SYLLABUS OF PHYSICS DSE 15c

THEORY COMPONENT

Unit – I **(8 Hours)**

Radiation and its interaction with matter: Basic ideas of different type of radiation electromagnetic (X-ray, gamma rays, cosmic rays etc.), nuclear radiation and their origin (stable and unstable isotopes), half life and mean life

Nuclear Radiation: Basic idea of alpha, beta, gamma and neutron radiation and their sources (sealed and unsealed sources). Kinematics of nuclear reactions, Q value

Interaction of charged particles (including alpha particles): Heavy charged particles (e.g.

accelerated ions) - Beth-Bloch formula, scaling laws, mass stopping power, range, straggling. Cherenkov radiation
Interaction of beta particles: Collision and Radiation loss (Bremsstrahlung).
Interaction of photons: Linear and Mass Attenuation Coefficients. Interaction of Neutrons: Collision, slowing down and Moderation.

Unit - II **(8 Hours)**
Radiation Units, dosage and safety management:
Radiation Quantities and Units: Biological effects of ionizing radiation, Interaction of ionising and non-ionising radiation at the cellular level. Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, quality factor, radiation and tissue weighting factors, annual limit of intake (ALI) and derived air concentration (DAC).
Radiation safety management: Operational limits and basics of radiation hazards, its evaluation and control: radiation protection standards. Concept of ALARA Principle using Distance, time and shielding

Unit - III **(8 Hours)**
Radiation detection and monitoring devices: Basic concepts and working principle of gas detectors, Scintillation Detectors, Solid State Detectors and Neutron Detectors, Types of Radiation Dosimeters: thermoluminescence, radiographic films, calorimetry, semiconductor diodes; Relation between detection and dosimetry, Interaction of ionising and non-ionising radiation at the cellular level.

Unit - IV **(6 Hours)**
Application of radiation as a technique: Application in medical science (e.g., basic principles of X- rays, MRI, PET, CT scan, Projection Imaging Gamma Camera, Radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

References:
Essential Readings:
1) Basic ideas and concepts in nuclear physics: An introductory approach, K. Heyde, 3rd edition, 1999, IOP Publication.
2) Nuclear Physics, S. N. Ghoshal, 1st edition, 2010, S. Chand Publication
3) Nuclear Physics: Principles and Applications, J. Lilley, 2006, Wiley Publication
4) Fundamental Physics of Radiology, W. J. Meredith and B. Massey, 1989, John Wright and Sons, UK
5) An introduction to radiation protection by A Martin and S A Harbisor, John Willey & Sons, Inc. NewYork, 1981.
6) Radioactivity and Radiation, C. Grupen and M. Rodgers, 2016, Springer
7) Introduction to radiation protection, C. Grupen, 2010, Springer
8) An introduction to radiation protection, A. Martin, S. Harbison, K. Beach and P. Cole, H. Arnold, 2012.

Additional Readings:
1) Radiation detection and measurement, G. F. Knoll, 4th edition, 2010, Wiley Publications
2) Techniques for Nuclear and Particle Physics experiments, W. R. Leo, 1994, Springer
3) Thermoluminescence dosimetry, A. F. Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5)

4) Medical Radiation Physics, W. R. Hendee, 1981, Year book Medical Publishers, Inc., London
5) Physics and Engineering of Radiation Detection, S. N. Ahmed, 2007, Academic Press Elsevier
6) Nuclear and Particle Physics, W. E. Burcham and M. Jobes, 1995, Harlow Longman Group
7) IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least five experiments need to be performed from the following list.

1) Estimate the energy loss of different projectiles/ions (at least 3 projectiles between ZP = 1 to 92, where ZP is atomic number of projectile/ion) in water and carbon, using SRIM/TRIM etc. simulation software.
2) Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
3) Comparison of interaction of projectiles with ZP = 1 to 92 (where ZP is atomic number of projectile/ion) in a given medium (Mylar, Aluminium, cadmium, lead) using simulation software (SRIM etc).
4) SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be ZP = 6 to 92 on ZA = 16 to 92 (where ZP and ZA are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
5) Calculation of absorption/transmission of X-rays, γ-rays through Mylar, Be, C, Al, Fe and ZA = 47 to 92 (where ZA is atomic number of atoms to be investigated as targets) using XCOM, NIST (https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html).
6) Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics; University of Delhi and gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/).
7) Study the background radiation levels using Radiation meter
8) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
9) Study of counting statistics using background radiation using GM counter.
10) Study of radiation in various materials (e.g. KSO_4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
11) Study of absorption of beta particles in Aluminium using GM counter.
12) Detection of α particles using reference source & determining its half life using spark counter.
13) Gamma spectrum of gas light mantle (Source of Thorium).
14) Demonstration of radiation detection equipment for dose, risk and crime scene management.

References for laboratory work:

1) Schaum's Outline of Modern Physics, 1999, McGraw-Hill
2) Schaum's Outline of College Physics, E. Hecht, 11th edition, 2009, McGraw Hill
3) Modern Physics, K Sivaprasath and R Murugeshan, 2010, S. Chand Publication
4) AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011
5) AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

Category II

Physical Science Courses (with Electronics) with Physics and Electronics discipline as Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 9: ELEMENTS OF MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Elements of Modern Physics PHYSICS DSC 9	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values; Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

SYLLABUS OF PHYSICS DSC – 9

THEORY COMPONENT

Unit - I **(8 Hours)**

Origin of Quantum Theory: Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

Unit - II **(7 Hours)**

The Schrodinger Equation: The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators.

Unit – III **(5 Hours)**

Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

Unit – IV **(5 Hours)**

Atomic Physics: Beyond the Bohr's Quantum Model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra.
Correspondence principle
X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley law

Unit – V **(5 Hours)**

Basic Properties of Nuclei: Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.
Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages); discovery of new elements of the periodic table

References:

Essential Readings:

1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning
5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
8) Modern Physics, R. Murugeshan, S Chand & Co. Ltd
9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.

17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers
18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

Additional Readings:

1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster`s focusing; determination of angle of prism.

At least six experiments to be performed from the following list

1) Measurement of Planck's constant using black body radiation and photo-detector
2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
3) To determine the work function of material of filament of directly heated vacuum diode.
4) To determine the Planck's constant using LEDs of at least 4 different colours.
5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
6) To determine the ionization potential of mercury.
7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8) To show the tunneling effect in tunnel diodes using I-V characteristics.
9) To determine the wavelength of a laser source using diffraction of a single slit.
10) 10. To determine the wavelength of a laser source using diffraction of double slits.
11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
12) One innovative experiment designed by the teacher relevant to the syllabus.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal.
3) Advanced level physics practicals, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted, 1985, Heinemann Educational Publishers.
4) A laboratory manual of physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Publisher.
5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 3: SEMICONDUCTOR DEVICES FABRICATION

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Semiconductor Devices Fabrication PHYSICS DSE 3	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices, thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail. By the end of the syllabus, students will have an understanding of MEMS based transducers.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes.

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czochralski technique, on which a present day electronics and IT revolution is based.
- Students will understand about the various techniques of thin film growth and processes.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (Micro-Electro-Mechanical System) and MEMS based transducers.

SYLLABUS OF PHYSICS DSE – 3

THEORY COMPONENT

Unit – I **(9 Hours)**

Introduction: Review of energy bands in materials, metal, semiconductor and insulator, doping in semiconductors, defects (point, line, Schottky and Frenkel), single crystal, polycrystalline and amorphous materials, Czochralski technique for silicon single crystal growth, silicon wafer slicing and polishing.

Vacuum Pumps: Primary pump (mechanical) and secondary pumps (diffusion, turbomolecular, cryopump, sputter-ion) – basic working principle, throughput and characteristics in reference to pump selection, vacuum gauges (Pirani and Penning)

Unit – II **(10 Hours)**

Thin film growth techniques and processes: Sputtering, evaporation (thermal, electron beam),

pulse laser deposition (PLD), chemical vapour deposition (CVD), epitaxial growth
Thermal oxidation process (dry and wet) passivation, metallization, diffusion

Unit – III **(7 Hours)**
VLSI Processing: Clean room classification, line width, photolithography: resolution and process, positive and negative shadow masks, photoresist, step coverage, developer, electron beam lithography, etching: wet etching, dry etching (RIE and DRIE), basic fabrication process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology, wafer bonding, wafer cutting, wire bonding and packaging issues (qualitative idea)

Unit – IV **(4 Hours)**
Micro Electro-Mechanical System (MEMS): Introduction to MEMS, materials selection for MEMS devices, selection of etchants, surface and bulk micromachining, sacrificial subtractive processes, additive processes, cantilever, membranes, general idea of MEMS based pressure, force, and capacitance transducers

References:
Essential Readings:

1) Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
2) Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
3) Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons
4) VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.

Additional Readings:

1) Handbook of Thin Film Technology, L. I. Maissel and R. Glang

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list
1) Deposition of thin films using dip coating and deposition of metal contacts using thermal Evaporation and study its IV characteristics
2) Deposition of thin films using spin coating and deposition of metal contacts using thermal evaporation and study its I-V characteristics
3) Fabrication of p-n Junction diode and study its I-V characteristics
4) Create vacuum in a small tube (preferably of different volumes) using a mechanical rotary pump and measure pressure using vacuum gauges.
5) Selective etching of different metallic thin films using suitable etchants of different concentrations.
6) Wet chemical etching of Si for MEMS applications using different concentration of etchant.
7) Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75)
8) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150C) by four-probe method.
9) To fabricate a ceramic and study its capacitance using LCR meter.
10) To fabricate a thin film capacitor using dielectric thin films and metal contacts and study its capacitance using LCR meter

References for laboratory work:

1) The science and Engineering of Microelectronics Fabrication, S. A. Champbell, 2010, Oxford University Press
2) Introduction to Semiconductor Devices, F. Kelvin Brennan, Cambridge University Press, 2010

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 4: ELECTRONICS INSTRUMENTATION

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Electronics Instrumentation Physics DSE 4	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of digital electronics and analog electronics

LEARNING OBJECTIVES

This course aims to provide an exposure on basics of measurement and instrumentation and its various aspects and their usage through hands-on mode. It also aims to provide exposure of various measurement instruments such as power supply, oscilloscope, multivibrators, signal generators are also discussed. It also aims to develop an understanding of virtual instrumentation and transducers.

LEARNING OUTCOMES

At the end of this course, students will have understanding of,

- Basic principles of the measurement and errors in measurement, specifications of basic Measurement instruments and their significance with hands on mode.
- Principles of voltage measurement, advantages of electronic voltmeter over conventional multimeter in terms of sensitivity etc.
- Measurement of impedance using bridges, Power supply, Filters, IC regulators and Load and line regulation.
- Specifications of CRO and their significance, the use of CRO and DSO for the measurement of voltage (dc and ac), frequency and time period.
- Multivibrators, working circuits of astable and monostable multivibrators.
- Explanation and specifications of signal and pulse generators
- The Interfacing techniques, Arduino microcontroller and interfacing software,
- Understanding and usage of transducers

SYLLABUS OF PHYSICS DSE 4

THEORY COMPONENT

Unit – I **(12 Hours)**

Measurements: Shielding and grounding, electromagnetic interference

Basic Measurement Instruments: DC measurement-ammeter, voltmeter, ohm meter, AC measurement, digital voltmeter systems (integrating and non-integrating), digital multimeter, block diagram, principle of measurement of I, V, C, measurement of impedance - A.C. bridges, measurement of self-inductance (Anderson's bridge), measurement of capacitance (De-Sauty's bridge), measurement of frequency (Wien's bridge)

Unit - II **(6 Hours)**

Power supply: Using IC regulators (78XX and 79XX), line and load regulation, short circuit protection, idea of switched mode power supply (SMPS) and uninterrupted power supply

(UPS)
Oscilloscope: Block diagram, CRT, deflection (qualitative), screens for CRT, oscilloscope probes, measurement of voltage, frequency, and phase by oscilloscope, digital storage oscilloscope

Unit – III **(3 Hours)**
Multivibrators (IC 555): Block diagram, astable and monostable multivibrator circuits
Signal Generators: Function generator (black box approach)

Unit – IV **(9 Hours)**
Virtual Instrumentation: Introduction, interfacing techniques (RS 232, GPIB, USB), idea about Arduino microcontroller and interfacing software like lab View
Transducers: Classification of transducers, measurement of temperature (RTD, semiconductor IC sensors), light transducers (photo resistors and photovoltaic cells)

References:
Essential Readings:

1) Electronic Instrumentation and Measurement Techniques, W. D. Cooper and A. D. Helfrick, 2005, Prentice Hall
2) Measurement Systems: Application and Design, E. O. Doebelin, 5th edition, 2003, McGraw Hill Book
3) Electronic Devices and Circuits, D. A. Bell, 2015, Oxford University Press

Additional Readings:

1) Instrumentation Devices and Systems, S. Rangan, G. R. Sarma and V. S. Mani, 1998, Tata McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)
- Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab."

At least eight experiments to be performed from the following list
1) Measurement of resistance by Wheatstone bridge and measurement of bridge sensitivity.
2) Measurement of Capacitance by De Sauty's bridge.
3) Design a regulated power supply of given rating (5 V or 9V).
4) To determine the Characteristics of Thermistors and RTD.
5) Measurement of temperature by Thermocouples.
6) To design an astable multivibrator of given specification using IC 555 Timer.
7) To design a monostable multivibrator of given specification using IC 555 Timer.
8) To design and study the sample and hold circuit.
9) To plot the frequency response of a microphone.
10) Glow an LED via USB port of PC.
11) Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

References for laboratory work:

1) Measurement and Instrumentation Principles, A. S. Morris, 2008, Elsevier (Butterworth Heinmann)
2) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino and M. A. Miller, 1990, Mc-Graw Hill

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 5: DIGITAL SIGNAL PROCESSING

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Digital Signal Processing Physics DSE 5	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of digital electronics and analog electronics

LEARNING OBJECTIVES

This paper describes the discrete-time signals and systems, Fourier transform representation of aperiodic discrete time signals. This paper also highlights the concept of filters and realization of digital filters. At the end of the syllabus, students will develop an understanding of discrete and fast Fourier transform.

LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes.

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyse the discrete time signals and systems. They will learn to analyse a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer Function and difference-equation system will be introduced. Also, they will learn to solve difference equations.
- Students will develop an ability to analyse DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite and infinite impulse response filters for various applications.

SYLLABUS OF PHYSICS DSE 5

THEORY COMPONENT

Unit – I **(7 Hours)**

Discrete-Time Signals and Systems: Classification of signals, transformations of the independent variable, periodic and aperiodic signals, energy and power signals, even and odd signals, discrete time systems, system properties, impulse response, convolution sum, graphical and analytical method, properties of convolution (general idea), sum property system response to periodic inputs, relationship between LTI system properties and the impulse response

Unit – II **(9 Hours)**

Discrete time Fourier transform: Fourier transform representation of aperiodic discrete time signals, periodicity of DTFT, properties; linearity; time shifting; frequency shifting; differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z- Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Differentiation in the z-Domain; Power Series Expansion Method (General Idea). Transfer Function and Difference-Equation System.

Unit – III **(10 Hours)**

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters.Only Qualitative treatment

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation (General Idea), Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution).

Unit – IV **(4 Hours)**

Realization of Digital Filters: FIR Filter structures; Direct-Form; Cascade-Form

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR Filters

References:

Essential Readings:

1) Digital Signal Processing, T. K. Rawat, 2015, Oxford University Press, India
2) Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3) Principles of Signal Processing and Linear Systems, B. P. Lathi, 1st edition, 2009, Oxford University Press.
4) Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press
5) Digital Signal Processing Principles Algorithm & Applications, J. G. Proakis and D. G. Manolakis, 4th edition, 2007, Prentice Hall.

Additional Readings:

1) Digital Signal Processing, A. Kumar, 2nd edition, 2016, PHI learning Private Limited.
2) Digital Signal Processing, P. S. R. Diniz, E. A. B. da Silva and S. L. Netto, 2nd edition, 2017, Cambridge University Press

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Introduction to numerical computation software Scilab/Matlab/Python be introduced in the lab.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab"

At least six experiments to be performed from the following using Scilab/ Matlab/ Python

1) Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence *u(n)*, (c) ramp sequence *r(n)*, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \leq n \leq 50$.
2) Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5

$$x(n) = rect\left(\frac{n}{2N}\right) = \prod \left(\frac{n}{2N}\right) = \{1 \quad -N \leq n \leq N \; 0 \qquad otherwise$$

3) An LTI system is specified by the difference equation *y(n)=0.8y(n-1)+x(n)*
   (a)Determine $H(e^{iw})$
   (b) Calculate and plot the steady state response *y(n)* to $x(n) = cos\, cos\, (0.5\pi n)\, u(n)$
4) Given a casual system *y(n)=0.9y(n-1)+x(n)*
   (a) Find H(z) and sketch its pole-zero plot
   (b) Plot the frequency response $|H(e^{jw})|$ and $\angle H(e^{jw})$
5) Design a digital filter to eliminate the lower frequency sinusoid of *x(t)=sin7t+sin200t*. The sampling frequency is 500 Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.
6) Let *x(n)* be a 4-point sequence:
   $x(n) = \{\underset{\uparrow}{1},1,1,1\} = \{1 \;\; 0 \leq n \leq 3 \; 0 \;\; otherwise$

   Compute the DTFT $X(e^{jw})$ and plot its magnitude
   (a) Compute and plot the 4 point DFT of *x(n)*
   (b) Compute and plot the 8 point DFT of *x(n)* (by appending 4 zeros)
   (c) Compute and plot the 16 point DFT of *x(n)* (by appending 12 zeros)

7) Let *x(n)* and *h(n)* be the two 4-point sequences,
   $x(n)=\{1,\underset{\uparrow}{2},2,1\}$ $\qquad$ $h(n)=\{1,-1,\underset{\uparrow}{-1},1\}$
   Write a program to compute their linear convolution using circular convolution.

8) Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.
9) Design an FIR filter to meet the following specifications:
   Passband edge F_p=2 KHz
   Stopband edge F_s=5 KHz
   Passband attenuation A_p=2 dB
   Stopband attenuation A_s=42 dB
   Sampling frequency F_{sf}=20 KHz
10) The frequency response of a linear phase digital differentiator is given by

$$H_d\left(e^{jw}\right) = jwe^{-j\tau w} \; |w| \leq \pi$$

   Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response

References for laboratory work:

1) A Guide to MATLAB, B. R. Hunt, R. L. Lipsman and J. M. Rosenberg, 3rd edition, 2014, Cambridge University Press.
2) Fundamentals of Digital Signal processing using MATLAB, R. J. Schilling and S. L. Harris, 2005, Cengage Learning.
3) Getting started with MATLAB, R. Pratap, 2010, Oxford University Press.

ANNEXURE-2

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B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC -16: STATISTICAL MECHANICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Statistical Mechanics DSC – 16	4	3	1	0	Class XII pass with Physics and Mathematics as main subjects	Thermal physics and quantum mechanics papers of this course or their equivalents. Basics of probability and statistics

LEARNING OBJECTIVES

Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behaviour of atoms and molecules that comprises it. The main objective of this course is to introduce the techniques of statistical mechanics which has applications in various fields including astrophysics, semiconductor physics, plasma physics, biophysics etc. and in many other directions. All the problems of different units should be done in the tutorial classes.

LEARNING OUTCOMES

By the end of the course, students will be able to,

- Understand the concepts of phase space, macrostate, microstate, thermodynamic probability and partition function.
- Understand the use of thermodynamic probability and partition function for calculation of thermodynamic properties for physical systems (ideal gas, finite level system).
- Understand the difference between classical and quantum statistics and their applicability.
- Understand the properties and laws associated with thermal radiation.
- Apply the Fermi- Dirac distribution to model problems such as electrons in solids and white dwarf stars
- Apply the Bose-Einstein distribution to model problems such as blackbody radiation and liquid Helium.

SYLLABUS OF DSC – 16

THEORY COMPONENT

Unit - I **(22 Hours)**

Classical Statistics: Phase space, macrostates and microstates, entropy and thermodynamic probability, concept of ensemble - Introduction to three types, Maxwell-Boltzmann distribution law, partition function, thermodynamic functions of an ideal gas, Gibbs paradox, Sackur-Tetrode equation. Saha's ionization formula, Law of equipartition of energy (with proof) – Applications to specific heat of gases (monoatomic and diatomic), solids and its limitations, thermodynamic functions of a finite level system, negative temperature

Unit – II **(5 Hours)**

Radiation: Blackbody radiation and its spectral distribution. Kirchhoff law (No Proof), Planck's quantum postulates, Planck's law of blackbody radiation, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law, ultraviolet catastrophe

Unit – III **(9 Hours)**

Bose-Einstein Statistics: Bose-Einstein distribution law, thermodynamic functions of a strongly degenerate Bose gas (non- relativistic), Bose-Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and thermodynamic functions of photon gas. Bose derivation of Planck's law

Unit – IV **(9 Hours)**

Fermi-Dirac Statistics: Fermi-Dirac distribution law, thermodynamic functions of a completely and strongly degenerate fermions (non-relativistic), specific heat of metals, relativistic Fermi gas, white dwarf stars, Chandrasekhar mass limit.

References:

Essential Readings:

1) Statistical Mechanics, R. K. Pathria and P. D. Beale, Academic Press
2) Introductory Statistical Mechanics, R. Bowley and M. Sanchez, Oxford Univ. Press
3) Statistical Physics, F. Mandl, Wiley
4) A treatise on Heat, M. N. Saha and B. N. Srivastava, Indian Press
5) Problems and Solutions on Thermodynamics and Statistical Mechanics, Lim Yung-Kou, Sarat Book House
6) An Introduction to Thermal Physics, D. Schroeder, Pearson
7) Statistical Physics, Berkeley Physics Course, F. Reif, McGraw-Hill

Additional Readings:

1) An Introduction to Statistical Physics, W. G. V. Rosser, Wiley
2) Thermal Physics, Kittel and Kroemer, CBS
3) Concepts in Thermal Physics, Blundell and Blundell, Oxford University Press
4) Statistical and Thermal Physics, Loknathan and Gambhir, PHI
5) Thermodynamics, Kinetic theory and Statistical thermodynamics, Sears and Salinger, PHI
6) Statistical Mechanics, G. Sanon, Alpha Science International Ltd.

DISCIPLINE SPECIFIC CORE COURSE – DSC - 17: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Atomic, Molecular and Nuclear Physics DSC – 17	4	3	1	0	Class XII pass with Physics and Mathematics as main subjects	Light and Matter, Modern Physics and Quantum Mechanics-I of this course or their equivalent

LEARNING OBJECTIVES

This course introduces the basic concepts of atomic, molecular and nuclear physics to an undergraduate student. Advanced mathematics is avoided and the results of quantum mechanics are attempts to explain, or even to predict, the experimental observations of spectroscopy. The student learns to visualize a nucleus, an atom or molecule as a physical entity rather than a series of mathematical equations.

LEARNING OUTCOMES

On successful completion of the module students should be able to elucidate the following main features.

- Stern-Gerlach experiment, electron spin, spin magnetic moments, space quantization and Zeeman effect, spectral notations for atomic and molecular states and corresponding term symbols, understanding of atomic spectra and molecular spectra
- Basic principle of Raman spectroscopy and Franck Condon principle.
- The radioactive processes, stability of the nuclei and the nuclear models
- The full scientific potential lies on how we are able to interpret the fundamental astrophysical and nuclear data. The acquired knowledge can be applied in the areas of astrophysics, nuclear, medical, geology and other interdisciplinary fields of Physics, Chemistry and Biology. It will enhance the special skills required for these fields

SYLLABUS OF DSC - 17

THEORY COMPONENT

Unit – I - Atomic Physics (15 Hours)

One-electron atoms: Degeneracy of energy levels and selection rules, modes of relaxation of an excited atomic state.

Fine structure of Hydrogenic atoms: Shifting of energy levels, Splitting of spectral lines, relativistic correction to kinetic energy, spin-orbit term, Darwin term, fine structure spectral lines, Lamb shift (qualitative idea).

Atoms in external magnetic fields: Larmor's theorem, Stern-Gerlach experiment, normal Zeeman Effect, Paschen Back effect, anomalous Zeeman effect, Lande g-factor.

Unit - II – Molecular Physics (15 Hours)

Molecular structure: The Born-Oppenheimer approximation, Concept of bonding and anti-bonding molecular orbitals, Concept of Potential energy curve for a diatomic molecule, Morse potential, Classification of molecular states of diatomic molecule, The Franck-Condon principle

Molecular spectra of diatomic molecule: Rotational Spectra (rigid and non-rigid rotor), Vibrational Spectra (harmonic and anharmonic), Vibration-Rotation Spectrum of a diatomic molecule, Isotope effect, Intensity of spectral lines

Raman Effect: Classical theory (with derivation) of Raman effect, pure rotational Raman Lines, Stoke's and Anti-Stoke's Lines, comparison with Rayleigh scattering.

Unit – III – Nuclear Physics (15 Hours)

Nucleus stability: *Alpha decay:* Energetics of alpha-particle decay, barrier penetration model, Geiger-Nuttall rule, α- decay spectroscopy, decay Chains. *Beta Decay:* Q-values for beta decay, β-spectrum, positron emission, electron capture, neutrino hypothesis, Qualitative idea about Fermi theory, Fermi and Gamow-Teller decays, the role of angular momentum and parity, electron capture, and selection rules. *Gamma decay:* Gamma-ray production, and multipolarities, Weisskopf estimates, the role of angular momentum and parity, internal conversion.

Nuclear models: Evidence of shell structure in nuclei, Magic numbers, nuclear mean field, single particle shell model, spin-orbit splitting, shell model configurations for nuclear ground states, and low-lying excited levels

References:

Essential Readings:

1) Physics of Atoms and Molecules, B. H. Bransden and C. J. Jochain, 2nd edition, Pearson
2) Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 1994, Tata McGraw – Hill
3) Atomic physics, J. B. Rajam and foreword by Louis De Broglie, 2010, S. Chand & Co.
4) Atoms, Molecules and Photons, W. Demtroder, 2nd edition, 2010, Springer
5) Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. A. Kriz and J. R. Vyvyan, 5th edition, 2014, Brookes/Cole
6) Concept of Nuclear Physics, B. L. Cohen, 2003, Tata McGraw – Hill
7) Nuclear Physics, S. N. Ghoshal, 1st edition, 2019, S. Chand Publication
8) Introducing Nuclear Physics, K. S. Krane, 2008, Wiley India

Additional Readings:

1) Basic Atomic and Molecular Spectroscopy, J. M. Hollas, Royal Society of Chemistry
2) Molecular Spectra and Molecular Structure, G. Herzberg
3) Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach (Series in Fundamental and Applied Nuclear Physics), K. Heyde (Institute of Physics Publishing 3rd edition
4) Nuclear Physics: principles and applications, John Lilley, 2006, Wiley
5) Schaum's Outline of Modern Physics, 1999, McGraw-Hill Education
6) Introduction to elementary particles, D. J. Griffiths, 2008, Wiley
7) Atomic and molecular Physics, R. Kumar, 2013, Campus Book Int.
8) The Fundamentals of Atomic and Molecular Physics (Undergraduate Lecture Notes in Physics), 2013, Springer

DISCIPLINE SPECIFIC CORE COURSE – DSC - 18: STATISTICAL ANALYSIS IN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Statistical Analysis in Physics DSC – 18	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basic understanding of statistics and probability

LEARNING OBJECTIVES

This course provides an elementary introduction to the principles of Bayesian statistics and working knowledge of some of the data analysis techniques. The objective is to equip the students with certain techniques so that they may successfully apply these to the real world problems, in their research areas as well as in industry.

LEARNING OUTCOMES

After completing this course, students will be able to,

- Understand the fundamental concepts in statistical data analysis.
- Define in a Bayesian context, the likelihood, prior and posterior distributions and their role in Bayesian inference and hypothesis testing.
- Estimate the parameters of a distribution from sample.
- Perform hypothesis testing and validate a model.
- Apply multi-linear and logistic models to real life situation.

In the practical component, students will be able to

- Learn basic data analysis techniques such as linear and non-linear fittings
- Apply hypothesis testing techniques in physics
- Perform multi-linear and logistic regression analysis for a given data
- Understand the concept of gradient descent and use it for the regression analysis
- Understand the stochastic processes, Markov chains and transition probability matrix.

SYLLABUS OF DSC - 18

THEORY COMPONENT

Unit – I **(8 Hours)**

Random variables, Discrete and Continuous Probability Distributions. Bivariate and multivariate random variables, Joint Distribution Functions (with examples from Binomial, Poisson and Normal). Mean, variance and moments of a random vector, covariance and correlation matrix, eigendecomposition of the covariance matrix (bivariate problem). Cumulative Distribution Function and Quantiles. Point Estimation, Interval estimation, Central Limit Theorem (statement, consequences and limitations).

Unit – II **(11 Hours)**

Bayesian Statistics: Conditional probability and Bayes Theorem, Prior and Posterior probability distributions, examples of Bayes theorem in everyday life. Bayesian parameter estimation. Normal, Poisson and Binomial distributions, their conjugate priors and properties. Bayes factors and model selection.

Unit – III **(11 Hours)**

Bayesian Regression: Introduction to Bayesian Linear Regression. Bayesian logistic regression and its applications. Bayesian parameter estimation for regression models. Posterior distribution of model parameters and the posterior predictive distributions.

References:

Essential Readings:

1) Schaum's Outline Series of Probability and Statistics, M. R. Spiegel, J. J. Schiler and R. A. Srinivasan, 2012, McGraw Hill Education
2) Schaum's Outline Series of Theory and Problems of Probability, Random Variables, and Random Processes, H. Hsu, 2019, McGraw Hill Education
3) Bayesian Logical Data Analysis for the Physical Sciences: A Comparative Approach with Mathematica Support, P. Gregory, 2010, Cambridge University Press
4) Linear Regression: An Introduction to Statistical Models, P. Martin, 2021, Sage Publications Ltd.
5) Data Analysis: A Bayesian Tutorial, D. S. Sivia and J. Skilling, 2006, Oxford University Press
6) Data Reduction and Error analysis for the Physical Sciences, P. R. Bevington and D. K. Robinson, 2002, McGraw-Hill Education

Additional Readings:

1) A Guide to the Use of Statistical Methods in the Physical Sciences, R. J. Barlow, 1993, Wiley Publication
2) An Introduction to Error Analysis, J. R. Taylor, 1996, Univ. Sci. Books
3) Applied Multivariate Data Analysis, Volume I: Regression and Experimental Design, J. D. Jobson, 2012, Springer-Verlag
4) Statistical Rethinking A Bayesian Course with Examples in R and STAN, Richard McElreath, 2020, CRC Press
5) Introduction to Bayesian Statistics, W. Bolstad, 2007, John Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

The objective of this lab is to familiarise the students with the techniques of data analysis. The instructors are required to discuss the concepts and the pseudo-codes of the recommended programs in the practical sessions before their implementation. The implementation can be in any programming language. Inbuilt libraries can be used wherever applicable. **All units are mandatory.**

Unit 1 (12 Hours)

Probability Distributions

1) Generate sequences of N random numbers M (at least 10000) number of times from different distributions (e.g. Binomial, Poisson, Normal). Use the arithmetic mean of each random vector (of size N) and plot the distribution of the arithmetic means. Verify the Central Limit Theorem (CLT) for each distribution. Show that CLT is violated for the

Cauchy-Lorentz distribution.

2) Given a data for two independent variables (x_i, y_i). Write a code to compute the joint probability in a given sample space. Verify the same for the data generated by random number generator based on a given probability distribution of pair of independent variables (both discrete and continuous).

Unit 2 (16 Hours)

1) Hypothesis testing
   Make a random number generator to simulate the tossing of a coin n times with the probability for the head being q. Write a code for a Binomial test with the Null hypothesis H_0 ($q = 0.5$) against the alternative hypothesis H_1 ($q \neq 0.5$).

2) Bayesian Inference
   a) In an experiment of flipping a coin N times, M heads showed up (fraction of heads $f = M/N$). Write a code to determine the posterior probability, given the following prior for the probability of f:
      i. Beta Distribution $B(a, b)$ with given values of a and b .
      ii. Gaussian Distribution with a given mean and variance.
   b) Using the Likelihood of Binomial distribution, determine the value of f (fraction of heads) that maximizes the probability of the data.
   c) Plot the Likelihood (normalised), Prior and Posterior Distributions.

Unit 3 (20 hours)

Regression Analysis and Gradient Descent:

1) Given a dataset (Xi, Yi). Write a code to obtain the parameters of linear regression equation using the method of least squares with both constant and variable errors in the dependent variable (Y). The data obtained in a physics lab may be used for this purpose. Also obtain the correlation coefficient and the 90% confidence interval for the regression line. Make a scatter plot along with error bars. Also, overlay the regression line and show the confidence interval.

2) Write a code to minimize the cost function (mean squared error) in the linear regression using gradient descent (an iterative optimization algorithm, which finds the minimum of a differentiable function) with at least two independent variables. Determine the correlation matrix for the regression parameters.

3) Write a code to map a random variable X that can take a wide range of values to another variable Y with values lying in limited interval say [0, 1] using a sigmoid function (logistic function). Considering the Log Loss as the cost function of logistic regression, compute its minimum with gradient descent method and estimate the parameters.

Unit 4 (12 Hours)

Markov Chain (Any one)

1) Write a code to generate a Markov chain by defining (a finite number of) M (say 2) states. Encode states using a number and assign their probabilities for changing from state i to state j. Compute the transition matrix for $1, 2, \ldots, N$ steps. Following the rule, write a code for Markovian Brownian motion of a particle.

2) Given that a particle may exist in one of the given energy states (E_i, $i = 1, \ldots 4$) and the

transition probability matrix T, so that T_{ij} gives the probability for the particle to make transition from energy state E_i to state E_j. Determine the long-term probability of a particle to be in state in the state E_f if the particle was initially in state E_i.

References for laboratory work:

1) Data Science from Scratch – First Principles with Python, J. Grus, O'Reilly, 2019, Media Inc.
2) Bayes' Rule with Python: A tutorial introduction to Bayesian Analysis, J. V. Stone, 2016, Sebtel Press
3) Practical Bayesian Inference, B. Jones, 2017, Cambridge University Press
4) Modeling and Simulation in Scilab/Scicos with Scicos Lab 4.4, S. L. Campbell, Jean-P. Chancelier and R. Nikoukhah, Springer.
5) Scilab Textbook Companion for Probability And Statistics For Engineers And Scientists, S. M. Ross, 2005, Elsevier
6) Numerical Recipes: The art of scientific computing, W. H. Press, S. A. Teukolsky and W. Vetterling, 2007, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 9: ADVANCED MATHEMATICAL PHYSICS II

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Advanced Mathematical Physics II DSE – 9	4	3	1	0	Class XII pass with Physics and Mathematics as main subjects	DSC Mathematical Physics-I and Mathematical Physics-II of this course or their equivalent

LEARNING OBJECTIVES

The emphasis of the course is to acquire advanced mathematical inputs while solving problems of interest to physicists. The course aims to introduce the students to the principles of tensor analysis and equip them to use the concept in modelling of continuous media, electrodynamics, elasticity theory and the general theory of relativity. The mathematical skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will,

- Have a knowledge and understanding of tensor analysis and tensor calculus
- Be able to do computation with tensors, both in coordinates and in coordinate-free form.
- Understand the transformation properties of covariant, contravariant and mixed tensors under general coordinate transformation.
- Be able to apply the concepts of tensors in anisotropic media with examples of moment of inertia tensor, elasticity tensor and polarizability tensor.
- Understand physical examples of tensors such as Moment of Inertia and Elasticity of asymmetrical physical systems.
- Be able to write down the Lorentz Transformation in four vector notation.
- Understand inner product and outer product of general tensors.
- Understand the concept of covariant derivatives.

SYLLABUS OF DSE - 9

THEORY COMPONENT

Unit - I **(12 Hours)**

Cartesian Tensors: Transformation of co-ordinates under rotation of axes. Einstein's Summation Convention. Relation between direction cosines. Transformation Law for a tensor of rank n. Sum, inner product and outer product of tensors, contraction of tensors, Quotient Law of tensors, symmetric and anti-symmetric tensors. Invariant tensors (Kronecker and Alternating Tensor). Association of anti-symmetric tensor of rank two with vectors. Vector algebra and calculus in tensor notation. Differentiation, gradient, divergence and curl of Tensor Fields. Vector Identities in tensor notation.

Unit - II **(12 hours)**

Applications of Cartesian Tensors: Equation of a Line, Angle between Lines, Projection of a Line on another Line, Condition for Two Lines to be Coplanar and Length and Foot of the Perpendicular from a Point on a Line. Rotation Tensor and its properties.

Moment of Inertia Tensor, Stress and Strain Tensors, Elasticity Tensor, Generalized Hooke's Law, Electric Polarizability Tensor.

Unit - III **(9 hours)**

General Tensors: Transformation of co-ordinates and contravariant and covariant vectors. Transformation law for contravariant, covariant and mixed tensors. Kronecker Delta and permutation tensors. Algebra of general tensors. Quotient Law general tensors. Symmetric and anti-symmetric tensors. Metric Tensor. Reciprocal Tensors. Associated Tensors.

Unit - IV **(12 hours)**

Christoffel Symbols of first and second kind and their transformation laws. Covariant derivative, gradient, divergence and curl of tensor fields.

Minkowski Space, Four Vectors (four-displacement, four-velocity, four-momentum, four-vector potential, four- current density,). Tensorial form of Lorentz Transformation.

References:

Essential Readings:

1) Vector Analysis and Cartesian Tensors, 3rd edition, D. E. Bourne, P. C. Kendall, 1992
2) Cartesian Tensors, H. Jeffreys, 1931, Cambridge University Press.
3) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
4) A Brief on Tensor Analysis, J. G. Simmonds, 1997, Springer.
5) Schaum's outlines series on Vector Analysis, M. Spiegel, 2nd edition, 2017.
6) Schaum's Outline Series on Tensor Calculus, D. Kay, Revised 1st edition, 2011.
7) An Introduction to Tensor Calculus and Relativity, D. F. Lawden, 2013, Literary Licensing
8) Matrices and tensors in physics by A. W. Joshi, 1995, New Age International Publications.

Additional Readings:

1) A Student's Guide to Vectors and Tensors, D. A. Fleisch, 2011, Cambridge Univ. Press.
2) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, 2008, Narosa Publishing House.
3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2009, Wiley Publication.
4) A Primer in Tensor Analysis and Relativity, I. L. Shapiro, 1st edition, 2019, Springer.
5) Gravity-An introduction to Einstein's General Relativity, J. B. Hartle, 2009, Pearson Education.
6) A first course in general relativity, B. F. Schutz, 2004, Cambridge University Press.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 10: MICROPROCESSOR

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Microprocessor DSE – 10	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Basics of Digital Electronics

LEARNING OBJECTIVES

Students will be able to outline the types and the functions of storage, learn the characteristics of RAM and ROM and their architecture, describe the architecture of 8085 microprocessors and develop programs for microprocessor 8085

LEARNING OUTCOMES

At the end of the course, students will develop ability to,

- Define storage state the types and functions of storage
- Describe the characteristics of RAM and ROM and their architecture.
- Describe memory organization, addressing, interfacing and mapping
- Describe the architectures of 8085 microprocessors
- Draw timing diagram
- Write programs using 8085

SYLLABUS OF DSE - 10

THEORY COMPONENT

Unit – I - Introduction to 8085 Microprocessor Architecture (16 Hours)

Introduction to microprocessor: Basic computer system organization, introduction, classification and applications of microprocessors, types of memory-primary memory types (SRAM, DRAM, PROM, EPROM, EEPROM), secondary memory (SSD, Optical Drive) memory organization and addressing

Microprocessor 8085 Architecture: Features, architecture-block diagram, general purpose registers, register pairs, flags, stack pointer, program counter, types of buses, multiplexed address and data bus, generation of control signals, pin description of microprocessor 8085, basic memory interfacing concepts, Memory mapped I/O and I/O mapped I/O.

Unit – II - 8085 Programming (14 Hours)

Operation code, operand and mnemonics, instruction set of 8085, instruction classification, addressing modes, instruction format, data transfer instructions, arithmetic instructions, increment & decrement instructions, logical instructions, branch instructions and machine control instructions, subroutine, call and return instructions, timing diagrams-instruction cycle, machine cycle, T- states, basic idea of interrupts, assembly language programming examples (addition with and without carry, subtraction with and without borrow, double addition, multiplication by repeated addition, division by repeated subtraction, block data transfer and checking of parity of a binary number)

References:

Essential Readings:

1) Microprocessor Architecture Programming and applications with 8085, R. S. Gaonkar, 2002, Prentice Hall
2) Microelectronic Circuits, S. Sedra
3) Fundamentals of Microprocessor and Microcomputer, B. Ram, Dhanpat Rai Publications
4) The Intel Microprocessors - Architecture, Programming and Interfacing, B. Brey, 2003, Pearson Education

Additional Readings:

1) Microprocessors and Microcontrollers, M. Ali Mazidi, 2006, Pearson

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list.

8085 Assembly language programs

1) Add two 8-bit numbers using Direct and Indirect Addressing Mode
2) Subtract two 8-bit numbers using Direct and Indirect Addressing Mode
3) Multiply two 8-bit numbers with and without subroutine
4) Divide two-8 bit numbers with and without subroutine
5) Add a list of 8-bit numbers
6) Transfer a Block of Data
7) Add two 16 bit numbers with DAD and without DAD
8) Convert byte to Nibble
9) Convert nibble to Byte
10) Check the parity of a given number

References for laboratory work:

1) Microprocessor Architecture Programming and applications with 8085, R. S. Gaonkar, 2002, Prentice Hall
2) Microelectronic Circuits, S. Sedra
3) Fundamentals of Microprocessor and Microcomputer, B. Ram, Dhanpat Rai Publications
4) Microprocessors and Microcontrollers, M. Ali Mazidi, 2006, Pearson
5) The Intel Microprocessors - Architecture, Programming and Interfacing, B. Brey, 2003, Pearson Education

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 11: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology DSE – 11	4	3	0	1	Class XII pass with Physics and Mathematics as main subjects	Basic ICT related skills

LEARNING OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be trained in the following.

- Skills to review literature and frame research problem
- Comprehend the relevance of the tools for data collection and analysis
- Writing a scientific report/research proposal
- Software tools for research in physical sciences
- Research integrity and publication ethics
- Importance of intellectual property rights
- Role of funding agencies in research

SYLLABUS OF DSE - 11

THEORY COMPONENT

Unit - I - Introduction to research methodology (6 Hours)

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation (15 Hours)

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);
Curve fitting using linear and nonlinear regression (parameter space, gradient search method

and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)
Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)
Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)
Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)
Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

References:
Essential Readings:
1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings:

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and M. H. Davis, 2000, West Group Publishers

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:

1) Identify a research problem, write its brief summary and make a corresponding flow chart
2) Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3) Write a literature review for a research problem.
4) Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:

1) Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2) Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3) Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:

1) Review any three research papers.
    a) List the major strengths and weakness of all of them.
    b) For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2) Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:

1) Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2) Write a scientific synopsis of a research paper using LaTeX.
3) Create a presentation using LaTeX and Beamer on any research topic
4) Select a funding agency and any two schemes or fellowships offered by them. Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

Category II

Physical Science Courses
with Physics discipline as one of the Core Disciplines

(B. Sc. Physical Science with Physics as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 6: SOLID STATE PHYSICS

<table>
<tr><th rowspan="2">Course Title & Code</th><th rowspan="2">Credits</th><th colspan="3">Credit distribution of the course</th><th rowspan="2">Eligibility Criteria</th><th rowspan="2">Pre-requisite of the course</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>Solid State Physics

PHYSICS DSC – 6</td><td>4</td><td>2</td><td>0</td><td>2</td><td>Class XII pass with Physics and Mathematics as main subjects</td><td>Understanding of basic concepts of Physics</td></tr>
</table>

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and its planes
- Understand the elementary lattice dynamics and its influence on the properties of materials
- Understanding about origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

SYLLABUS OF PHYSICS DSC – 6

THEORY COMPONENT

Unit – I - Crystal Structure (10 Hours)

Solids: amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit cell, types of lattices, Miller indices, reciprocal lattice, Ewald's construction (geometrical approach), Brillouin zones, diffraction of X-rays by crystals. Bragg's law

Unit – II - Elementary Lattice Dynamics (6 Hours)

Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustical and optical phonons, Dulong and Petit's law, qualitative discussion of Einstein and Debye theories, T^3 law.

Unit – III - Elementary Band Theory **(5 Hours)**

Qualitative understanding of Kronig and Penny model (without derivation) and formation of bands in solids, concept of effective mass, Hall effect in semiconductor, Hall coefficient, application of Hall Effect, basic introduction to superconductivity

Unit – IV - Magnetic Properties of Matter **(6 Hours)**

dia-, para-, and ferro- magnetic materials, classical Langevin theory of dia– and para-magnetism (no quantum mechanical treatment), qualitative discussion about Weiss's theory of ferromagnetism and formation of ferromagnetic domains, B-H curve hysteresis and energy loss

Unit – V - Dielectric Properties of Materials **(3 Hours)**

Polarization, local electric field in solids, electric susceptibility, polarizability, Clausius Mossoti equation, qualitative discussion about ferroelectricity and PE hysteresis loop

References:

Essential Readings:

1) Introduction to Solid State Physics, C. Kittel, 8th edition, 2004, Wiley India Pvt. Ltd.
2) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
3) Introduction to Solids, L. V. Azaroff, 2004, Tata Mc-Graw Hill
4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
5) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Superconductivity: A very short introduction, S. J. Blundell, Audiobook

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method)
2) To measure the magnetic susceptibility of solids
3) To determine the coupling coefficient of a piezoelectric crystal
4) To study the dielectric response of materials with frequency
5) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique
6) To determine the refractive index of a dielectric layer using SPR technique
7) To study the PE Hysteresis loop of a ferroelectric crystal
8) To draw the BH curve of iron (Fe) using a Solenoid and determine the energy loss from hysteresis loop
9) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150^{o} C) by four-probe method and determine its band gap
10) To determine the Hall coefficient of a semiconductor sample
11) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size
12) Measurement of change in resistance of a semiconductor with magnetic field.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
3) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5) Practical Physics, G. L. Squires, 4th edition, 2015
6) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16a: MATHEMATICAL PHYSICS II

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Mathematical Physics II PHYSICS DSE 16a	4	3	1	0	Class XII pass with Physics and Mathematics as main subjects	Mathematics as DSC course containing linear algebra and calculus

LEARNING OBJECTIVES

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. The mathematical tools might be building blocks to understand the fundamental computational physics skills and hence enable them to solve a wide range of physics problems. Overall, to help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Understand Complex Analysis
- Understand algebraic structures in n-dimension and basic properties of the linear vector spaces.
- Apply vector spaces and matrices in the quantum world.
- Learn Fourier Transforms (FTs)

SYLLABUS OF PHYSICS DSE 16a

THEORY COMPONENT

Unit – I **(20 Hours)**

Complex Analysis: Introduction to complex variables, Functions of Complex variable, limit, continuity, Analytic functions, Cauchy-Riemann equations, singular points, Cauchy Integral Theorem, Cauchy's Integral Formula, Residues, Cauchy's residue theorem, application of contour integration in solving real integrals.

Unit – II **(15 Hours)**

Linear Algebra: Linear Vector Spaces, Inner Product of Vectors and Norm of a Vector, Euclidean spaces, unitary spaces and inner product spaces. Properties of inner product spaces, Cauchy-Schwartz inequality, concept of length and distance, metric spaces. Orthogonality of vectors, orthonormal basis. Eigenvalue and Eigenvector, Adjoint of a linear operator, Hermitian or Self adjoint operators and their properties and Unitary Operators. Hilbert Space (Definition only).

Unit – III **(10 Hours)**

Fourier Transforms (FTs): Fourier Integral Theorem. Sine and Cosine Transforms. Properties of FTs: (1) FTs of Derivatives of Functions, (2) Change of Scale Theorem, (3) FTs of Complex Conjugates of Functions, (4) Shifting Theorem, (5) Modulation Theorem, (6) Convolution Theorems, and (7) Parseval's Identity.

References:

Essential Readings:

1) Complex Variables and Applications, J. W. Brown and R. V. Churchill, 9th edition, 2021, Tata McGraw-Hill
2) Mathematical Tools for Physics, J. Nearing, 2010, Dover Publications
3) Theory and Problems of Linear Algebra, S. Lipschutz, 1987, McGraco-Hill Inc.
4) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
5) Introduction to Matrices & Linear Transformations, D. T. Finkbeiner, 1978, Dover Pub.
6) Matrices and tensors in Physics: A.W. Joshi, 2017, New Age International Pvt.
7) Mathematical Methods in the Physical Sciences, M. L. Boas, 3rd edition, 2007, Wiley India.
8) Advanced Engineering Mathematics, E. Kreyszig, 2008, Wiley India.

Additional Readings:

1) Elementary Linear Algebra, Applications Version, H. Anton and C. Rorres, Wiley Student edition.
2) Mathematics for Physicists, S. M. Lea, 2004, Thomson Brooks/Cole
3) An Introduction to Linear Algebra and Tensors, M. A. Akivis, V. V. Goldberg, Richard and Silverman, 2012, Dover Publications

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16b: COMMUNICATION SYSTEM

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Communication System PHYSICS DSE 16b	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of digital and analog electronics

LEARNING OBJECTIVES

This paper aims to describe the fundamental concepts of communication systems and communication techniques based on analog modulation, analog and digital pulse modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

LEARNING OUTCOMES

At the end of this course, students will be able to

- Understand fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- In the laboratory course, students will apply the theoretical concepts to gain hands-on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

SYLLABUS OF PHYSICS DSE 16b

THEORY COMPONENT

Unit – I - Electronic communication and analog modulation (8 Hours)

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system, channels and base-band signals

Analog Modulation: Amplitude modulation, modulation index and frequency spectrum. Generation of AM (emitter modulation), amplitude demodulation (diode detector), Single sideband (SSB) systems, advantages of SSB transmission, frequency modulation (FM) and phase modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

Unit – II - Analog Pulse Modulation (4 Hours)
Sampling theorem, basic principles - PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing)

Unit – III - Digital Pulse Modulation (10 Hours)
Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding, concept of amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), and binary phase shift keying (BPSK)

Unit – IV - Satellite Communication and Mobile Telephony system (8 Hours)
Satellite communication: Need for satellite communication, geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), uplink and downlink, Ground and earth stations
Mobile Telephony System: Concept of cell sectoring and cell splitting, SIM number, IMEI number, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset.

References:
Essential Readings:

1) Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2) Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3) Electronic Communication systems, G. Kennedy, 3rd edition, 1999, Tata McGraw Hill.
4) Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5) Modern Digital and Analog Communication Systems, B. P. Lathi, 4th edition, 2011, Oxford University Press.
6) Communication Systems, S. Haykin, 2006, Wiley India
7) Wireless communications, A. Goldsmith, 2015, Cambridge University Press

Additional Readings:

1) Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
2) Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
3) Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To design an amplitude modulator using transistor
2) To design envelope detector for demodulation of AM signal
3) To study FM - generator and detector circuit
4) To study AM transmitter and receiver
5) To study FM transmitter and receiver
6) To study time division multiplexing (TDM)

7) To design pulse amplitude modulator using transistor.
8) To design pulse width modulator using 555 timer IC.
9) To design pulse position modulator using 555 timer IC
10) To study ASK, PSK and FSK modulators and demodulators

References for laboratory work:

1) Electronic Communication system, Blake, Cengage, 5th edition
2) Introduction to Communication systems, U. Madhow, 1st edition, 2018, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16c: LASER PHYSICS AND ITS APPLICATIONS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Laser Physics and its Applications PHYSICS DSE 16c	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Waves and optics paper of this course or its equivalent. Basic idea of energy levels in atoms and molecules

LEARNING OBJECTIVES

Laser physics is a branch of optics that covers the fundamental and applied aspects of laser science. Laser is an acronym for 'Light Amplification by Stimulated Emission of Radiation'. This radiation has some specific properties different from the common light. The main objective of this course is to introduce the basic principle of its production, its types, the different kinds and techniques of laser devices and applications of laser in various fields including research, high energy applications, medical applications, industrial applications, and nuclear science. Also to perform experiments and to measure some physical quantities based on the experiments using lasers.

LEARNING OUTCOMES

After completing this course, students should be able to,

- Understand the nature of interaction of radiation with matter in the form of absorption of light, spontaneous and stimulated emission of radiation.
- Understand the principle of laser action, including population inversion, metastable states, gain medium, optical pumping, feedback mechanism and threshold condition for laser beam generation
- Understand the various types of lasers such as three and four-level lasers
- Understand various characteristic properties of lasers and how they are utilized in different applications
- Know the importance of lasers in holography and in fibre optics
- Perform some experiments based on the laser technique and to be able to measure some quantities through these experiments

SYLLABUS OF PHYSICS DSE 16c

THEORY COMPONENT

Unit 1 – Introduction **(12 Hours)**

Planck's theory of radiation (qualitative idea), energy levels, absorption process, spontaneous and stimulated emission processes, theory of laser action, population inversion, Einstein's A and B coefficients of transition, optical pumping, optical amplification, threshold for laser oscillation, line shape function (various line broadening mechanisms: collisional broadening, natural broadening, Doppler broadening), coherence (temporal and spatial type, role of coherence in laser action), optical resonator (different configurations and stability condition)

Unit 2 – Types of Laser **(8 Hours)**
Doped insulator laser (Nd:YAG laser, Ruby laser)
Semiconductor lasers (GaAs laser): Energy bands and carrier distribution in semiconductors, absorption and emission in a semiconductor, optical gain, laser oscillation, threshold current density, power output
Gas lasers: He-Ne laser, noble gas ion laser, carbon dioxide laser

Unit 3 – Applications of Laser **(10 Hours)**
Properties of laser light: Mono-chromaticity, directionality, line width, beam coherence, intensity, focussing
Applications: Measurement of distance (interferometry method, beam modulation telemetry), Holography (basic principle, coherence, recording and reconstruction method, white light reflection hologram, application in microscopy and character recognition), medical applications, laser tweezers, high energy applications, industrial applications, laser induced nuclear fusion

References:
Essential Readings:
1) Laser Physics, M. Sargent, M. O. Scully and W. E. Lamb Jr., 1974, Western Press
2) Laser Physics and Spectroscopy, P. N. Ghosh, 2016, Levant Books, India
3) Lasers: Fundametnals and applications, K. Thyagarajan and A. K. Ghatak, 2010, Tata McGraw Hill
4) Optical systems and processes, J. Shamir, 2009, PHI Learning Pvt. Ltd.
5) Fundamental of optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand and Co. Publications
6) Optics, E. Hecht, 4th edition, 2014, Pearson Education
7) Laser applications, M. Ross, 1968, McGraw Hill

Additional Readings:
1) Physics for scientists and engineers with modern physics, Jewett and Serway, 2010, Cengage Learning
2) Optical Physics, A. Lispon, S. G. Lipson and H. Lipson, 4th edition, 1996, Cambridge University Press
3) Fibre optics through experiments, M. R. Shenoy, S. K. Khijwania, et.al. 2009, Viva Books
4) Industrial applications of lasers, J. F. Ready, 2nd edition, 1997, Academic Press
5) Semiconductor optoelectronics, J. Singh, 1995, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To determine the wavelength and angular spread of laser light by using plane diffraction grating.
2) To determine the wavelength of laser source using diffraction of single slit.
3) To determine the wavelength of laser source using diffraction of double slits.

4) To determine the grating radial spacing of the compact disc by reflection using He-Ne or solid state laser.
5) To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
6) To find the polarization angle of laser light using polarizer and analyser
7) To measure the numerical aperture of an optical fibre
8) To study the variation of the bending loss in a multimode fibre
9) To study thermal expansion of quartz using laser
10) To study the characteristics of solid state laser

References for laboratory work:

1) Advanced Practical Physics for students: B. L. Flint and H. T. Worsnop, Asia Publishing
2) Optoelectronics: An introduction, 3rd edition, 1998, Pearson Education
3) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16d: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology PHYSICS DSE 16d	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Basic ICT related skills

LEARNING OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be sufficiently trained in the following.

- Skills to review literature and frame research problem
- Comprehend the relevance of the tools for data collection and analysis
- Writing a scientific report/research proposal
- Software tools for research in physical sciences
- Research integrity and publication ethics
- Importance of intellectual property rights
- Role of funding agencies in research

SYLLABUS OF Physics DSE 16d

THEORY COMPONENT

Unit - I - Introduction to research methodology (6 Hours)

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation (15 Hours)

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);

Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)
Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)
Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)
Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)
Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

References:
Essential Readings:

1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings:

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and M. H. Davis, 2000, West Group Publishers

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)
Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:

1) Identify a research problem, write its brief summary and make a corresponding flow chart
2) Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3) Write a literature review for a research problem.
4) Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:

1) Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2) Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3) Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:

1) Review any three research papers.
    a) List the major strengths and weakness of all of them.
    b) For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2) Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:

1) Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2) Write a scientific synopsis of a research paper using LaTeX.
3) Create a presentation using LaTeX and Beamer on any research topic
4) Select a funding agency and any two schemes or fellowships offered by them. Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

Category II

Physical Science Courses (with Electronics)
with Physics and Electronics discipline as Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 10: SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Solid State Physics PHYSICS DSC 10	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Understanding of basic concepts of Physics

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and its planes
- Understand the elementary lattice dynamics and its influence on the properties of materials
- Understanding about origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

SYLLABUS OF PHYSICS DSC – 10

THEORY COMPONENT

Unit – I - Crystal Structure (10 Hours)

Solids: amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit cell, types of lattices, Miller indices, reciprocal lattice, Ewald's construction (geometrical approach), Brillouin zones, diffraction of X-rays by crystals. Bragg's law

Unit – II - Elementary Lattice Dynamics (6 Hours)

Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustical and optical phonons, Dulong and Petit's law, qualitative discussion of Einstein and Debye theories, T^3 law.

Unit – III - Elementary Band Theory (5 Hours)

Qualitative understanding of Kronig and Penny model (without derivation) and formation of bands in solids, concept of effective mass, Hall effect in semiconductor, Hall coefficient, application of Hall effect, basic introduction to superconductivity

Unit – IV - Magnetic Properties of Matter (6 Hours)

dia-, para-, and ferro- magnetic materials, classical Langevin theory of dia– and para-magnetism (no quantum mechanical treatment), qualitative discussion about Weiss's theory of ferromagnetism and formation of ferromagnetic domains, B-H curve hysteresis and energy loss

Unit – V - Dielectric Properties of Materials (3 Hours)

Polarization, local electric field in solids, electric susceptibility, polarizability, Clausius Mossoti equation, qualitative discussion about ferroelectricity and PE hysteresis loop

References:

Essential Readings:

1) Introduction to Solid State Physics, C. Kittel, 8^{th} edition, 2004, Wiley India Pvt. Ltd.
2) Elements of Solid-State Physics, J. P. Srivastava, 2^{nd} edition, 2006, Prentice-Hall of India
3) Introduction to Solids, L. V. Azaroff, 2004, Tata Mc-Graw Hill
4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
5) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Superconductivity: A Very short Introduction – Stephen J Blundell - Audiobook

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method)
2) To measure the magnetic susceptibility of solids
3) To determine the coupling coefficient of a piezoelectric crystal
4) To study the dielectric response of materials with frequency
5) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique
6) To determine the refractive index of a dielectric layer using SPR technique
7) To study the PE Hysteresis loop of a ferroelectric crystal
8) To draw the BH curve of iron (Fe) using a solenoid and determine the energy loss from hysteresis loop
9) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150^{o} C) by four-probe method and determine its band gap
10) To determine the Hall coefficient of a semiconductor sample
11) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size

12) Measurement of change in resistance of a semiconductor with magnetic field.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
3) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5) Practical Physics, G. L. Squires, 4th edition, 2015
6) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 13: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology PHYSICS DSE 13	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Basic ICT related skills

LEARNING OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be trained in the following.

- Skills to review literature and frame research problem
- Comprehend the relevance of the tools for data collection and analysis
- Writing a scientific report/research proposal
- Software tools for research in physical sciences
- Research integrity and publication ethics
- Importance of intellectual property rights
- Role of funding agencies in research

SYLLABUS OF Physics DSE - 13

THEORY COMPONENT

Unit - I - Introduction to research methodology (6 Hours)

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation (15 Hours)

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);

Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)
Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)
Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)
Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)
Basic concepts and types of intellectual property (patent, copyright and trademark); Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

References:
Essential Readings:
1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings:

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and M. H. Davis, 2000, West Group Publishers

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)
Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:
1) Identify a research problem, write its brief summary and make a corresponding flow chart
2) Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3) Write a literature review for a research problem.
4) Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:
1) Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2) Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3) Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:
1) Review any three research papers.
    a) List the major strengths and weakness of all of them.
    b) For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2) Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:
1) Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2) Write a scientific synopsis of a research paper using LaTeX.
3) Create a presentation using LaTeX and Beamer on any research topic
4) Select a funding agency and any two schemes or fellowships offered by them. Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 14: VERILOG AND FPGA BASED SYSTEM DESIGN

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Verilog and FPGA based System Design Physics DSE 14	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of digital electronics

LEARNING OBJECTIVES

This course trains the students to use VLSI design methodologies and simulate simple digital systems. Students will understand the HDL design flow and the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. The emphasis of this course is to enhance the understanding of Programmable Logic Devices so as to implement the Digital Designs on FPGAs using Verilog HDL

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Write synthesizable Verilog code.
- Write a Verilog test bench to test Digital Logic Design.
- Design and simulate digital circuits using Verilog modules.
- Understand various types of programmable logic building blocks such as PAL, PLA, CPLDs and FPGAs and their trade-offs.
- Design and implement digital systems on programmable logic device FPGA using Verilog HDL.

SYLLABUS OF PHYSICS DSE 14

THEORY COMPONENT

Unit – I **(20 Hours)**

Introduction to Verilog: Introduction to HDL, importance of HDL, popularity of Verilog HDL, design flow, structure of HDL module, Verilog modules (design and stimulus), introduction to language elements - keywords, identifiers, white space, comments, format, integers, real and strings, logic values, data types, scalars and vector nets, parameters, system tasks, compiler directives

Gate level modelling: Introduction, built in primitive gates, buffers, multiple input gates, gate delays.

Data flow modelling: Continuous assignment, net declaration assignments, net delays, operator types and operators precedence

Behavioral modelling: Always and initial constructs, procedural assignment (blocking and non-blocking statements), If-else, case statements, loop structures (while, for, repeat and forever), sequential and parallel Blocks

Modelling of combinational and sequential digital circuits using different levels of abstraction

Hierarchical modelling concepts: Design methodologies, design a 4-bit adder using four 1-bit full adders

Unit – II **(10 Hours)**

Look up Tables: 2-input, 3-input and 4-input LUTs, Implement logic functions with LUT, advantages and disadvantages of lookup tables

Programmable Logic Devices: Difference between PAL and PLA, Realize simple logic functions using PAL and PLA, CPLD and FPGA architectures, types of FPGA, logic cell structure, programmable interconnects, logic blocks and I/O Ports, placement and routing, applications of FPGAs

References:

Essential Readings:

1) Verilog HDL. Pearson Education, S. Palnitkar, 2nd edition, 2003
2) FPGA Based System Design. W. Wolf, Pearson Education
3) Digital Signal processing, S. K. Mitra, 1998, McGraw Hill
4) VLSI design, D. P. Das, 2nd edition, 2015, Oxford University Press.
5) Digital Signal Processing with FPGAs, U. Meyer Baese, Springer, 2004

Additional Readings:

1) Fundamentals of Digital Logic with Verilog Design, S. B. Zvonko Vranesic, 2016, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Session on how to write the design module and test benches using required software and simulate the combinational and sequential circuits.
- Sessions on how to configure FPGA using Verilog HDL for the final implementation of the logic design.

At least six experiments to be performed from the following list

1) Half adder, Full Adder using basic and derived gates.
2) Half subtractor and Full Subtractor using basic and derived gates.
3) Design and simulate 4-bit Adder using Data Flow Modeling.
4) Multiplexer (4x1) and Demultiplexer(1X4) using Data Flow Modeling.
5) Decoder and Encoder using case structure/gates.
6) Clocked D, JK and T Flip flops (with Reset inputs)
7) 4-bit Synchronous up/downCounter
8) To design and study switching circuits (LED blink shift)
9) To interface LCD using FPGA
10) To interface a multiplexed seven segment display.
11) To interface a stepper motor and DC motor.

References for laboratory work:

1) Digital System Designs and Practices: Using Verilog HDL and FPGAs, Ming-Bo Lin, Wiley India Pvt Ltd.

2) Verilog Digital System Design, Z. Navabi, 2nd edition, TMH
3) Designing Digital Computer Systems with Verilog, D. J. Laja and S. Sapatnekar, 2015, Cambridge University Press
4) Verilog HDL primer, J. Bhasker. BSP, 2nd edition, 2003

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15: PHOTONIC DEVICES AND POWER ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Photonic Devices and Power Electronics Physics DSE 15	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Analog electronics

LEARNING OBJECTIVES

This paper aims to provide students with in-depth understanding of the principles, concepts, and applications of photonic devices and power electronics. The course covers a range of topics, including, semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications. Students will develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems. The course also emphasizes the practical aspects of device design, fabrication, and characterization, preparing students for real-world challenges and opportunities in these fields.

LEARNING OUTCOMES

Upon completion of the course on Photonic Devices and Power Electronics, students are expected to achieve the following learning outcomes.

- Understand the basic principles and concepts of photonic devices and power electronics, including semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications.
- Develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems.
- Gain practical experience in device design, fabrication, and characterization.
- Apply the knowledge and skills learned in the course to real-world challenges and opportunities in the fields of photonics and power electronics.
- Develop problem-solving skills, critical thinking skills, and the ability to apply scientific and engineering principles to practical problems.
- Understand the ethical considerations and professional responsibilities associated with the development and use of photonic and power electronic devices and systems.
- Overall, students will gain a comprehensive understanding of photonic devices and power electronics and be well-equipped to pursue careers in these fields or continue their studies at the graduate level.

SYLLABUS OF PHYSICS DSE 15

THEORY COMPONENT

Unit – I **(4 Hours)**

Classification of photonic devices: Radiative transition and optical absorption. Light Emitting Diodes (Construction, materials and operation)

Semiconductor LASER: Condition for amplification, laser cavity, LASER diode.

Unit – II **(8 Hours)**
Photodetectors: Photoconductor, photodiodes (p-i-n, avalanche) and photo transistors, quantum efficiency and responsivity
Solar Cell: Construction, working and characteristics.
LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays.

Unit – III **(4 Hours)**
Introduction to Fiber Optics: Element of an Optical Fiber Transmission link- Optical Fiber Modes and Configurations, Overview of Modes -Single Mode Fibers-Graded Index fiber structure.

Unit – IV **(8 Hours)**
Power Devices: Need for semiconductor power devices, Power MOSFET (qualitative); introduction to family of thyristors; Silicon Controlled Rectifier (SCR) - structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Gate-triggering circuits; DIAC and TRIAC- Basic structure, working and V-I characteristics
Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics, switching characteristics, device limitations and safe operating area (SOA)

Unit – V **(6 Hours)**
Applications of SCR: Phase controlled rectification, AC voltage control using SCR and Triac as a switch. Power Invertors- Need for commutating circuits and their various types, dc link invertors, Parallel capacitor commutated invertors.

References:
Essential Readings:

1) Optoelectronics, J. Wilson and J. F. B. Hawkes, 1996, Prentice Hall India
2) Optoelectronics and Photonics, S. O. Kasap, 2009, Pearson Education
3) Electronic Devices and Circuits, D. A. Bell, 2015, Oxford University Press
4) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press
5) Power Electronics, M. D. Singh and K. B. Khanchandani, Tata McGraw Hill.

Additional Readings:

1) Power Electronics, J. S. Chitode, Technical Publications
2) Basic Electrical and Electronics Engineering, R. Saravanakumar V. Jegathesan and K. V. Kumar, Wiley
3) Power Electronics: Essentials & Applications, L. Umanand, Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)
At least six experiments to be performed from the following list

1) Diffraction experiments using a LASER.
2) To determine characteristics of (a) LEDs, (b) Photovoltaic cell and (c) Photodiode.
3) To study the Characteristics of LDR and Photodiode with (i) Variable Illumination

intensity, and (ii) Linear Displacement of source.
4) To measure the numerical aperture of an optical fiber.
5) Output and transfer characteristics of a power MOSFET.
6) Study of I-V characteristics of SCR.
7) SCR as a half wave and full wave rectifier with R and R - L loads.
8) AC voltage controller using TRIAC with UJT triggering.
9) Study of I-V characteristics of DIAC.
10) Study of I-V characteristics of TRIAC

References for laboratory work:

1) Power Electronics, P. C. Sen, Tata McGraw Hill.
2) Power Electronics Circuits, Devices & Applications, 3rd edition, M. H. Rashid, Pearson Education
3) A Textbook of Electrical Technology, Vol-II, B. L. Thareja and A. K. Thareja, S. Chand.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16: ANTENNA THEORY AND WIRELESS NETWORK

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Antenna Theory and Wireless Network Physics DSE 16	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of digital and analog electronics and communication systems

LEARNING OBJECTIVES

This course gives an overview of wireless communication elements and networks. Students will develop an understanding of basics of antenna, its various parameters, its usage as a transmitter and receiver. Cellular concept and system design fundamentals are described and the evolution of current wireless systems in real world such as 2G, 3G, 4G and LTE networks is discussed.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes.

- Identify basic antenna parameter (radiating wire structures).
- Determine directions of maximum signal radiations and the nulls in the radiation patterns.
- Design array antenna systems from specifications.
- Identify the characteristics of radio-wave propagation.
- Identify wireless networks 4G and LTE, and 5G.
- Design cellular systems

SYLLABUS OF PHYSICS DSE 16

THEORY COMPONENT

Unit – I **(14 Hours)**

ANTENNA THEORY

Introduction: Antenna as an element of wireless communication system, antenna radiation mechanism, types of antennas, fundamentals of EMFT: Maxwell's equations and their applications to antennas

Antenna Parameters: Antenna parameters: Radiation pattern (polarization patterns, field and phase patterns), field regions around antenna, radiation parameters (general idea): intensity, beam width, gain, directivity, polarization, bandwidth, efficiency and antenna temperature

Unit – II **(5 Hours)**

Antenna as a transmitter/receiver: Effective height and aperture, power delivered to antenna, input impedance, general idea of radiation from an infinitesimal small current element and radiation from an elementary dipole (Hertzian dipole)

Unit – III **(5 Hours)**

WIRELESS NETWORKS:
Introduction: General idea of cellular and wireless systems, current wireless systems, examples of wireless communication systems, idea about global mobile communication system

Unit – IV **(3 Hours)**
Modern wireless communication systems: General idea 2G,3G and wi-fi, 4G and LTE, and 5G wireless networks, wireless local area networks (WLANs), bluetooth and personal area networks (PANs).

Unit – V **(3 Hours)**
Cellular Concept and System Design Fundamentals: Cellular concept and cellular system fundamentals, cellular systems design considerations (qualitative idea only)

References:
Essential Readings:

1) Antenna Theory, Ballanis, 2nd edition, 2003, John Wiley & Sons
2) Electro Magnetic Waves and Radiating Systems, Jordan and Balmain, E. C., 3rd edition, 1968, Reprint (2003), PHI
3) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, 2014, Cambridge University Press
4) Wireless communication and Networks, U. Dalal, 2015, Oxford University Press.
5) Mobile Communication Design and Fundamentals, Lee, William C.Y., 4th edition, 1999

Additional Readings:

1) Wireless communications, A. Goldsmith, 2015, Cambridge University Press
2) Modern Wireless Communication, H. S. and M. M. Pearson, 3rd edition, 2005

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Study of simple dipole and folded dipole (l/2) antenna, plot and compare the radiation pattern of both antennas.
2) Study of simple dipole 5 element Yagi-UDA and folded dipole 5 element Yagi Uda antenna, plot and compare the radiation pattern of both antennas
3) Study of loop antenna and slot antennas and plot their radiation patterns
4) Study the radiation pattern of ground plane antenna and observe the difference in radiation pattern with single element rod, detector and reflector rods
5) To study the variation of radiated field with distance from transmitting antenna.
6) To study modulation of sine wave on RF transmitted and observe the demodulated wave on detector receiver
7) Study of the reciprocity theorem for antennas
8) Study the role of matching stub in antenna transmission.
9) To study working of current sensor and measurement of current in various elements of antenna.
10) To study and measure SWR using various types of antennas.
11) To study different parts of a 4G Volte mobile phone and observe constellation diagram

for transmitter and receiver IQ signals

12) To study various types of faults in a 4G volte mobile phone.

References for laboratory work:

1) Antenna Theory, Ballanis, 2nd edition, 2003, John Wiley & Sons
2) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, 2014, Cambridge University Press
3) Mobile Communication Design and Fundamentals, Lee, William C.Y., 4th edition, 1999

UNIVERSITY OF DELHI

CNC-II/093/1(28)/2023-24/283

Dated: 08.11.2023

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1-6/-(6) dated 09.06.2023 and 27-1-1/-(7) dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-IV, V and VI of the following Programmes of Department of Chemistry under Faculty of Science based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23 :

(i) BSc. (Hons.) Chemistry

(ii) BSc. (Physical Science) with Chemistry as one of Core Discipline

(iii) BSc. (Life Science) with Chemistry as one of the Core Discipline

(iv) BSc. (Industrial Chemistry) – Chemistry Component

(v) BSc (Hons.) Applied Life Sciences with Agrochemicals and Pest Management.

DEPARTMENT OF CHEMISTRY

SEMESTER IV

B Sc. (Hons) Chemistry

DISCIPLINE SPECIFIC CORE COURSE - 10(DSC-10): Coordination Chemistry and Reaction Mechanism

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Coordination Chemistry and Reaction Mechanism (DSC-10: Inorganic Chemistry - IV)	04	03	--	01	Class 12^{th} with Physics, Chemistry, Mathematics	--

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with coordination compounds which find manifold applications in diverse areas.
- To acquaint the student with the concept of Inorganic reaction mechanism.

Learning Outcomes

By studying this course, the students will be able to:

- Explain the terms- ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds.
- Discuss the various types of isomerism possible in such compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.

- Explain the meaning of the terms Δ_o, Δ_t, pairing energy, CFSE, high spin and low spin complexes and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on the basis of Crystal Field Theory.
- Explain the reaction mechanism of coordination compounds and differentiate between kinetic and thermodynamic stability.

SYLLABUS OF DSC-10

Unit-1: Coordination Chemistry **(Hours: 28)**

Werner's Coordination theory, simple problems based on this theory

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds (coordination numbers 4 and 6). Valence bond theory and its application to complexes of coordination numbers 4 and 6.

Crystal field theory, measurement of Δ_o. Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δ_o. Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry: Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory (for octahedral σ-donor, π- acceptor and π- donor complexes).

Unit-2: Stability of complexes and Inorganic Reaction Mechanism: **(Hours: 17)**

Brief discussion of thermodynamic and kinetic stability, Factors affecting stability of complexes, such as chelate effect, macrocyclic effect, resonance effect etc., trends in step wise formation constant, interpretation of lability and inertness based on VBT and CFT.

Introduction to inorganic reaction mechanisms, concept of reaction pathways, transition state, intermediate and activated complex. Substitution reactions in square planar complexes, factors affecting the rate of Substitution reactions in square planar complexes- such as charge effect, solvent effect and Trans- effect (Theories of trans-effect).

Practical component
Practical: **Credits: 01**
(Laboratory periods: 15 classes of 2 hours each)

(A) Argentometry

Estimation of Cl^-

(i) By Mohr's method

(ii) By Vohlard's method and

(iii) By Fajan's method

(B) Complexometric Titrations:

(i) Complexometric estimation of Mg^{2+}/ Zn^{2+} using EDTA

(ii) Estimation of total hardness of water samples

(iii) Estimation of Ca^{2+} in solution by substitution method

(iv) Estimation of Ca/Mg in drugs or biological samples**.**

(C) Properties of Complexes

Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, dimethyl glyoxime, glycine) by substitution method.

Essential/recommended readings

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, Fifth Edition, Pearson.
3. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
4. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry,** John Wiley & Sons.
5. Cotton, F.A.; Wilkinson, G.(1999), **Advanced Inorganic Chemistry,** Wiley-VCH.
6. Sodhi G.S. (2018), **Principles of Inorganic Chemistry,** Viva Books India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis,** John Wiley and Sons,
2. Harris, D. C.; Lucy, C. A. (2016), **Quantitative Chemical Analysis,** 9th Edition, Freeman and Company.
3. Day, R. A.; Underwood, A. L. (2012), **Quantitative Analysis**, Sixth Edition, PHI Learning Private Limited.
4. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE -11 (DSC-11): Carbohydrates, Lipids and Heterocyclic Compounds

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Carbohydrates, Lipids and Hetero cyclic Compounds (DSC-11, Organic Chemistry IV)	04	03	--	01	Class 12th with Physics, Chemistry	--

Learning Objectives

The Objectives of this course are as follows:

- To familiarize students with the chemistry of carbohydrates, lipids, and heterocyclic compounds
- To enable students to develop novel, efficient, convenient, selective and environmentally benign synthetic methods for synthesis of heterocyclic compounds.

Learning outcomes

By studying this course, the students will be able to:

- Describe uses and applications carbohydrates, lipids and heterocycles
- Use the knowledge gained from study of carbohydrates, lipids and heterocycles to propose greener and better synthetic routes.
- Use the chemistry and biology of carbohydrates, lipids and heterocycles to better serve the mankind.

SYLLABUS OF DSC-11

Unit-1: Carbohydrates & Lipids (Hours: 24)

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projection and conformational structures; Interconversion of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Linkage between monosaccharides: Comparative study of the structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch, cellulose and glycogen) excluding their structure elucidation. Reactions of disaccharides-reducing property, hydrolysis, methylation and acetylation.
Lipids: Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3&6 fatty acids, trans fats, hydrogenation, hydrolysis, acid value, saponification value, iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

Unit-2: Heterocyclic Compounds (Hours:21)

Classification and nomenclature of heterocyclic compounds (containing only one hetero atom). Structure, aromaticity in 5-membered and 6-membered rings containing one heteroatom; Basicity and relative reactivity towards electrophilic substitution reactions (amongst five membered and six membered rings.

General methods of synthesis for: furan, thiophene, pyrrole (Paal-Knorr synthesis, Hantzsch synthesis), pyridine (Hantzsch synthesis), indole (Fischer Indole synthesis), quinoline (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis)

Properties: Physical properties, discussion on the following reaction (with mechanism) for furan, pyrrole, thiophene, pyridine, indole and quinoline: Electrophilic substitution- nitration, sulphonation, halogenation, formylation, acylation, mercuration and carboxylation. Oxidation, reduction, addition, reactions showing acidic /basic character, reaction with diazonium salts, ring opening, ring expansion and nucleophilic substitution reaction wherever applicable should be discussed.

Practical: Credits: 01
(Laboratory periods: 15 classes of 2 hours each)

1. Estimation of sugars by using Fehling solution.
2. Functional group tests for amine, nitro and amides.
3. Determination of saponification value of the given oil.
4. Determination of iodine number of the given oil.
5. Systematic qualitative analysis of the given organic compounds containing monofunctional groups (carboxylic acids, carbonyl compounds, carbohydrates and esters) and preparation of one suitable derivative.

Essential/recommended readings

Theory:

1. Berg, J.M., Tymoczko, J.L., Stryer, L. (2019), **Biochemistry**, 9^{th} Edition W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), **Principles of Biochemistry**. W.H. Freeman and Co., International Edition.
3. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7^{th} Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
4. Parashar, R.K., Negi, B. (2016) **Chemistry of Heterocyclic Compounds**, Ane Books Pvt Ltd.
5. Kuashik, S., Singh, A. (2023), **Biomolecules: From Genes to Proteins**, I^{st} Edition, Berlin, Boston: De Gruyter.
6. Finar, I.L., (2012), **Organic Chemistry** Volume 1, 6^{th} Edition, Pearson Education.
7. Singh J, Awasthi S K, Singh J, **Fundamentals of Organic Chemistry**, Pragati Prakashan Meerut.

Practical:

1. Vogel, A.I. (2012), **Quantitative Organic Analysis**, Part 3, Pearson Education.
2. Mann, F.G., Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
4. Ahluwalia, V.K., Aggarwal, R. (2004), **Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis**, University Press
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–I**, I K International Publishing house Pvt. Ltd, New Delhi
6. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–II**, I K International Publishing house Pvt. Ltd, New Delhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-12 (DSC-12): Electrochemical Cells, Chemical Kinetics and Catalysis

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Electrochemical Cells, Chemical Kinetics and Catalysis (DSC-12, Physical Chemistry IV)	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry, Mathematics**	**--**

Learning Objectives

The Objectives of this course are as follows:

- To provide a detailed understanding about galvanic cells and their types
- To explain the applications of galvanic cells and EMF measurements.
- To get an understanding of the kinetics of simple and complex chemical reactions
- To give basic concept about catalysts and enzymes.
- To teach the working of potentiometer and different electrodes for performing potentiometric titrations
- To explain the experimental study of kinetics of simple reactions

Learning outcomes

By studying this course, the students will be able to:

- Explain the working of electrochemical cells and different types of galvanic cell.
- Devise a spontaneous galvanic cell using various combinations of half-cells.
- Understand the concept of concentration cell
- Use the appropriate galvanic cell to measure pH, calculate thermodynamic parameters and perform potentiometric titrations.
- Write rate law and derive rate equations for simple and complex reactions and understanding of theories of reaction rates.
- Understand different types of catalysts and mechanism of enzyme catalysis.
- Perform potentiometric titrations using appropriate electrodes for quantitative analysis.
- Set up experiments to study the kinetics of simple reactions.

SYLLABUS OF DSC-12

Unit-1: Electrochemical Cells **(Hours: 21)**

Rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). Structure of electric double layer (qualitative aspects only).

Unit-2: Chemical Kinetics **(Hours: 18)**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods for determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates, introduction to electrode kinetics (qualitative aspects only).

Unit-3: Catalysis: **(Hours: 6)**

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Practical: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

(A) Potentiometry:

Perform the following potentiometric titrations:

1. Strong acid vs. strong base
2. Weak acid vs. strong base
3. Dibasic acid vs. strong base
4. Mixture of strong and weak acid vs strong base
5. Potassium dichromate vs. Mohr's salt

(B) Chemical Kinetics:

Study the kinetics of the following reactions

1. Iodide-persulphate reaction by Initial rate method
2. Acid hydrolysis of methyl acetate with hydrochloric acid.
3. Saponification of ethyl acetate by conductometric measurements.

Suggested experiments

1. To study the kinetics of Iodide-persulphate reaction using integrated rate method.
2. Comparison of the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Essential/recommended readings
Theory:

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry Ed**., 10th Edition, Oxford University Press.
2. Ball, D. W. (2017), **Physical Chemistry,** 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 3, 6th Edition, McGraw Hill Education.
5. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 5, 3rd Edition, McGraw Hill Education.
6. Laidler K.J. (2003), **Chemical Kinetics**, 3rd Edition, Pearson Education India.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-V

BSC. (HONS.) CHEMISTRY

DISCIPLINE SPECIFIC CORE COURSE -13 (DSC-13): Basics of Organometallic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basics of Organometallic Chemistry (DSC-13)-Inorganic Chemistry-V	04	03	--	01	Class 12^{th} with Physics, Chemistry, Mathematics	-

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with the interactions of metal atom with organic molecules (or not so typical organic molecule), which is in an entirely different fashion as compared to coordination compounds.
- To familiarize the students with the structure and bonding in organometallic compounds
- To familiarize the student with how organometallic compounds can act as good catalysts for organic transformations and hencehave industrial importance associated with medicines, bioorganic synthesis, and energy production.

Learning Outcomes

By studying this course, the students will be able to:

- Identify and classify organometallic compounds of different types.
- Explain the stability of organometallic compounds and hence the requirement of special experimental conditions for their synthesis.
- Explain the bonding modes through VBT and MOT in these compounds.
- Explain the chemical nature of these compounds through various reactions thus acquiring skills to understand their applications.
- Explain the mechanism of catalysis by these compounds. This may prepare the student to predict the catalytic pathways for new reactions

SYLLABUS OF DSC-13

Unit-1: Introduction to Organometallic Chemistry (Hours: 6)

Definition, brief history, classification of organometallic compounds on the basis of bond type. Common notation used in organometallic chemistry, concept of hapticity of organic ligands, importance of organometallic chemistry, organometallic compounds as reagents, additives, and catalysts. Introduction to the 18-electron rule or effective atomic number rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series and finding metal-metal bonds.

Unit-2: Structure and Bonding in Organometallic Compounds (Hours : 12)

Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. Molecular orbital theory applied to organometallic compounds, description of bonding of two electron ligands to transition metals. π-acceptor behavior of CO (MO diagram of CO to be discussed), π-bonding of CO with metal (synergic effect) and use of IR data to explain extent of back bonding, bonding modes of CO, symmetry of metal carbonyls.

Bonding between metal atoms and organic π- systems: linear (ethylene, allyl, butadiene) and cyclic (cyclopentadiene, benzene), Zeise's salt and comparison of synergic effect with that in carbonyls.

Metal alkyls and Metal-carbene complexes

Unit-3: Synthesis, Reactions and Applications of Organometallic Compounds (Hours: 16)

General methods of synthesis of metal carbonyls: direct carbonylation, reductive carbonylation, thermal and photochemical decomposition, of mono and binuclear carbonyls of 3d series.

Reaction of metal carbonyls: reduction, oxidation, photochemical substitution, migratory insertion of carbonyls, and nucleophilic addition of CO.

Synthesis of metal-alkene complexes through ligand addition, reduction and substitution and reaction of metal bound alkenes, Zeise's salt

Metal–sandwich compounds**:** Ferrocene: synthesis, physical properties and reactions: acylation, sulfonation, alkylation metallation, acetylation, chloromercuration, Mannich reaction, comparison of aromaticity and reactivity of ferrocene with that of benzene.

Synthesis and reactions of Metal alkyls and Metal-carbenes

Unit-4: Catalysis by Organometallic Compounds (Hours: 11)

General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis. (Catalytic steps, examples and industrial applications), deactivation and regeneration of catalysts, (catalytic poisons and promoter).

Organometallic catalysis of the following reactions of commercial importance and their mechanism:

1. Alkene hydrogenation (using Wilkinson's Catalyst)
2. Synthetic gasoline preparation (Fischer Tropsch reaction)
3. Polymerisation of ethene using Ziegler-Natta catalyst
4. Wacker oxidation process (Smidth process)
5. Hydroformylation reaction (Oxo-process)
6. Monsanto Acetic Acid process

Theoretical aspects of enlisted practicals are also to be included in the theory paper.

Practical component

Practical: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. To study and compare the UV-Vis spectrum of ferrocene (in methanol or acetonitrile) and potassium ferrocyanide (in water).
2. To study the cyclic voltammogram of ferrocene.
3. Preparation of Bis(acetylacetonato)copper(II) complex and characterisation through UV-Visible spectrum of its aqueous solution..
4. Preparation of tris(acetylacetonato)manganese(III) complex.
5. Preparation of Potassium tris(oxalato)ferrate(III) complex.
6. Preparation of Tetraamminecopper(II) sulphate monohydrate complex.
7. Preparation of Pentaamminechloridocobalt(III) chloride.
8. Preparation of Hexaamminecobalt(III) chloride
9. Determination of number of chloride ions in ionisation sphere to confirm the formula of complexes prepared in (6) and (7) through potentiometric titration or conductance measurements. (See reference 5 & 6 of Practicals)
10. Compare and interpret the visible spectrum of complexes prepared in (6) and (7) for shifts in wavelength maxima.

Any other organometallic compounds synthesised from time to time may also be included.

Essential/recommended readings

Theory:

1. Gary L Miesler, Paul J Ficsher, and Donald A Tarr, **Inorganic Chemistry** 5th Edition , Pearson.
2. Shriver & Atkins **Inorganic Chemistry,** Edn V, W.H. Freeman and Company.
3. F.A. Cotton & G. Wilkinson, Advanced Inorganic Chemistry, 5th Edition.
4. William W. Porterfield, Inorganic Chemistry, Ist Edition.
5. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
6. Principles of Organometallic Chemistry by M.L.H Green, Coward, G.E Coates and K.Wade 3rd Edition.
7. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
8. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
9. Gupta, B. D., Elias, A. J., (2013) **Basic Organometallic Chemistry: Concepts, Syntheses and Applications,** 2nd Edition, Universities Press.

Practicals:

1. ChemTexts (2020) 6:22, https://doi.org/10.1007/s40828-020-00119-6
2. J. Chem Education: 1971, Volume 48(2), 133
3. Front. Chem. Sci. Eng. 2013, 7(3): 329–337, DOI 10.1007/s11705-013-1339-0
4. Orbital: Electron. J. Chem. 2019, 11 (6): 348-354

6. Vogel’s text book of quantitative chemical analysis. Edn V

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE - 14 (DSC-14): Nucleic Acids, Amino Acids, Proteins and Enzymes

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nucleic Acids, Amino Acids, Proteins and Enzymes (DSC-14, Organic Chemistry- V)	**04**	**02**	**--**	**02**	Class 12th with Physics, Chemistry	**--**

Learning Objectives

The objectives of this course are as follows:

- To familiarize students with the fascinating chemistry and biology of biomolecules, *i.e.*, nucleic acids and proteins etc..
- To develop the interest of students in the basic concepts of heredity, which are imparted through replication, transcription, and translation processes.
- To discuss basic fundamentals of enzyme action and inhibition, which forms the basis of drug action.

Learning outcomes

By studying this course, the students will be able to:

- Demonstrate how structure of biomolecules determines their reactivity and biological role.
- Gain insight into concepts of heredity through the study of genetic code, replication, transcription, and translation
- Demonstrate basic understanding of enzyme action and role of inhibitors
- Use knowledge gained to solve real world problems.

SYLLABUS OF DSC-14

Unit-1: Nucleic Acids **(Hours: 8)**

Structure of components of nucleic acids: Bases, Sugars, Nucleosides and Nucleotides. Nomenclature of nucleosides and nucleotides, structure of polynucleotides (DNA and RNA) and factors stabilizing them, biological roles of DNA and RNA; Concept of heredity: Genetic Code, Replication, Transcription and Translation.

Unit-2: Amino Acids, Peptides and Proteins (Hours: 14)

Amino acids and their classification; α-amino acids - Synthesis, ionic properties, and reactions. zwitterions, pKa values, isoelectric point, and electrophoresis; Study of peptides: determination of their primary structure-end group analysis; Synthesis of peptides using N-protecting, C-protecting and C-activating groups, Solid-phase synthesis; Overview of primary, secondary and tertiary structures of proteins, protein denaturation.

Unit-3: Enzymes (Hours: 8)

Introduction, classification, and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as an example), factors affecting enzyme action, coenzymes, and cofactors (including ATP, NAD, FAD), specificity of enzyme action (including stereospecificity). Enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive, and non-competitive inhibition including allosteric inhibition).

Practical component
Practical: Credits: 02
(Laboratory periods: 15 classes of 4 hours each)

1. Study of the titration curve of glycine.
2. Estimation of glycine by Sorenson Formol Titration
3. Qualitative analysis of proteins- Ninhydrin test, Biuret test, Millon's reagent test, Xanthoproteic test.
4. Estimation of proteins by Lowry's method.
5. Study of the action of salivary amylase on starch at room temperature.
6. Effect of temperature on the action of salivary amylase.
7. Effect of pH on the action of salivary amylase
8. Study the inhibition of α-Amylase by copper sulphate
9. Isolation and estimation of DNA using cauliflower/onion.

Essential/recommended readings

Theory:

1. Berg, J.M., Tymoczko, J.L., Stryer, L. (2019), **Biochemistry**, Nineth Edition W.H. Freeman and Co.
2. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), **Principles of Biochemistry**. W.H. Freeman and Co., International Edition.
3. Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2009), **Harper's Illustrated Biochemistry**. Lange Medical Books/McGraw-Hill.
4. Brown, T.A. (2018), **Biochemistry**, (First Indian Edition) Viva Books.
5. Kuashik, S., Singh, A. (2023), **Biomolecules: From Genes to Proteins**, First Edition, Berlin, Boston: De Gruyter.
6. Voet, D., Voet, J.G. (2010), **Biochemistry**, Fourth Edition, Wiley.

7. Singh J, Awasthi S K, Singh J, **Fundamentals of Organic Chemistry**, Pragati Prakashan Meerut.

Additional Resources:

1. Finar, I.L. (2008), **Organic Chemistry**, Volume 2, Fifth Edition, Pearson Education.
2. Bruice, P.Y. (2020), **Organic Chemistry,** Egighth Edition, Pearson Education.

Practicals:

1. **Manual of Biochemistry Workshop** (2012), Department of Chemistry, University of Delhi.
2. Kumar, A., Garg, S., Garg, N. (2015), **Biochemical Tests: Principles and Protocols**. Viva Books.
3. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–II**, I K International Publishing house Pvt. Ltd, New Delhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE-15 (DSC-15): Quantum Chemistry and Organic Chemistry IV Covalent bonding

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Quantum Chemistry and Covalent bonding (DSC-15, Physical Chemistry V)	**04**	**03**	**--**	**01**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning objectives

The objectives of this course are as follows:

- To make students understand the limitations of classical mechanics and the need of quantum chemistry
- To familiarize the students with the postulates of quantum chemistry
- To explain how to apply the postulates to derive equations for various models and extend to hydrogen atom and hydrogen like atoms.
- To explain the valence bond and molecular orbital theories and their applications to simple molecules
- To explain the use of some computational software

Learning outcomes

By studying this course, students will be able to:

- Explain the limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.
- Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle
- Set up Schrodinger equations for different types of systems
- Explain the concept of covalent bonding based on valence bond theory and molecular orbital theory.
- Perform calculations using different software and plot different wavefunctions and probability distribution curves.
- Perform simple calculations using appropriate quantum mechanical methods in different computational software

SYLLABUS OF DSC-15

Unit-1: Quantum Chemistry **(Hours: 22)**

Postulates of quantum mechanics, quantum mechanical operators and commutation rules, Schrödinger equation and its application to free particle and particle in a box rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three- dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation in Cartesian and spherical polar coordinates (derivation not required). Separation of variables. Spherical harmonics. Discussion of solution (Qualitative).

Unit-2: Hydrogen atom (Hours: 08)

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Zeeman effect, Introduction of spin quantum number and magnetic spin quantum number Setting up of Schrödinger equation for many electron atoms (He, Li), Indistinguishability of electrons and Pauli exclusion principle, Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Unit-3: Covalent bonding (Hours: 15)

Setting up of Schrödinger equation, Born-Openheimer approximation, LCAO-MO treatment of H_2^+ and its qualitative extension to H_2, Valence bond (VB) treatment of H_2, Comparison of LCAO-MO and VB wave functions of H_2 and their refinements, Qualitative description of LCAO-MO of homonuclear and heteronuclear diatomic molecules-HF and LiH.

Practical component

Practical: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Plot the radial wavefunctions and probability distribution for H atom's 1s, 2s, 2p orbital using software like EXCEL.
2. Using a software such as ArgusLab, plot HOMO, LUMO and ESP maps of various molecules.
3. Draw probability plots for a particle in a 1-dimensional box for different values of quantum number n - commenting on the number of points of zero probability and then correlate them with the correspondence principle.
4. Plot the electron density contour maps of sigma molecular orbitals for diatomic homonuclear molecules.
5. Plotting of the wave function and probability curve for simple harmonic motion and interpret the results for first two levels.

6. Plotting energy as a function of distance for simple harmonic motion - parabolic curve.
7. Using software such as ArgusLab calculate properties such as dipole moment and Mulliken charges using quantum mechanical methods.

Note: Any other suitable software may also be used .

Essential/recommended readings

Theory:

1. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
2. House, J.E. (2004), **Fundamentals of Quantum Chemistry**, 2nd Edition, Elsevier.
3. McQuarrie, D.A. (2016), **Quantum Chemistry**, Viva Books.
4. Chandra, A. K. (2001), **Introductory Quantum Chemistry**, Tata McGraw-Hill.
5. House, J.E. (2004), **Fundamentals of Quantum Chemistry**, 2nd Edition, Elsevier

Suggested Readings

1. Atkins, P.W.; Friedman, R. (2010), **Molecular Quantum Mechanics**, 5th Edition, Oxford University Press.

Practical:

1. McQuarrie, D. A. **Mathematics for Physical Chemistry** University Science Books (2008).
2. Mortimer, R. **Mathematics for Physical Chemistry**. 3rd Ed. Elsevier (2005).
3. Steiner, E**. The Chemical Maths Book** Oxford University Press (1996).
4. Yates, P. **Chemical Calculations**. 2nd Ed. CRC Press (2007).
5. Levie, R. de, **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press (2001) 487 pages.
6. Noggle, J. H. **Physical Chemistry on a Microcomputer**. Little Brown & Co. (1985).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-VI

BSC. (HONS.) CHEMISTRY

DISCIPLINE SPECIFIC CORE COURSE -16 (DSC-16): Principles in Qualitative Analysis and Bioinorganic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Principles in Qualitative Analysis and Bioinorganic Chemistry (DSC-16: Inorganic Chemistry -VI)	**04**	**02**	**--**	**02**	Class 12th with Physics, Chemistry, Mathematics	**--**

Learning Objectives

The Objectives of this course are as follows:

- To discuss the principles of qualitative analysis
- To understand the concept of solubility products and the common ion effect on the separation of cations.
- To discuss the importance of metal ions in biological systems.
- To discuss the applications of iron in physiology, including iron transport and storage.

Learning Outcomes:

By the end of the course, the students will be able to:

- Explain the basic principles of qualitative inorganic analysis.
- Discuss the influence of solubility products and the common ion effect on the separation of cations.
- Discuss the identification of interfering anions and their removal.
- Explain and discuss the importance of metal ions in biological systems, through discussions on
  metal-containing enzymes, the sodium-potassium pump.
- Discuss the applications of iron in physiology, including iron transport and storage system.

Unit-1: Theoretical Principles in Qualitative Analysis (Hours: 12)

Basic principles involved in analysis of cations and anions. Solubility product, common-ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate), need to remove them after Group II and methods of removal. Analysis of insoluble substances.

Unit-2: Bioinorganic Chemistry (Hours: 18)

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / potassium pump, conduction of nerve impulses, Ca-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine, Cisplatin as an anti-cancer drug.

Iron and its application in bio-systems, Haemoglobin, Myoglobin, cytochrome-C-oxidase ; Storage and transfer of iron.

Practical: Credits: 02

(Laboratory periods: 15 classes of 4 hours each)

(A) Qualitative semi-micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}

(B) Mixtures should preferably contain one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of anions e.g. CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, $Cl^-$and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot tests should be done whenever possible.

Essential/recommended readings

1. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**,7th Edition, Prentice Hall.
2. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O. K. (2009), **Inorganic Chemistry Principles of Structure and Reactivity**, Pearson Education.
3. Lippard, S.J.; Berg, J.M. (1994), **Principles of Bioinorganic Chemistry**, Panima Publishing Company.
4. *Biological Inorganic Chemistry* by **RR Crichton** in additional books
5. *Bioinorganic Chemistry- Inorganic Elements in the Chemistry of Life: An Introduction and Guide*, 2nd Edition by **Wolfgang Kaim, Brigitte Schwederski, Alex Klein**
6. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), 5th Edition, Oxford University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 17 (DSC-17): Polynuclear Hydrocarbons, Photochemistry, Pericyclic Reactions, and Spectroscopy of Organic Compounds

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Polynuclear Hydrocarbons, Photochemistry, Pericyclic Reactions, and Spectroscopy of Organic Compounds (DSC-17, Organic Chemistry-VI)	04	03	--	01	Class 12th with Physics, Chemistry	-

Learning objectives

The objectives of this course are as follows:

- To provide thorough knowledge of the chemistry of polynuclear hydrocarbons .
- To detail the basic principles and applications of pericyclic reactions and photochemistry
- To familiarize students with the various tools and techniques for identifying and characterizing the organic compounds through their interactions with electromagnetic radiations *viz.* UV-Visible, IR and NMR spectroscopy.

Learning outcomes

By studying this course, students will be able to:

- Discuss and use the chemistry of polynuclear hydrocarbons for application in real world problems.
- Discuss and use the pericyclic reactions and photochemistry for research and other applications.
- Use spectroscopic techniques to determine structure and stereochemistry of known and unknown compounds.

SYLLABUS OF DSC-17

Unit-1: Polynuclear Hydrocarbons **(Hours: 6)**

Introduction, classification, structure, nomenclature and uses. Aromaticity of polynuclear hydrocarbons, structure elucidation of Naphthalene and general methods of preparation of naphthalene and anthracene (including Haworth method, Friedel Craft acylation, Diels Alder reaction, Elbs reaction). Relative reactivity of naphthalene and anthracene in comparison to benzene.

Discussion on the following reactions (with mechanism) for Naphthalene and Anthracene: Addition reactions, Oxidation, Electrophilic substitution- Friedel Craft reaction, Chloromethylation, Halogenation, Formylation, Nitration and sulphonation. Reduction reaction and Diels Alder reaction.

Unit-2: **Photochemistry and Pericyclic reactions** **(Hours: 12)**

Photochemistry

Introduction and basic principles of photochemistry, photochemical energy, photolytic cleavage, photochemistry of carbonyl compounds (Norrish type 1, Norrish type 2 and Peterno Buchi reactions)

Pericyclic Reactions

Introduction: Types of pericyclic reactions (Electrocyclic, Cycloaddition and Sigmatropic Rearrangements), Symmetry in σ and π molecular orbitals, Frontier Molecular Orbitals.

Electrocyclic Reactions: Conrotatory and Disrotatory motion in ring opening and ring closing reactions in (4n) and (4n+2) π electron systems, FMO method, Woodward Hoffmann rule.

Cycloaddition Reactions: [2+2] and [4+2] π cycloaddition reactions, Diels Alder reaction (electron rich and electron poor dienes and dienophiles, Stereochemistry, Alder rule of endo addition).

Sigmatropic Reactions: [1,3], [1,5] and [3,3] sigmatropic rearrangements, Cope rearrangement, Claisen Rearrangements.

Unit-3: **Spectroscopy of Organic Compounds (Hours: 27)**

UV-Visible Spectroscopy: Types of electronic transitions, λ_{max}, chromophores and Auxochromes, bathochromic and hypsochromic shifts, intensity of absorption, factors affecting λ_{max} values, application of Woodward Rules for calculation of λ_{max} for the following systems: α, β-unsaturated aldehydes, ketones, carboxylic acids and esters; conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between *cis* and *trans* isomers by UV; Colour concept, Theory of colour and constitution-Witt's theory, valence bond and molecular orbital theory.

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorption positions of O and N containing functional groups; effect of H-bonding, conjugation, resonance and ring size on IR absorptions; fingerprint region and its significance, application of IR in functional group analysis.

^{1}H-NMR Spectroscopy: Basic principles of proton magnetic resonance, chemical shift and factors, influencing it; equivalent and non-equivalent protons (chemical and magnetic equivalence), Spin–Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics. Interpretation of NMR spectra of simple compounds containing AX, AX_2, AX_3, A_2X_3 spin systems, special case of 1-nitropropane.

Applications of IR, UV and ^{1}H-NMR Spectroscopy for identification of simple organic compounds (spectra to be provided for some representative compounds).

Practical component

Practical: Credits: 01

(Laboratory periods: 15 classes of 2 hours each)

1. Systematic qualitative analysis of the given organic compounds containing monofunctional groups (Aryl halides, nitro compounds, amines and amides) and simple

bifunctional compounds like salicylic acid, cinnamic acid, *p*-nitro phenol etc. and preparation of one suitable crystalline derivative.

2. Differentiation between of *o*-/*p*-hydroxybenzaldehyde by IR spectroscopy (Spectra to be provided).
3. Differentiation between of benzoic acid and cinnamic acid by UV spectroscopy (Spectra to be provided).

Essential/recommended readings

Theory:

1. Morrison, R. N., Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
2. Finar, I.L. **Organic Chemistry** Volume 1, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
3. Finar, I.L. **Organic Chemistry** Volume 2, Dorling Kindersley (India) Pvt. Ltd., Pearson Education.
4. Solomons, T.W.G., Fryhle, C.B.; Snyder, S.A. (2017), **Organic Chemistry**, 12th Edition, Wiley.
5. Silverstein R.M. (2005), **Spectrometric Identification of organic compounds**, 7th edition, John Wiley and Sons,
6. Kemp W. (2019), **Organic Spectroscopy**, Third Edition, MacMillan.
7. Pavia, D. (2015), **Introduction to Spectroscopy**, Fifth Edition, Cengage Learning India Pvt. Learning.
8. Scheinmann, F., **Introduction to spectroscopic methods for identification of organic compounds**, Volume 2, Pergamon Press.
9. Ahluwalia, V.K., Parashar, R.K. (2011), **Organic Reaction Mechanisms**, 4th Edition, Narosa Publishing House.
10. Horspool, W.M. (1976) **Aspects of Organic Photochemistry**, Academic Press.
11. Singh J, Awasthi S K, Singh J, **Fundamentals of Organic Chemistry**, Pragati Prakashan Meerut.

Practical:

1. Vogel, A.I. (2012), **Quantitative Organic Analysis**, Part 3, Pearson Education.
2. Mann, F.G., Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.
3. Furniss, B.S., Hannaford, A.J., Smith, P.W.G., Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Fifth Edition, Pearson.
4. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
5. Ahluwalia, V.K., Aggarwal, R. (2004), **Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis**, University Press
6. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–I**, I K International Publishing house Pvt. Ltd, New Delhi
7. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–II**, I K International Publishing house Pvt. Ltd, New Delhi

DISCIPLINE SPECIFIC CORE COURSE-18 (DSC-18): Photochemistry and Spectroscopy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Photochemistry and Spectroscopy (DSC-18, Physical Chemistry VI)	04	02	-	02	Class XII with Physics, Chemistry and Mathematics	

Learning Objectives:

The Learning Objectives of this course are as follows:

- To make students understand the laws of photochemistry and their applications
- To understand the basis of molecular spectroscopy
- To study different types of spectroscopic techniques and their applications

Learning Outcomes:

By studying this course, students will be able to:

- Explain low and high quantum yield
- Explain photosensitized reactions
- Apply the concept of quantization to spectroscopy.
- Interpret various types of spectra and know about their application in structure elucidation

SYLLABUS OF DSC-18

Unit-1: Introduction to Molecular Spectroscopy and Photochemistry (Hours: 6)

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.

Characteristics of electromagnetic radiation. Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitized reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

Unit-2: Rotational, Vibrational , Raman and Electronic Spectroscopy (Hours: 14)

Rotational spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic molecules, isotopic substitution, classification of molecules based on moment of inertia, applications of rotation spectroscopy (e.g. microwave appliances)

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy

Franck-Condon principle, electronic transitions, singlet and triplet states, Jablonski diagrams, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Unit-3: NMR and ESR (Hours: 10)

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales (δ and T), spin-spin coupling and high resolution spectra, interpretation of PMR spectra of simple organic molecules like methanol, ethanol and acetaldehyde.

Principles of ESR spectroscopy, hyperfine structures, ESR of simple radicals

Practical component

Practical: Credits: 02

(Laboratory periods: 15 classes of 4 hours each)

(A) Colorimetry :

1. Verify Lambert-Beer's law and determine the concentration of (i) $CuSO_4$ (ii) $KMnO_4$ (iii) $K_2Cr_2O_7$ in a solution of unknown concentration

2. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenathroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide

(B) UV/Visible spectroscopy:

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2- propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

(C) Analysis of the given vibration-rotation spectrum of HCl(g)

Essential/recommended readings

Theory:

1. Banwell, C.N.; McCash, E.M. (2006), **Fundamentals of Molecular Spectroscopy**, Tata McGraw- Hill.
2. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, McGraw Hill Education, Vol 4, 5th Edition, McGraw Hill Education.
3. Kakkar, R. (2015), **Atomic & Molecular Spectroscopy**, Cambridge University Press.

Suggested Readings:

1. Engel, T.; Reid, P. (2013), **Quantum Chemistry and Spectroscopy**, Pearson

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
2. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York
3. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

POOL OF DSE FOR III/IV/V/VI SEMESTER

DISCIPLINE SPECIFIC ELECTIVE COURSE - 1 (DSE-1): Inorganic Materials of Industrial Importance

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Inorganic Materials of Industrial Importance (DSE-1)	**04**	**03**	**--**	**01**	Class 12th with Physics, Chemistry	**--**

Learning Objectives

The objectives of this course are as follows:

- To make students understand the diverse roles of inorganic materials in the industry and to give an insight into how these raw materials are converted into products used in day-to-day life.
- To make students learn about silicates, fertilizers, surface coatings, batteries, engineering materials for mechanical construction.
- To develop the interest of students in the frontier areas of inorganic and material chemistry.

Learning outcomes

By studying this course, the students will be able to:

- State the composition and applications of the different kinds of glass.
- State the composition of cement and discuss the mechanism of setting of cement.
- Defend the suitability of fertilizers for different kinds of crops and soil.
- Explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings.
- Describe the principle, working and applications of different batteries.
- Evaluate the synthesis and properties of nano-dimensional materials, various semiconductor and superconductor oxides.

SYLLABUS OF DSE-1

Unit 1: Silicate Industries **(6 Hours**

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

Unit 2: Fertilizers **(6 Hours)**

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime and potassium nitrate.

Unit 3: Surface Coatings **(18 Hours**

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC)and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing.

Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.

Unit 4: Batteries **(9 Hours)**

Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Li-ion batteries, Li-polymer batteries, solid state electrolyte batteries, fuel cells, solar cells and polymer cells.

Unit 5: Nano dimensional materials **(6 Hours)**

Introduction to zero, one and two-dimensional nanomaterial: Synthesis, properties and applications of fullerenes, carbon nanotubes, carbon fibres, semiconducting and superconducting oxides.

Practical component

Practicals: **Credits:**

01 (Laboratory periods:15 classes of 2 hours each)

(At least four experiments to be performed)

1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.

2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.

3. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.

4. Analysis of (Cu, Ni) in alloy or synthetic samples (methods involving Gravimetry and Spectrophotometry).

5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, and Potentiometry).

6. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

7. Synthesis of silver nanoparticles by green and chemical approach methods and its characterization using UV-visible spectrophotometer

Essential/recommended readings

Theory:

1. West, A. R. (2014),**Solid State Chemistry and Its Application**, Wiley
2. Smart, L. E.; Moore, E. A. (2012),**Solid State Chemistry An Introduction**, CRC Press Taylor & Francis.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010),**Shriver and Atkins Inorganic Chemistry**, W. H. Freeman and Company.
4. Kent, J. A. (ed) (1997), **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
5. Poole Jr.; Charles P.; Owens, Frank J.(2003), **Introduction to Nanotechnology**, John Wiley and Sons.

Practical:

1. Svehla, G.(1996),**Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
2. Banewicz, J. J.; Kenner, C.T. **Determination of Calcium and Magnesium in Limestones and Dolomites**, Anal. Chem., 1952, 24 (7), 1186–1187.
3. Ghorbani, H. R.; Mehr, F.P.; Pazoki, H.; Rahmani B. M. **Synthesis of ZnO Nanoparticles by Precipitation Method.** Orient J Chem 2015;31(2).
4. Orbaek, W.; McHale, M.M.; Barron, A.R. **Synthesis and characterization of silver nanoparticles for an undergraduate laboratory**, J. Chem. Educ. 2015, 92, 339−344.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 2 (DSE-2): Green Chemistry in Organic Synthesis

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Green Chemistry in Organic Synthesis (DSE-2)	04	03	--	01	Class 12^{th} with Physics, Chemistry	Basic knowledge of organic reactions

Learning objectives

The objectives of this course are as follows:

- To create awareness about the chemistry that is not harmful for human health and the environment.
- To provide thorough knowledge of the green chemistry principles that can be used to develop chemistry in greener way.
- To familiarize students with new remediation technologies for the cleaning up of hazardous substances.
- To use green chemistry for boosting profits, increase productivity and ensure sustainability with absolute zero waste.
- To learn about innovations and applications of green chemistry in education that helps companies to gain environmental benefits as well as to achieve economic and societal goals also
- The objective of the practical component is to develop basic skills to be able to design, develop and run chemical processes in a sustainable way.

Learning outcomes

By studying this course, students will be able to:

- List the twelve principles of green chemistry and build the basic understanding of toxicity, hazard and risk related to chemical substances.
- Calculate atom economy, E-factor and relate them in all organic synthesis
- State the uses of catalyst over stoichiometric reagents
- Debate and use green solvents, renewable feedstock, and renewable energy sources for carrying out safer chemistry
- Use green chemistry for problem solving, innovation and finding solutions to environmental problems.

- Design safer processes, chemicals, and products through understanding of inherently safer design (ISD)
- Discuss the success stories and use real-world cases to practice green chemistry

SYLLABUS OF DSE-2

UNIT – 1: Introduction **(3 Hours**

Introduction to Green Chemistry, some important environmental laws, pollution prevention Act of 1990, emergence of green chemistry, need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry. Green chemistry in sustainable development.

UNIT – 2: Application of Green Chemistry Principles **(36 Hours**

Principles of Green Chemistry and designing a chemical synthesis
Concept familiarization and application of green chemistry principles using specific examples

1. Prevention of waste/ by products; waste or pollution prevention hierarchy
2. Green metrics to assess greenness of a reaction: Calculation of atom economy of the rearrangement, addition, substitution, and elimination reactions; calculation of E-factor for industrial processes
3. Prevention/ minimization of hazardous/ toxic products
4. Safer Solvent and Auxiliaries: Problems associated with conventional reaction media Some Common Green solvents: Introduction, application, advantages, and disadvantages of green solvents in organic synthesis (taking suitable examples). Special emphasis on the following:
   i. Super Critical Fluids (with special reference to carbon dioxide)
   ii. Water: Concept of In-water, and on-water reactions (with special reference to synthesis of terpinol and linalool in water, Benzoin condensation, Heck reaction)
   iii. Ionic Liquids: Physical properties and classification of Ionic Liquids (with special reference to Diels Alder reaction and Coumarin synthesis in ionic liquids)
   iv. Biomass derived Solvents: Physicochemical properties, Use of glycerol and its derivatives (Mizoroki–Heck reaction) and 2-methyltetrahydrofuran (Suzuki–Miyaura reaction).
5. Design for energy efficiency: Phenomenon of accelerating organic reactions by using the following Green Chemistry tools (taking suitable examples) and its advantages:
   i. Mechanochemistry
   ii. Ultrasound assisted reactions: Taking examples like Simmons Smith reaction, Diels–Alder reaction,
   iii. Microwave assisted reactions: Special emphasis on solvent-free synthesis- copper phthalocyanine and aspirin, In-water reactions-Hofmann Elimination, methyl benzoate to benzoic acid and Decarboxylation reaction;
   iv. Electrocatalysis: Taking examples like adiponitrile synthesis, synthesis of 3-bromothiophene.
   v. Visible light induced Reactions: with examples such as, syntheses of caprolactam and vitamin D_3, cis-trans isomerization of alkenes
6. Use of renewable starting materials: Illustrate with few examples such as biodiesel, bioethanol, polymers from renewable resources (PLA from corn), Synthesis and

properties of 2-Methyltetrahydrofuran, furfural and 5-Aminolevulinic acid (DALA) from levulinic acid

7. Avoidance of unnecessary derivatization – careful use of blocking/protecting groups (taking specific examples like selective oxidation of aldehydic group and synthesis of 6-Aminopenicillanic Acid (6-APA) from penicillin G
8. Catalysis and green chemistry
   Introduction to Catalysis (including concept of selectivity, turnover frequency and turnover number), Types of Catalysts: Heterogeneous catalysis and homogeneous catalysis (H-beta and zeolites in organic synthesis), General catalytic cycle for heterogeneous catalysis; Asymmetric catalysis (Monsanto route to L-dopa via asymmetric hydrogenation, synthesis of carbapenhem via Asymmetric reduction); Photocatalysis (with special reference to TiO_2); Biocatalysis (Synthesis of adipic acid/catechol using biocatalyst) and Nanocatalysis (oxazole synthesis using nanocatalyst)
9. Design for degradation: (Illustrate with the help of examples: soaps and detergents, pesticides, polymers)
10. Real Time monitoring of chemical processes using inline, offline, and online techniques
11. Inherently safer design/chemistry:
    Principle and subdivision of ISD, Bhopal Gas Tragedy (safer route to carbaryl) and Flixiborough accident (safer route to cyclohexanol, Asahi Process)

UNIT – 3: Industrial Applications and Success Stories (6 Hours)

- Vitamin C Synthesis using enzymes (Hoffman La Roche)
- Zoloft -Presidential Chemistry Award Winning Innovation (Pfizer)
- Methyl Methacrylate syngas process (Eastman Chemicals)
- Synthesis of herbicide disodium iminodiacetate
- Rightfit pigments azo dyes synthesis and their applications
- Healthier Fats and oils by Green Chemistry: Enzymatic Interesterification for production of No Trans-Fats and Oils.
- Synthesis of anti-tuberculosis drug Paramycin from waste water stream

Practical component Credits:

01 (Laboratory periods:15 classes of 2 hours each)

Note: Characterization by melting point, UV-Visible spectroscopy, IR spectroscopy and any other specific method should be done (wherever applicable).

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.
2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, solubility, combustion test, density, viscosity, gel formation at low temperature and IR can be provided).
3. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.
4. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.
5. Mechanochemical solvent free, solid-solid synthesis of azomethine using p-toluidine and o-vanillin/p-vanillin.
6. Microwave-assisted Knoevenagel reaction using anisaldehyde, ethylcyanoacetate and ammonium formate.

7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
8. Photochemical conversion of dimethyl maleate to dimethyl fumarate (cis-trans isomerisation)
9. Benzil- Benzilic acid rearrangement: Preparation of benzilic acid in solid state under solvent-free condition.
10. Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method.

Essential/recommended readings

Theory:

1. Anastas, P.T., Warner, J.C. (2014), **Green Chemistry, Theory and Practice**, Oxford University Press.
2. Lancaster, M. (2016), **Green Chemistry: An Introductory Text**, 3rd Edition, RSC Publishing.
3. Cann, M. C., Connely, M.E. (2000), **Real-World cases in Green Chemistry, American Chemical Society**, Washington.
4. Matlack, A.S. (2010), **Introduction to Green Chemistry**, 2nd Edition, Boca Raton: CRC Press/Taylor & Francis Group publisher.
5. Alhuwalia,V.K., Kidwai, M.R. (2005), **New Trends in Green chemistry**, Anamalaya Publishers.
6. Sidhwani, I.T, Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.

Practicals:

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.
2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
3. Pavia, D.L.; Lamponam, G.H.; Kriz, G.S.W. B. (2012), **Introduction to organic Laboratory Technique- A Microscale approach**, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry.
4. Sidhwani I.T. (2015), Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. **DU Journal of Undergraduate Research and Innovation**, 1(1),131-151. ISSN: 2395-2334.
5. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
6. **Monograph on Green Chemistry Laboratory Experiments**, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.
7. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–I**, I K International Publishing house Pvt. Ltd, New Delhi
8. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume–II**, I K International Publishing house Pvt. Ltd, New Delhi

DISCIPLINE SPECIFIC ELECTIVE COURSE -3(DSE-3): Solutions, Colligative properties, Phase Equilibria and adsorption

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Solutions, Colligative properties, Phase Equilibria and adsorption (DSE-3)	**04**	**03**	**-**	**01**	Class 12^{th} with Physics, Chemistry	

Learning Objectives

The Learning Objectives of this course are as follows:

- To make the students understand the various properties of dilute solutions.
- To make the students understand the thermodynamic basis of colligative properties.
- To explain the concept of phase, co-existence of phases, phase diagram for various types of system, CST and distribution law.
- To introduce the concept of adsorption, its dependence on various conditions and applications

Learning outcomes

By studying this course, students will be able to:

- Explain different types of phase equilibrium, draw a well labelled phase diagram.
- Predict the existence of a substance in a given phase under different conditions of temperature and pressure
- Apply the concepts of phase, solutions and distribution law while studying other chemistry courses and every-day life processes.
- Explain the type of adsorption that can take place in different systems and predict the conditions to get maximum adsorption.

SYLLABUS OF DSE-3

UNIT-1: Solutions and Colligative Properties **(12 Hours**

Dilute solutions; lowering of vapour pressure, Raoult's law, Henry's law. Thermodynamic basis of the colligative properties - lowering of vapour pressure, elevation of Boiling Point, Depression of Freezing point and Osmotic pressure and derivation of expressions for these using chemical potential. Application of colligative properties in calculating molar masses of normal, dissociated and associated solutes in solutions, van't Hoff factor and its applications. Concept of activity and activity coefficients.

UNIT-2: Phase Equilibria **(24 Hours)**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems (H_2O and S), with applications. A comparison between the phase diagram of CO_2 and H_2O. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions (excluding partial miscibility). Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), Konovalov's laws, azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.
Three component systems, water-chloroform-acetic acid system, triangular plots.

UNIT-3: Surface chemistry **(9 Hours**

Physical adsorption, chemisorption, adsorption isotherms (Langmuir and Freundlich). Nature of adsorbed state. Multilayer adsorption, BET equation derivation, thermodynamic treatment of adsorption-Gibbs equation.

Practical component Credit: 01
(Laboratory periods: 15 classes of 2 hours each)

Practical

Phase Equilibrium

1. Determination of critical solution temperature and composition at CST of the phenol water system
2. To study the effect of impurities of sodium chloride and succinic acid on the CST of phenol-water system.
3. To study the cooling curves for the following systems:
   (i) simple eutectic
   (ii) congruently melting systems.

Adsorption

Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Essential/recommended readings

Theory:

1. Peter, A.; Paula, J. de. (2011), **Physical Chemistry**, 9th Edition, Oxford University Press.
2. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
3. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 3, 6th Edition, McGraw Hill Education.
4. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol 5, 6th Edition, McGraw Hill Education.
5. Ball, D. W. (2017), **Physical Chemistry,** 2nd Edition, Cengage Learning, India.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
2. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Suggestive readings

1. Levine, I.N. (2010), **Physical Chemistry**, Tata Mc Graw Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -4 (DSE-4): Nuclear and Environmental Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nuclear and Environmental Chemistry (DSE-4)	**04**	**03**	**--**	**01**	Class 12th with Physics, Chemistry	**--**

Learning Objectives

The Objectives of this course are as follows:

- To make students know more about nuclear chemistry
- To familiarise the students about environmental chemistry, especially with respect to air and water

Learning outcomes

By studying this course, the students will be able to:

- Gain knowledge about Nuclear chemistry, radioactive decay, nuclear disasters, and nuclear waste and their disposal.
- Describe the composition of air, various air pollutants, effects and control measures of air pollutants.
- List different sources of water, water quality parameters, impacts of water pollution, water treatment.
- Identify different industrial effluents and their treatment methods.

SYLLABUS OF DSE-4

Unit-1 : Nuclear Chemistry **(21 Hours**

The nucleus: subatomic particles, e liquid drop model; forces in nucleus-mesons; stability of nucleus-n/p ratio, binding energy; radioactive elements.
Radioactive decay- α-decay, β-decay, γ-decay; neutron emission, positron emission; unit of radioactivity (curie); half life period; radioactive displacement law, radioactive series.
Measurement of radioactivity: ionization chamber, Geiger Counters, Scintillation counters.
Nuclear reactions: Nuclear fission-theory of nuclear fission; chain reaction; nuclear fusion; nuclear reactors-fast breeder reactors, fuels used in nuclear reactors, separation of isotopes, moderators, coolants; nuclear reactors in India.
Applications: Dating of rocks and minerals, carbon dating, neutron activation analysis, isotopic labeling studies, nuclear medicine- ^{99m}Tc radio pharmaceuticals.
Nuclear disasters – Chernobyl disaster, Three Mile Island Disaster, Disposal of nuclear waste and its management.

UNIT – 2: Air Pollution **(**12 Hours

Major regions of atmosphere, chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature, Major sources of air pollution, Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul-smelling gases, methods of estimation of CO, NO_x, SO_x and control procedures.

Chemistry and environment impact of the following: Photochemical smog, Greenhouse effect, Ozone depletion

Air pollution control, Settling Chambers, Venturi Scrubbers, Electrostatic Precipitators (ESPs).

UNIT – 3 : Water Pollution: **(12 Hours)**

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological cycle and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment).

Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion-exchange). Water quality parameters for wastewater, industrial water and domestic water.

Practical component
Practical: **Credits: 01**
(Laboratory periods:15 classes of 2 hours each)
(At least four experiments to be performed)

1. Determination of dissolved oxygen in a given sample of water.
2. Determination of Chemical Oxygen Demand (COD) in a given sample of water.
3. Determination of Biological Oxygen Demand (BOD) in a given sample of water.

4. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO$_3$ and potassium chromate).
5. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
6. Measurement of dissolved CO_2 in a given sample of water.
7. Determination of hexavalent Chromium Cr(VI) concentration in tannery wastes/ waste water sample using UV-Vis spectrophotometry technique.

Essential/recommended readings

Theory:

1. Stanley E. Manahan, 10th edition, **Environmental chemistry,** CRC Press, Taylor and Francis Group, US, 2017
2. Baird, C. and Cann, M., **Environmental Chemistry,**(2012), Fifth Edition, W. H. Freemann & Company, New York, US.
3. VanLoon, G.W. and Duffy, J.S.(2018) **Environmental Chemistry - A global perspective**, Fourth Edition, Oxford University Press
4. Brusseau, M.L.; Pepper,I.L. and Gerba, C., (2019) **Environmental and Pollution Science**, Third Edition, Academic Press.
5. Masters, G.M., (1974) **Introduction to Environmental Science and Technology**, John Wiley & Sons.
6. Masters, G.M., (2015) **Introduction to Environmental Engineering and Science.** JPrentice Hall India Learning Private Limited.
1. 7.Arnikar, H.J., (1987), Second Edition, **Essentials of Nuclear Chemistry,** Wiley Blackwell Publishers
7. Arnikar, H.J.; Rajurkar, N. S.,(2016) **Nuclear Chemistry through Problems,** New Age International Pvt. Ltd.
8. De, A.K.(2012), **Environmental Chemistry,** New Age International Pvt., Ltd.
9. Khopkar, S.M.(2010), **Environmental Pollution Analysis**, New Age International Publisher.
10. Das, A. K. (2010), ***Fundamentals of Inorganic Chemistry***, Volume 1, Second Edition, CBS Publishers & Distributors Pvt Ltd.
11. Das, A. K. (2012), ***Environment Chemistry with Green chemistry***, Books and Allied (P) Ltd.

Practical:

1. Vowles, P.D.; Connell, D.W. (1980), **Experiments in Environmental Chemistry: A Laboratory Manual**, Vol.4, Pergamon Series in Environmental Science.
2. Gopalan, R.; Anand, A.; Sugumar R.W. (2008), **A Laboratory Manual for Environmental Chemistry**, I. K. International.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5 (DSE-5): Reactions, Reagents and Chemical Process

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reactions, Reagents and Chemical Process (DSE-5)	04	03	--	01	Class 12th with Physics, Chemistry	Basic knowledge of organic reactions

Learning objectives

The objectives of this course are as follows:

- To study the important organic name and rearrangement reactions that are crucial for the synthesis of valuable organic compounds.
- To give the knowledge belonging to the role of reagents in organic reactions for the synthesis of chemo-, diastereo- and enantio-selective products.
- To impart the knowledge of process chemistry that is a key part of the large-scale synthesis of chemical products essential for day-to-day life

Learning outcomes

By studying this course, students will be able to:

- Explain the reaction mechanism of various name and rearrangement reactions
- Discuss the role of the reagents in organic synthesis and apply these reagents for the bulk chemical synthesis
- Debate and use oxidizing and reducing reagents for selective synthesis organic products
- Apply the learnt techniques to chemical processes
- Acquire skills for human resource building especially in the chemical industry.

SYLLABUS OF DSE-5

UNIT – 1: Name Reactions **(15 Hours)**

Application, scope and mechanism of following reactions: Prevost Reaction, Chugaev Reaction, Maukaiyama Aldol Reaction, Mozingo Reaction, Ramberg Backlund Reaction, Shapiro Reaction, Barbier Reaction, Clark- Eschweiler Reaction, Darzen's Reaction, Julia-Olifination Reaction, Tiffeneaus Damjanov Reaction, Darkin West Reaction, Bischler-Napieralaski Reaction, Birch reduction of aromatic compounds, Appel Reaction, Mitsunobu

Reaction, Corey Kim Oxidation, Azide-alkyne 1,3-dipolar cycloaddition reaction, Olefin metathesis: Grubbs reaction, Heck Reaction, Suzuki coupling and Wittig reaction.

UNIT – 2: Reducing Reagents (9 Hours)

Reactions, mechanism and applications of following reducing agents: Sodium borohydride, Lithium aluminium hydride, $NaBH_3CN$, DIBALH, lithium-tri-*tert*-butoxyaluminum hydride, Red-Al $Na[AlH_2(OCH_2OCH_2OCH_3)_2]$, Zinc borohydride, L and K selectrides, $LiBHEt_3$ and $KBHEt_3$, Luche Reagent $NaBH_4$-$CeCl_3$, $K[BH(OAc)_3]$, *bis*-Boric Acid (BBA), Catecholborane, DEMS (Diethoxymethylsilane), 3-Mercapto propionic acid, Polymethylhydrosiloxane (PMHS), Schwartz's Reagent (Zirconocene chloride hydride).

UNIT – 3: Oxidizing Reagents (9 Hours

Reactions, mechanism and applications of following oxidizing agents: Jones Reagent (CrO_3, H_2SO_4, H_2O), Swern Reagent (DMSO, oxalyl chloride), Dess Martin, TEMPO, TPAP (Tetrapropyl ammonium perruthenate), Fetizon's Reagent, Fenton's Reagent [H_2O_2 + Fe(II) ion], Sodium perborate NaH_2BO_4, Sodium Bismuthate $NaBiO_3$, ABNO (9-Azabicyclo[3.3.1]nonane N-oxyl), DEAP (Diethyl allyl phosphate, 

), AZADO (2-Azaadamantane N-oxyl], Wacker oxidation.

UNIT – 4: Process Chemistry (12 Hours)

1. Process chemistry a) Introduction, stages of scale up process: Bench, pilot, and large-scale process with at least two examples of scale up process of API. b) In-process control and validation of large-scale process.
2. Unit Processes: The following unit processes should be studied with mechanism and one example of each process Nitration: Nitrating agents, process equipment for technical nitration. Halogenation: Types of halogenations, catalytic halogenations. Reduction: Catalytic hydrogenation, hydrogen transfer reactions, metal hydrides. Oxidation: Types of oxidative reactions, and non-metallic oxidizing agents such as H, sodium hypochlorite, oxygen gas, ozonolysis.

Practical component Credits:

01 (Laboratory periods:15 classes of 2 hours each)

1. Oxidation of alcohols to acid using Jones reagent.
2. Reduction of acetophenone and its derivatives to 1-phenyl ethanol derivatives by $NaBH_4$.
3. Reduction of 4-tert-butyl-cyclohexanone to cis and trans 4-tert-butyl-cyclohexanol.
4. Synthesis of 2,5-dimethyl-2,5-hexanediol from tert-butanol using Fenton's reagents.
5. Wittig reaction of benzyltriphenylphosphonium chloride and 4-bromobenzaldehyde using potassium phosphate (tribasic).
6. Substitution (S_N2) reaction of 1-iodobutane and 2-naphthol.
7. Aldol condensation reaction: solventless synthesis of chalcones.
8. Borohydride reduction of a ketone: hydrobenzoin from benzil.
9. Visit to chemical industry of the demonstration of pilot scale.

Essential/recommended readings

Theory:

2. Clayden, J. Greeves, N., Warren, S. **Organic Chemistry**, South Asian Edition, Oxford University Press, USA
3. Gadamasetti K., **Process Chemistry in the Pharmaceutical Industry: Challenges in an Ever- Changing Climate-An Overview**, Vol-2, CRC Press, London.
4. Murphy R.M., **Introduction to Chemical Processes: Principles, Analysis, Synthesis**, McGraw-Hill Education, New York.
5. Harrington P. J., **Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale up**, John Wiley and Sons, Inc, New Jersey.
6. Parashar, R.K.; Ahluwalia, V.K. (2018), **Organic Reaction Mechanism,** 4th Edition, Narosa Publishing House.

Practical:

1. Mann F.G, Saunders, B.C., **Practical Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.
2. Vogel A.I., **Elementary Practical Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 6 (DSE- 6): Polymers, Colloids, Surfaces and Interfaces

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Polymers, Colloids, Surfaces and Interfaces (DSE- 6)	**04**	**03**	**--**	**01**	Class 12th with Physics, Chemistry	**--**

Learning Objectives

The objectives of this course are as follows:

- To give students a comprehensive coverage of important physical aspects of polymers chemistry, colloids, emulsions, surfaces and interfaces.
- to study the applications of these aspects.

Learning outcomes

By studying this course, the students will be able to:

- Explain the types of polymers, kinetics of polymerization and polymer properties.
- Understand and apply the concepts of properties of polymer solutions and their thermodynamics.
- Comprehend the basic concepts of surface chemistry specifically in relation to colloids.
- Have a thorough understanding of applications of colloids in various areas.

SYLLABUS OF DSE-6

UNIT 1: Introduction to polymers **(Hours: 6)**

Recapitulation of basic concepts of polymers. Types of polymerizations and their mechanism and kinetics: Free radical, ionic, step-growth, coordination, copolymerization. Polymerization techniques: Bulk, solution, suspension, and emulsion.

UNIT 2: Polymer solution **(Hours: 9)**

Polymer solution – solubility parameter, properties of dilute solutions and their criteria, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change. Flory Huggins theory.

UNIT 3: Introduction to Colloid Chemistry (Hours: 9)

Recapitulation of basic concepts of Adsorption, Distinction among true solutions, colloids and suspensions, Components of Colloids, classification of colloids - lyophilic, lyophobic; Preparation methods and properties of lyophobic solutions, Hydrophile-lyophile balance (HLB), multi molecular, macromolecular and associated colloids (micelles formation), preparation and properties of colloids - Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation; Charge on Colloidal particles and Electrical double layer concept, Suspensions and their characteristics, Emulsions and their characteristics.

UNIT 4: Surface chemistry in relation to colloids (Hours: 12)

Surface film on liquid surface, surface potential, monomolecular films, Langmuir Blodgett layers. Emulsions, foams and aerosols; electrical aspects of surface chemistry; Surface of solids, solid-liquid interface, stability of dispersions, stabilization of suspensions

UNIT 5: Application of colloids (Hours: 9)

Characterization of colloidal particles, Role of colloid chemistry in Nanotechnology (wet colloid chemical approach, "bottom up" fabrication of nanoparticles and nanostructured materials), applications of colloid chemistry in petroleum recovery, coating and painting, food, pharmaceuticals and cosmetic industry, medicinal chemistry (use in drug formulations), Sewage disposal, Purification of water, cleansing action of soap, Formation of Delta, Smoke precipitation, Photography, Artificial rain

Practical component

Practicals: Credits: 01

(Laboratory periods:15 classes of 2 hours each)

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA)/MethylAcrylate (MA).
2. Preparation of nylon 6,6
3. Determination of molecular weight of polyvinyl propylidene in water by viscometry.
4. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.
5. Determination of molecular weight by end group analysis of polymethacrylic acid.
6. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
7. Preparation of Colloidal Sols of following
    A. Arsenic sulphide,

B. Antimony sulphide

C. Ferric chloride

D. Aluminium hydroxide

8. To find out the precipitation values of arsenious sulphide sol by using monovalent, bivalent and trivalent cations.

9. To determine the nature of charge on particle in given colloidal solution and their electrophoretic velocity and zeta potential.

10. To prepare lyophilic sol of starch.

Essential/recommended readings

Theory:

1. Carraher,C. E. Jr. (2013), **Seymour's Polymer Chemistry**, Marcel Dekker, Inc.
2. Odian, G. (2004), **Principles of Polymerization**, John Wiley.
3. Billmeyer, F.W. (1984), **Text Book of Polymer Science**, John Wiley
4. Myers D.,Surface, interfaces and colloids Principles and Applications, 2nd Edition, Wiley-VCH
5. V.R. Gowarikar (2010), **Polymer Science**, New Age International Publishers Ltd.

Practical:

1. Sperling, L.H. (2005), **Introduction to Physical Polymer Science**, John Wiley & Sons

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -7 (DSE-7): Novel Inorganic Solids

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Novel Inorganic Solids (DSE-7)	04	03	--	01	Class 12th with Physics, Chemistry	--

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with the characterization techniques of inorganic solids
- To familiarize the students with use and manifold applications of composites, carbon or high-tech ceramics

Learning Outcomes:

By studying this course, the students will be able to:

- Explain the mechanism of solid-state synthesis.
- Explain about the different characterization techniques and their principle.
- Explain the importance of composites and their applications.
- Discuss and explain the usage of solid materials in various instruments, batteries, etc. which would help them to appreciate the real-life importance of these materials

SYLLABUS OF DSE- 7

Unit 1: Synthesis of inorganic solids (Hours: 5)

Conventional heat and beat method, Co-precipitation method, Sol-gel method, Hydrothermal method, Chemical vapor deposition (CVD), Ion-exchange and Intercalation method.

Unit 2: Characterization techniques of inorganic solids (Hours: 10)

Powder X-ray Diffraction, UV-visible spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Fourier-Transform Infrared (FTIR) spectroscopy, Brunauer–Emmett–Teller (BET) surface area analyser, Dynamic Light Scattering (DLS)

Unit 3: Pigments **(Hours: 10)**

Cationic, anionic and mixed solid electrolytes and their applications. Inorganic pigments – coloured, white and black pigments.

One-dimensional metals, molecular magnets, inorganic liquid crystals.

Unit 4: Composite materials **(Hours: 10)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, bio-nanocomposites, environmental effects on composites, applications of composites.

Unit 5: Speciality polymers **(Hours: 10)**

Speciality polymers: Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene, polyaniline. and polypyrrole, applications of conducting polymers, ion-exchange resins and their applications.

Ceramic & Refractory: Introduction, classification, properties, manufacturing and applications of ceramics, refractory and superalloys as examples.

Practicals **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. Preparation of polyaniline and its characterization using UV-visible spectrophotometer.
2. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.
3. Synthesis of the following inorganic pigments:

   (i) $PbCrO_4$ / chrome yellow

   (ii) Barium white

   (iii) Prussian Blue

   (iv) Malachite

. 4.- Preparation of zeolite A and removal of Mg and Ca ions from water samples quantitatively using zeolite.

5. Determination of exchange capacity of cation exchange resins and anion exchange resins.

6. Determination of a mixture of cobalt and nickel (UV-visible spectroscopy).
7. Preparation of a disc of a ceramic compound using ball milling, pressing and sintering, and study its XRD.

Essential/recommended readings

Theory:

1. West, A. R. (2014), **Solid State Chemistry and Its Application**, Wiley.
2. Smart, L. E.; Moore, E. A., (2012),**Solid State Chemistry: An Introduction** CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997),**New Direction in Solid State Chemistry**, Cambridge University Press.
4. Poole Jr.; Charles P.; Owens, Frank J. (2003), **Introduction to Nanotechnology**, John Wiley and Sons.

Practicals:

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; **Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory**,J. Chem. Educ. 2015, 92, 339−344.
2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), **Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis**, L. Alcaeer (ed.), Conducting Polymers, 105-120, D. Reidel Publishing.
3. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981),**Hexagonal Tungsten Trioxide and Its Intercalation Chemistry**, Solid State Ionics, 5, 1981, 355-358.
4. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; **Synthesis of ZnO Nanoparticles by Precipitation Method**, Orient J Chem 2015, 31(2).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 8 (DSE-8): Applied Organic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applied Organic Chemistry (DSE-8)	04	03	--	01	Class 12[th] with Physics, Chemistry	--

Learning Objectives

The objectives of this course are as follows:

- To make students aware of the importance of organic compounds in daily life.
- To familiarize students with the chemistry and uses of dyes, polymers, terpenoids, alkaloids, steroids and pharmaceutical compounds and their direct or indirect effect on human life and health

Learning outcomes

By the end of this course the students will be able to:

- Discuss and demonstrate the chemistry and uses of commercially important and naturally occurring compounds like dyes, polymers, terpenoids, alkaloids, steroids and pharmaceuticals.
- Appreciate the chemistry of biodegradable and conducting polymers and their importance to human life and society.
- Comprehend the chemistry of dyeing and dyes. Explain why some dyes are better than others. Describe the applications of various types of dyes including those in foods and textiles.
- Comprehend the synthetic routes and mode of action of some selected pharmaceutical compounds
- Use the knowledge gained to solve real world problems

SYLLABUS OF DSE-8

Unit 1: Dyes (Hours: 7)

Nomenclature of commercial dyes with at least one example. Suffixes - G, O, R, B, 6B, L, S; colour index and colour index number. Classification of dyes based on structure and application; Chemistry of dyeing.

Synthesis and applications of the following types of dyes: Azo dyes - Methyl orange, Congo red; Triphenyl methane dyes-Malachite green, Rosaniline and Crystal violet; Phthalein Dyes - Phenolphthalein; Natural dyes - Structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes (natural and synthetic) with examples and effect of synthetic food colours on health.

Unit 2: Polymers (Hours:12)

Introduction and classification based on origin, monomer units, thermal response, mode of formation, structure, application and tacticity; di-block, tri-block and amphiphilic polymers; Weight average molecular weight, number average molecular weight, glass transition temperature (Tg) of polymers; Polymerisation Reactions-Addition and condensation. Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes.

Preparation and applications of: Plastics -thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics -natural (cellulose and synthetic derivatives of cellulose like rayon and viscose); synthetic (acrylic, polyamide, polyester); Rubbers-natural and synthetic: Buna-N, Buna-S, Neoprene, silicon rubber; Vulcanization; Polymer additives; Introduction to Specialty Polymers: electroluminescent (Organic light emitting diodes), Conducting, biodegradable polymers and liquid crystals.

Unit 3: Natural Product Chemistry- An Introduction to Terpenoids, Alkaloids and Steroids (Hours: 12)

Terpenes: Introduction, occurrence, classification, uses, isoprene and special isoprene rule; structure elucidation, synthesis and industrial application of citral.

Alkaloids: Introduction, occurrence, classification, uses, general structural features, general methods for structure elucidation including Hoffmann's exhaustive methylation and Emde's method. Structure elucidation, synthesis and physiological action of Nicotine.

Steroids: Introduction, occurrence, structure, Diel's hydrocarbon, nomenclature of steroid hydrocarbons, structure and biological functions of the following steroids- Cholesterol, Sex Hormones (Estrogen, androgen and progesterone), Adrenocortical hormones (Cortisone and cortisol) and Ergosterol (antirachitic effect).

Unit 4: Pharmaceutical Compounds **(Hours:14)**

Introduction, classification; Synthesis, uses, mode of action and side effects of the following drugs:

Antipyretics -Paracetamol; Analgesics- Ibuprofen; Antimalarials - Chloroquine; Antitubercular drugs - Isoniazid.

An elementary treatment of Antibiotics and detailed study of chloramphenicol including mode of action. Structure and medicinal uses of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Practical component

Practical: **Credits: 01**

(Laboratory periods:15 classes of 2 hours each)

(At least five experiments to be performed)

1. Synthesis of urea formaldehyde resin and test the solubility.
2. Preparation of Starch-PVA Film.
3. Preparation of Methyl orange.
4. Separation of a mixture of dyes by Thin Layer Chromatography (TLC).
5. Isolation and estimation of the content of aspirin in a commercial tablet.
6. Synthesis of 4-methyl-7-hydroxycoumarin by condensation of resorcinol with ethyl acetoacetate.
7. Synthesis of 3,5-dimethyl pyrazole by condensation of acetylacetone and hydrazine.
8. Synthesis of benzimidazole.
9. Synthesis of 2,3-diphenylquinoxaline.
10. Synthesis of paracetamol

Essential/recommended readings

Theory:

1. Finar, I.L. Fifth Edition **Organic Chemistry**, Volume 2, Pearson Education, 2008.
2. Saunders, K. J., (1988), **Organic Polymer Chemistry,** Second Edition Chapman & Hall, London.
3. Campbell, Ian M., (2000), **Introduction to Synthetic Polymers**, Second Edition, Oxford University Press, USA.
4. Bahadur, P. and Sastry, N.V. (2002) **Principles of Polymer Science** Narosa, New Delhi
5. Patrick, G. **An Introduction to Medicinal Chemistry** (2013), Fourth Edition, Oxford University Press.
6. Beale J.M. Block J., (2010) **Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry,** Twelfth Edition, Lippincott Williams and Wilkins.
7. Alagarsamy, V. (2010), **Textbook of Medicinal Chemistry**, Volume II, Second Edition, Reed Elsevier India Private Limited.

Practical:

1. Sciam, A.J. **TLC of mixture of dyes**; *J. Chem. Educ*., **1985**, 62(4), 361. https://pubs.acs.org/doi/10.1021/ed062p361.
2. McKone, H.T.; Nelson, G.J**. Separation, and identification of some FD &C dyes by TLC. An undergraduate laboratory experiment**, *J. Chem. Educ*., **1976**, *53*(11), 722. DOI: 10.1021/ed053p722.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE- 9 (DSE-9): Applications of Computers in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applications of Computers in Chemistry (DSE 9)	**04**	**03**	**-**	**01**	Class 12th with Physics, Chemistry	

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with the fundamental building blocks and syntax of coding in Python with
- To apply python programming to solve simple Chemistry problems by thinking algorithmically and coding structurally

Learning outcomes

By studying this course, the students will be able to:

- Understand the importance of python programming in chemistry and its applications in the field of AI and ML
- Perform simple computations in python after learning the basic syntax, loop structure, string data manipulation etc.
- Solve chemistry problems such as finding pKa of a weak acid, solving Schrodinger's equation etc.
- Plot experimental data and perform regression analysis

SYLLABUS OF DSE-9

UNIT–1: Basic Computer system **(Hours: 3)**

Hardware and Software; Input devices, Storage devices, Output devices, Central Processing Unit (Control Unit and Arithmetic Logic Unit); Number system (Binary, Octal and

Hexadecimal Operating System); Computer Codes (BCD and ASCII); Numeric/String constants and variables. Operating Systems (DOS, WINDOWS, and Linux); Software languages: Low level and High-Level languages (Machine language, Assembly language; QBASIC, C, C++, FORTRAN 90&95); Compiled versus interpreted languages. Debugging Software Products (Office, chemsketch, scilab, matlab, and hyperchem), internet application

UNIT-2: Introduction to Python **(Hours: 3)**

Why Python? Python coding environment setup, Python as an interpreted language, Brief history of Python, Uses of Python (including artificial intelligence and machine learning), Applications of Python in Chemistry

UNIT-3: Coding in Python **(Hours: 18)**

(i) Basic syntax including constants and variables, Operators, Data Types, Declaring and using Numeric data types: int, float, string etc. (ii) Program Flow Control Conditional blocks: if, else and else if, simple FOR loops, FOR loop using ranges, string, list and dictionaries. Use of while loops, Loop manipulation using pass, continue, break and else. (iii) Complex data types: String, List, Arrays, Tuples and Dictionary, String operations and manipulation methods, List operations including slicing, in-built Python Functions. (iv) Python packages - usage of numpy and scipy for mathematical computations.

UNIT-4: Plotting graphs **(Hours: 9)**

Matplotlib for Plotting - Simple plots, formatting of plots, multiple plots, histograms, bar graphs, distributions, curve fitting – linear regression.

UNIT-5: Numerical Methods in Chemistry **(Hours: 12)**

Solution of quadratic equation, polynomial equations (formula, iteration, Newton – Raphson methods and binary bisection) with examples of polynomial equations used in chemistry; Numerical differentiation – finite difference method (backward, central and forward), Numerical integration - Trapezoidal and Simpson's rule to calculate area under the curves for chemistry problems, e.g., entropy calculations, Simultaneous equations, Statistical analysis- mean, variance, standard deviation, error, Curve fitting – linear regression, Solving Schrödinger's equation using Python packages.

Practical component

Practicals: Python Programming for Chemists **Credits: 01**

4. **Writing simple programs using scipy and numpy**
    a. syntax, data types
    b. loop structure, conditional loops

c. To learn string data manipulation
d. Array and lists
e. Sorting, matrix manipulations

5. **Plotting graphs using matplotlib**
    a. Planck's distribution law
    b. Maxwell-Boltzmann distribution curves as a function of temperature and mass
    c. Radial distribution curves for hydrogenic orbitals
    d. Gas law Isotherms – Ideal and Real
    e. Data from phase equilibria studies
    f. Wavefunctions and Probabilities as multiplots
    g. Kinetics data with linear fitting

6. **Numerical Methods in Chemistry**
    a. Solving equations involved in chemical equilibria such as pH of a weak acid at a given concentration, cubic equation obtained from solving van der Waals equation of real gases using Iteration, Newton-Raphson, and Binary Bisection Method
    b. Numerical Differentiation – finding equivalence point given pH metric and potentiometric titrations data by finding the first and the second derivative using the finite difference method
    c. Numerical Integration – Trapezoidal and Simpson's 1/3 rule to calculate enthalpy and entropy of an ideal gas
    d. Statistical Analysis – Calculating Mean, Variance, Standard Deviation
    e. Solving Schrodinger's Equation

Essential/recommended readings

Theory:

7. Dr. M. Kanagasabapathy(2023), **Python for Chemistry: An introduction to Python algorithms, Simulations, and Programing for Chemistry** (English Edition), BPB Publications
8. Robert Johansson (2021), **Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib**, 2nd Edition, Apress

Practical

1. Urban M., Murach J., **Murach's Python programming,** 2nd Indian reprint 2018, Shroff publishers and distributors
2. Gaddis T., **Starting out with python plus My programming Lab** with Pearson e-text-Access card package, 3rd ed.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 10(DSE-10): Analytical Methods in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Analytical Methods in Chemistry (DSE-10)	04	03	--	01	Class 12th with Physics, Chemistry	-

Learning Objectives

The Objectives of this course are as follows:

- To familiarize the students with concept of sampling, Accuracy, Precision, Statistical test data-F, Q and t test.
- To familiarize the students with the laws of spectroscopy and selection rules governing the possible transitions in the different regions of the electromagnetic spectra.
- To familiarize the students with important separation methods like solvent extraction and chromatography

Learning Outcomes:

By studying this course, the students will be able to:

- Perform experiment with accuracy and precision.
- Develop methods of analysis for different samples independently.
- Test contaminated water samples.
- Use basic principle of instrument like Flame Photometer, UV-Visible spectrophotometer learnt for practical applications.
- Apply knowledge of geometrical isomers and keto-enol tautomers to analysis.
- Determine composition of soil.
- Estimate macronutrients using Flame photometry.

SYLLABUS OF DSE-10

Unit 1: Qualitative and Quantitative Aspects of Analysis: (Hours: 5)

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression.

Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit 2: Optical Methods of Analysis (Hours: 25)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Transmittance. Absorbance and Beer-Lambert law

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs). Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal, Techniques for the quantitative estimation of trace level of metal ions from water samples.

Unit 3: Thermal methods of analysis (Hours: 5)

Theory of thermogravimetry (TG) and basic principle of instrumentation of thermal analyser. Techniques for quantitative estimation of Ca and Mg from their mixture.

Unit 4: Separation techniques (Hours:10)

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation, Technique of extraction: batch, continuous and counter current extractions, Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.

Chromatography: Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition & ion-exchange

Practicals Credits 01

(Laboratory periods: 15 classes of 2 hours each)

1. Separation of constituents of leaf pigments by Thin Layer Chromatography

2. Solvent Extractions

   (i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+} DMG complex in chloroform, and determine its concentration by spectrophotometry.

3. Analysis of soil:

   (i) Total soluble salt
   (ii) Estimation of exchangeable calcium and magnesium
   (iii) Estimation of carbonate and bicarbonate
   (iv) Qualitative detection of nitrate and phosphate
4. Separation of amino acids from organic acids by ion exchange chromatography.
5. Spectrophotometry

   (i) Verification of Lambert-Beer's law and determination of concentration of a coloured species ($CuSO_4$ / $KMnO_4$ /$CoCl_2$ / $CoSO_4$)
   (ii) Spectrophotometric analysis of caffeine and benzoic acid in a soft drink
   (iii) Determination of concentration of coloured species via following methods;
   (a) Graphical method, (b) Epsilon method, (c) Ratio method, (iv) Standard addition method
6. Flamephotomerty
   (i) Estimation of potassium, calcium and magnesium using flame photometry

Essential/recommended readings

Theory:

1. Willard, H.H.(1988),**Instrumental Methods of Analysis**, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D.(2004),**Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C.(2007),**Quantitative Chemical Analysis**,6th Edition, Freeman.
4. Khopkar, S.M. (2008), **Basic Concepts of Analytical Chemistry,** New Age International Publisher.
5. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis,** Thomson Asia Pvt. Ltd.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),**Vogel's Textbook of Quantitative Chemical Analysis**,John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 11 (DSE-11): Basic Principles of Food Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basic Principles of Food Chemistry (DSE-11)	04	03	--	01	Class 12th with Physics, Chemistry	--

Learning Objectives

The objectives of this course are as follows:

- To make students understand the sources, importance, stability and transformations of food components during handling and processing.
- To make students aware about nature and importance of additives in food chemistry.

Learning outcomes

By studying this course, the students will be able to:

- Develop a strong understanding of basic fundamentals of food chemistry
- Discuss and demonstrate how alterations /transformations during processing and handling affect the quality and stability of food
- Develop an elementary idea on the nature and importance of additives in food chemistry.
- Apply the knowledge gained to real world problems

SYLLABUS OF DSE-11

Unit 1: Introduction **(Hours:3)**

What is food chemistry; An overview of the following: alterations during handling or processing (texture, flavour, colour), chemical and biochemical reactions leading to alteration in food quality (browning, oxidation, hydrolysis, protein denaturation), cause and effect relationship pertaining to food handling; factors governing stability of food (chemical and environmental factors) and role of food chemists.

Unit 2: Water **(Hours:3)**

Definition of water in food, structure of water and ice, types of water, sorption phenomenon, water activity and packaging, water activity and shelf-life.

Unit 3: Carbohydrates (Hours:6)

Introduction, sources, functions, deficiencies, structure and importance of polysaccharides in food chemistry (Agar and Agarose, Pectin, Hemicellulose, Cyclodextrins, Gums, Alginate, Starches, modified starches), Non-enzymatic browning and its prevention, caramelisation, formation of acrylamide in food, role of carbohydrates as sweeteners and comparison with artificial sweeteners.

Unit 4: Proteins (Hours:6)

Introduction, sources, classification, functions, deficiencies, physico-chemical & functional properties of proteins, nature of food proteins (plant and animal proteins).

Unit 5: Lipids (Hours:6)

Introduction, sources, classification and physical properties, functions, deficiencies, effect of frying on fat, reaction of lipids: hydrogenation, interesterification, hydrolysis, auto-oxidation and its prevention; flavour reversion, fat replacers: fat mimetics and fat substitutes.

Unit 6: Vitamins and Minerals (Hours:6)

Vitamins: Introduction, sources, classification: water soluble and water insoluble vitamins, essential vitamins, physiological function, deficiencies, causes of variation and loss in foods, vitamin like compounds, effect of food processing.

Minerals: Introduction, sources, classification: major minerals and trace elements, physiological function, deficiencies, factors affecting mineral content of food, fortification and enrichment of foods with minerals, effect of food processing.

Unit 7: Food Additives (Hours:15)

Additives: Introduction, importance, classification, antioxidants, emulsifiers, stabilizers, gelling agents, gums, thickeners, sweeteners, acidulants, preservatives, humectants, food toxins

Colouring Agents and Pigments: Introduction, natural food colourants: anthocyanins, carotenoids, chlorophyll, caramel, betalains; examples of pigments in common food; Nature-identical colourants: β-Carotene, canthaxanthin and riboflavin; artificial colouring agents; artificial/synthetic colourants: Azo dyes (e.g. amaranth dye, tatrazine, citrous red, Allura red); quinoline (e.g. quinoline yellow); phthalein (e.g. erythrosine); triarylmethanes and indigoid (e.g. indigo carmine), FD&C Dyes and lakes; properties of certified dyes, colours exempt from certification.

Food Flavor: Sensation of taste and odour, chemical dimension of basic types of taste (Salty, Sweet, Bitter, Sour, Umami taste), other sensations like astringency, coolness, pungency/pungency); non-nutritive sweeteners (aspartame, saccharin, sucralose, cyclamate) and nutritive sweeteners, molecular mechanism of flavour perception, biogenesis of fruits and vegetable flavors, taste inhibition, modification and enhancement, common vegetable and spice flavors.

Practical component

Practical: **Credits: 01**

(Laboratory periods:15 classes of 2 hours each)

(At least four experiments to be performed)

1. Determination of moisture in food products by hot air oven-drying method.
2. Paper chromatography of synthetic food dyes.
3. Quantitative determination of food dyes in powdered drink mixes by spectrophotometric method.
4. Colorimetric determination of Iron in vitamin / dietary tablets.
5. Determination of rancidity of edible oils by Kriess Test.
6. Estimation of Vitamin C in a given solution/ lemon Juice/chillies by 2, 6-dichlorophenol by Indophenol Method.
7. Isolation of casein from milk.
8. Qualitative estimation of cholesterol by Liebermann-Burchard method.
9. Detecting the presence of Vanaspati and rancidity in the given Ghee sample through qualitative tests.

Essential/recommended readings

Theory:

1. DeMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), **Principles of Food Chemistry**, Fourth Edition, Springer.
2. Msagati, T.A.M. (2013), **Chemistry of Food Additives and Preservatives**, Wiley-Blackwell.
3. Fennema, O.R. (2017), **Food Chemistry**, Fifth Edition, CRC Press.
4. Attokaran, M. (2017), **Natural Food Flavors and Colorants**, Second Edition, Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H, (1995) **Food Science,** Fifth Edition, Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), **Food Additives**, Second Edition, CRC Press.
7. Coultate, T. (2016), **Food: The Chemistry of its Components**, Sixth Edition, Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), **Food Chemistry**, Springer.
9. Course: Food Chemistry (iasri.res.in)

Practical:

1. Ranganna, S. (2017). **Handbook of analysis and quality control for fruits and vegetable products**, Second Edition, McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), **Introductory Practical Biochemistry**, Narosa Publishing House

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

DISCIPLINE SPECIFIC ELECTIVE COURSE -12 (DSE-12): Computational Methods & Molecular Modelling

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Computational Methods & Molecular Modelling (DSE-12)	**04**	**03**	**--**	**01**	Class 12^{th} with Physics, Chemistry and Mathematics	**--**

Learning Objectives

The Objectives of this course are as follows:

- To make students learn the theoretical background of computational techniques in molecular modelling.
- To give the different flavours of computational chemistry by the end of this course.
- To provide hands-on experience in molecular modelling on various software

Learning outcomes

By studying this course, the students will be able to:

- Explain the theoretical background of computational techniques and selective application to various molecular systems.
- Compare computational and experimental results and explain deviations.
- Perform Optimization of geometry parameters of a molecule (such as shape, bond length and bond angle) through the use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.
- Perform analysis of molecular properties using various software.

SYLLABUS OF DSE-12

UNIT-1 : Introduction **(Hours: 6)**

Introduction to computational chemistry: Overview of Classical and Quantum Mechanical Methods (Ab initio, DFT, Semi-empirical, Molecular Mechanics, Molecular Dynamics, and Monte Carlo)

UNIT – 2: Potential Energy Surfaces **(Hours: 6)**

Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, Geometry optimization and energy minimization, the concept of transition state with examples, Hessian matrix

UNIT – 3 : Molecular Mechanics & Molecular Dynamics **(Hours: 9)**

Molecular Mechanics

Force Fields (A brief explanation of all the terms of a basic force field), the basic idea of MM1, MM2, MM3, MM4, MM+, AMBER, BIO+, OPLS.

Molecular Dynamics

The concept of the periodic box, ensembles (microcanonical, canonical, isothermal – isobaric), steps in a typical MD simulation.

UNIT-4: Huckel Molecular Orbital Theory **(Hours: 6)**

Huckel MO with examples: ethene and propenyl systems, Properties calculated – energy, charges, bond order, electronic energies, resonance energies.

UNIT- 5: Computational Methods **(Hours: 18)**

Ab-initio methods
Antisymmetry principle, Slater determinants, SCF method, Hartree-Fock method.
Basis sets, Basis functions, STOs and GTOs, diffuse and polarization functions. Minimal basis sets, Basis set superposition error (BSSE) - Effective core potentials (ECP)
Advantages of ab initio calculations.

Density Functional Theory
A brief description of Density Functional Theory (DFT). Calculation of Electronic Properties in ground and Excited states

Semi-empirical methods
Basic idea about Zero differential overlap (ZDO) approximation

Some important concepts

Concepts of atomic charges, electrostatic potential maps, computation of thermodynamic properties and spectroscopic observables

Practical component

Practical: **Credits: 01**

(Laboratory periods:15 classes of 2 hours each)

1) Write the Z-Matrix of a given set of molecules.

2) Carry out geometry optimisation on H_2O, H_2S, H_2Se molecules compare the optimized bond angles and dipole moments from the results obtained. Obtain the ESP-mapped density surfaces and interpret the results obtained with reference to bonding in these molecules.

   Suggestive: A comparative analysis of results of the above exercise may be carried out using different quantum mechanical methods.

3) Calculate the energy of the following chemical species and arrange them in order of increasing stability.

   1-hexene, 2-methyl-2-pentene, (E)-3-methyl-2-pentene, (Z)-3-methyl-2-pentene, and 2,3- dimethyl-2-butene in order of increasing stability.

4) Carry out geometry optimisation on the following chemical species and compare the shapes and dipole moments of the molecules.

   1-pentanol, 2-pentanol, 3-pentanol, 2-methylbutan-1-ol, 3-methylbutan-1-ol, 2-methylbutan-2-ol, 2-methylbutan-3-ol and 2,2-dimethylpropanol.

   Correlate the computationally obtained values of the dipole moments with the experimental values of the boiling points: (118 ºC, 100 ºC, 108 ºC, 82 ºC, of 1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2- propanol respectively).

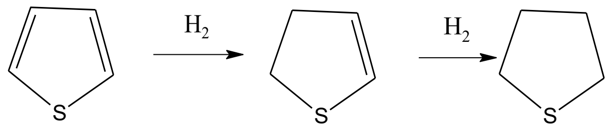
5) Based on the implicit electronic structure calculations, determine the heat of hydrogenation of Propylene.

6) Based on the calculations of enthanlies of the participating chemical species on optimized geometry of the molecules, calculate the reaction enthalpy at 298 K for the following, industrially important reactions:

   $CH_4 + H_2O \rightarrow CO + 3H_2$ (steam reforming of methane)

   ≡≡ (Haber-Bosch process)

7) Carry out geometry optimisation and determine the energy of the participating chemical species in the following reactions Using these results calculate the resonance energy of thiophene.



8) Carry out geometry optimisation & Energy calculations on the following species and obtain Frontier Molecular Orbitals. Visualize the Molecular Orbitals of these species and interpret the results for bonding in these molecules.
Benzene, Naphthalene, and Anthracene.

9) Compare the gas phase basicities of the methylamines by comparing the enthalpies of the following reactions:

$$BH^{+} + NH_3 \rightarrow B + NH_4^{+}$$

Where B = CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N$

10) On the basis of results of geometry optimization and energy calculations, determine the enthalpy of isomerization of cis and trans 2-butene.

11) Perform a conformational analysis of butane. Plot the graph between the angle of rotation and the energy of the conformers using spreadsheet software.

12) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.

13) Calculate the electronic UV/Visible absorption spectrum of Benzene.

14) Calculate the electronic absorption spectra of formaldehyde.

15) Plot the electrostatic potential mapped on electron density for benzene and use it to predict the type of stacking in the crystal structure of benzene dimer.

16) On a given set of molecules methylamine (CH_3NH_2) carry out geometry optimization, single point energy and NBO calculations and interpret the output results treated at the ab initio RHF/3-21G level.

17) Study the mechanism of SN_2 reaction between Cl^- and CH_3Br involving a Walden inversion computationally.

18) Perform a geometry optimization followed by a frequency assessment (opt+freq keyword) using the B3LYP method and 6-31-G(d) basis set on a given set of small molecules i.e. BH_3, CH_4.
Suggestive: A greater number of molecules may be studied as per instructions received from the concerned teacher.

19) Based on the fundamentals of conceptual DFT calculate the ionization potential (IP), electron affinity (EA), electronegativity and electron chemical potential of a given set of molecules.

20) Perform molecular docking of Sulfonamide-type D-Glucose inhibitor into MurrD active site using Argus Lab.

21) Perform molecular dynamics (MD) simulation of a given alkali metal ion in aqueous function (RDF)

Essential/recommended readings

Theory:

1. Lewars, E. (2003), **Computational Chemistry**, Kluwer academic Publisher.
2. Cramer, C.J. (2004), **Essentials of Computational Chemistry**, John Wiley & Sons.
3. Hinchcliffe, A. (1996), **Modelling Molecular Structures**, John Wiley & Sons.
4. Leach, A.R. (2001), **Molecular Modelling**, Prentice-Hall.
5. House, J.E. (2004), **Fundamentals of Quantum Chemistry**, 2nd Edition, Elsevier.
6. McQuarrie, D.A. (2016), **Quantum Chemistry**, Viva Books.
7. Levine, I. N.; **Physical Chemistry**, 5th Edition, McGraw –Hill.

Practical:

1. https://www.afs.enea.it/software/orca/orca_manual_4_2_1.pdf
2. https://dasher.wustl.edu/chem430/software/avogadro/learning-avogadro.pdf
3. http://www.arguslab.com/arguslab.com/ArgusLab.html
4. https://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf
5. https://gaussian.com/techsupport/
6. https://gaussian.com/man/
7. https://gaussian.com/wp-content/uploads/dl/gv6.pdf
8. https://dasher.wustl.edu/chem478/software/spartan-manual.pdf
9. http://www.mdtutorials.com/gmx/
10. https://vina.scripps.edu/manual/

Important Instruction Note on working approach:

- A student is required to perform/investigate a minimum of 10 exercises from the given set of exercises.
- The students may use open source softwares; ArgusLab, Avogadro and ORCA. In case a licenced version softwares is available, if procured by the college, other licenced softwares may also be used.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 13 (DSE-13): Research Methodology for Chemists

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology for Chemists (DSE-13)	04	03	--	01	Class 12th with Physics, Chemistry	

Learning objectives

The objectives of this course are as follows:

- To make the students aware of fundamental but mandatory ethical practices in chemistry.
- To introduce the concept of data analysis.
- To learn to perform literature survey in different modes.
- To make the students aware of safety handling and safe storage of chemicals.
- To make students aware about plagiarism and how to avoid it.
- To teach the use of different e-resources.

Learning outcomes

By studying this course, students will be able to:

- Follow ethical practices in chemistry
- Do Data analysis
- Literature survey in different modes
- Use e-resources.
- Avoid plagiarism, understand the consequences and how to avoid

SYLLABUS OF DSE-13

UNIT – 1: Scope of Research **(Hours: 3)**

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

UNIT – 2: **Literature Survey, Databases and Research metrics** **(Hours: 15)**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results.
Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index.
Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN

UNIT – 3: Communication in Science **(Hours: 12)**

Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis.
Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

UNIT – 4: Research and Publication ethics **(Hours: 9)**

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkund etc), redundant dublications

Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals

IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

UNIT – 5: Statistical analysis for chemists **(Hours: 6)**

Types of data, data collection-Methods and tools, data processing, hypothesis testing, Normal and Binomial distribution, tests of significance: t-test, F-test, chi- square test, ANOVA, multiple range test, regression and correlation.

Features of data analysis with computers and softwares -Microsoft Excel, Origin, SPSS

Practical component **Credits: 01**

(Laboratory periods:15 classes of 2 hours each)

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
4. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.
5. Collection of chemical structure using ChemSpider and creating a database.
6. Curve fitting using freely available softwares/apps (any one)
7. Making of power point presentation
8. Experimental learning of safe storage hazardous chemicals
9. Experimental learning of handling of hazardous chemicals
10. Technical writing on topics assigned.
11. Demonstration for checking of plagiarism using recommended software

Essential/recommended readings:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
4. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
5. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
   OSU safety manual 1.01

Note:

- **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**
- **The students are required to opt one paper each from DSEs 1-3 in Semester 3, DSEs 4-6 in Semester 4, DSEs 7-9 in Semester 5 and DSEs 10-13 in Semester 6.**
- **Research Methodology (DSE 13) shall be offered as one of the DSE courses in semester VI or VII. If a student wishes to pursue four years Honours Degree with Research, he/she shall compulsorily opt for a Research Methodology course in either Semester VI or VII.**

BSC. (PHYSICAL SCIENCES)- CHEMISTRY COMPONENT

SEMESTER - IV

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC -10: Chemistry- IV: Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles DSC-10: Chemistry-IV	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students learn about the chemistry of carboxylic acids and their derivatives (aliphatic and aromatic)
- To give basic understanding of amines (aliphatic & aromatic), diazonium salts
- To provide basic understanding of heterocyclic systems.

Learning outcomes

By studying this course, students will be able to:

- Understand reactions of carboxylic acids, esters, amides, amines and diazonium salts
- Understand the concept of protection and deprotection.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Gain theoretical understanding of chemistry of heterocyclic compounds.

Syllabus

Unit 1: Carboxylic Acids and their Derivatives (aliphatic and aromatic) (1 3 Lectures)

Preparation: Oxidation reactions of alcohols, aldehydes and ketones, Acidic and alkaline hydrolysis of esters; Reactions: Hell-Volhard Zelinsky reaction,

Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Claisen condensation. Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky reaction, Perkin condensation.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of ethyl acetoacetate

Unit 2: Amines (aliphatic & aromatic) and Diazonium Salts (Hours:10)

Amines

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hoffmann bromamide reaction. Reactions: Hoffmann *vs* Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO_2, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation; basicity of amines.

Diazonium salt

Preparation: from aromatic amines; Reactions: conversion to benzene, phenol and dyes.

Unit 3: Heterocyclic Compounds (Hours: 7)

Introduction, classification, structure, nomenclature and uses. Preparation and properties of the following heterocyclic compounds with reference to electrophilic and nucleophilic substitution: furan, pyrrole, thiophene, and pyridine.

Practical Component: Credits: 02

(Laboratory periods: 60)

1. Systematic qualitative analysis and preparation of suitable crystalline derivative (carboxylic acids, carbonyl, alcohols, phenols, amines (1°, 2°, 3°) and amides).
2. Preparation:
   a. Acetylation of Aniline and Phenols.
   b. Benzoylation of Aniline and phenols

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

References:

Theory:

1. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. **Organic Chemistry** (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson

Education).

3. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), **Intermediate for Organic Synthesis**, I.K. International.
4. Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016), **Organic Chemistry**, 12^{th} Ed., Wiley.

Practical:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry**, University Press (India) Ltd.
2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume II**, I K International Publishing House Pvt. Ltd., New Delhi.
5. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.
6. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

BSC. (PHYSICAL SCIENCES)- CHEMISTRY COMPONENT
SEMESTER - V

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC -13: Chemistry- V: Coordination Chemistry and Organometallics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Coordination Chemistry and Organometallics DSC-13: Chemistry- V	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of coordination chemistry and organometallics which are of immense importance to biological systems, qualitative quantitative analysis, catalysis, medicines, paints and pigments etc.
- The students learn nomenclature, isomerism and bonding in coordination compounds with special emphasis on important coordination compounds in the biological system.
- To understand classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species with special emphasis on metal carbonyls.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms Δ_o., Δ_t, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.

- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory
- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
- Learn how IR data can be used to understand extent of back bonding in metal carbonyls.

Syllabus

Unit 1: Introduction to Coordination compounds (Hours: 6)

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

Unit 2: Bonding in Coordination Compounds (Hours: 14)

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion

Unit 3: Organometallic Chemistry (Hours: 10)

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, sigma, pi and multicentre bonds), Structure and bonding of methyl lithium and Zeise's salt, Structure and bonding of ferrocene, mononuclear and polynuclear carbonyls of 3d metals, 18-electron rule as applied to carbonyls, π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Practical Component Credits:02

(Laboratory periods:60)

1. Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
2. Estimation of Zn^{2+} by direct complexometric titrations using EDTA.
3. Estimation of Ca^{2+} by direct complexometric titrations using EDTA.
4. Estimation of total hardness of a given sample of water by complexometric titration.
5. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1, 10-phenanthroline complex in solution by Job's method.

6. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1,10-phenanthroline complex in solution by mole ratio method
7. Preparation of the following inorganic compounds:
   a). Tetraamminecopper(II) sulphate
   b). Potassium trioxalatoferrate(III) trihydrate
   c). Chrome alum
   d). *Cis*- and *trans*-Potassium diaquadioxalatochromate(III)
8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References:

Theory:

1. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
2. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic *Chemistry***, 5th Edition, W. H. Freeman and Company.
4. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
5. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
6. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
7. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
8. Sodhi G.S., **Principles of Inorganic Chemistry**, 3rd Edition, Viva Books India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.
3. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

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BSC. (PHYSICAL SCIENCES)- CHEMISTRY COMPONENT
SEMESTER -VI

DISCIPLINE SPECIFIC CORE COURSE -16: Chemistry -VI Quantum Chemistry and Spectroscopy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Quantum Chemistry and Spectroscopy DSC-16: Chemistry-VI	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the concepts and methodology of quantum mechanics
- Application of Quantum chemistry to spectroscopy
- To establish the relation between structure determination and spectra.

Learning outcomes

By studying this course, students will be able to:

- Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions.
- Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra.

Syllabus

Unit 1: Quantum Chemistry **(Hours: 16)**

Postulates of quantum mechanics, quantum mechanical operators.

Schrodinger equation and its application to free particle and particle in a 1-D box (complete solution), quantization, normalization of wave functions, concept of zero-point energy.

Qualitative treatment of H and H like atoms. Setting up of Schrodinger equation for many electron atoms.

Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.

Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels.

Unit 2: Spectroscopy (Hours: 14)

Electromagnetic radiation and its interaction with matter. Lambert-Beer's law, Jablonski's diagram. Florescence and Phosphorescence.
Difference between atomic and molecular spectra. Born- Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.

Microwave Spectroscopy: Microwave (pure rotational) spectra of diatomic molecules. Selection rules.
Structural information derived from rotational spectroscopy.

IR Spectroscopy: Selection rules, IR spectra of diatomic molecules. Structural information derived fromvibrational spectra. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.

Electronic Spectroscopy: Electronic excited states. Free electron model and its application to electronicspectra of polyenes. chromophores, auxochromes, bathochromic and hypsochromic shifts.

Practical component Credits:02

(Laboratory periods: 60)

UV/Visible spectroscopy

1. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of

organic compounds.

Colorimetry

4. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$/ $CoCl_2$ in a solution of unknown concentration
5. Determine the concentrations of KMnO4 and $K_2Cr_2O_7$ in a mixture.
6. Study the kinetics of iodination of propanone in acidic medium.
7. Determine the amount of iron present in a sample using 1, 10-phenanthroline.
8. Determine the dissociation constant of an indicator (phenolphthalein).
9. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

References:

Theory:

1. Banwell, C.N.; McCash, E.M.(2006), **Fundamentals of Molecular Spectroscopy**, Tata McGraw- Hill.
2. Kapoor, K.L.(2015),**A Textbook of Physical Chemistry**, McGraw Hill Education, ,Vol 4, 5th Edition, McGraw Hill Education.
3. McQuarrie, D.A.(2016),**Quantum Chemistry**, Viva Books.
4. Chandra, A. K.(2001),**Introductory Quantum Chemistry**, Tata McGraw-Hill.
5. Dua A and Tyagi P, **Molecular Spectroscopy: Quantum to Spectrum**, (2022) Atlantic Publishers & Distributors Pvt Ltd.
6. Dua A, Singh C, **Quantum Chemistry: Classical to Computational** (2015) ManakinPress.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015),**Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
2. Kapoor, K.L. (2019),**A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),**Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Additional Resources:

1. Castellan, G. W .(2004),**Physical Chemistry**, Narosa.
2. Petrucci, R. H.(1989),**General Chemistry: Principles and Applications**, Macmillan Publishing

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POOL OF DISCIPLINE SPECIFIC ELECTIVES FOR SEMESTER -III/IV/V/VI

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -1: Main Group Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Chem-DSE 1: Main Group Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide basic understanding of the fundamental principles of metallurgy through study of the different methods of extraction and refining of metals.
- To illustrate the diversity and fascinating aspects of inorganic chemistry through the study of structure, properties and utilities of s- and p-block elements and their compounds.

Learning outcomes

By studying this course, students will be able to:

- Understand the basis of occurrence of metals in nature and the methods that can be applied on minerals to extract the metals from them.
- Explain the importance of free energy of formation of oxides with the choice of reducing agents for extracting the metals.
- Understand and explain the importance of refining of metals and the choice of a refining procedure.
- Explain the group trends observed for different properties of s and p block elements.
- Explain the structures and the bonding of compounds of s- and p- block elements
- Explain the unique properties of alkali metals and some other main group elements
- Understand and explain the polymerization mechanism of inorganic ions to generate inorganic polymers and the difference between organic and inorganic polymers.

Syllabus

Unit 1: General Principles of Metallurgy **(Hours: 6)**

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining.

Unit 2: General Properties **(4 Hours)**

General group trends of s- and p-block elements with special reference to melting and boiling points, flame colour, metallic character and complex formation tendency, diagonal relationship and anomalous behaviour of first member of each group, Alkali metal solutions in liquid ammonia

Unit 3: Structure, Bonding, Properties and Applications **(Hours: 16)**

Structure, bonding, properties (Acidic/Basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, thermal stability) and applications of the following:

Crown Ethers and cryptates of Alkali metals
Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.
Oxides: Oxides of nitrogen, phosphorus and sulphur.
Oxoacids: oxoacids of phosphorus, sulphur and chlorine
Halides of phosphorus

Unit 4: Inorganic Polymers **(4 Hours)**

Preparation, properties, structure and uses of the following:
Borazine, Silicates and Silicones.

Practicals **Credits:02**

(Laboratory periods:60)

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations (preferably 7-8 mixtures). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}.
The mixtures may contain combination of anions/one interfering anion.
Spot tests should be preferred wherever applicable.

References:

Theory:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and **Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
5. Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.
6. F.A. Cotton & G. Wilkinson (1999), **Advanced Inorganic Chemistry**, 6th Edition, John Wiley & Sons.

Practicals:

1. Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.
2. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
3. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

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DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -2: Green Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-2: Green Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To learn about the environmental status, public awareness in evolution, principles involved in green chemistry, bio-catalytic reactions, global warming and its control measures, availability of green analytical methods.
- To practice chemistry in the safest way possible
- To imbibe safeworking conditions in the laboratories as well as the chemical industry extending to society in a sustainable future for the planet.

Learning outcomes

By studying this course, students will be able to:

- Understand the twelve principles of green chemistry and also build the basic understanding of toxicity, hazard and risk related to chemical substances.
- Calculate atom economy, E-factor and relate them in all organic synthesis
- Appreciate the use of catalyst over stoichiometric reagents
- Learn to use green solvents, renewable feedstock and renewable energy sources for carrying out safer chemistry
- Appreciate the use of green chemistry in problem solving skills and critical thinking to innovate and find solutions to environmental problems.
- Learn to design safer processes, chemicals and products through understanding of inherently safer design (ISD)
- Appreciate the success stories and real-world cases as motivation for them topractice green chemistry

Syllabus

Unit 1: Introduction **(Hours: 8)**

Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry.

Need of green chemistry.

Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each).

A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).

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Unit 2: Twelve Principles of Green Chemistry **(Hours: 12)**

The twelve principles of the Green Chemistry with their explanations Special emphasis on the following:

- Prevention of waste / by products, pollution prevention hierarchy.
- Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.
- Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.
- Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- Green energy and sustainability.
- Real-time analysis for pollution prevention.

Prevention of chemical accidents, designing greener processes, principles of inherent safer design (ISD). Bhopal Gas Tragedy (safer route to carbaryl) and Flixborough accident (safer route to cyclohexanol), subdivision of ISD, minimization, simplification, substitution, moderation and limitation.

Unit 3: Real-world Cases in Green Chemistry **(Hours: 10)**

Discussion of the following Real-world Cases in green chemistry: Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifoulant. Right fit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

Practical Component **Credits:02**

(Laboratory periods:60)

Characterization by melting point, UV-Visible spectroscopy, IR spectroscopy and any other specific method should be done (wherever applicable).

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.

2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, solubility, combustion test, density, viscosity, gel formation at low temperature and IR can be provided).

3. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.

4. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.

5. Mechanochemical solvent free, solid-solid synthesis of azomethine using p-toluidine and o-vanillin/p-vanillin.

6 Microwave-assisted Knoevenagel reaction using anisaldehyde, ethyl cyanoacetate and ammonium formate.

7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

8. Photochemical conversion of dimethyl maleate to dimethyl fumarate (cis-trans isomerisation)

9. Benzil- Benzilic acid rearrangement: Preparation of benzilic acid in solid state under solvent-free condition.

References:

Theory:

1. Anastas, P.T., Warner, J.C. (2014), **Green Chemistry**, **Theory and Practice**, Oxford University Press.
2. Lancaster, M. (2016), **Green Chemistry: An Introductory Text**, 3rd Edition, RSC Publishing.
3. Cann, M. C., Connely, M.E. (2000), **Real-World cases in Green Chemistry**, American Chemical Society, Washington.
4. Matlack, A.S. (2010), **Introduction to Green Chemistry**, 2nd Edition, Boca Raton: CRC Press/Taylor & Francis Group publisher.
5. Alhuwalia, V.K., Kidwai, M.R. (2005), **New Trends in Green chemistry**, Anamalaya Publishers.
6. Sidhwani, I.T, Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.

Practicals:

7. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.

8. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
9. Pavia, D.L.; Lamponam, G.H.; Kriz, G.S.W. B. (2012), **Introduction to organic Laboratory Technique- A Microscale approach**, 4th Edition, Brooks-Cole Laboratory Series -for Organic chemistry.
10. Sindhwani I.T. (2015), **Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated**. DU Journal of Undergraduate Research and Innovation, 1(1),131-151. ISSN: 2395- 2334.
11. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
12. **Monograph on Green Chemistry Laboratory Experiments**, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 3: Chemistry of Colloids and Adsorption

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 3: Chemistry of Colloids and Adsorption	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic concepts of colloids and colloidal phenomenon.
- Preparation and characterization of sols, understanding about applications of colloid in food, petroleum and cosmetic industry.
- Basic understanding of adsorption, types of adsorption, chemistry of adsorption and its applications.

Learning outcomes

By studying this course, students will be able to:

- Understand colloid solutions, preparation of sols.
- Understand the concept of Electrical double layer, charge on colloidal particles.
- Characterize the colloids sols, learn colloid phenomenon like Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation.
- Understand adsorption, types of adsorption. Characteristics, factors affecting adsorption and its applications

Syllabus

Unit 1: Colloidal State **(Hours: 8)**

Distinction among true solutions, colloids and suspensions, components of Colloids, classification of colloids - lyophilic, lyophobic; Preparation methods and properties of lyophobic solutions, Hydrophile-lyophile balance (HLB), multi molecular, macromolecular and associated colloids (micelles formation), Schulze -Hardy law.

Unit 2: Preparation and Properties of Colloids **(Hours: 14)**

Methods of preparation of colloids, Tyndall effect, Brownian movement, coagulation and flocculation; electrophoresis, dialysis.

Emulsification by surfactants, selection of surfactants as emulsifying agent, colloidal phenomenonin food chemistry, Protein based functional colloids.

Unit 3: Surface Chemistry **(Hours: 8)**

Adsorption, Distinction between adsorption and absorption, Types of Adsorption, Physisorption and chemisorption and their characteristics, factors affecting adsorption of gases on solids - Freundlich and Langmuir adsorption isotherms, Adsorption from solutions. Applications of Adsorption phenomenon in living systems.

Practical component **Credits: 02**

(Laboratory periods: 60)

1. Preparation of Colloidal Sols of following
   a. Egg Albumin
   b. Starch /Gum
   c. Ferric chloride
   d. Aluminum hydroxide
   e. Antimony Sulphide

2. To find out the precipitation values of Antimony Sulphide sol by using monovalent, bivalentand trivalent cations.
3. To verify the Schulze -Hardy law.
4. To verify the Freundlich's Adsorption isotherms.
5. Study of adsorption of HAc on charcoal and prove the validity of Langmuir's adsorption isotherms
6. Study of adsorption of Oxalic acid on charcoal and prove the validity of Langmuir's adsorption isotherms.

References:

Theory:

1. Puri B. R., Sharma L. R. and Pathania M.S., (2020) Principles of Physical Chemistry, Vishal Publishing Co.Jalandhar, Punjab, India.
2. Kapoor K L, **Text Book of Physical Chemistry, Vol. 4,** McGraw Hill Education (India) Private Limited, Chennai, India.
3. Evans D F and Wennerström's, **The Colloidal Domain**, Second Edition, John Wiley & Sons Inc.
4. Adamson A. W. and Gast A., **Physical Chemistry of Surfaces** (Main text) Sixth Edition, John Wiley & Sons Inc.
5. Berg J. C., **An Introduction to Interfaces and Colloids,** World Scientific Publishing Co., Inc. New Jersey.
6. Israelachvili J. N., **Intermolecular and Surface Forces,** Elsevier Inc.

Practical:

1. Giri, S; Bajpai, D.N.; Pandey, O.P. **Practical Chemistry**, S. Chand Limited.
2. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER IV

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -4: Nanoscale Materials and their Applications

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-4: Nanoscale Materials and their Applications	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce nanoscale materials and their applications.
- To provide an insight into bottom-up and top-down-approach, the methods of synthesis of nanoparticles, simple characterization techniques and applications of nanomaterials.

Learning outcomes

By studying this course, students will be able to:

- Understand the concept of nano dimensions.
- Know the various methods of preparation of nanomaterials.
- Understand the principles of optical and electron microscopy techniques of characterizing nanomaterials.
- Understand and appreciate the real life applications of nanomaterials.

Syllabus

Unit 1: Introduction to Nanodimensions (Hours: 12)

0D, 1D, 2D nanomaterials, Quantum Dots, Nanoparticles, Nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects in nano systems, Quantum confinement and its consequences, Semiconductors. Band structure and band gap. Optical Properties Surface plasmon resonance

.

Unit 2: Preparation of Nanomaterials (Hours: 10)

Top down and Bottom up approach, Photolithography. Ball milling. Vacuum deposition. Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, Sol-Gel synthesis, Hydrothermal synthesis, Spray pyrolysis, Electrochemical deposition, Pulsed Laser deposition. Characterization of nanomaterials: Basic principle of optical methods and electron microscopy.

Unit 3: Applications of Nanomaterials **(Hours: 8)**

Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts, Nanocomposites as catalysts. Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbon nanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

Practical Component **Credits:02**

(Laboratory periods:60)

1. Synthesis of silver nanoparticles by chemical methods and characterization using UV-visible spectrophotometer.
   a. Turkevich Method
   b. Burst Method

2. Synthesis of silver nanoparticles by green approach methods (using soluble starch, glucose or cinnamon bark) and characterization using UV-visible spectrophotometer.

3. Synthesis of metal sulphide nanoparticles and characterization using UV-visible spectrophotometer.
   a. MnS
   b. ZnS
   c. CuS

4. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.

5. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.

6. Phytochemicals mediated synthesis of gold nanoparticles (AuNPs) using tea leaves and to study the effect of size on color of gold/silver nanoparticles.

7. Preparation of magnetic nanoparticles (MNPs) of Fe_3O_4 using green tea leaf extract.

8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References:

Theory:

1. West, A. R. (2014), **Solid State Chemistry and Its Application**, John Wiley and Sons Inc.
2. Smart, L. E.; Moore, E. A., (2012), **Solid State Chemistry: An Introduction**, CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997), **New Direction in Solid State Chemistry**, Cambridge University Press.

4. Poole Jr.; Charles P.; Owens, Frank J. (2003), **Introduction to Nanotechnology**, John Wiley and Sons. Inc. Harris, D. C. (2007), **Quantitative Chemical Analysis**, 6th Edition, Freeman.
5. Chattopadhyay, K.K.; Banerjee, A. N. (2009), **Introduction to Nanoscience and Technology**, Prentice Hall India.

Practicals:

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; **Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory**, J. Chem. Educ. 2015, 92, 339−344.
2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), **Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis**, L. Alcaeer (ed.), Conducting Polymers, 105-120, D. Reidel Publishing.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -5: Molecules of Life

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-5: Molecules of Life	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To deliver information about the chemistry of carbohydrates, proteins & enzymes and its relevance in the biological system using suitable examples.
- To provide an insight into the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural details.

Learning outcomes

By studying this course, students will be able to:

- Learn and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
- Gain an insight into the mechanism of enzyme action and inhibition.
- Understand the basic principles of drug-receptor interaction and SAR.

Syllabus

Unit 1: Carbohydrates (Hours: 12)

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of configuration of glucose (Fischer proof), cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

.

Unit 2: Amino acids, Peptides and Proteins (Hours: 10)

Classification of amino acids and biological uses of amino Acids, peptides and proteins. Zwitterion structure, isoelectric point and correlation to acidity and basicity of amino acids. Determination of primary structure of peptides, determination of N-terminal amino acid (by Edman method) and C–

terminal amino acid (with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by N-protection (t-butyloxycarbonyl) & C-activating groups (only DCC) and Merrifield solid phase synthesis, Overview of primary, secondary, tertiary and quaternary structure of proteins, denaturation of proteins.

Unit 3: Enzymes **(Hours: 4)**

Classification of enzymes and their uses (mention Ribozymes). Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in enzyme action, specificity of enzyme action (including stereospecificity).

-

Unit 4: Nucleosides, Nucleotides and Nucleic Acids **(Hours: 4)**

Components of Nucleic acids: Adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA.

Practical Component **Credits:02**

(Laboratory periods:60)

1. Estimation of glucose by Fehling's solution.
2. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).
3. Study of the titration curve of glycine and determine the isoelectic point of glycine.
4. Estimation of proteins by Lowry's method.
5. Qualitative tests for amino acids, proteins and carbohydrates.
6. Separation and identification of mixture of sugars by paper chromatography.
7. Separation and identification of mixture of Amino acids by paper chromatography.
8. Study of the action of salivary amylase on starch under optimum conditions and find the enzyme activity.
9. Study the effect of temperature on activity of salivary amylase.
10. Extraction of DNA from onion/cauliflower.

References:

Theory:

1. Finar, I. L. **Organic Chemistry (Volume 1 & 2)**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry, 7th Edition**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education India).
3. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2019), **Biochemistry, 9th Ed.**, W. H. Freeman Co Ltd.

Practicals:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), Vogel's **Textbook of Practical Organic Chemistry**, Pearson Education India.
2. **Manual of Biochemistry Workshop, 2012**, Department of Chemistry, University of Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -6: Conductance, Electrochemistry and Chemical Kinetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 6: Conductance, Electrochemistry and Chemical Kinetics	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of electrolytic and galvanic cells.
- Measurementof conductance and its applications, measurement of emf and its applications.
- To understand reaction rate, order, activation energy and theories of reaction rates.

Learning outcomes

By studying this course, students will be able to:

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand the importance of Nernst equation, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatic.

Syllabus

Unit 1: Conductance **(Hours: 8)**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions, Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, Conductometric titrations (only acid-base).

Unit 2: Electrochemistry **(Hours: 12)**

Concept of reversible and irreversible electrochemical cells, Standard hydrogen electrode, standard electrode potential, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes (Reference and inert electrodes), electrochemical series.

Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. pH determination using glass electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Unit 3: Chemical Kinetics and Catalysis **(Hours: 10)**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, integrated rate equations for zero, first and second order reactions (derivation not required), half–life of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Catalysis: Types of catalyst, specificity and selectivity, generalized treatment of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Practical component **Credits:02**

Laboratory periods: 60

1. Determination of molar conductance, degree of dissociation and dissociation constant of aweak acid.
2. Perform the following conductometric titrations: Strong acid vs strong base.
3. Perform the following conductometric titrations: Weak acid vs strong base.
4. Determination of TDS of water from different sources.
5. Determination of Soil pH of soil collected from various locations.
6. Perform the potentiometric titrations of strong acid vs strong base
7. Perform the potentiometric titrations of Weak acid vs strong base.
8. Perform the potentiometric titrations of Potassium dichromate vs. Mohr's salt.
9. Perform the potentiometric titrations of $KMnO_4$ vs. Mohr's salt.
10. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.

References:

Theory:

1. Castellan, G. W .(2004), **Physical Chemistry**, Narosa Publications.
2. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.
4. Puri, B.R., Sharma, L.R. and Pathania M.S. (2020),**Principles of Physical Chemistry,** Vishal Publishing Co.

*

Practicals:

1. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGrawHill Education.
2. Batra, S.K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry,** Book Age series.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER V

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -7: Inorganic Materials of Industrial Importance

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-7: Inorganic Materials of Industrial Importance	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- The course introduces learners to the importance of Inorganic compounds in Industries.
- To provide an insight into how the inorganic materials form a basis of the products used in day-to-day life like silicates, fertilizers, surface coatings.

Learning outcomes

By studying this course, students will be able to:

- Learn the composition and applications of the different kinds of glass.
- Understand glazing of ceramics and the factors affecting their porosity.
- Give the composition of cement and discuss the mechanism of setting of cement.
- Explain the suitability of fertilizers for different kinds of crops and soil.
- Understand and explain the polymerization of inorganic ions to generate inorganic polymers and the difference between organic and inorganic polymers.

Syllabus

Unit 1: Silicate Industries **(Hours: 10)**

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Ceramics: Brief introduction to types of ceramics. glazing of ceramics.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

Unit 2: Fertilizers **(Hours: 8)**

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime, potassium chloride and potassium nitrate. Environmental impact of fertilizers.

Unit 3: Surface Coatings **(Hours: 12)**

Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties, pigment volume concentration (PVC) and critical pigment volume concentration (CPVC), fillers, thinners, enamels and emulsifying agents. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings (electrolytic and electroless with reference to chrome plating and nickel plating), metal spraying and anodizing. Contemporary surface coating methods like physical vapor deposition, chemical vapor deposition, galvanising, carburizing, sherardising, boriding, nitriding and cementation.

Practical Component
Credits:02

(Laboratory periods:60)

1. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
2. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
3. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).
4. Analysis of (Cu, Ni) in alloy or synthetic samples (Multiple methods involving Complexometry, Gravimetry and Spectrophotometry).
5. Analysis of (Cu, Zn) in alloy or synthetic samples (Multiple methods involving Iodometry, Complexometry and Potentiometry).
6. Preparation of following Inorganic Pigments:

a). Barium white
b). Chrome Yellow

c). Malachite
d).Chromium oxide
e). Prussian Blue
7. Any suitable experiment other than the listed ones.

References:

Theory:

1. West, A. R. (2014*),* **Solid State Chemistry and Its Application**, Wiley & sons.
2. Smart, L. E.; Moore, E. A. (2012), **Solid State Chemistry An Introduction**, CRC Press Taylor & Francis.
3. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A.(2010), **Inorganic Chemistry**, W. H. Freeman and Company.
4. Kent, J. A. (ed**)** (1997), **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
5. Jain P.C., Jain M., **Engineering Chemistry**, Dhanpat Rai & Sons, Delhi.
6. Gopalan R., Venkappaya D.,Nagarajan S., **Engineering Chemistry***,* Vikas Publications, New Delhi.
7. Sharma, B.K., **Engineering Chemistry***,* Goel Publishing House, Meerut.
8. Kingery W.D., Bowen H. K., Uhlmann, D.R., (1976), **Introduction to Ceramics***,* Wiley & sons, Delhi.

Practicals:

1. Vogel A. I., Vogel'**s Quantitative Inorganic Analysis**, Pearson Education.
2. Banewicz, J. J.; Kenner, C.T. **Determination of Calcium and Magnesium in Limestones and Dolomites**, Anal. Chem., 1952, 24 (7), 1186–1187.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 8: Polynuclear Hydrocarbons, Pharmaceutical Compounds, UV- Visible & IR Spectroscopy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 8: Polynuclear Hydrocarbons, Pharmaceutical Compounds, UV-Visible & IR Spectroscopy	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an insight to the fundamentals of polynuclear hydrocarbons and heterocyclic compounds
- The course introduces learners to IR and UV-Vis spectroscopic techniques and their importance in functional group identification.

Learning outcomes

By studying this course, students will be able to:

- Understand the fundamentals of polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques.
- Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules.

Syllabus

UNIT-1: Polynuclear Hydrocarbons (Hours: 6)

Introduction, classification, uses, aromaticity of polynuclear compounds, Structure elucidation of naphthalene, preparation and properties of naphthalene and anthracene.

UNIT-2: Pharmaceutical Compounds (Hours: 12)

Introduction, classification, general mode of action of antipyretics and analgesics, aspirin; Synthesis, uses and side effects of the following drugs:

Antipyretics - Paracetamol (with synthesis and mode of action); Analgesics- Ibuprofen (with synthesis and overview of the mode of action); Antimalarials - Chloroquine (synthesis and mode of action).

An elementary treatment of Antibiotics and detailed study of chloramphenicol including mode of action. Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

UNIT-3: UV-Vis and IR Spectroscopy (Hours: 12)

UV-Vis and IR Spectroscopy and their application to simple organic molecules. Electromagnetic radiations and their properties; double bond equivalence and hydrogen deficiency. UV-Vis spectroscopy (electronic spectroscopy): General electronic transitions, λ_{max} & ε_{max}, chromophores & auxochromes, bathochromic & hypsochromic shifts. Application of Woodward rules for the calculation of λ_{max} for the following systems: conjugated dienes - alicyclic, homoannular and heteroannular; α, β-unsaturated aldehydes and ketones, charge transfer complex.

Infrared (IR) Spectroscopy: Infrared radiation and types of molecular vibrations, the significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Practical component Credit:02

(Laboratory periods: 15 classes of 4 hours each)

1. Isolation and estimation of the amount of aspirin in a commercial tablet.
2. Synthesis of ibuprofen.
3. Systematic qualitative identification and derivative preparation of organic compounds (Aromatic hydrocarbons, Aryl halides)
4. Detection of simple functional groups through examination of IR spectra (spectra to be provided). IR spectra of simple compounds like phenols, aldehydes, ketones, carboxylic acids may be given.
5. Differentiation between of o-/p-hydroxybenzaldehyde by IR spectroscopy (Spectra to be provided).
6. Differentiation between benzoic acid and cinnamic acid by UV spectroscopy.
7. Laboratory preparation of paracetamol.
8. Diel’s Alder reaction using Anthracene and Maleic anhydride.

References:

Theory:

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.
4. Pavia, D.L. **Introduction to Spectroscopy**, Cengage learning (India) Pvt. Ltd.
5. Kemp, W. (1991), **Organic Spectroscopy**, Palgrave Macmillan.

Practicals

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry**, University Press (India) Ltd.
2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry**: Qualitative Analysis, University Press.
3. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 9: Computer Applications in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 9: Computer Applications in Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to basic computer skills that will help them in solving chemistry problems using spreadsheets and BASIC language.
- To acquaint the students with different software for data tabulation, calculation, graph plotting, data analysis and document preparation.
- To expose the students to the concept of molecular modelling, its applications to various molecular systems, energy minimization techniques, analysis of Mulliken Charge and ESP Plots.

Learning outcomes

By studying this course, students will be able to:

- Have knowledge of most commonly used commands and library functions used in programming in BASIC language.
- Develop algorithm to solve problems and write corresponding programs in BASIC language for performing calculations involved in laboratory experiments.
- Use various spreadsheet software to perform theoretical calculations and plot graphs

Syllabus

Unit 1: Programming using BASIC **(Hours: 20)**

Programming Language – Elements of BASIC language, Numeric and string Constants and Variables, arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the various QBASIC commands: REM, CLS, INPUT, PRINT, GOTO, IF, IF…THEN, IF...THEN..ELSE, IF and END IF, FOR and NEXT etc., DIM, READ, DATA, GOSUB, RETURN, RESTORE, DEF FNR and Library Functions, Simple programs based on usage of the commands mentioned above.

Statistical analysis using BASIC: Mean, Least square fit - Linear regression, variance, standard deviation.

Unit 2 : Handling of Numerical Data (Hours: 4)

Spreadsheet software: MS Excel. Creating a spreadsheet, entering and formatting information, applying basic functions and formulae to the data, drawing charts, tables and graphs, displaying the equation of graph along with the R^2 value, incorporating tables and graphs in Word files, graphical solution of equations, plotting pressure-volume curves of van der Waals gases, Maxwell-Boltzmann distribution, concentration versus time graphs, spectral data, titration curves, etc.

Unit 3: Molecular Modelling (Hours: 6)

Introduction to molecular modelling, overview of classical and quantum mechanical methods (molecular mechanics, semi empirical, ab initio and DFT), general considerations and comparison of these methods.

Practical component Credit:02

(Laboratory periods: 15 classes of 4 hours each)

Exercises of Programing

1. Calculate pressure of a real gas using Van der Waal's Equation.
2. Calculate the most probable speed, average speed and root men square velocity of an ideal gas.
3. Roots of quadratic equations
4. Binomial coefficient using GOSUB statement.
5. Mean, standard deviation
6. Least square curve fitting method for linear equation.

Plotting graphs using a spreadsheet

1. Van der Waals isotherms
2. Maxwell-Boltzmann distribution curves as function of temperature and molecular weight
3. Plot the conductometric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base
4. Plot the pH metric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base and determine the pK_a of the weak acid
5. Plot the graphs for the kinetics of first order reaction and determine the rate constant
6. Plot the UV-vis absorbance spectra and determine the molar absorption coefficient.

Molecular Modelling

1. Optimize and compare the geometry parameters of H_2O and H_2S using ArgusLab.
2. Compare the basicities of N atom in ammonia, methylamine, dimethylamine and trimethylamine using ArgusLab by comparing Mulliken charges and ESP map in ArgusLab.

3. Compare C-C bond lengths and bond order in ethane, ethene and ethyne using ArgusLab.
4. Determine enthalpy of isomerization of cis and trans-2-butene using ArgusLab.
5. Compare the HAH bond angles for the second row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory.

References:

Theory:

1. Levie, R. de. (2001), **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press.
2. Venit, S.M. (1996), **Programming in BASIC: Problem solving with structure and style**. Jaico Publishing House.
3. Lewars, E. (2003), **Computational Chemistry,** Kluwer academic Publisher.
4. Cramer, C.J.(2004), **Essentials of Computational Chemistry,** John Wiley & Sons.
5. Hinchcliffe, A. (1996), **Modelling Molecular Structures,** John Wiley & Sons.
6. Leach, A.R.(2001), **Molecular Modelling,** Prentice-Hall.

Practicals

1. Lewars, E. **(2003), Computational Chemistry,** Kluwer academic Publisher.
2. Cramer, C.J. **(2004), Essentials of Computational Chemistry,** John Wiley & Sons.
3. Hinchcliffe, A. **(1996), Modelling Molecular Structures,** John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER VI

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -10: Analytical Methods in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-10: Analytical Methods in Chemistry	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the concepts of sampling, errors in analysis, accuracy, precision and introduce basics of statistical analysis.
- To introduces students to important instrumentation and separation techniques routinely used in the laboratory analysis of samples. The experiments expose students to instrumentation and they learn to detect and separate analytes in a mixture.

Learning outcomes

By studying this course, students will be able to:

- Understand various sources of errors in chemical analysis.
- Learn about methods to minimize error.
- Understand basic principle of instrumentation (Flame Photometer, UV-vis spectrophotometer, Atomic Absorption spectrophotometer).
- Apply the principles of analysis and instrumentation to analyse soil samples, soft drinks and synthetic mixtures provided in the laboratory.
- Learn basic principles of separation techniques (chromatography and solvent extraction) and apply them to separate mixtures.
- Understand principles of Gravimetric analysis and apply them in determination of Ni^{2+} and Al^{3+}
- Analyse samples independently in the laboratory.

Syllabus

Unit 1: Errors in Chemical Analysis **(Hours: 8)**

Types of errors, Accuracy and Precision, Absolute and relative uncertainty, propagation of uncertainty. The Gaussian distribution, mean and standard deviation, confidence intervals.

Unit 2: Optical Methods of Analysis (Hours: 10)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, Beer's-Lambert Law.

UV-Vis Spectrophotometry

Basic principles of instrumentation for single and double beam instruments. Determination of concentration of unknown compounds, composition of metal complexes using Job's method of continuous variation and mole ratio method.

Flame Atomic Absorption and Emission Spectroscopy

Basic principles of instrumentation. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal.

Application of these techniques in analysis of samples.

Unit 3: Separation Techniques (Hours: 12)

Solvent extraction

Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions.

Chromatography

Principles of Chromatographic separations, Classification of Chromatographic techniques, Thin Layer Chromatography, Column Chromatography, efficiency of separation (Resolution, Efficiency of Resolution, Plate Height) Application of these techniques in analysis of samples.

Practical Component Credits:02

(Laboratory periods:60)

1. Analysis of soil.
   a. Determination of pH of soil, Total soluble salts, carbonate and bicarbonate, calcium and magnesium by titration.
   b. Estimation of Potassium, calcium and magnesium by flame photometry.
2. Separation of constituents of leaf pigments by thin layer chromatography.
3. Determination of the ion exchange capacity of an anion exchange resin.
4. Determination of the ion exchange capacity of a cation exchange resin.
5. Separation of amino acids by ion exchange chromatography.

6. Spectrophotometric analysis of Co^{2+} and Ni^{2+} ions in a mixture.
7. Spectrophotometric analysis of Caffeine and Benzoic acid in a soft drink.

8. Gravimetric estimation of Ni^{2+} using Dimethylglyoxime or Al^{3+} using oxine.

References:

Theory:

1. Willard, H.H. (1988), **Instrumental Methods of Analysis**, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D. (2004), **Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C. (2007), **Quantitative Chemical Analysis**,6th Edition, Freeman.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis**, Thomson Asia Pvt. Ltd.
5. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), V**ogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Christian, G.D. (2004), **Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C. (2007), **Quantitative Chemical Analysis**, 6th Edition, Freeman.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis**, Thomson Asia Pvt. Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 11: Chemistry of Polymers, Dyes and Natural Products

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 11: Chemistry of Polymers, Dyes and Natural Products	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To familiarize the basic nomenclature of polymers, dyes and natural products, classification and important terms.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

Unit 1: Polymers **(Hours: 12)**

Introduction and classification based on origin, monomer units, thermal response, mode of formation, structure, application and tacticity; di-block, tri-block and amphiphilic polymers;

Weight average molecular weight, number average molecular weight, glass transition temperature (T_g) of polymers; Polymerisation Reactions-Addition and condensation. Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes.

Preparation and applications of: Plastics -thermosetting (phenol-formaldehyde, polyurethanes) and thermosoftening(PVC, polythene); Fabrics -natural (cellulose and synthetic derivatives of cellulose like rayon and viscose); synthetic (acrylic, polyamide, polyester); Rubbers-natural

and synthetic: Buna-N, Buna-S, Neoprene, silicon rubber; Vulcanization; Polymer additives; Introduction to Specialty Polymers: electroluminescent (Organic light emitting diodes), conducting, biodegradable polymers and liquid crystals.

Unit 2: Dyes (Hours: 8)

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing. Synthesis and applications of Azo dyes – Methyl orange, Congo red; Triphenyl methane dyes- Crystal violet; Phthalein Dyes – Phenolphthalein; Natural dyes –Structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Unit 3: Natural Product Chemistry- An Introduction to Terpenoids and Alkaloids (Hours: 10)

Terpenes: Introduction, occurrence, classification, uses, isoprene and special isoprene rule; structure elucidation, synthesis and industrial application of citral.

Alkaloids: Introduction, occurrence, classification, uses, general structural features, general methods for structure elucidation including Hoffmann's exhaustive methylation and Emde's method. Structure elucidation, synthesis and physiological action of Nicotine.

Practical component Credits: 02

(Laboratory periods: 60)

1. Preparation of Methyl Orange.
2. Preparation of Malachite Green.
3. Recycling of Plastic: Moulding of plastic or Cracking of plastic.
4. Preparation of Urea-formaldehyde resin.
5. Preparation of Methyl Orange.
6. (a) Dyeing of different fabrics (cotton, wool, silk) using Alizarin or any other dye.
7. (b) Preparation of azo dye on the surface of the fabric.
8. Qualitative test for identification of alkaloids (Dragendorff's reagent and Mayer's reagent test) and terpenoids (Salkowski test).
9. Preparation of perichromic dye using p-amino phenol and p-nitro benzaldehyde.

References:

Theory:

1. Finar, I.L. (2008), **Organic Chemistry**, Vol 2, 5th Edition, Pearson Education

2. Saunders, K. J. (1988), **Organic Polymer Chemistry**, 2nd Edition Chapman & Hall, London

3. Campbell, Ian M., (2000), **Introduction to Synthetic Polymers**, 2nd Edition Oxford University Press, USA.

4. Bahadur, P. and Sastry, N.V. (2002) **Principles of Polymer Science**, Narosa, New Delhi

5. Patrick, G. **An Introduction to Medicinal Chemistry** (2013), 4th Edition, Oxford University Press.

6. Priscilla Abarca, Patricia Silva, Iriux Almodovar and Marcos Caroli ezende*Quim. Nova, Vol. 37, No. 4, 745-747, 2014. http://dx.doi.org/10.5935/0100- 4042.20140120

Practical:

1. Furniss B S., Hannaford A. J., Smith Peter W. G. & Tatchell Austin R., **Vogel's Textbook of Practical Organic Chemistry** Fifth Edition, Longman Scientific & Technical.

2. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -12: Phase Equilibria and Photochemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 12: Phase Equilibria and Photochemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of Phase, Component, Degree of freedom, basic principles of phase equilibria,
- To understand phase diagram of one and two component systems.
- The students will also gain an understanding of Binary solution, distillation of binary solution, CST and distribution law & its applications.

Learning outcomes

By studying this course, students will be able to:

- Understand phase equilibrium, criteria, CST, Gibbs-Duhem-Margules equation.
- Apply the concepts of phase, conductance and distribution law while studying otherchemistry courses and every-day life.
- Explain low and high quantum yield, photosensitized reactions

Syllabus

Unit 1: Phase Equilibria **(Hours: 22)**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, Phase diagram for one component systems (H_2O and S). Phase diagrams for systemsofsolid-liquid equilibria involving eutectic, congruent and incongruent melting points.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernstdistribution law: its derivation and applications.

Unit 2: Photochemistry **(Hours: 8)**

Characteristics of electromagnetic radiation. Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, examples of low and high quantum yields

Photosensitized reactions, Jablonski's diagram. Role of photochemical reactions in biochemical processes, chemiluminescence.

Practical component **Credits: 02**

(Laboratory periods: 60)

Phase Equilibrium

1. Determination of critical solution temperature and composition at CST of the phenol water system.
2. Effect of impurity on CST of phenol-water system (NaCl and succinic acid).
3. Construction of the phase diagram using cooling curves :
   a. Simple eutectic.
   b. Congruent melting system(s).
4. Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane.
5. Study of equilibrium of any one of the following reactions by distribution method:

   (i) I_2 (aq) + I^- (aq) $\rightleftharpoons$ I_3^-(aq)
   (ii) Cu^{2+} (aq) + $nNH_3 \rightleftharpoons [Cu(NH_3)n]^{2+}$

References:

Theory:

1. Atkins, P.W.; Paula, J.de. (2014), **Atkin's Physical Chemistry Ed.**, 10th Edition, OxfordUniversity Press.
2. Ball, D. W. (2017), **Physical Chemistry**, 2nd Edition, Cengage Learning, India.
3. Castellan, G. W. (2004), **Physical Chemistry**, 4th Edition, Narosa.
4. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 1, 6th Edition, McGrawHill Education.
5. Kapoor, K.L., **A Textbook of Physical Chemistry**, Vol 3, 5th Edition, McGraw HillEducation.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015), **Senior Practical Physical Chemistry**, R.Chand & Co, New Delhi.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGrawHill Education.
3. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P. (2003), **Experiments in PhysicalChemistry**, 8th Edition, McGraw-Hill, New York

Additional Resources:

1. Moore, W.J. (1972), **Physical Chemistry**, 5th Edition, Longmans Green & Co. Ltd.
2. Glasstone, S. (1948), **Textbook of Physical Chemistry**, D. Van Nostrand company, NewYork.

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DISCIPLINE SPECIFIC ELECTIVE COURSE – 13 (DSE-13): Research Methodology for Chemists

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology for Chemists (DSE-13)	04	03	--	01	Class 12th with Physics, Chemistry	

Learning objectives

The objectives of this course are as follows:

- To make the students aware of fundamental but mandatory ethical practices in chemistry.
- To introduce the concept of data analysis.
- To learn to perform literature survey in different modes.
- To make the students aware of safety handling and safe storage of chemicals.
- To make students aware about plagiarism and how to avoid it.
- To teach the use of different e-resources.

Learning outcomes

By studying this course, students will be able to:

- Follow ethical practices in chemistry
- Do Data analysis
- Literature survey in different modes
- Use e-resources.
- Avoid plagiarism, understand the consequences and how to avoid

SYLLABUS OF DSE-13

UNIT – 1: Scope of Research (Hours: 3)

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

UNIT – 2: Literature Survey, Databases and Research metrics (Hours: 15)

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results.
Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index.
Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN

UNIT – 3: Communication in Science (Hours: 12)

Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis.
Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

UNIT – 4: Research and Publication ethics (Hours: 9)

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkund etc), redundant dublications

Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals

IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

UNIT – 5: Statistical analysis for chemists (Hours: 6)

Types of data, data collection-Methods and tools, data processing, hypothesis testing, Normal and Binomial distribution, tests of significance: t-test, F-test, chi- square test, ANOVA, multiple range test, regression and correlation.

Features of data analysis with computers and softwares -Microsoft Excel, Origin, SPSS

Practical component Credits: 01

(Laboratory periods:15 classes of 2 hours each)

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
4. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.

5. Collection of chemical structure using ChemSpider and creating a database.
6. Curve fitting using freely available softwares/apps (any one)
7. Making of power point presentation
8. Experimental learning of safe storage hazardous chemicals
9. Experimental learning of handling of hazardous chemicals
10. Technical writing on topics assigned.
11. Demonstration for checking of plagiarism using recommended software

Essential/recommended readings:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
4. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
5. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
   OSU safety manual 1.01

BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-IV

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC -10: Chemistry- IV: Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles DSC-10: Chemistry- 04	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basics of coordination chemistry and which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc.
- Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms $\Delta o.$, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory
- Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.
- Discuss the application of coordination compounds in the biological systems such as Heamoglobin, myoglobin and some enzymes

Syllabus

Unit 1: Carboxylic acids and their Derivatives (aliphatic and aromatic) (Hours:13)

Preparation: Oxidation reactions of alcohols, aldehydes and ketones, Acidic and alkaline hydrolysis of esters; Reactions: Hell-Volhard Zelinsky reaction,

Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Claisen condensation. Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky reaction, Perkin condensation.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of ethyl acetoacetate

Unit 2: Amines (aliphatic & aromatic) and Diazonium Salts (Hours:10)

Amines

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann *vs* Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO_2, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation; basicity of amines.

Diazonium salt

Preparation: from aromatic amines; Reactions: conversion to benzene, phenol and dyes.

Unit 3: Heterocyclic Compounds (Hours:07)
Introduction, classification, structure, nomenclature and uses. Preparation and properties of the following heterocyclic compounds with reference to electrophilic and nucleophilic substitution: furan, pyrrole, thiophene, and pyridine.

PRACTICALS: Credits: 02

(Laboratory periods: 60)

1. Systematic qualitative analysis and preparation of suitable crystalline derivative (carboxylic acids, carbonyl, alcohols, phenols, amines (1°, 2°,3°) and amides).
2. Preparation:

   a. Acetylation of Aniline and Phenols.
   b. Benzoylation of Aniline and phenols.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization and melting point.

References:

Theory:

1. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. **Organic Chemistry** (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), **Intermediate for Organic Synthesis**, I.K. International.

4. Solomons, T. W. G.; Fryhle, C. B.; Snyder, S. A. (2016), **Organic Chemistry**, 12th Ed., Wiley.

5. Parashar, R.K., Negi, B. (2016) **Chemistry of Heterocyclic Compounds**, Ane Books Pvt Ltd.

Practical:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry**, University Press (India) Ltd.

2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.

3. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume II**, I K International Publishing House Pvt. Ltd., New Delhi.

5. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.

6. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

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BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT

SEMESTER-V

DISCIPLINE SPECIFIC CORE COURSE CHEM-DSC -13: Chemistry- V: Coordination Chemistry and its Application in Biological Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Coordination Chemistry and its Application in Biological Systems DSC-13 Chemistry- 5	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the basics of coordination chemistry and which are of immense importance to biological systems, qualitative and quantitative analysis, catalysis, medicines, paints and pigments etc.
- Nomenclature, isomerism, bonding in coordination compounds has been dealt with in sufficient detail along with special emphasis on important coordination compounds in the biological system.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.
- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms Δ_o., Δ_t, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory

- Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.
- Discuss the application of coordination compounds in the biological systems such as Heamoglobin, myoglobin and some enzymes

Syllabus

Unit 1: Introduction to Coordination Compounds (Hours: 6)

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

Unit 2: Bonding in Coordination Compounds (Hours: 14)

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion.

Unit 3: Thermodynamic and Kinetic aspects of Metal Complexes (Hours: 6)

A brief outline of thermodynamic and kinetic stabilities of metal complexes and factors affecting the stability. Substitution reactions of square-planar complexes – Trans effect: cisplatin and transplatin.

Unit 4: Application of coordination compounds in biological systems (Hours: 4)

Haemoglobin, Myoglobin, carboxypeptidase, carbonic anhydrase

Practicals Component Credits: 02
(Laboratory periods: 60)

1. Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
2. Estimation of Zn^{2+} by direct complexometric titrations using EDTA.
3. Estimation of Ca^{2+} by direct complexometric titrations using EDTA.
4. Estimation of Zn^{2+} in zinc tablet.
5. Estimation of Ca^{2+} in milk sample.
6. Estimation of total hardness of a given sample of water by complexometric titration.
7. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} -1,10-phenanthroline complex in solution by Job's method
8. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1,10-phenanthroline complex in solution by mole ratio method

9. Preparation of the following inorganic compounds:
   a). Tetraamminecopper(II) sulphate
   b). Potassium trioxalatoferrate(III) trihydrate
   c). Chrome alum
10. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References:

Theory:

9. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
10. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
11. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic *Chemistry***, 5th Edition, W. H. Freeman and Company.
12. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
13. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
14. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
15. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
16. Sodhi G.S., Principles of Inorganic Chemistry, Third Edition, Viva Books, India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B.W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.
3. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

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BSC. (LIFE SCIENCE)- CHEMISTRY COMPONENT
SEMESTER-VI

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSC 16: Chemistry- VI: Conductance, Electrochemistry and Chemical Kinetics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Conductance, Electrochemistry and Chemical Kinetics DSC-16: Chemistry- 6	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of electrolytic and galvanic cells.
- Measurementof conductance and its applications, measurement of emf and its applications.
- To understand reaction rate, order, activation energy and theories of reaction rates.

Learning outcomes

By studying this course, students will be able to:

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand the importance of Nernst equation, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand rate law and rate of reaction, theories of reaction rates and catalysts; both chemical and enzymatic.

Syllabus

Unit 1: Conductance **(Hours: 8)**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions, Ionic velocity, mobility and their determination, transference number and its relation to ionic mobility, Conductometric titrations (only acid-base).

Unit 2: Electrochemistry **(Hours: 12)**

Concept of reversible and irreversible electrochemical cells, Standard hydrogen electrode, standard electrode potential, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes (Reference and inert electrodes), electrochemical series.

Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. pH determination using glass electrode, Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Unit 3: Chemical Kinetics and Catalysis **(Hours: 10)**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, integrated rate equations for zero, first and second order reactions (derivation not required), half–life of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Catalysis: Types of catalyst, specificity and selectivity, generalized treatment of catalyzed reactions at solid surfaces. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Practical Component: **Credits:02**

Laboratory periods: 60

1. Determination of molar conductance, degree of dissociation and dissociation constant of a weak acid.
2. Perform the following conductometric titrations: Strong acid vs strong base.
3. Perform the following conductometric titrations: Weak acid vs strong base.
4. Determination of TDS of water from different sources.
5. Determination of Soil pH of soil collected from various locations.
6. Perform the potentiometric titrations of strong acid vs strong base
7. Perform the potentiometric titrations of Weak acid vs strong base.
8. Perform the potentiometric titrations of Potassium dichromate vs. Mohr's salt.
9. Perform the potentiometric titrations of $KMnO_4$ vs. Mohr's salt.
10. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.

References:

Theory:

1. Castellan, G. W .(2004), **Physical Chemistry**, Narosa Publications.
2. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2015),**A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.
4. Puri, B.R., Sharma, L.R. and Pathania M.S. (2020), **Principles of Physical Chemistry,** Vishal Publishing Co.

Practical:

1. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.
2. Kapoor, K.L. (2019), **A Textbook of Physical Chemistry**, Vol 7, 1st Edition, McGraw Hill Education.
3. Batra, S.K., Kapoor, V and Gulati, S. (2017) 1st Edition, **Experiments in Physical Chemistry,** Book Age series.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSEs)

SEMESTER III

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -1: Chemistry of Major and Minor Biogenic Elements

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-1: Chemistry of Major and Minor Biogenic Elements	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce learners to review periodic properties of main group elements and their role in the biological systems. It further discusses the patterns and trends exhibited by main group elements and their compounds with emphasis on synthesis, structure, bonding and their diverse applications in the environment, industry and in the biological system.
- To develop the interest of students in the frontier areas of inorganic and material chemistry, it gives an insight into how these compounds such as oxides of N and S affect our day-to-day life. Students learn about inorganic polymeric compounds borazine, silicates, silicones, phosphonitrilic compounds and their applications.

Learning outcomes

By studying this course, students will be able to:

- Understand the periodicity in atomic and ionic radii, electronegativity, ionization enthalpy, electron gain enthalpy of elements of the periodic table.
- Understand oxidation states with reference to the existence of elements in unusual and rare oxidation states in alkalides, carbides and nitrides.

- Understand vital role of sodium, potassium, calcium and magnesium ions etc. in biological systems and the role of oxides of N and S in our environment.
- Distribution of major and minor biogenic elements in human beings

Syllabus

Unit 1: Periodic Properties **(Hours: 6)**

Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, the concept of exchange energy, inert pair effect.
General group trends of main group elements with special reference to size (atomic and ionic), Ionization Enthalpy, Electron Gain Enthalpy, Electronegativity, oxidation states (including rare oxidation states of alkali metals, carbides and nitrides), melting and boiling points, flame colour, metallic character and complex formation tendency (crown ethers and cryptates), Alkali metal solutions in liquid ammonia
Distribution of major and minor biogenic elements in human beings

Unit 2: Structure, Bonding and Properties **(Hours: 16)**

Structure, bonding and properties: Acidic/Basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, thermal stability of the following:
Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.
Oxides: Oxides of nitrogen, phosphorus and sulphur
Oxoacids: oxoacids of phosphorus, sulphur and chlorine
Halides of phosphorus
Relevance of above compounds in industrial/environmental/biological systems wherever applicable

Unit 3: Preparation, Properties, Structure and Uses **(Hours: 8)**

Preparation, properties, structure and uses of the following compounds: Borazine, Silicates, silicones, Phosphonitrilic halides $\{(PNCl_2)_n$ where $n = 3$ and $4\}$

Practicals **Credits:02**
(Laboratory periods: 60)

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations (preferably 7-8 mixtures). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
CO_3^{2-}, NO_2^- , S^{2-}, SO_3^{2-}, SO_4^{2-} , $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^- , BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-},
NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}
The mixtures may contain combination of anions/one interfering anion.
Spot tests should be preferred wherever applicable.

References:

Theory:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins **Inorganic Chemistry**, 5th Edition, Oxford University Press.
5. Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.

Practicals:

4. Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.
5. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
6. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -2: Polynuclear Hydrocarbons, Pharmaceutical Compounds,

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-2: Polynuclear Hydrocarbons, Pharmaceutical Compounds, UV- Visible & IR Spectroscopy	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the chemistry and applications of polynuclear hydrocarbons and heterocyclic compounds.
- Introduction to spectroscopy, an important analytical tool which allows identification of organic compounds by correlating their spectra to structure.

Learning outcomes

By studying this course, students will be able to:

- Understand the fundamentals of polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
- Gain insight into the basic fundamental principles of IR and UV-Vis spectroscopic techniques.
- Use basic theoretical principles underlying UV-visible and IR spectroscopy as a tool for functional group identification in organic molecules.

Syllabus

UNIT-1: Polynuclear Hydrocarbons (Hours: 6)

Introduction, classification, uses, aromaticity of polynuclear compounds, Structure elucidation of naphthalene, preparation and properties of naphthalene and anthracene.

UNIT-2: Pharmaceutical Compounds (Hours: 12)

Introduction, classification, general mode of action of antipyretics and analgesics, aspirin; Synthesis, uses and side effects of the following drugs:
Antipyretics - Paracetamol (with synthesis and mode of action); Analgesics- Ibuprofen (with synthesis and overview of the mode of action); Antimalarials - Chloroquine (synthesis and mode of action).
An elementary treatment of Antibiotics and detailed study of chloramphenicol including mode of action. Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

UNIT-3: UV-Vis and IR Spectroscopy (Hours: 12)

UV-Vis and IR Spectroscopy and their application to simple organic molecules. Electromagnetic radiations and their properties; double bond equivalence and hydrogen deficiency. UV-Vis spectroscopy (electronic spectroscopy): General electronic transitions, λ_{max} & ε_{max}, chromophores &auxochromes, bathochromic & hypsochromic shifts. Application of Woodward rules for the calculation of λ_{max} for the following systems: conjugated dienes - alicyclic, homoannular and heteroannular; α, β-unsaturated aldehydes and ketones, charge transfer complex.

Infrared (IR) Spectroscopy: Infrared radiation and types of molecular vibrations, the significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Practical component Credit:02

(Laboratory periods: 15 classes of 4 hours each)

1. Isolation and estimation of the amount of aspirin in a commercial tablet.
2. Preparation of Aspirin.
3. Synthesis of ibuprofen.
4. Systematic qualitative identification and derivative preparation of organic compounds (Aromatic hydrocarbons, Aryl halides)
5. Detection of simple functional groups through examination of IR spectra (spectra to be provided). IR spectra of simple compounds like phenols, aldehydes, ketones, carboxylic acids may be given.
6. Differentiation between of o-/p-hydroxybenzaldehyde by IR spectroscopy (Spectra to be provided).
7. Differentiation between benzoic acid and cinnamic acid by UV spectroscopy.
8. Diel's Alder reaction using Anthracene and Maleic anhydride.
9. Partial Reduction of m-dinitrobenzene to m-nitroaniline and then analysing the IR spectra of reactant and Product.
10. Laboratory preparation of Paraacetamol.

References:

Theory:

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry,** Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

4. Pavia, D.L. **Introduction to Spectroscopy**, Cengage learning (India) Pvt. Ltd.
2. Kemp, W. (1991), **Organic Spectroscopy**, Palgrave Macmillan.

Practicals:

1. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry,** University Press (India) Ltd.
2. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.
5. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I K International Publishing House Pvt. Ltd., New Delhi.

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DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 3: Chemistry of Colloids and Adsorption

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 3: Chemistry of Colloids and Adsorption	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic concepts of colloids and colloidal phenomenon.
- Preparation and characterization of sols, understanding about applications of colloid in food, petroleum and cosmetic industry.
- Basic understanding of adsorption, types of adsorption, chemistry of adsorption and its applications.

Learning outcomes

By studying this course, students will be able to:

- Understand colloid solutions, preparation of sols.
- Understand the concept of Electrical double layer, charge on colloidal particles.
- Characterize the colloids sols, learn colloid phenomenon like Tyndall effect, Brownian movement, electrophoresis, dialysis, coagulation and flocculation.
- Understand adsorption, types of adsorption. Characteristics, factors affecting adsorption and its applications

Syllabus

Unit 1: Colloidal State **(Hours: 8)**

Distinction among true solutions, colloids and suspensions, components of Colloids, classificationof colloids - lyophilic, lyophobic; Preparation methods and properties of lyophobic solutions, Hydrophile-lyophile balance (HLB), multi molecular, macromolecular and associated colloids (micelles formation), Schulze -Hardy law.

Unit 2: Preparation and properties of colloids **(Hours: 14)** Methods of preparation of colloids, Tyndall effect, Brownian movement, coagulation and flocculation; electrophoresis, dialysis.

Emulsification by surfactants, selection of surfactants as emulsifying agent, colloidal phenomenonin food chemistry, Protein based functional colloids.

UNIT 3: Surface Chemistry **(Hours: 8)**

Adsorption, Distinction between adsorption and absorption, Types of Adsorption, Physisorption and chemisorption and their characteristics, factors affecting adsorption of gases on solids - Freundlich and Langmuir adsorption isotherms, Adsorption from solutions. Applications of Adsorption phenomenon in living systems.

Practical component **Credits: 02**

(Laboratory periods: 60)

7. Preparation of Colloidal Sols of following
   a. Egg Albumin
   b. Starch /Gum
   c. Ferric chloride
   d. Aluminum hydroxide
   e. Antimony Sulphide
8. To find out the precipitation values of Antomony Sulphide sol by using monovalent, bivalent and trivalent cations.
9. To verify the Schulze -Hardy law.
10. To verify the Freundlich's Adsorption isotherms.
11. Study of adsorption of HAc on charcoal and prove the validity of Langmuir's adsorption isotherms
12. Study of adsorption of Oxalic acid on charcoal and prove the validity of Langmuir's adsorption isotherms.

References:

Theory:

7. Puri B. R., Sharma L. R. and Pathania M.S., (2020) Principles of Physical Chemistry, Vishal Publishing Co.Jalandhar, Punjab, India.
8. Kapoor K L, **Text Book of Physical Chemistry, Vol. 4,** McGraw Hill Education (India) Private Limited, Chennai, India.
9. Evans D F and Wennerström's, **The Colloidal Domain**, Second Edition, John Wiley & Sons Inc.
10. Adamson A. W. and Gast A., **Physical Chemistry of Surfaces** (Main text) Sixth Edition, John Wiley & Sons Inc.
11. Berg J. C., **An Introduction to Interfaces and Colloids,** World Scientific Publishing Co., Inc.
    New Jersey.
12. Israelachvili J. N., **Intermolecular and Surface Forces,** Elsevier Inc.

Practical:

3. Giri, S; Bajpai, D.N.; Pandey, O.P. **Practical Chemistry**, S. Chand Limited.
4. Khosla, B.D.; Garg, V.C.; Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -4: Acids & Bases and Aqueous Chemistry of Metal Ions

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-4: Acids & Bases and Aqueous Chemistry of Metal Ions	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide basic understanding of the various concepts of acids and bases and Buffers to students and the factors responsible for variable acid and bases strength. This will help the learner to understand the importance of pH maintenance for a large number of biological processes especially enzyme systems.
- The unit of Aqueous Chemistry of metal ions provides an insight into the types of reactions a metal ion undergoes in aqueous medium- hydration, hydrolysis, redox, complexation, precipitation. The knowledge of these let a learner ascertain the feasibility of a proposed reaction and also to predict the possible outcomes of a new reaction. This additionally equips a biology student to understand different biological processes involving metal ions in a better way.

Learning outcomes

By studying this course, students will be able to:

- Define the Arrhenius, Bronsted Lowry, Lewis and Hard & soft acids and bases.
- Distinguish one class of acids and bases from the other and will be able to classify different types of available acids (synthetic and natural) under these classes.
- Understand the parameters affecting the relative strength of acids and bases and the effect of solvent on them.
- Explain the effect of mixing a strong/weak acid with a weak/strong base and will be able to calculate the pH of buffers.
- Correlate the concepts of acids and bases to the biological processes, the importance of pH and the buffers in sustaining specific metabolic activities.
- Explain the behavior of metal ions in aqueous solutions in presence of other reagents

- Differentiate between solvation and solvolysis and explain the formation of oxo ions as a result of hydrolysis.
- Write the redox reactions involving metal ions, use the Nernst equation to calculate redox potentials and correlate them with the relative oxidizing/reducing strength of metal ions
- Explain the successive reduction or oxidation of a metal ion capable of displaying more than two oxidation states and hence predict the spontaneity of a redox reaction
- Explain the disproportionation of an oxidation state and the stability of an oxidation state in aqueous medium by comparing the redox potentials with that of water at different pH.
- Explain the chemistry involved in the quantitative chemical analysis involving redox
- reactions like redox titrations.
- Explain the formation of metal complexes based on two different modes of ligand metal interaction.
- Understand the importance of complexation process in stabilizing some oxidation states more than the other.
- Write the reactions involving the precipitation of metal ions, and predict the relative precipitations based on solubility products.
- Explain the identification and separation of metal ions in a mixture based on difference in precipitation behavior of metal ions.
- Correlate the redox, complexation and precipitation behavior of metal ions in aqueous medium to the role of metal ions and metalloproteins in biological systems.

Syllabus

Unit 1: Acids & Bases **(Hours: 10)**

Concepts: Arhenius, Bronsted-Lowry (aqua, hydroxo, oxo), Lewis acids and bases, Hard and Soft acids and bases.
Strength of Acids and Bases: factors affecting relative strength of acids and bases, solvent levelling, superacids and superbases.
Buffers (NH_4OH/NH_4Cl, NaOAc/HOAc, boric acid and borate, Phosphate buffers, Universal Buffer), buffer capacity, calculation of pH of buffer solutions, pH calculation using Handerson-Hasselbalch equation, Applications of Acids & Bases and buffers in biological processes

Unit 2: Aqueous Chemistry of Metal ions **(Hours: 20)**

Solvation effects on metal ions, oxocations and oxoanions
Redox reactions: Half reactions, balancing of redox reactions, Nernst equation, standard potentials and spontaneity, trends in standard potentials, electrochemical series
Redox stability of species in aqueous solutions (influence of pH, effect of solvation, redox reaction with water, disproportionation)
Diagrammatic presentation of potential data: Latimer diagrams, Frost diagrams and Pourbaix diagrams their significance
Applications of redox reactions in quantitative analysis: permanganate, dichromate & iodine titrations
Examples of Redox reactions in biological processes
Complexation behaviour of metal ions: Lewis acid – base type (d block), electrostatic interactions based (s block elements with crown ethers and cryptates), stabilisation of oxidation states by complexation (Cu(I), Mn(III)),
Applications of complexes in biological systems with special mention of metalloenzymes.

Precipitation: Insoluble salts with anions like S^{2-}, SO_4^{2-}, PO_4^{3-}, halides, OH^-, $C_2O_4^{2-}$, CO_3^{2-} and their application in metal ions analysis.

Practical Component: **Credits:02**

(Laboratory periods: 60)

1. Preparation of Potassium trioxalatochromate(III).
2. Preparation of Potassium trisoxalatomanganate(III).
3. Preparation of acetylacetonato complexes of
   a). Cu(II)
   b). Fe(III)
4. Determination of strength of oxalate ions and oxalic acid in a mixture titrimetrically.
5. Determination of available chlorine in bleaching powder iodometrically.
6. Preparation of a phosphate buffer solution and measurement of its pH using pHmeter.
7. Determination of buffer capacity of phosphate buffer.
8. Determination of strength of chloride ions argentometrically
   a). Volhard's Method
   b). Fajan's Method
   c). Mohr's Method
9. pHmetric titration of a strong acid with a strong base.
10. Any suitable experiment other than the listed ones.

References:

Theory:

1. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
2. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic Chemistry**, 5th Edition, W. H. Freeman and Company.
3. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
4. Miessler, G. L. (2008*).* **Inorganic chemistry**. Pearson Education India.
5. Sharpe, A. G. (1992). **Inorganic chemistry**. Longman Publishing Group.
6. Lehninger, A. L., Nelson, D. L., Cox, M. M., & Cox, M. M. (2005). **Lehninger principles of biochemistry**. Macmillan India.
7. Svehla, G. (2008). **Vogel's qualitative inorganic analysis***, 7/e*. Pearson Education India.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's **Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 5 Biomolecule-I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 5: Biomolecules-I	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To teach students about important biomolecules essential to life processes.
- 2. To discuss aspects of the principles of organic chemistry in the structure and function of important biomolecules.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

Unit 1: Chemistry of Carbohydrates (Hours:10)

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of the configuration of glucose (Fischer proof), the cyclic structure of glucose. Haworth projections. The cyclic structure of fructose. The linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Unit 2: Nucleosides, Nucleotides and Nucleic Acids (Hours:10)

Components of Nucleic acids: Adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation.

Unit-3: Lipids (Hours:10)

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Lipids: Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins.

Properties, functions and biochemical functions of steroid hormones.

PRACTICALS: Credits: 02
(Laboratory periods: 60)

1. Preparation of osazone of glucose, fructose and Maltose (Comparing the time of formation of the two and the shape of crystals using microscope).
2. Identification of given carbohydrates as
    a. Reducing and Non-reducing
    b. Monosaccharide and Disaccharide
    c. Aldose and Ketose
3. Estimation of glucose by Fehling's solution.
4. Determination of the iodine number of oil.
5. Determination of the saponification number of oil.
6. Identification and separation of mixture of sugars by paper chromatography.
7. Isolation of DNA from cauliflower/ onion.
8. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).

References:

Theory

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2002), **Biochemistry**, W. H. Freeman.

4.Devlin, T.M. (2010), **Textbook of Biochemistry with Clinical Correlation**, Wiley.

5. Satyanarayana, U.; Chakrapani, U. (2017), **Fundamentals of Biochemistry**, Books and Allied (P) Ltd.

6. Lehninger, A.L; Nelson, D.L; Cox, M.M. (2009), Principles of Biochemistry, W. H. Freeman.

Practical:

1. Dean, J.R.; Jones, A.M.; Holmes, D;, Reed, R.; Jones, A.Weyers, J. (2011), **Practical skills in chemistry**, Prentice-Hall.

2. Wilson, K.; Walker, J. (2000), **Principles and techniques of practical biochemistry**, Cambridge University Press.

3. Gowenlock. A.H. (1988), **Varley's Practical Clinical Biochemistry**, CRC Press.

4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume II, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -6 Quantum Chemistry and Spectroscopy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 6: Quantum Chemistry and Spectroscopy	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the concepts and methodology of quantum mechanics
- Application of Quantum chemistry to spectroscopy
- To establish the relation between structure determination and spectra.

Learning outcomes

By studying this course, students will be able to:

- Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions.
- Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra.

Syllabus

Unit 1: Quantum Chemistry **(Hours: 16)**

Postulates of quantum mechanics, quantum mechanical operators.

Schrodinger equation and its application to free particle and particle in a 1-D box (complete solution),quantization, normalization of wave functions, concept of zero-point energy.

Qualitative treatment of H and H like atoms. Setting up of Schrodinger equation for many electron atoms.

Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.

Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels.

Unit 2: Spectroscopy **(Hours: 14)**

Electromagnetic radiation and its interaction with matter. Lambert-Beer's law, Jablonski's diagram. Florescence and Phosphorescence.
Difference between atomic and molecular spectra. Born- Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.

Microwave Spectroscopy: Microwave (pure rotational) spectra of diatomic molecules. Selection rules.
Structural information derived from rotational spectroscopy.

IR Spectroscopy: Selection rules, IR spectra of diatomic molecules. Structural information derived fromvibrational spectra. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.

Electronic Spectroscopy: Electronic excited states. Free electron model and its application to electronicspectra of polyenes. chromophores, auxochromes, bathochromic and hypsochromic shifts.

Practical component **Credits:02**

(Laboratory periods: 60)

UV/Visible spectroscopy

10. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).
11. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$
12. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colorimetry

13. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$/ $CoCl_2$ in a solution of unknown concentration
14. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
15. Study the kinetics of iodination of propanone in acidic medium.
16. Determine the amount of iron present in a sample using 1, 10-phenanthroline.
17. Determine the dissociation constant of an indicator (phenolphthalein).
18. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

References:

Theory:

1. Banwell, C.N.; McCash, E.M.(2006), **Fundamentals of Molecular Spectroscopy**, Tata McGraw- Hill.
2. Kapoor, K.L.(2015),**A Textbook of Physical Chemistry**, McGraw Hill Education, ,Vol 4, 5th Edition, McGraw Hill Education.
3. McQuarrie, D.A.(2016),**Quantum Chemistry**, Viva Books.
4. Chandra, A. K.(2001),**Introductory Quantum Chemistry**, Tata McGraw-Hill.
5. Dua A and Tyagi P, **Molecular Spectroscopy: Quantum to Spectrum**, (2022) Atlantic Publishers & Distributors Pvt Ltd.
6. Dua A, Singh C, **Quantum Chemistry: Classical to Computational** (2015) ManakinPress.

Practical:

4. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015),**Senior Practical Physical Chemistry**, R. Chand & Co, New Delhi.
5. Kapoor, K.L. (2019),**A Textbook of Physical Chemistry**, Vol.7, 1st Edition, McGraw Hill Education.
6. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),**Experiments in Physical Chemistry**, 8th Edition, McGraw-Hill, New York.

Additional Resources:

3. Castellan, G. W .(2004),**Physical Chemistry**, Narosa.
4. Petrucci, R. H.(1989),**General Chemistry: Principles and Applications**, Macmillan Publishing

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -7: Analytical Methods in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE-7: Analytical Methods in Chemistry	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the concepts of sampling, errors in analysis, accuracy, precision and introduce basics of statistical analysis. The course introduces students to important instrumentation and separation techniques routinely used in the laboratory analysis of biological samples.
- To expose students to instrumentation in the practical and they learn to detect and separate analytes in a mixture.

Learning outcomes

By studying this course, students will be able to:

- Understand various sources of errors in chemical analysis.
- Learn about methods to minimize error.
- Understand basic principle of instrumentation (Flame Photometer, UV-vis spectrophotometer, Atomic Absorption spectrophotometer).
- Apply the principles of analysis and instrumentation to analyse soil samples, soft drinks and synthetic mixtures provided in the laboratory.
- Learn basic principles of separation techniques (chromatography and solvent extraction) and apply them to separate mixtures.
- Understand principles of Gravimetric analysis and apply them in determination of Ni^{2+} and Al^{3+}
- Analyse samples independently in the laboratory.

Syllabus

Unit I: Errors in Chemical Analysis **(Hours: 8)**

Types of errors, Accuracy and Precision, Absolute and relative uncertainty, propagation of uncertainty. The Gaussian distribution, mean and standard deviation, confidence intervals.

Unit 2: Optical Methods of Analysis (Hours: 10)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, Beer's-Lambert Law.

UV-Visible Spectrophotometry: Basic principles of instrumentation for single and double beam instruments. Determination of concentration of unknown compounds, composition of metal complexes using Job's method of continuous variation and mole ratio method.

Flame Atomic Absorption and Emission Spectroscopy: Basic principles of instrumentation. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal.

Application of these techniques in analysis of biological samples.

Unit 3: Separation Techniques (12 Hours)

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions.

Chromatography: Principles of Chromatographic separations, Classification of Chromatographic techniques, Thin Layer Chromatography, Column Chromatography, efficiency of separation (Resolution, Efficiency of Resolution, Plate Height)

Application of these techniques in analysis of biological samples.

Practical Component Credits: 02

(Laboratory periods: 60)

1. Analysis of soil**.**
   (a) Determination of pH of soil, Total soluble salts, carbonate and bicarbonate, calcium and magnesium by titration.
   (b) Estimation of Potassium, calcium and magnesium by flame photometry.
2. Separation of constituents of leaf pigments by thin layer chromatography.
3. Determination of the ion exchange capacity of an anion exchange resin.
4. Determination of the ion exchange capacity of a cation exchange resin.
5. Separation of amino acids by ion exchange chromatography.
6. Spectrophotometric analysis of Co^{2+} and Ni^{2+} ions in a mixture.
7. Spectrophotometric analysis of Caffeine and Benzoic acid in a soft drink
8. Gravimetric estimation of Ni^{2+} using Dimethylglyoxime.
9. Gravimetric estimation of Al^{3+} using oxine.
10. Any suitable experiment (other than the listed ones) based upon analytical techniques discussed in theory section.

References:

Theory:

1. Willard, H.H. (1988), **Instrumental Methods of Analysis**, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D. (2004), **Analytical Chemistry**, 6th Edition, John Wiley & Sons, New York.
3. Harris, D. C. (2007), **Quantitative Chemical Analysis**, 6th Edition, Freeman.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), **Principles of Instrumental Analysis**, Thomson Asia Pvt. Ltd.
5. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Practical:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's **Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Marr, G.; Rockett, B. W. (1972), **Practical Inorganic Chemistry**, Van Nostrand Reinhold.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 8: Biomolecule-II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 8: Biomolecules-II	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To teach students about important biomolecules essential to life processes.
- 2. To discuss aspects of the principles of organic chemistry in the structure and function of important biomolecules.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

Unit 1: Amino acids, Peptides & Proteins (Lecture : 12)

Amino Acids and Peptides -Zwitterion, isoelectric point and electrophoresis. Preparation of amino acids: Strecker synthesis and using Gabriel's phthalimide synthesis. Reactions of amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Determination of the primary structure of peptides by degradation Edman degradation (N-terminal) and C– terminal (thiohydantoin and with carboxypeptidase enzyme).

Synthesis of simple peptides (up to dipeptides) by N-protection (*t*-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis. An Overview of primary, secondary, tertiary and quaternary structure of proteins.

UNIT 2 : Enzymes **(Hours: 08)**

Classification of enzymes and their uses (mention ribozymes). Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereo-specificity), enzyme inhibitors and their importance, and the phenomenon of inhibition (competitive and non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure – activity relationships of drug molecules, binding role of –OH group, -NH_2 group, double bond and aromatic ring.

Unit 3: Concept of Energy in Biosystems **(Hours: 10)**

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD+, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate-glycolysis, fermentation, Krebs cycle. The caloric value of food, the standard caloric content of food types.

PRACTICALS:
Credits: 02

(Laboratory periods: 60)

1. Qualitative tests for amino acids and proteins.
2. Separation and identification of mixture of amino acids by paper chromatography.
3. Study of the action of salivary amylase on starch under optimum conditions and determine the enzyme activity.
4. Study the effect of temperature on activity of salivary amylase.
5. Isolation of casein from milk.
6. Estimation of proteins by Lowry's method.
7. Estimation of glucose by Fehling's solution.
8. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).
9. Study of the titration curve of glycine and determine the isoelectric point of glycine.
10. Estimation of proteins by Lowry's method.
11. Estimation of Glycine by Sorensen's method.

References:

Theory:

1. Devlin, T.M. (2010), **Textbook of Biochemistry with Clinical Correlation**, Wiley.

2. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2019), **Biochemistry**, 9th Ed., W. H. Freeman Co Ltd.

3. Lehninger, A.L; Nelson, D.L; Cox, M.M. (2009), **Principles of Biochemistry**, W. H. Freeman.

5. Finar, I.L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Practical:

1. Dean, J.R.; Jones, A.M.; Holmes, D., Reed, R.; Jones, A. Weyers, J. (2011), **Practical skills in chemistry**, Prentice-Hall.
2. Wilson, K.; Walker, J. (2000), **Principles and techniques of practical biochemistry**, Cambridge University Press.
3. Gowenlock. A.H. (1988), **Varley's Practical Clinical Biochemistry**, CRC Press.
4. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume II, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 9: Computer Applications in Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 9: Computer Applications in Chemistry	04	02	-	02	Class XII with Science	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to basic computer skills that will help them in solving chemistry problems using spreadsheets and BASIC language.
- To acquaint the students with different software for data tabulation, calculation, graph plotting, data analysis and document preparation.
- To expose the students to the concept of molecular modelling, its applications to various molecular systems, energy minimization techniques, analysis of Mulliken Charge and ESP Plots.

Learning outcomes

By studying this course, students will be able to:

- Become familiar with the simple use of BASIC Language.
- Use software for tabulating data, plotting graphs and charts, carry out statistical analysis of the data.
- Solve chemistry problems and simulate graphs.
- Prepare documents that will incorporate chemical structure, chemical equations, mathematical expressions from chemistry.
- Understand theoretical background of computational techniques and selective application to various molecular systems.
- Learn Energy minimization methods through use of different force fields.
- Learn ESP Plots by suitable soft wares, electron rich and electron deficient sites.
- Compare computational and experimental results and explain deviations.
- Perform Optimization of geometry parameters of a molecule (such as shape, bond length and bond angle) through use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.

Syllabus

Unit 1: Programming using BASIC **(Hours: 20)**

Programming Language – Elements of BASIC language, Numeric and string Constants and Variables, arithmetic expressions, hierarchy of operations, inbuilt functions. Syntax and use of the various QBASIC commands: REM, CLS, INPUT, PRINT, GOTO, IF, IF…THEN, IF...THEN..ELSE, IF and END IF, FOR and NEXT etc., DIM, READ, DATA, GOSUB, RETURN, RESTORE, DEF FNR and Library Functions, Simple programs based on usage of the commands mentioned above.

Statistical analysis using BASIC: Mean, Least square fit - Linear regression, variance, standard deviation.

Unit 2 : Handling of Numerical Data **(Hours: 4)**

Spreadsheet software: MS Excel. Creating a spreadsheet, entering and formatting information, applying basic functions and formulae to the data, drawing charts, tables and graphs, displaying the equation of graph along with the R^2 value, incorporating tables and graphs in Word files, graphical solution of equations, plotting pressure-volume curves of van der Waals gases, Maxwell-Boltzmann distribution, concentration versus time graphs, spectral data, titration curves, etc.

Unit 3: Molecular Modelling **(Hours: 6)**

Introduction to molecular modelling, overview of classical and quantum mechanical methods (molecular mechanics, semi empirical, ab initio and DFT), general considerations and comparison of these methods.

Practical component Credit:02

(Laboratory periods: 15 classes of 4 hours each)

Exercises of Programing

7. Calculate pressure of a real gas using Van der Waal's Equation.
8. Calculate the most probable speed, average speed and root men square velocity of an ideal gas.
9. Roots of quadratic equations
10. Binomial coefficient using GOSUB statement.
11. Mean, standard deviation
12. Least square curve fitting method for linear equation.

Plotting graphs using a spreadsheet

4. Van der Waals isotherms
5. Maxwell-Boltzmann distribution curves as function of temperature and molecular weight

6. Plot the conductometric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base

5. Plot the pH metric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base and determine the pK_a of the weak acid

7. Plot the graphs for the kinetics of first order reaction and determine the rate constant
8. Plot the UV-vis absorbance spectra and determine the molar absorption coefficient.

Molecular Modelling

6. Optimize and compare the geometry parameters of H_2O and H_2S using ArgusLab.
7. Compare the basicities of N atom in ammonia, methylamine, dimethylamine and trimethylamine using ArgusLab by comparing Mulliken charges and ESP map in ArgusLab.
8. Compare C-C bond lengths and bond order in ethane, ethene and ethyne using ArgusLab.
9. Determine enthalpy of isomerization of cis and trans-2-butene using ArgusLab.
10. Compare the HAH bond angles for the second row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory.

References:

Theory:

7. Levie, R. de. (2001), **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press.
8. Venit, S.M. (1996), **Programming in BASIC: Problem solving with structure and style**. Jaico Publishing House.
9. Lewars, E. (2003), **Computational Chemistry,** Kluwer academic Publisher.
10. Cramer, C.J.(2004), **Essentials of Computational Chemistry,** John Wiley & Sons.
11. Hinchcliffe, A. (1996), **Modelling Molecular Structures,** John Wiley & Sons.
12. Leach, A.R.(2001), **Molecular Modelling,** Prentice-Hall.

Practicals

4. Lewars, E. **(2003), Computational Chemistry,** Kluwer academic Publisher.
5. Cramer, C.J. **(2004), Essentials of Computational Chemistry,** John Wiley & Sons.
6. Hinchcliffe, A. **(1996), Modelling Molecular Structures,** John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE -10: Applied Inorganic Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	**Credits**	**Credit distribution of the course**			**Eligibility criteria**	**Pre-requisite of the course** (if any)
		Lecture	**Tutorial**	**Practical/ Practice**		
Chem-DSE 10: Applied Inorganic Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the principles of catalysis. It further discusses the types of catalysts and their industrial applications. It gives an insight into different types of fertilizers and chemistry involved in their manufacturing.
- To learn about applications of metals and inorganic compounds as diagnostic agents and medicines. The course helps develop the interest of students in the frontier areas of applied inorganic and medicinal chemistry.

Learning outcomes

By studying this course, students will be able to:

- Get a general idea of catalysis and describe in detail the mechanism of Wilkinson's catalyst, Zeigler- Natta catalyst and synthetic gasoline manufacture by Fischer-Tropsch process and applications of zeolites and biocatalysis.
- Explain the suitability of fertilizers for different kinds of crops and soil.
- Explain the inorganic compounds and metals in medicine and, specifically, the role of cisplatin in cancer therapy

Syllabus

Unit 1: Catalysis **(Hours: 10)**

General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis (catalytic steps, examples) and their industrial applications, deactivation and regeneration of catalysts, catalytic poison, promoter. Study of the following processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Synthetic gasoline (Fischer-Tropsch reaction)

3. Polymerisation of ethene and propene using Ziegler-Natta catalyst
4. Application of zeolites as catalysts.

Introduction and importance of biocatalysis

Unit 2: Fertilizers (Hours: 8)

Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime and potassium chloride, Environmental aspects of fertilizers.

Unit 3: Medical Applications of Inorganic Compounds (Hours: 12)

Introduction, Use of Chelating agents, metal complexes as diagnostic agents, Lithium in mental health, Gold containing drugs, role of metals in Neurodegenerative Diseases, Inorganic compounds in Chemotherapy: Cisplatin; mode of action, basic idea of second and third generation drugs.

Practical Component Credits:02
(Laboratory Periods: 60)

1. Preparation of magnesium pyrosilicate (Antacid).
2. Determination of ascorbic acid in vitamin C tablets by iodometric titrations.
3. Preparation of borax.
4. Preparation of boric acid.
5. Catalytic oxidation of potassium sodium tartrate by cobalt(II) chloride.
6. Estimation of boric acid and borax in a mixture by titrimetric analysis
7. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
8. Detection of constituents of Superphosphate fertilizer (Calcium and Phosphate ions) and estimation of phosphoric acid content.
9. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration)

References:

Theory:

1. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
2. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins **Inorganic Chemistry**, 5th Edition, Oxford University Press.
3. Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.
4. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
5. Lippard, S.J.; Berg, J.M. (1994), **Principles of Bioinorganic Chemistry**, Panima Publishing Company.
6. Spessard, Gary O.; Miessler, Gary L. (1996), **Organometallic Chemistry**, Prentice-Hall.

7. Fertilizers and Their Composition, Characteristics, Quality, Transformations and Applications, Tandon, H.L.S., 2008., **Riegel's Handbook of Industrial Chemistry**, CBS Publishers, New Delhi.
8. Patrick, G. (2017), **Introduction to Medicinal Chemistry**, Oxford University Press.
9. Wolfgang Kaim, Brigite Schwederski, Axel Klein, **Bioinorganic chemistry: Inorganic elements in the chemistry of life,** Jojn Wiley & Sons Inc.

Practicals:

1. Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.
2. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.
3. Marsh, D.G.; Jacobs, D.L.; Veening, H., J. Chem. Educ., Analysis of commercial vitamin C tablets by iodometric and coulometric titrimetry. 1973, 50 (9), p 626. DOI: 10.1021/ed050p626
4. https://edu.rsc.org/experiments/catalytic-oxidation-of-potassium-sodiumtartrate/1736.article

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 11: Chemistry of Polymers, Dyes and Natural Products

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 11: Chemistry of Polymers, Dyes and Natural Products	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the process of converting knowledge of chemistry into marketable products for commercial gain.
- To familiarize the basic nomenclature of polymers, dyes and natural products, classification and important terms.

Learning outcomes

By studying this course, students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Syllabus

UNIT-1: Polymers **(Hours: 12)**

Introduction and classification based on origin, monomer units, thermal response, mode of formation, structure, application and tacticity; di-block, tri-block and amphiphilic polymers; Weight average molecular weight, number average molecular weight, glass transition

temperature (Tg) of polymers; Polymerisation Reactions-Addition and condensation. Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes.
Preparation and applications of: Plastics -thermosetting (phenol-formaldehyde, polyurethanes) and thermosoftening(PVC, polythene); Fabrics -natural (cellulose and synthetic derivatives of cellulose like rayon and viscose); synthetic (acrylic, polyamide, polyester); Rubbers-natural and synthetic: Buna-N, Buna-S, Neoprene, silicon rubber; Vulcanization; Polymer additives; Introduction to Specialty Polymers: electroluminescent (Organic light emitting diodes), conducting, biodegradable polymers and liquid crystals.

UNIT 2: Dyes (Hours: 08)

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing. Synthesis and applications of Azo dyes – Methyl orange, Congo red; Triphenyl methane dyes- Crystal violet; Phthalein Dyes – Phenolphthalein; Natural dyes –Structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Unit 3: Natural Product Chemistry- An Introduction to Terpenoids and Alkaloids (Hours: 10)

Terpenes: Introduction, occurrence, classification, uses, isoprene and special isoprene rule; structure elucidation, synthesis and industrial application of citral.
Alkaloids: Introduction, occurrence, classification, uses, general structural features, general methods for structure elucidation including Hoffmann's exhaustive methylation and Emde's method. Structure elucidation, synthesis and physiological action of Nicotine.

Practicals: - Credits: 02
(Laboratory periods: 60)

1. Preparation of Starch-PVA Film.
2. Recycling of Plastic: Moulding of plastic or Cracking of plastic.
3. Preparation of Urea-formaldehyde resin.
4. Preparation of Methyl Orange.
   (a) Dyeing of different fabrics (cotton, wool, silk) using Alizarin or any other dye.
   (b) Preparation of azo dye on the surface of the fabric.
5. Qualitative test for identification of alkaloids (Dragendorff Reagent and Mayer's reagent test) and terpenoids (Salkowski test).
6. Preparation of Malachite Green.
7. Preparation of perichromic dye using p-amino Phenol and p-nitro benzaldehyde.

References:

Theory

1. Finar, I.L. (2008), **Organic Chemistry**, Volume 2, 5th Edition, Pearson Education
2. Saunders, K. J. (1988), **Organic Polymer Chemistry**,2nd Edition Chapman & Hall, London
3. Campbell, Ian M., (2000), **Introduction to Synthetic Polymers**, 2nd Edition Oxford University Press, USA.
4. Bahadur, P. and Sastry, N.V. (2002) **Principles of Polymer Science** Narosa Publications, New Delhi
5. Patrick, G. **An Introduction to Medicinal Chemistry** (2013), 4th Edition, Oxford University Press.

6. Priscilla Abarca, Patricia Silva, Iriux Almodovar and Marcos Caroli Rezende* Quim. Nova, Vol. 37, No. 4, 745-747, 2014. http://dx.doi.org/10.5935/0100-4042.20140120

Practical:

1. Ashraf S.M., Ahmad S., Riaz U., **A Laboratory Manual of Polymers**, I. K. International Publishing House Pvt. Ltd., New Delh.
2. Hannaford FA J., Smith P. W. G. & Tatchell A. R.; **Vogel's Textbook of Practical Organic Chemistry** Fifth Edition, Longman Scientific and Technical.
3. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry**: Volume I, I K International Publishing House Pvt. Ltd., New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE CHEM-DSE 12: Biophysical Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chem-DSE 12: Biophysical Chemistry	**04**	**02**	**-**	**02**	**Class XII with Science**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide students with a sound background of latest techniques used in biophysical research
- To provide them with an understanding of the principles underlying these techniques.

Learning outcomes

By studying this course, students will be able to:

- The students will acquire knowledge of structure and biological functions of proteins and enzyme.
- Students will acquire knowledge about the principles and applications of latest methods used to analyse amino acid and proteins.
- The course will also provide students an opportunity for hands-on-experience to develop their laboratory skills expected for working in a biophysical research lab.

Syllabus

Unit I: Fundamentals of Biological Macromolecules (Hours: 10)

Structure and physical properties of amino acids, structure, function, and folding of proteins, internal rotational angle, conformations of proteins (Ramachandran plot, secondary, tertiary and quaternary structure). Structures of nucleic acids, Properties of nucleosides and nucleotides;composition of nucleic acids, Stabilizing interactions in biomolecules.

Unit II: Biophysical techniques for the Structural and Conformational Analysis (Hours: 20)

Overview : General principle and qualitative treatment of the techniques to understand the structure and characteristics of enzymes, protein and nucleic acid: X-ray crystallography – protein crystals, myoglobin, nitrogenase, pepsinogen; NMR spectroscopy-NMR spectra of amino acids, UV-vis absorption spectroscopy, Fluorescence spectroscopy and Vibrational spectroscopy. Determination of protein structures by spectroscopic methods (FTIR, NMR), thermodynamics of protein folding by spectroscopic methods, protein conformational study by NMR and fluorescence spectroscopy. Methods for the separation of biomolecules: General principles, including Chromatography; Sedimentation, Moving Boundary Sedimentation, Electrophoresis, Isoelectric focusing.

Practical Component **Credits: 02**

(Laboratory periods: 60)

1. Separate and identify amino acids by paper chromatography.
2. Determine the isoelectric point of the given proteins.
3. Estimation of Proteins by Biuret, Lowry and Bradford.
4. Estimation of Urea.
5. Separation and identification of Sugars/lipids by TLC.
6. To check the purity of the proteins by calculating A260/ A280 ratio spectrophotometrically.
7. Agarose gel electrophoresis to check the size of DNA (For example- Calf ThymusDNA).
8. Characterization of the DNA (genomic/ designed oligonucleotide) as a function of pH, salt-concentration spectrophotometrically.
9. Determination of the isobestic point by titrating DNA sample with any ligand using UV- Visiblespectrophotometer.
10. SDS-PAGE analysis of proteins.

References:

Theory:

1. Lesk, A.M., **Introduction to Protein Science: Architecture, Function, and Genomics**, 2nd edition, 2010, Oxford University Press.
2. Cantor, C.R. and Schimmel, P.R., **Biophysical Chemistry**, 1980, Freeman.
3. Van Holde, K.E., Johnson, W.C. and Ho, P.S., **Principles of Physical Biochemistry**, 2nded,2006, Pearson Education.
4. Harding, S.E. and Chowdhry, B. Z. **Protein-Ligand Interactions**, Oxford UniversityPress.

Practical:

1. Hofmann, A ., Clokie,S., Wilson and Walker’s Principles & Techniques of Practical Biochemistry, 2018, Cambridge University Press.

2. Friefelder D. Physical Biochemistry- Application to Biochemistry and Molecular Biology, 1983, WH Freeman and Company.

3. R. N. Roy, Viva and Practical Physiology, Biochemistry and Biophysics, 1998, Books and allied Pvt. Ltd.

4. Sawhney, S.K. and Singh , R.,Introductory Practical Biochemistry , 2nd Edition, 2005, Alpha Science International.

5. Keith Wilson , John Walker, John M. Walker Principles and Techniques of Practical Biochemistry, 5th Edition, 2000, Cambridge University Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology for Chemists (DSE-13)	04	03	--	01	Class 12th with Physics, Chemistry	

Learning objectives

The objectives of this course are as follows:

- To make the students aware of fundamental but mandatory ethical practices in chemistry.
- To introduce the concept of data analysis.
- To learn to perform literature survey in different modes.
- To make the students aware of safety handling and safe storage of chemicals.
- To make students aware about plagiarism and how to avoid it.
- To teach the use of different e-resources.

Learning outcomes

By studying this course, students will be able to:

- Follow ethical practices in chemistry
- Do Data analysis
- Literature survey in different modes
- Use e-resources.
- Avoid plagiarism, understand the consequences and how to avoid

SYLLABUS OF DSE-13

UNIT – 1: Scope of Research **(Hours: 3)**

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

UNIT – 2: **Literature Survey, Databases and Research metrics** **(Hours: 15)**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science,

Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results.
Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index.
Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN

UNIT – 3: Communication in Science (Hours: 12)

Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis.
Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

UNIT – 4: Research and Publication ethics (Hours: 9)

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkund etc), redundant dublications

Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals

IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

UNIT – 5: Statistical analysis for chemists (Hours: 6)

Types of data, data collection-Methods and tools, data processing, hypothesis testing, Normal and Binomial distribution, tests of significance: t-test, F-test, chi- square test, ANOVA, multiple range test, regression and correlation.

Features of data analysis with computers and softwares -Microsoft Excel, Origin, SPSS

Practical component Credits: 01

(Laboratory periods:15 classes of 2 hours each)

12. Collection of journal articles on a particular topic using Google Scholar and creating a database.
13. Collection of journal articles on a particular topic using Science Direct and creating a database.
14. Collection of journal articles on a particular topic using Scopus and creating a database.
15. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.
16. Collection of chemical structure using ChemSpider and creating a database.
17. Curve fitting using freely available softwares/apps (any one)

18. Making of power point presentation
19. Experimental learning of safe storage hazardous chemicals
20. Experimental learning of handling of hazardous chemicals
21. Technical writing on topics assigned.
22. Demonstration for checking of plagiarism using recommended software

Essential/recommended readings:

7. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
8. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
9. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
10. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
11. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
12. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
    OSU safety manual 1.01

Bachelor of Sciences in Industrial Chemistry

Category II

Industrial Chemistry Course for Undergraduate Programme of study with Industrial Chemistry as one of the Core Disciplines

SEMESTER IV

DISCIPLINE SPECIFIC CORE COURSE – 10: (DSC-10) PHARMACEUTICALS, COSMETICS AND PESTICIDES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pharmaceuticals, Cosmetics and Pesticides (DSC-10: Industrial Chemistry -IV)	04	02	--	02	Physics, Chemistry, Mathematics, in Class XII	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- To imparts basic knowledge of chemistry of inorganic materials such as silicates, non-silicates, ceramics, and cement.
- To enrich students with the knowledge of various types of batteries like Pb acid Battery, Li-ion Battery, Fuel Cells, Solar cell and Polymer cell.
- To impart the theoretical and practical knowledge of estimation and determination of various industrially important chemicals.

Learning outcomes

By the end of this course, students will be able to:

- Establish an appreciation of the role of inorganic chemistry in the chemical sciences.
- Analyse inorganic materials like silicates, ceramics and cement.

- Familiarized with scientific method of planning, developing, conducting, reviewing and reporting experiments.
- Draw various concepts of industrial metallurgy which will help them to explore new innovative areas of research.
- Explain scientific methods employed in inorganic chemistry.

SYLLABUS OF DSC-10

Unit 1: Drugs and Pharmaceuticals **Hours: 12**

Drug discovery, design and development. Synthesis of the representative drugs of the following classes: analgesics, antipyretics, antiinflammatory agents (Aspirin, Paracetamol.), antibiotics (Penicillin, Cephalosporin, Chloromycetin, Streptomycin and Chloramphenicol), antibacterial and antifungal agents (Sulphonamides, Sulfamethoxazole), antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular drugs (Glyceryl trinitrate), antileprosy drug (Dapsone).

Unit 2: Cosmetics **Hours: 08**

Introduction to cosmetics and perfumes, preparation and uses of the following: Hair dye, hair spray. Shampoo. Sun-tan lotions, face powder, lipsticks. talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants.

Unit 3: Pesticides **Hours: 10**

Introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides. Synthesis and technical manufacture, uses of representative pesticides in the following classes: Organochlorines (DDT, Gammaxene), Organophosphates (Malathion, Parathion), Carbamates (Carbofuran and carbaryl), Quinones (Chloranil), Anilides (Alachlor and Butachlor).

Practical

(Credits: 2, Laboratory periods: 60)

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of nail enamel
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of Aspirin and its analysis.
7. Preparation of nail polish and nail polish remover.
8. To calculate acidity in a given sample of pesticide formulations as per BIS specifications.
9. To calculate alkalinity in a given sample of pesticide formulations as per BIS specifications.
10. Preparation of Antacid.
11. Preparation of paracetamol.

References (Theory and practical):

1. Vermani, O. P.; Narula, A. K. (2004), **Industrial Chemistry**, Galgotia Publications Pvt. Ltd., New Delhi.
2. Bhatia, S. C. (2004), **Chemical Process Industries,** Vol. I & II, CBS Publishers, New Delhi.
3. Barel, A.O.; Paye, M.; Maibach, H.I.(2014), **Handbook of Cosmetic Science and Technology**, CRC Press.
4. Gupta, P.K.; Gupta, S.K.(2011),**Pharmaceutics and Cosmetics**, Pragati Prakashan
5. Butler, H. (2000),**Poucher's Perfumes, Cosmetic and Soap**, Springer.
6. Kumari,R.(2018),**Chemistry of Cosmetics**,Prestige Publisher.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –DSC 11: Chemistry of Carboxylic acids & derivatives, Amines and Heterocycles

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Carboxylic Acids & their Derivatives, Amines and Heterocycles DSC-10: Chemistry-IV	**04**	**02**	**-**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students learn about the chemistry of carboxylic acids and their derivatives (aliphatic and aromatic)
- To give basic understanding of amines (aliphatic & aromatic), diazonium salts
- To provide basic understanding of heterocyclic systems.

Learning outcomes

By studying this course, students will be able to:

- Understand reactions of carboxylic acids, esters, amides, amines and diazonium salts
- Understand the concept of protection and deprotection.
- Use the synthetic chemistry learnt in this course to do functional group transformations.
- Gain theoretical understanding of chemistry of heterocyclic compounds.

Syllabus

Unit 1: Carboxylic Acids and their Derivatives (aliphatic and aromatic)
(Hours: 13)

Preparation: Oxidation reactions of alcohols, aldehydes and ketones, Acidic and alkaline hydrolysis of esters; Reactions: Hell-Volhard Zelinsky reaction,

Carboxylic acid derivatives (aliphatic): Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Claisen condensation. Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky reaction, Perkin condensation.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applicationsof ethyl acetoacetate

Unit 2: Amines (aliphatic & aromatic) and Diazonium Salts (Hours:10)

Amines
Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hoffmann bromamide reaction. Reactions: Hoffmann *vs* Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO_2, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation; basicity of amines.

Diazonium salt

Preparation: from aromatic amines; Reactions: conversion to benzene, phenol and dyes.

Unit 3: Heterocyclic Compounds (Hours: 7)
Introduction, classification, structure, nomenclature and uses. Preparation and properties of the following heterocyclic compounds with reference to electrophilic and nucleophilic substitution: furan, pyrrole, thiophene, and pyridine.

Practical Component: **Credits: 02**

(Laboratory periods: 60)

3. Systematic qualitative analysis and preparation of suitable crystalline derivative (carboxylic acids, carbonyl, alcohols, phenols, amines (1°, 2°, 3°) and amides).
4. Preparation:
   a. Acetylation of Aniline and Phenols.
   b. Benzoylation of Aniline and phenols

The above derivatives should be prepared using 0.5-1g of the organic compound. The solidsamples must be collected and may be used for recrystallization and melting point.

References:

Theory:

5. Morrison, R. N.; Boyd, R. N. **Organic Chemistry**, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
6. Finar, I. L. **Organic Chemistry** (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
7. Ahluwalia, V.K.; Bhagat, P.; Aggarwal, R.; Chandra, R. (2005), **Intermediate for OrganicSynthesis**, I.K. International.
8. Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016), **Organic Chemistry**, 12th Ed.,Wiley.

Practical:

7. Ahluwalia, V.K.; Dhingra, S.; Gulati, A. (2005), **College Practical Chemistry**, UniversityPress (India) Ltd.
8. Ahluwalia, V.K.; Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry:Qualitative Analysis**, University Press.
9. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume I**, I KInternational Publishing House Pvt. Ltd., New Delhi.
10. Pasricha, S., Chaudhary, A. (2021), **Practical Organic Chemistry: Volume II**, I KInternational Publishing House Pvt. Ltd., New Delhi.
11. Vogel, A.I. (1972), **Textbook of Practical Organic Chemistry**, Prentice-Hall.
12. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook ofQuantitative Chemical Analysis**, John Wiley and Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Sciences in Industrial Chemistry
SEMESTER V

DISCIPLINE SPECIFIC CORE COURSE – 13: (DSC-13) INDUSTRIAL CATALYSTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

<table>
<tr><th rowspan="2">Course title & Code</th><th rowspan="2">Credits</th><th colspan="3">Credit distribution of the course</th><th rowspan="2">Eligibility criteria</th><th rowspan="2">Pre-requisite of the course (if any)</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical/ Practice</th></tr>
<tr><td>Industrial Catalysts (DSC-13: Industrial Chemistry -V)</td><td>04</td><td>02</td><td>--</td><td>02</td><td>Physics, Chemistry, Mathematics, in Class XII</td><td>NIL</td></tr>
</table>

Learning Objectives:

The Learning Objectives of this course are as follows:

- To imparts basic knowledge of catalysis, properties of catalysts and mode of action of catalyst.
- To enrich students with the knowledge of various types of catalysts such as organometallic catalyst, biocatalyst, shape selective catalyst and photocatalysts.
- To impart the theoretical and practical knowledge of catalysts with the view of their industrial applications.

Learning Outcomes:

By the end of this course, students will be able to:

- Establish an appreciation of the role of catalyst in industrial applications.
- Gain sound knowledge of various types of catalyst.
- Get skilled in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
- Get skilled concepts of industrial catalysis which will help them to explore new innovative areas of research.

Unit 1: Introduction of Catalyst **Hours: 8**

General principles of catalysis, properties of catalysts, Mode of action of catalyst, Types of catalyst (homogeneous and heterogeneous catalysis), Deactivation and regeneration of catalysts, catalytic poison, Promoter, Turnover frequency, Turnover number, Specificity and selectivity

Unit 2: Catalysis by Organometallic Compounds **Hours: 6**

Study of the following industrial processes, catalytic cycle and their mechanism:
Alkene hydrogenation (Wilkinson's Catalyst), Synthetic gasoline (Fischer Tropsch reaction), Polymerisation of ethene using Ziegler-Natta catalyst

Unit 3: Biocatalysis Hours: 5

Introduction, Kinetics of enzyme–catalysed reactions, Industrial process with biocatalyst, Aspartame through enzymatic peptide synthesis, 4-Hydroxyphenoxypropionic acid as herbicide intermediate

Unit 4: Shape selective catalysis: Zeolites Hours: 6

Composition and structure of Zeolites, Catalytic properties of Zeolites, Shape selectivity, Isomorphic substitution of Zeolites, Metal doped Zeolites, Applications of Zeolites

Unit 5: Photocatalysis Hours: 5

Basic principle, Photoreduction and oxidation of water, Water reduction, Water oxidation, Photocleavage of water

Practical

(Credits: 2, Laboratory periods: 60)

1. Catalytic bromination of benzene. Catalyst: $FeCl_3/AlCl_3$
2. Catalytic chlorination of benzene. Catalyst: $FeCl_3/AlCl_3$
3. Catalytic Removal of Bromates from polluted Water: Synthesis of catalyst one lab, Removal of Bromates one lab.
4. Phase-Transfer Catalytic Reactions
5. Catalytic oxidation of ammonia using chromium(III) oxide as a catalyst. Catalytic Friedal-craft reaction using $AlCl_3$ and Lewis acid catalyst. Synthesis of toluene.
6. Synthesis of "Zeolite A" catalyst.
7. Zeolite Hydrogen-Y or dil.HCl/dil.H_2SO_4 as a Catalyst for the Preparation of an Ester.
8. Synthesis of biaryl using palladium catalyst.
9. Catalytic Transfer Hydrogenation of Castor Oil
10. Reduction of Nitrobenzene

References (Theory):

1. Huheey, J. E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
2. Cotton, F.A.; Wilkinson, G. (1999), **Advanced Inorganic Chemistry,** Wiley-VCH.
3. Jens Hagen (2015) **Industrial Catalysis: A Practical Approach** Wiley-VCH Verlag GmbH & Co

References (Practical):

1. Cerrillo, J. L.; López-Hernández, I.; Palomares, A. E. **Catalytic Removal of Bromates from Water: A Hands-On Laboratory Experiment to Solve a Water Pollution Problem through Catalysis** J. Chem. Educ. 2021, 98, 1726−1731.
2. Shabestary, N.; Khazaeli, S.; Hickman, R.; **Phase-Transfer Catalytic Reactions Journal of Chemical Education**, 1998, 75, 1470-1472.
3. Volkovich, V. A.; Griffiths, T. R.; **Catalytic Oxidation of Ammonia: A Sparkling Experiment** J. Chem. Educ. 2000, 77, 2, 177.

4. Williams, D. J.; Huck, B. E.; Wilkinson, A. P. **First-Year Undergraduate Laboratory Experiments with Zeolites Chem. Educator** 2002, 7, 33–36.
5. Coker, E. N.; Davis, P. J.; **Experiments with Zeolites at the Secondary-School Level: Experience from The Netherlands** Journal of Chemical Education 1999, 76, 10, 1417.
6. Hanson RW. **Catalytic transfer hydogenation reactions for undergraduate practical programs.** J Chem Educ. 2009, 74, 430.
7. Alwaseem H, Donahue CJ, Marincean S. **Catalytic transfer hydrogenation of castor oil.** J Chem Educ. 2014; 91, 575–8.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –DSC 14: COORDINATION CHEMISTRY AND ORGANOMETALLICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Coordination Chemistry and Organometallics DSC-13: Chemistry- V	04	02	-	02	Class 12th with Physics, Chemistry, Mathematics	

Learning Objectives

The Learning Objectives of this course are as follows:

- To develop basic understanding of coordination chemistry and organometallics which are of immense importance to biological systems, qualitative quantitative analysis, catalysis, medicines, paints and pigments etc.
- The students learn nomenclature, isomerism and bonding in coordination compounds with special emphasis on important coordination compounds in the biological system.
- To understand classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species with special emphasis on metal carbonyls.

Learning outcomes

By studying this course, students will be able to:

- Understand terms: ligand, denticity of ligands, chelate, coordination number.
- Systematically name coordination compounds.

- Discuss the various types of isomerism possible in Octahedral and Tetrahedral coordination compounds.
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes.
- Explain the meaning of the terms $\Delta o.$, Δt, pairing energy, CFSE, high spin and low spin and how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy.
- Explain magnetic properties and colour of complexes on basis of Crystal Field Theory
- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
- Learn how IR data can be used to understand extent of back bonding in metal carbonyls.

Syllabus

Unit 1: Introduction to Coordination compounds (Hours: 6)

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands. Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

Unit 2: Bonding in Coordination Compounds (Hours: 14)

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes, Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields, Crystal field stabilization energy (CFSE), concept of pairing energy, Factors affecting the magnitude of Δ, Spectrochemical series, Splitting of d orbitals in tetrahedral symmetry, Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry, Jahn-Teller distortion

Unit 3: Organometallic Chemistry (Hours: 10)

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, sigma, pi and multicentre bonds), Structure and bonding of methyl lithium and Zeise's salt, Structure and bonding of ferrocene, mononuclear and polynuclear carbonyls of 3d metals, 18-electron rule as applied to carbonyls, π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Practical Component Credits:02

(Laboratory periods:60)

8. Estimation of Mg^{2+} by direct complexometric titrations using EDTA.
9. Estimation of Zn^{2+} by direct complexometric titrations using EDTA.
10. Estimation of Ca^{2+} by direct complexometric titrations using EDTA.
11. Estimation of total hardness of a given sample of water by complexometric titration.
12. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1, 10- phenanthroline complex in solution by Job's method.
13. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+}-1,10-phenanthroline complex in solution by mole ratio method
14. Preparation of the following inorganic compounds:
    a). Tetraamminecopper(II) sulphate
    b). Potassium trioxalatoferrate(III) trihydrate
    c). Chrome alum
    d). *Cis*- and *trans*-Potassium diaquadioxalatochromate(III)

8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References:

Theory:

17. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry- Principles of Structure and Reactivity**, Pearson Education.
18. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
19. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Inorganic *Chemistry***, 5th Edition, W. H. Freeman and Company.
20. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition, Wiley India.
21. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
22. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier.
23. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.

Practicals:

4. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989),Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.
5. Marr, G.; Rockett, B.W. (1972), Practical Inorganic Chemistry, Van Nostrand Reinhold.
6. Dua A, Manav N, **Practical Inorganic Chemistry,** (2017), Manakin Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Sciences in Industrial Chemistry

SEMESTER VI

DISCIPLINE SPECIFIC CORE COURSE – 16: (DSC-16) FOOD ADDITIVES, CONTAMINATION AND SAFETY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Food Additives, Contamination and Safety (DSC-16: Industrial Chemistry - VI)	04	02	--	02	Physics, Chemistry, Mathematics, in Class XII	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the chemistry of food additives and their applications.
- To impart theoretical and practical knowledge on common food additives, contaminants and adulterants.
- To enhance the understanding of safety measures of food and evaluation techniques to determine toxicity of additives.
- To enhance knowledge about regulations and monitoring agencies of food.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand and describe applications of various food additives in food processing and preservation.
- Know the merits and demerits of synthetic and natural colouring, flavouring and sweetening agents as food additives.
- Identify and prevent potential sources of food contamination
- Know Safety measures of food additives, regulations and monitoring agencies and toxicological evaluation of additives.

Unit 1: Food Additives   Hours: 12

Introduction, need of food additives in food processing and preservation. Characteristics and classification of food additives.
Antimicrobial agents. -Nitrites, sulphides, sulphur dioxide, sodium chloride, hydrogen peroxide.

Antioxidants - Introduction, mechanism of action, natural and synthetic antioxidants, technological aspect of antioxidants.
Sweeteners- Introduction, importance, classification- natural and artificial, chemistry, technology and toxicology, consideration for choosing sweetening agents.
Colors- Introduction, importance, classification- natural, artificial, and natural identical, FD&C Dyes and Lakes. polymeric colors.

Unit 2: Food Contamination & adulterants Hours: 12

Contamination in Food: Physical, chemical contaminants- heavy metals, pesticide residues, agrochemicals, Antibiotics and Veterinary Drug residues, environmental pollutants, radionuclides, solvent residues, NOTS (Naturally Occurring Toxic Substances)
Contaminants formed during processing & packaging – nitrosamines, acrylamide, alloys, benzene, dioxins, furans, persistent organic pollutants, polymers, PAH (Polycyclic Aromatic Hydrocarbons) in smoked foods, food. fumigants, autoxidation products.
Food adulteration - Common adulterants in foods and tests to detect common adulterants.

Unit 3: Food Safety, Risks and hazards Hours: 6

Food related hazards, regulations and monitoring agencies, interaction of additives with food ingredients and their toxicological aspects, quality evaluation of additives and contaminants, Acute and chronic studies, NOEL, ADI, LD50

Practical
Credits: 02, Laboratory periods: 60)

1. Determination of moisture content of foods by oven drying.
2. Determination of reducing and total sugar content in foods.
3. Chromatographic Separation and identification of sugars and amino acids.
4. Testing of turmeric powder, milk and mustard oil for adulterants.
5. Extraction of natural coloring and flavoring agent from flowers and fruits
6. Inspection of various food grains- cereals and coarse cereals
7. Determination of quality standards and inspection of spices and condiments.
8. Qualitative tests for hydrogenated fats, butter, and ghee.
9. Estimation of sulphur dioxide in beverages.
10. Qualitative estimation of benzoic acid in ketchup and sauces.
11. Chromatographic estimation of colour.
12. Study the effect of aerial oxidation of food.

References (Theory):

1. DeMan. (2007). **Principles of Food Chemistry**. Springer, 3rdedition
2. Emerton, V, (2008). **Food Colours**. Blackwell Publishing.
3. Wilson, R. (2007).**Sweeteners**. Blackwell Publishing.
4. Fennema OR.(1996). **Food Chemistry**. Marcel Dekker.
5. Pieternel A, Luning. & Willem, J. Marcelis. (2009). **Food Quality Management Technological and Managerial principles and practices**. Wageningen.

References (Practical):

1. Ranganna, S., & Ranganna, S. (2003). **Handbook of analysis and quality control for fruit and vegetable products**. New Delhi: Tata McGraw-Hill
2. Nielsen, S. S. (2017). **Food analysis**.
3. Vogel, Arthur I. (Arthur Israel). (1989). **Vogel's textbook of quantitative chemical analysis**. Harlow, Essex, England : New York :Longman Scientific & Technical ; Wiley,

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Quantum Chemistry and Spectroscopy DSC-16: Chemistry- VI	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry, Mathematics**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the concepts and methodology of quantum mechanics
- Application of Quantum chemistry to spectroscopy
- To establish the relation between structure determination and spectra.

Learning outcomes

By studying this course, students will be able to:

- Understand basic principles of quantum mechanics: operators, eigen values, averages, probability distributions.
- Understand and use basic concepts of microwave, IR and UV-VIS spectroscopy for interpretation of spectra.

Syllabus

Unit 1: Quantum Chemistry (Hours: 16)

Postulates of quantum mechanics, quantum mechanical operators.

Schrodinger equation and its application to free particle and particle in a 1-D box (complete solution), quantization, normalization of wave functions, concept of zero-point energy.

Qualitative treatment of H and H like atoms. Setting up of Schrodinger equation for many electron atoms.

Rotational Motion: Schrödinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels.

Vibrational Motion: Schrödinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels.

Unit 2: Spectroscopy (Hours: 14)

Electromagnetic radiation and its interaction with matter. Lambert-Beer's law, Jablonski's diagram. Florescence and Phosphorescence.
Difference between atomic and molecular spectra. Born- Oppenheimer approximation: Separation of molecular energies into translational, rotational, vibrational and electronic components.

Microwave Spectroscopy: Microwave (pure rotational) spectra of diatomic molecules. Selection rules.
Structural information derived from rotational spectroscopy.

IR Spectroscopy: Selection rules, IR spectra of diatomic molecules. Structural information derived fromvibrational spectra. Effect of hydrogen bonding (inter- and intramolecular) and substitution on vibrational frequencies.

Electronic Spectroscopy: Electronic excited states. Free electron model and its application to electronic spectra of polyenes. chromophores, auxochromes, bathochromic and hypsochromic shifts.

Practical component Credits:02

(Laboratory Periods: 60)UV/Visible spectroscopy

19. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and
determine the λ_{max} values. Calculate the energies of the two transitions in different units (J $molecule^{-1}$, kJ mol^{-1}, cm^{-1}, eV).
20. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$
21. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2- propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

Colorimetry

22. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$/$CoCl_2$ in a solution of unknown concentration
23. Determine the concentrations of KMnO4 and $K_2Cr_2O_7$ in a mixture.
24. Study the kinetics of iodination of propanone in acidic medium.
25. Determine the amount of iron present in a sample using 1, 10-phenanthroline.
26. Determine the dissociation constant of an indicator (phenolphthalein).

27. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

References:

Theory:

1. Banwell, C.N.; McCash, E.M.(2006), **Fundamentals of Molecular Spectroscopy**,Tata McGraw- Hill.
2. Kapoor, K.L.(2015),**A Textbook of Physical Chemistry**, McGraw Hill Education,
   ,Vol 4, 5th Edition, McGraw Hill Education.
3. McQuarrie, D.A.(2016),**Quantum Chemistry**, Viva Books.
4. Chandra, A. K.(2001),**Introductory Quantum Chemistry**, Tata McGraw-Hill.
5. Dua A and Tyagi P, **Molecular Spectroscopy: Quantum to Spectrum**, (2022)Atlantic Publishers & Distributors Pvt Ltd.
6. Dua A, Singh C, **Quantum Chemistry: Classical to Computational** (2015) ManakinPress.

Practical:

7. Khosla, B.D.; Garg, V.C.; Gulati, A. (2015),**Senior Practical Physical Chemistry**,
   R. Chand & Co, New Delhi.
8. Kapoor, K.L. (2019),**A Textbook of Physical Chemistry**,
   Vol.7, 1st Edition,McGraw Hill Education.
9. Garland, C. W.; Nibler, J. W.; Shoemaker, D. P.(2003),**Experiments in PhysicalChemistry**, 8th Edition, McGraw-Hill, New York.

Additional Resources:

5. Castellan, G. W .(2004),**Physical Chemistry**, Narosa.
6. Petrucci, R. H.(1989),**General Chemistry: Principles and Applications**, MacmillanPublishing

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Pool of Discipline Specific Elective Courses (DSE)

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Green Chemistry	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To make the society to become more and more environmentally conscious by knowing huge rise in environmental pollution, depleting resources, climate change, ozone depletion, heaps and heaps of landfills piling up has forced.
- To improve the creative and innovative thinking in undergraduate students towards sustainable practices of Green Chemistry. has arisen from these concerns.
- To know the Green chemistry in a way to boost profits, increase productivity and ensure sustainability with absolute zero waste. To trained them to practice chemistry in the safest way in the laboratories as well as the chemical industry and extends to society in a sustainable future for the planet.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the twelve principles of green chemistry and also build the basic understanding of toxicity, hazard and risk related to chemical substances.
- Calculate atom economy, E-factor and relate them in all organic synthesis
- Appreciate the use of catalyst over stoichiometric reagents
- Learn to use green solvents, renewable feedstock and renewable energy sources for carrying out safer chemistry
- Appreciate the use of green chemistry in problem solving skills and critical thinking to innovate and find solutions to environmental problems.
- Learn to design safer processes, chemicals and products through understanding of inherently safer design (ISD)
- Appreciate the success stories and real-world cases as motivation for them to practice green chemistry

Unit 1: Introduction Hours :08

Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry.

• Need of green chemistry

• Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each).

• A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).

Unit 2: Twelve Principles of Green Chemistry Hours : 12

The twelve principles of the Green Chemistry with their explanations, Special emphasis on the following:

• Prevention of waste / byproducts, pollution prevention hierarchy.

• Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.

• Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.

• Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

• Green energy and sustainability.

• Real-time analysis for pollution prevention.

• Prevention of chemical accidents, designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation

Unit 3: Hours : 10

The following Real-world Cases in green chemistry should be discussed: Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifoulant. Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

Practical
(Credits: 02, Laboratory periods: 60)

Characterization by melting point, UV-Visible spectroscopy, IR spectroscopy and any other specific method should be done (wherever applicable).

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.
2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, solubility, combustion test, density, viscosity, gel formation at low temperature and IR can be provided).
4. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.
5. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.
6. Mechanochemical solvent free, solid-solid synthesis of azomethine using *p*-toluidine and *o*-vanillin/*p*-vanillin.
8. 6 Microwave-assisted Knoevenagel reaction using anisaldehyde, ethylcyanoacetate and ammonium formate.
7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
8. Photochemical conversion of dimethyl maleate to dimethyl fumarate (*cis-trans* isomerisation)
9. Benzil- Benzilic acid rearrangement: Preparation of benzilic acid in solid state under solvent-free condition.

References (Theory):

1. Anastas, P.T., Warner, J.C. (2014), **Green Chemistry, Theory and Practice**, Oxford University Press.
2. Lancaster, M. (2016), **Green Chemistry: An Introductory Text**, 3rd Edition, RSC Publishing.
3. Cann, M. C., Connely, M.E. (2000), **Real-World cases in Green Chemistry, American Chemical Society**, Washington.
4. Matlack, A.S. (2010), **Introduction to Green Chemistry**, 2nd Edition, Boca Raton: CRC Press/Taylor & Francis Group publisher.
5. Alhuwalia, V.K., Kidwai, M.R. (2005), **New Trends in Green chemistry**, Anamalaya Publishers.
6. Sidhwani, I.T, Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.

References (Practical):

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.
2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
3. Pavia, D.L.; Lamponam, G.H.; Kriz, G.S.W. B. (2012), **Introduction to organic Laboratory Technique- A Microscale approach**, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry.
4. Sidhwani I.T. (2015), Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. **DU Journal of Undergraduate Research and Innovation**, 1(1),131-151. ISSN: 2395-2334.
5. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
6. **Monograph on Green Chemistry Laboratory Experiments**, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Analytical Methods in Chemistry	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To make the students aware of the concept of sampling, accuracy, precision, statistical test data-F, Q and t test.
- To learn the laws of spectroscopy and selection rules governing the possible transitions in the different regions of the electromagnetic spectrum, Thermal and electroanalytical methods of analysis.
- To learn important separation methods like solvent extraction and chromatography. The practical exposure to the latest instrumentation and to detect analytes in a mixture.

Learning Outcomes:

By the end of this course, students will be able to:

- Perform experiments with accuracy and precision.
- Develop methods of analysis for different samples independently.
- Test contaminated water samples.
- Understand basic principles of instruments like Flame Photometer, UV-vis spectrophotometer.
- Learn separation of analytes by chromatography.
- Apply knowledge of geometrical isomers and keto-enol tautomers to analysis.
- Determine composition of soil.
- Estimate macronutrients using Flame photometry.

Unit 1: Qualitative and quantitative aspects of analysis Hours : 04

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression. Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit 2: Optical methods of analysis Hours :10

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules. UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Transmittance. Absorbance and Beer-Lambert law. Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs).

Unit 3: Thermal methods of analysis Hours :04

Theory of thermogravimetry (TG) and basic principle of instrumentation of thermal analyser. Techniques for quantitative estimation of Ca and Mg from their mixture.

Unit 4: Electroanalytical methods Hours :04

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Unit 5: Separation techniques Hours :08

Solvent extraction: Classification, principle and efficiency of the technique. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media. Chromatography: Classification, principle and efficiency of the technique, Mechanism of separation: adsorption, partition &ion-exchange, Development of chromatograms: frontal, elution and displacement methods.

Practical
(Credits: 02, Laboratory periods: 60)

1. Separation of mixtures by paper chromatography and reporting the Rf values:
   (i) Co^{2+} and Ni^{2+}.
   (ii) Amino acids present in the given mixture.
2. Solvent Extractions

To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+} DMG complex in chloroform, and determine its concentration by spectrophotometry.

3. Analysis of soil:
   (i) Determination of pH of soil.
   (ii) Total soluble salt
   (iii) Estimation of calcium and magnesium
   (iv) Qualitative detection of nitrate and phosphate
4. Ion exchange:
   (i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
   (ii) Separation of amino acids from organic acids by ion exchange chromatography.

5. Spectrophotometry

    (i) Verification of Lambert-Beer's law and determination of concentration of a coloured species ($CuSO_4$, $KMnO_4$, $CoCl_2$, $CoSO_4$)

    (ii) Determination of concentration of coloured species via following methods;

        (a) Graphical method
        (b) Epsilon method
        (c) Ratio method
        (d) Standard addition method

References (Theory):

1. Willard, H.H.(1988),**Instrumental Methods of Analysis**, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D.(2004),**Analytical Chemistry**, 7th Edition, John Wiley & Sons, New York.
3. Harris, D. C.(2007),**Quantitative Chemical Analysis**,7th Edition, Freeman.
4. Khopkar, S.M. (2008), **Basic Concepts of Analytical Chemistry**, New Age International Publisher.
5. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2017), **Principles of Instrumental Analysis,** Thomson Asia Pvt. Ltd.

References (Practical):

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),**Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Basics of Polymer Chemistry	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To help the student to know about the synthesis, properties and applications of polymers.
- To give glimpse of polymer industry to the student and help them to choose their career in the field of polymer chemistry.

Learning Outcomes:

By the end of this course, students will be able to:

- Know about history of polymeric materials and their classification
- Learn about different mechanisms of polymerization and polymerization techniques
- Learn about different methods of finding out average molecular weight of polymers
- Differentiate between glass transition temperature (Tg) and crystalline melting point (Tm)
- Determine Tg and Tm
- Learn properties and applications of various useful polymers in our daily life.

Unit 1: Introduction to Polymeric Materials Hours:10

History of polymeric materials, Different schemes of classification of polymers, Polymer nomenclature
Molecular forces and chemical bonding in polymers, Physical and chemical properties of polymers
Solubility and Criteria for polymer solubility, Texture of Polymers, modification of polymers, Structure and property relationships, Introduction to conducting and biodegradable polymers.

Unit 2: Characterization of Polymers: Hours:10

Thermal characterisation of polymer: Glass transition temperature (Tg), thermal stability and decomposition of polymers, Molecular weight of polymers (Mn, Mw, etc.) by end group analysis, viscometry, light scattering technique and osmotic pressure methods.
Structural characterisation of polymers by IR and NMR spectroscopy.

Unit 3: Preparation, Properties and Uses of Polymers: Hours:10

Brief introduction to polymerisation, mechanism, properties and application of the following polymers: polyolefins, polystyrene, poly(vinyl chloride), poly(vinyl acetate), polyurethanes, acrylic polymers and polyamides. Phenol formaldehyde and urea formaldehyde, Silicone polymers, Conducting Polymers: polyacetylene, polyaniline, polypyrrole, polythiophene., Biopolymer: Cellulose and Chitosan.

Practical:
(Credits: 2, Laboratory periods: 60)

1. Preparation of nylon 6,6.
2. Redox polymerization of acrylamide.
3. polymerization of acrylonitrile.
4. Preparation of urea-formaldehyde resin.
5. Preparations of phenol-formaldehyde resin.

6. Determination of molecular weight of different polymers in water by viscometry.
7. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
8. Demonstration for chemical structure and functional group in polymers using IR spectroscopy.
9. Purification of monomer and polymerisation of Styrene and Polymethylmethacrylate using BPO (Benzoyl Peroxide).
10. Polymerization of aniline and pyrrole by chemical polymerisation method.
11. Preparation of poly methylacrylate by emulsion and bulk polymerisation and compare the results.
12. Characterisation of polymers by IR spectroscopy.

References (Theory):

1. Ahluwalia V.K. & Mishra A**. Polymer Science :A Textbook**(2009) Anne Books.
2. Odian, G. (2004), **Principles of Polymerization**, John Wiley.
3. Billmeyer, F.W. (1984),**Text Book of Polymer Science**,3rd Ed., John Wiley.
4. Ghosh, P. (2001),**Polymer Science & Technology**, Tata Mcgraw-Hill.
5. Lenz, R.W. (1967),**Organic Chemistry of Synthetic High Polymers**, Interscience (Wiley).

References (Practical):

1. Hundiwale ,D.G.,Athawale V.D ,Kapadi, U.R.& Gite V.V, **Experiments in Polymer Science ,**New Age International Publishers .
2. Allcock, H.R.; Lampe, F. W.; Mark, J. E. (2003), **Contemporary Polymer Chemistry**, Prentice-Hall.
3. Fried, J.R. (2003), **Polymer Science and Technology**, 2nd Ed, Prentice-Hall.
4. Munk, P.; Aminabhavi , T. M. (2002), **Introduction to Macromolecular Science,** John Wiley & Sons.
6. Sperling, L.H. (2005), **Introduction to Physical Polymer Science**, John Wiley & Sons.

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Molecules of Life	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To deliver information about the chemistry of carbohydrates, proteins & enzymes and its relevance in the biological system using suitable examples.
- To understand the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural details.

Learning Outcomes:

By the end of the course, the students will be able to:

- Learn and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
- Gain an insight into the mechanism of enzyme action and inhibition.
- Understand the basic principles of drug-receptor interaction and SAR.

Unit 1: Carbohydrates — Hours: 12

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of configuration of glucose (Fischer proof), cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Unit 2: Amino Acids, Peptides and Proteins — Hours: 10

Classification of amino acids and biological uses of amino Acids, peptides and proteins. Zwitterion structure, isoelectric point and correlation to acidity and basicity of amino acids. Determination of primary structure of peptides, determination of N-terminal amino acid (by Edman method) and C– terminal amino acid (with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by N-protection (t-butyloxycarbonyl) & C-activating groups (only DCC) and Merrifield solid phase synthesis, Overview of primary, secondary, tertiary and quaternary structure of proteins, denaturation of proteins.

Unit 3: Enzymes Hours: 04

Classification of enzymes and their uses (mention Ribozymes). Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in enzyme action, specificity of enzyme action (including stereospecificity).

Unit 4: Nucleosides, Nucleotides and Nucleic acids Hours: 04

Components of Nucleic acids: Adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA (types of RNA), difference between DNA and RNA

Practical
(Credits: 02, Laboratory periods: 60)

1. Estimation of glucose by Fehling's solution.
2. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).
3. Study of the titration curve of glycine and determine the isoelectic point of glycine.
4. Estimation of proteins by Lowry's method.
5. Qualitative tests for amino acids, proteins and carbohydrates.
6. Separation and identification of mixture of sugars by paper chromatography.
7. Separation and identification of mixture of Amino acids by paper chromatography.
8. Study of the action of salivary amylase on starch under optimum conditions and find the enzyme activity.
9. Study the effect of temperature on activity of salivary amylase.
10. Extraction of DNA from onion/cauliflower.

References (Theory):

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2019), **Biochemistry**, 9th Ed., W. H. Freeman Co Ltd.

References (Practical):

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. **Manual of Biochemistry Workshop**, 2012, Department of Chemistry, University of Delhi.

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Main Group Chemistry	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide basic understanding of the fundamental principles of metallurgy through study of the different methods of extraction and refining of metals.
- To illustrate the diversity and fascination of inorganic chemistry through the study of structure, properties and utilities of s- and p-block elements and their compounds

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand the basis of occurrence of metals in nature and the methods that can be applied on minerals to extract the metals from them.
- Explain the importance of free energy of formation of oxides with the choice of reducing agent for extracting the metals.
- Understand and explain the importance of refining of metals and the choice of a refining procedure
- Explain the group trends observed for different properties of s and p block elements
- Explain the structures and the bonding basis of compounds of s- and p- block elements
- Explain the uniqueness observed in alkali metals and some other main group elements
- Understand and explain the polymerization of inorganic ions to generate inorganic polymers and the difference between organic and inorganic polymers.

Unit 1: General Principles of Metallurgy   Hours: 06

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, Zone refining.

Unit 2: General Properties   Hours: 05

General group trends of s- and p-block elements with special reference to melting and boiling points, flame colour, metallic character and complex formation tendency, diagonal relationship and anomalous behaviour of first member of each group, Alkali metal solutions in liquid ammonia

Unit 3: Structure, Bonding, Properties and Applications Hours: 15

Structure, bonding, properties (Acidic/Basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, thermal stability) and applications of the following:
Crown Ethers and cryptates of Alkali metals
Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH_3 where E = N, P, As, Sb, Bi), Group 16 and Group 17.
Oxides: Oxides of nitrogen, phosphorus and sulphur.
Oxoacids: oxoacids of phosphorus, sulphur and chlorine
Halides of phosphorus

Unit 4: Inorganic Polymers Hours:04

Preparation, properties, structure and uses of the following:

Borazine, Silicates and Silicones

Practical
(Credits: 02, Laboratory periods: 60)

Qualitative semi-micro analysis of mixtures containing 2 anions and 2 cations (preferably 7-8 mixtures). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

CO_3^{2-}, NO_2^- , S^{2-}, SO_3^{2-}, SO_4^{2-} , $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^- , BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}

The mixtures may contain combination of anions/one interfering anion.

Spot tests should be preferred wherever applicable.

References (Theory):

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.

3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.
5. Housecraft, E. H.; Sharpe, A.G. (2018), **Inorganic Chemistry**, 5th Edition, Pearson.
6. F.A. Cotton & G. Wilkinson (1999), **Advanced Inorganic Chemistry**, 6th Edition, John Wiley & Sons.

References (Practical):

1. Vogel, A.I. (1972), **Qualitative Inorganic Analysis**, Longman.

2. Svehla, G. (1996), **Vogel's Qualitative Inorganic Analysis**, Prentice Hall.

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanoscale Materials and their applications	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide an introduction to nanoscale materials and their applications.
- To provides an insight into bottom-up and top-down-approach, the methods of synthesis of nanoparticles, simple characterization techniques and applications of nanomaterials.

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand the concept of nano dimensions.
- Know the various methods of preparation of nanomaterials.
- Understand the principles of optical and electron microscopy techniques of characterizing nanomaterials.
- Understand the Appreciate the real life applications of nanomaterials.

Unit 1: Introduction to Nanodimensions Hours: 12

0D, 1D, 2D nanomaterials, Quantum Dots, Nanoparticles, Nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects in nano systems, Quantum confinement and its consequences, Semiconductors. Band structure and band gap. Optical Properties Surface plasmon resonance

Unit 2: Preparation of Nanomaterials Hours: 10

Top down and Bottom up approach, Photolithography. Ball milling. Vacuum deposition. Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, Sol-Gel synthesis, Hydrothermal synthesis, Spray pyrolysis, Electrochemical deposition, Pulsed Laser deposition. Characterization of nanomaterials: Basic principle of optical methods and electron microscopy.

Unit 3: Applications of Nanomaterials Hours: 8

Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts, Nanocomposites as catalysts. Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbon nanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

Practical
(Credits: 02, Laboratory periods: 60)

1. Synthesis of silver nanoparticles by chemical methods and characterization using UV-visible spectrophotometer.
   a. Turkevich Method
   b. Burst Method
2. Synthesis of silver nanoparticles by green approach methods (using soluble starch, glucose or cinnamon bark) and characterization using UV-visible spectrophotometer.
3. Synthesis of metal sulphide nanoparticles and characterization using UV-visible spectrophotometer and determination of Band gap.
   a. MnS
   b. ZnS
   c. CuS
4. Intercalation of hydrogen in tungsten trioxide and its conductivity measurement using conductometer.
5. Synthesis of pure ZnO and Cu doped ZnO nanoparticles.
6. Phytochemicals mediated synthesis of gold nanoparticles (AuNPs) using tea leaves and to study the effect of size on color of gold/silver nanoparticles.
7. Preparation of magnetic nanoparticles (MNPs) of Fe_3O_4 using green tea leaf extract.

8. Any suitable experiment (other than the listed ones) based upon complexation reactions.

References (Theory):

1. West, A. R. (2014), **Solid State Chemistry and Its Application**, Wiley.
2. Smart, L. E.; Moore, E. A., (2012), **Solid State Chemistry: An Introduction**, CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J. (1997), **New Direction in Solid State Chemistry**, Cambridge University Press.
4. Poole Jr.; Charles P.; Owens, Frank J. (2003), **Introduction to Nanotechnology**, John Wiley and Sons. Harris, D. C. (2007), **Quantitative Chemical Analysis**,6th Edition, Freeman.
5. Chattopadhyay, K.K.; Banerjee, A. N. (2009), **Introduction to Nanoscience and Technology**, PHI.

References (Practicals):

1. Orbaek, W.; McHale, M.M.; Barron, A. R.; **Synthesis and Characterization of Silver Nanoparticles for An Undergraduate Laboratory**,J. Chem. Educ. 2015, 92, 339−344.
2. MacDiarmid, G.; Chiang, J.C.; Richter, A.F.; Somasiri, N.L.D.(1987), **Polyaniline: Synthesis and Characterization of the Emeraldine Oxidation State by Elemental Analysis**, L. Alcaeer (ed.), Conducting Polymers, 105-120, D. Reidel Publishing.
3. Cheng, K.H.; Jacobson, A.J.; Whittingham, M.S. (1981),**Hexagonal Tungsten Trioxide and Its Intercalation Chemistry, Solid State Ionics**, 5, 1981, 355-358.
4. Ghorbani H.R.; Mehr, F.P; Pazoki, H; Rahmani, B.M.; **Synthesis of ZnO Nanoparticles by Precipitation Method**, Orient J Chem 2015, 31(2).

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry of Polymers, Dyes and Natural Products	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- Introducing the students to the process of converting knowledge of chemistry into marketable products for commercial gain**.**
- To learn the applications of chemistry in small industries.
- To give knowledge for business opportunities for small and medium enterprises through chemistry.

Learning Outcomes:

By the end of this course the students will be able to:

- Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers.
- Understand the chemistry of biodegradable and conducting polymers and appreciate the need of biodegradable polymers with emphasis on basic principles.
- Comprehend the theory of colour and constitution as well as the chemistry of dyeing.
- Know applications of various types of dyes including those in foods and textiles.
- Understand the chemistry and applications of natural products like terpenoids and alkaloids.

Unit-1: Polymers **Hours:12**

Introduction and classification based on origin, monomer units, thermal response, mode of formation, structure, application and tacticity; di-block, tri-block and amphiphilic polymers; Weight average molecular weight, number average molecular weight, glass transition temperature (Tg) of polymers; Polymerisation Reactions-Addition and condensation. Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes.

Preparation and applications of: Plastics -thermosetting (phenol-formaldehyde, polyurethanes) and thermosoftening (PVC, polythene); Fabrics -natural (cellulose and synthetic derivatives of cellulose like rayon and viscose); synthetic (acrylic, polyamide, polyester); Rubbers-natural and synthetic: Buna-N, Buna-S, Neoprene, silicon rubber; Vulcanization; Polymer additives; Introduction to Specialty Polymers: electroluminescent (Organic light emitting diodes), conducting, biodegradable polymers and liquid crystals.

Unit-2: Dyes Hours: 08

Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing. Synthesis and applications of Azo dyes – Methyl orange, Congo red; Triphenyl methane dyes- Crystal violet; Phthalein Dyes – Phenolphthalein; Natural dyes –Structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Unit 3: Natural Product Chemistry- An Introduction to Terpenoids and Alkaloids Hours: 10

Terpenes: Introduction, occurrence, classification, uses, isoprene and special isoprene rule; structure elucidation, synthesis and industrial application of citral.

Alkaloids: Introduction, occurrence, classification, uses, general structural features, general methods for structure elucidation including Hoffmann's exhaustive methylation and Emde's method. Structure elucidation, synthesis and physiological action of Nicotine.

Practical

(Credits: 02, Laboratory periods: 60)

1. Preparation of Methyl Orange.
2. Preparation of Malachite Green.
3. Recycling of Plastic: Moulding of plastic or Cracking of plastic.
4. Preparation of Urea-formaldehyde resin.
5. (a) Dyeing of different fabrics (cotton, wool, silk) using Alizarin or any other dye.
   (b) Preparation of azo dye on the surface of the fabric.
6. Qualitative test for identification of alkaloids (Dragendorff Reagent and Mayer's reagent test) and terpenoids (Salkowski test).
7. Preparation of perichromic dye using p-amino Phenol and p-nitro benzaldehyde.

References (Theory):

1. Finar, I.L. (2008), **Organic Chemistry**, Volume 2, 5th Edition, Pearson Education
2. Saunders, K. J. (1988), **Organic Polymer Chemistry**,2nd Edition Chapman & Hall, London
3. Campbell, Ian M., (2000), **Introduction to Synthetic Polymers**, 2nd Edition Oxford University Press, USA.
4. Bahadur, P. and Sastry, N.V. (2002) **Principles of Polymer Science** Narosa, New Delhi
5. Patrick, G. **An Introduction to Medicinal Chemistry** (2013), 4th Edition, Oxford University Press.
6. Priscilla Abarca, Patricia Silva, Iriux Almodovar and Marcos Caroli ezende*Quim. Nova, Vol. 37, No. 4, 745-747, 2014. http://dx.doi.org/10.5935/0100-4042.20140120

Credit Distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Chemistry : IT Skills and Molecular Modelling	04	02	--	02	Class 12th with Physics, Chemistry, Mathematics	NA

Learning Objectives

The Learning Objectives of this course are as follows:

- To introduce the students to basic computer skills that are a must for a new age chemist.
- To acquaints the students with data tabulation, calculation, graph plotting, data analysis and document. Preparation using various software (preferably open-source).
- To learn about molecular modelling, its applications to various molecular systems, energy minimization techniques, analysis of Mulliken Charge and ESP Plots.

Learning Outcomes:

By the end of the course, the students will be able to:

- Become familiar with the use of computers
- Use software for tabulating data, plotting graphs and charts, carry out statistical analysis of the data.
- Solve chemistry problems and simulate graphs.
- Prepare documents that will incorporate chemical structure, chemical equations, mathematical expressions from chemistry.
- Understand theoretical background of computational techniques and selective application to various molecular systems.
- Learn ESP Plots by suitable software, electron rich and electron deficient sites.
- Compare computational and experimental results and explain deviations.
- Perform Optimization of geometry parameters of a molecule (such as shape, bond length and bond angle) through use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.

Unit 1: Introduction to important software in chemistry Hours:10

Introduction to different software available for drawing chemical structures (Proprietary and Open-source) like ACD Chemsketch and 3-D viewer, ChemDraw.
Carrying out simple calculations on anyone of the following software: ArgusLab, Pymol, Avogadro, Molview, MarvinSketch.
Draw structures of various compounds (aliphatic, aromatic, heterocyclic with different functional groups) using software. Save the structures in various file formats. Incorporate the structures in word document and powerpoint presentation. SMILES notation for the chemical structures. PDB Files.

Unit 2: Handling of Numerical Data Hours:10

Using a spreadsheet software: applying basic functions and formulae to the data, drawing charts, tables and graphs, displaying the equation of graph along with the R^2 value, incorporating tables and graphs in Word files, graphical solution of equations, plotting pressure-volume curves of van der Waals gases, Maxwell-Boltzmann distribution, concentration versus time graphs, spectral data, titration curves, etc.

Unit 3: Molecular Modelling Hours: 10

Introduction to molecular modelling, overview of classical and quantum mechanical methods (semi empirical, ab initio and DFT) and molecular mechanics method

Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, concept of transition state with examples.

Practical
(Credits: 02, Laboratory periods: 60)

Plotting graphs using a spreadsheet

1. van der Waals isotherms
2. Maxwell-Boltzmann distribution curves as function of temperature and molecular weight
3. Plot the conductometric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base

4. Plot the pH metric titration curve for

   a) strong acid vs strong base and b) weak acid vs strong base

5. Plot the graphs for the kinetics of first order reaction.

Molecular Modelling

6. Optimise and compare the geometry parameters of H_2O and H_2S using Argus Lab.

7. Compare the basicities of ammonia, methylamine, dimethylamine and trimethylamine using Argus Lab by comparing Mulliken charges and ESP maps.
8. Compare C-C bond lengths and bond order in ethane, ethene and ethyne using Argus Lab.
9. Determine enthalpy of isomerization of cis and trans-2-butene in Argus Lab.
10. Compare the HAH bond angles for the second row hydrides (BeH_2, CH_4, NH_3, H_2O) and compare with the results from qualitative MO theory.

References (Theory):

1. Levie, R. de. (2001), **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge Univ. Press.
2. Lewars, E. (2003), **Computational Chemistry,** Kluwer academic Publisher.
3. Cramer, C.J.(2004), **Essentials of Computational Chemistry,** John Wiley & Sons.
4. Hinchcliffe, A. (1996), **Modelling Molecular Structures,** John Wiley & Sons.
5. Leach, A.R.(2001), **Molecular Modelling,** Prentice-Hall.

References (Practical):

1. Lewars, E. **(2003), Computational Chemistry,** Kluwer academic Publisher.
2. Cramer, C.J. **(2004), Essentials of Computational Chemistry,** John Wiley & Sons.
3. Hinchcliffe, A. **(1996), Modelling Molecular Structures,** John Wiley & Sons.

Note: Some of the papers are same as in B Sc (H) Chemistry and B Sc Physical Sciences.

Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER-IV

BOTANY COMPONENT - DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Phytopathology ALS BOT DSC 04	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to introduce students with various fungi, fungus like organisms, bacteria and viruses.
- to give an understanding of their characteristics, reproduction and ecology.
- to introduce students with the principles and concepts of plant pathology.
- to acquaint with various plant diseases, symptomatology, causal organisms and their control measures.

Learning Outcomes:

By studying this course, students will be able to:

- understand the world of different types of pathogens of plants.
- identify the characteristic symptoms of different groups of plant pathogens in the fields.

- understand the ecological and economical impact of plant diseases.
- identify common plant diseases and their control measures.
- understand the application and significance of integrated disease management.
- explicate the economic and pathological importance of fungi, bacteria and viruses.

Unit 1: Introduction **(3 Hours)**

Definition, Concepts and Terminology; General symptoms; Classification of diseases.

Unit 2: **Key events of Disease development** **(6 Hours)**

Disease cycle; Host pathogen relationships; Plant defence mechanism (Structural and biochemical); Epidemiology and Disease forecasting.

Unit 3: Fungal Diseases **(5 Hours)**

General symptoms; Disease cycle and Control measures - Powdery mildew of Pea.

Black stem Rust of Wheat; Smut of Barley (Loose and Covered smut).

Unit 4: Diseases caused by Oomycota **(3 Hours)**

General symptoms; Disease cycle and Control measures – White rust of Crucifers; Late blight of Potato.

Unit 5: Bacterial Diseases **(3 Hours)**

General symptoms; Disease cycle and Control measures - Citrus canker; Angular leaf spot of Cotton.

Unit 6: Viral Diseases **(3 Hours)**

General symptoms; Mode of transmission and Control measures-- Tobacco mosaic disease; Vein clearing of Bhindi.

Unit 7: Plant Disease Control **(7 Hours)**

Quarantine, Cultural practices, Physical methods, Chemical methods, Biological control (Antibiosis, Hyper-parasitism, Predation, Induced Systemic Resistance).

PRACTICAL (60 Hours)

1. Study of White rust of crucifers, Symptoms on leaves and hypertrophy with the help of live or preserved specimens. Study of causal organism (*Albugo candida*) with the help of temporary tease/section mount. Permanent section mount of somatic and reproductive phases.
2. Study of Late blight of Potato through specimens, temporary mounts (V.S. of leaf showing infection) and permanent slides.
3. Study of Powdery mildew of Pea, Symptoms on leaves and stem of Pea with the help of live or preserved specimens. Study of *Erysiphe* asexual stage with the help of temporary tease/ section mount and sexual stage through permanent slides.
4. Study of Black stem Rust of Wheat, Symptoms on both Wheat and Barberry with the help of live or preserved specimens/photographs. Study of *Puccinia graminis tritici* with the help of temporary tease/section mount of Wheat . Permanent slides of somatic and reproductive phases on both the hosts.
5. Study of Smut of Barley, Symptoms of Loose and Covered smut through live or preserved specimens. Study of teliospores through temporary mount.
6. Study of Bacterial Diseases through the specimens - Citrus canker; Angular leaf spot of Cotton.
7. Study of Viral Diseases through specimens - Tobacco mosaic Disease; Vein clearing of Bhindi.
8. Study of Phylloplane Mycoflora through cellotape method.

9. Study through digital images / photographs – Chlorosis, Tuber rot, Apple scab, Mycoparasite, Predaceous fungi.

Essential/ Recommended readings:

1. Oliver, R. (2023) *Agrios' Plant Pathology* 6th edition, Academic Press.
2. Agrios, G.N. (2005) *Plant Pathology* 5th edition, Elsevier Academic Press, Amsterdam.
3. Sharma, P.D. (2014) *Plant Pathology* Rastogi Publications, Meerut, U.P.
4. Singh, R.S. (2021) *Plant Diseases* 10th revised edition, Medtech, New Delhi.
5. Schumann, G.L. and D'Arcy C.J. (2009) *Essential Plant Pathology* 2nd edition, American Phytopathological Society, U.S.A.

Suggestive readings:

1. Singh, R.S. (2017) *Introduction to Principles of Plant Pathology, 5*th edition, Medtech, New Delhi.
2. Gupta, R. and Chugh, G. (2022) *Plant, Microbes and Diseases*. I.K. International Pvt. Ltd., Delhi.
3. Tronsmo A.M., Munk L., Anika D., Tronsmo A., Yuen J and Collinge D.B. (2020) *Plant Pathology and Plant Diseases*. CABI Publishing, U.S.A.
4. Ownley B.H. and Trigiano R.N. (2016) *Plant Pathology Concepts and Laboratory Exercises* 3rd edition, CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

BOTANY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 02)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Crop Genetics and Plant Breeding ALS BOT DSE 02	4	2	0	2	Class 12^{th} Pass with Science	NIL

Learning Objectives:

The Learning Objectives of this course are as follows:

- to develop an understanding of the concepts of plant breeding and its applications.
- to provide adequate knowledge on the natural breeding systems of different agriculturally important plant and strategies employed for crop improvement.
- to impart skills on plant genome analysis and gene mapping using DNA markers and their use in increasing efficiency of plant breeding.
- to understand the genetic basis of hybrid vigour and development of hybrid varieties.
- to make students familiar with the concept of varietal release and rights of a farmer and plant breeder.

Learning Outcome:

By studying this course, the students will be able to:

- gain knowledge on the importance of plant breeding for developing new cultivars and use of breeding strategies for improvement of crop plants.

- understand the concept of gene pool and germplasm resources that are fundamental to crop improvement.
- explicate the breeding methods for commercially important crop plants.

Unit 1: Introduction **(2 Hours)**

Importance of plant breeding and its history; Breeding systems in crop plants; Self-incompatibility, male sterility and apomixis, Important achievements in plant breeding.

Unit 2: Sources of Variation **(4 Hours)**

Plant genetic resources- their management and conservation, utilization of gene pools in breeding programs. Chromosome manipulation- induced mutations, haploidy, polyploidy, somatic hybridization, somaclonal variation.

Unit 3: Conventional Breeding Methods **(8 Hours)**

Selection methods for self-pollinated, cross-pollinated and vegetatively propagated crop plants; Hybridization for self-pollinated, cross-pollinated and vegetatively propagated crop plants- procedure, advantage and limitations.

Unit 4: Heterosis Breeding **(3 Hours)**

Genetic and molecular basis of heterosis (hybrid vigour); Development of hybrid varieties through exploitation of hybrid vigour. Inbreeding depression.

Unit 5: Molecular Genetics and Plant Breeding **(10 Hours)**

Molecular markers as tools in plant breeding; Principle of genetic linkage; Concept of genetic distance; Development and choice of mapping populations (F_2, NILs, RILs, BC etc); Linkage map construction; Quantitative traits - Principles and methods of QTL mapping, QTL Introgression; Marker-assisted breeding- Gene tagging; Marker-aided selection (foreground and background selection); Elimination of linkage drags; Marker assisted recurrent selection (MARS). Novel Plant Breeding Tools (TALEN's, CRISPR-Cas9, Base editing).

Unit 6: Intellectual Property Rights and Varietal Release (3 Hours)

IPR, Patenting; Breeder's Right; Release of New Varities-Trials & their evaluation, Prerelease, Notification and its Release; Plant variety protection; Farmer's Right.

PRACTICAL (60 Hours)

1. Introduction to open/controlled pollinations in field and laboratory (Breeders kit; temporal details of anthesis, anther dehiscence, CMS, stigma receptivity, emasculation, bagging).
2. Analysis of the breeding system of chosen crop species by calculating pollen:ovule ratio.
3. Calculation of Index of self-incompatibility (ISI).
4. Study of dominant/ codominant nature of different molecular markers.
5. Assessment of phenotypic diversity in different accessions of given plant material using morphological markers.
6. Assessment of genetic diversity and construction of dendrogram using molecular markers.
7. Phenotypic screening of a mapping population/ land races for biotic stress resistance and calculating the log of percentage severity and symptom score.
8. Study of floral biology, emasculation and hybridization techniques in self-pollinated and cross-pollinated crops.
9. Estimation of heterosis, inbreeding depression and heritability.
10. Project: Case study based on gene mapping.
11. Field trip to plant breeding station.

Essential/recommended readings

1. Acquaah, G. (2012). *Principles of Plant Genetics & Breeding*. 2nd edition. Hoboken, NJ, Wiley.

2. Allard, R.W. (1999). *Principles of Plant Breeding*. John Wiley, New York.
3. Singh, B.D. (2022). *Plant Breeding: Principles and Methods*, 12th edition. New Delhi, Delhi: Kalyani Publishers.
4. Frey, K. J. (1982). *Plant Breeding II.* Kalyani Publishers, New Delhi.

Suggestive readings:

1. Welsh, J. R. (1981). *Fundamentals of Plant Genetics and Breeding*. John Wiley and Sons, New York.
2. Poehlman J. M. and Sleper D. A. (1995). *Breeding Field Crops,* 4th Ed. Panima Publishing Corporation, New Delhi.
3. Chopra, V.L. (2023). *Plant Breeding: Theory and Practice* 2nd Restructured Edition, New India Publishing Agency, New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER-IV

Chemistry Component - DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Agrochemistry ALS CHEM DSC 04	**4**	**2**	**0**	**2**	**Class 12th Pass with Science**	**NIL**

Learning Objectives:

The Learning objectives of this course are as follows:

- to develop a scientific understanding of the diverse approaches to classify the agrochemicals.
- to make them familiar of chemical structure, mode of action and uses of pesticides.
- to impart the knowledge of pesticide formulation, their types, advantages and disadvantages.
- to make them aware of the hazards of agrochemicals and their impact on human health.

Learning Outcomes:

By studying this course, students will be able to:

- learn classification of pesticides.
- analyze the impact of stereochemical aspects on pesticidal activity.

- carry out preparation of formulations and analysis.
- handle pesticides safely in view of human health and environment.

Unit 1: Pesticides **(5 Hours)**

Different classes of pesticides based on use or target pests (Only definitions and examples- no structural requirement): Herbicides, Fungicides, Insecticides, Rodenticides, Acaricides, Bactericides**,** Chemosterillant, Molluscicide, Nematicides, Plant growth regulators, Repellents, Antifeedants, Sex attractants, Classification of pesticides based on chemical nature, mode of entry, mode of action and toxicity.

Unit 2: Herbicides **(6 Hours)**

Structure, uptake, mode of action and uses along with key points on human toxicity, with special reference to the individual compounds mentioned (synthesis excluded):

a) Aryl alkanoic acids: 2, 4 D, 2,4DB, MCPA and other acid derivatives: dicamba, dichlorobenil, dalapon {along with structure-activity relationship (SAR)}
b) Aromatic carbamates: Barban and asulam.
c) Triazines: Simazine, Atrazine
d) Bipyridinium: Paraquat
e) Organophosphorous: Glyphosate
f) Sulfonylurea: Chlorosulfuron
g) Uracils: Bromacil
h) Ureas: Monuron and Isoproturon

Unit 3: Fungicides **(6 Hours)**

Structure, mode of action and uses along with key points on human toxicity, with special reference to the individual compounds mentioned (synthesis excluded):

a) Copper and mercury derivatives
b) Dithiocarbamates: Thiram, Ziram, Nabam
c) Dinitro phenols: 2, 4-Dinitro o-Cresol (DNOC)

d) Quinines: Dichlone

e) Benzimidazoles: Benomyl

f) Organophosphorus fungicides: Kitazine

g) Phenyl amides: Metalaxyl

h) Triazoles: Propiconazole

i) Thiophanates: Thiophanates

Unit 4: Conventional Pesticides **(4 Hours)**

With special reference to the individual compounds mentioned (*synthesis excluded*): Structure, pesticidal properties and stereochemical aspects (*if any*), mode of action, uses and comments on human toxicity

a) Carbamate insecticides: Carbaryl, Methomyl

b) Organophosphorus insecticides: Malathion, Parathion

c) Organochlorine Insecticides: Chlordane, Heptachlor, DDT

Unit 5: Introduction to other Pesticides **(4 Hours)**

Structure, stereochemical aspects (if any), use and toxicity of the following (*synthesis excluded*):

a) Alkaloid family: Nicotine

b) Pyrethrins: Pyrethrin-I and II

c) Fumigants: Example of Halogenated Hydrocarbons

d) Rodenticides: Inorganic and organic (Two examples each)

e) Repellents: DEET, Diethylphthalate

Unit 6: Pesticide Formulations **(5 Hours)**

1. Definition and purpose of formulations.
2. Brief discussion on the following type of formulations:
   a) Solid formulations: dusts (D), granules (G), pellets (P), wettable powders (WP or W), dry flowable (DF), soluble powders (SP); poison baits (B)

b) Liquid formulations: emulsified concentrates (EC or E), solutions, flowing suspensions (F or L), Suspension Concentrate (SC), aerosols (A)

c) Other type of formulations: fumigants (F); microencapsulated product (M) for controlled-release.

PRACTICAL **(60 Hours)**

1. Preparation of Bordeaux mixture and Bordeaux paste.

2. Preparation of Dithiocarbamate fungicide analogous from aromatic/aliphatic amine and separated as sodium /zinc/ manganese salt.

3. Preparation of homemade rodent bait.

4. Preparation of Emulsifiable concentrate (EC) formulation of given organic compound as oil in water emulsion(O/W).

5. Preparation of EC formulation: Emulsifiable concentrate of neem oil.

6. Preparation of standard hard water.

7. To determine the emulsion stability of given EC formulation.

8. Determination of bulk density of WP formulation.

9. **Project Writing**: For project work pesticides to be selected from the theory portion

   (a) Use of Globally Harmonized System (GHS) of classification and labelling of chemicals
   (b) The impact of pesticides on the environment.
   (c) Pesticide exposure and its impact on human health.

Essential /Recommended readings:

1. Buchel, K. H**.,** (1983) *Chemistry of Pesticides*, John Wiley & Sons Inc ISBN 13 978-0471056829
2. Melnikov,N.N. (1971) *Chemistry of Pesticides,* Edited By: Frances A. Gunther, Jane Davies Gunther, Springer, ISBN: 978-1-4684-6253-1
3. Cremlyn, R. (1978) *Pesticides: Preparation and mode of action*, 1st edition (October 19, 1978) John Wiley & Sons., 0471996319

4. Kenneth, A., Hessall (2013) *The chemistry of Pesticides, their Metabolism, Mode action and uses in crop*, Bio-Green Books, ISBN13: 978-9386237118
5. Sree Ramulu, U. S. (1979) *Chemistry of insecticides and fungicides,* 3rd Edition, Scientific Publishers; Edition: 2020, ISBN: 9789389832020
6. Roberts, T.R., Hutson, D.H., Jewess P.J., (1998) *Metabolic pathways of agrochemicals: insecticides and fungicides.* Royal Society of Chemistry
7. Handa, S.K., (2008) *Principles of Pesticide Chemistry*, Ed. By Agrobios (India) ISBN-13: 9788177542165
8. Singh Anupama et. al (2022) *Basics of Agrochemical Formulations*, Brillion Publishing ; ISBN: 9789392725128
9. Parmar, B.S., Tomar, S.S., (2010) *Pesticide formulation-Theory and practice* , CBS Publisher; ISBN 13: 9788123911243

Suggestive readings

1. Matolcsy,G., Nádasy,M., Andriska,V.,(1989) *Pesticide Chemistry,* 1st Edition - January 1, 1989; eBook ISBN: 9780080874913
2. Vyas, S. C. (1993) *Handbook of Systemic Fungicides: Compounds*. Tata McGraw-Hill.
3. Ashworth, R. D. B., (1970) *Analysis of technical and formulated pesticides,* Volume 1 ,*CIPAC handbook.*
4. Jim A. Turner, (2018*) The Pesticide Manual: A World Compendium*, British Crop Production Council.
5. World Health Organization. (2011). *International code of conduct on the distribution and use of pesticides: guidelines for quality control of pesticides* (No. WHO/HTM/NTD/WHOPES/2011.4). World Health Organization.
6. Zweig, G. (Ed.). (2013). *Principles, Methods, and General Applications: Analytical Methods for Pesticides, Plant Growth Regulators, and Food Additives, Vol. 1* (Vol. 1). Elsevier.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CHEMISTRY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 02)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Organic Chemistry in Pesticide Synthesis ALS CHEM DSE 02	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The Learning objectives of this course are as follows:

- to familiarize students to different types of classification of pesticides.
- to familiarize with factors that make the organic compound to be considered as pesticide.
- to understand the correlation of stereochemistry of pesticide and pesticidal activity.
- to inculcate the awareness about the hazards of pesticides.

Learning Outcomes:

By studying this course, students will be able to:

- analyze important aspects attributing pesticidal activity to organic molecules.
- explain the strategies involved in synthesis of different pesticides.

- illustrate the impact of stereochemical aspects on pesticidal activity.
- handle pesticides safely in view of human health and environment.

Unit 1: Key Consideration for Pesticidal Activity of Organic Compounds (3 Hours)

a) Chemical structure (key functional groups in pesticides)

b) Mode of action to the selected target

c) Metabolism and metabolites

d) Toxicity concerns mainly human toxicity and ecotoxicity

Unit 2: Insecticides (5 Hours)

Structure, stereochemical aspects and toxicity of the following (synthesis excluded):

a) Alkaloid family: Nicotine

b) Nicotine analogous: Imidacloprid

c) Pyrethrins: Pyrethrin-I and II

d) Pyrethroids: Cypermethrin

Unit 3: Organic Halogenated Compounds as Pesticides (9 Hours)

a) Synthesis of Halogenated Hydrocarbons as Fumigants

   I. Methyl bromide (Bromomethane)

   II. 1,2-Dibromoethane

   III. 1,2-Dichloroethane

   IV. Carbon tetrachloride

b) Synthesis of DDT and Methoxychlor.

c) Synthesis of Hexachlorocyclohexane (BHC) and discussion of its stereoisomers.

d) Synthesis of Chlordane and Heptachlor from Hexachlorocyclopentadiene (HCCP) by Diels Alder reaction and discussion of their stereoisomers.

Ecological problems due to Organic Halogenated Compounds as Pesticides, their toxicity and effect on Human Health

Unit 4: Organophosphorus Insecticides: **(6 Hours)**

General chemistry of phosphate esters (Esters of Phosphoric and Phosphorothioic acids)

Synthesis of:

- **a)** Vinyl organophosphates: Dichlorvos, Mevinphos (Phosdrin)
- **b)** Phosphorothioates: Parathion, Methyl-parathion
- **c)** Phosphorodithioate: Malathion
- **d)** Heterocyclic phosphorodithioate: Phosmet

Unit 5: Carbamates **(4 Hours)**

General chemistry of carbamates: N-methyl carbamates and N, N-dimethyl (alkyl) carbamates

Synthesis of Carbaryl, Bendiocarb, MTMC, and Methomyl

Unit 6: Other Agrochemicals **(3 Hours)**

Synthesis of DNOC, Captan, 2,4-D, Ziram, Zineb, DEET and their uses.

PRACTICAL **(60 Hours)**

The following synthesis should be carried out starting from 0.5-1.0 g of the organic compound. The product to be recrystallized and melting point to be determined.

(*Experiments 1 to 6 are synthetic analogues of selected chemical class of pesticides*)

1. Synthesis of aryloxy acetic acid class of herbicide (any one of the following)
   - a) 4-chlorophenoxy acetic acid
   - b) 4-methylphenoxy acetic acid
   - c) 2-methylphenoxy acetic acid

2. Preparation of Dithiocarbamate fungicide analogous from aromatic/aliphatic amine and separated as sodium /zinc/ manganese salt.
3. Preparation of urea derivative from phenylisocynate and aniline.
4. Preparation of carbamate derivative from phenylisocynate and alcohol/phenol.
5. Preparation of benzimidazole/2-benzylimidazole /2-Methylbenzimidazole.
6. Synthesis of 3,5-dimethylpyrazole.
7. Preparation of mosquito repellent Diethyl phthalate in two steps:

   Step-1: Preparation of phthalic anhydride

   Step-2 : Preparation of Diethyl phthalate
8. To prepare Neem extract from neem leaves and/or seeds.
9. **Project Writing**: Insecticidal properties of Neem extract and its uses.

Essential /Recommended readings:

1. Buchel, K. H**.** (1983) *Chemistry of Pesticides* **,** John Wiley & Sons, ISBN 13 978-0471056829
2. Melnikov, N.N. (1971) *Chemistry of Pesticides***,** Edited By: Frances A. Gunther, Jane Davies Gunther, Springer, ISBN: 978-1-4684-6253-1
3. Cremlyn, R. (1978) *Pesticides. Preparation and mode of action*, 1st edition John Wiley & Sons, 0471996319
4. Kenneth A, Hessall (2013), *The chemistry of Pesticides, their Metabolism, Mode action and uses in crop,* Bio-Green Books, ISBN13: 978-9386237118
5. Sree Ramulu, U. S. (1979) *Chemistry of insecticides and fungicides*, 3rd Scientific Publishers; Edition: 2020, ISBN: 9789389832020
6. Roberts, T.R., Hutson, D.H., Jewess, P.J. (1998) *Metabolic pathways of agrochemicals: insecticides and fungicides*, Royal Society of Chemistry
7. Matolcsy, G., Nádasy,M., Andriska,V. (1989) *Pesticide Chemistry* 1st Edition, eBook ISBN: 9780080874913

Suggestive readings

1. Handa, S.K. (2008) *Principles of Pesticide Chemistry*, Ed. By Agrobios (India) ISBN-13: 9788177542165
2. Vyas, S. C. (1993*) Handbook of Systemic Fungicide Compounds*. Tata McGraw-Hill.
3. Jim A. Turner (2018) *The Pesticide Manual: A World Compendium*, British Crop Production Council.
4. World Health Organization (2011) *International code of conduct on the distribution and use of pesticides: guidelines for quality control of pesticides* (No. WHO/HTM/NTD/WHOPES/2011.4). World Health Organization.
5. Zweig, G. (Ed.), (2013) *Principles, Methods, and General Applications: Analytical Methods for Pesticides, Plant Growth Regulators, and Food Additives, Vol. 1* (Vol. 1). Elsevier.
6. “IARC Monograph on Evaluation of Carcinogenic Risk of Chemicals to Humans”, Supplement 7, International Agency for Research on Cancer, Lyon, 1987.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER-IV

ZOOLOGY COMPONENT – DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Agricultural Pests ALS ZOO DSC 04	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to impart knowledge about the various agricultural pests and the nature of damage caused by them.
- to apprise the students of the lifecycle of the pest and the specific stage at which it is destructive to the host.
- to acquaint them of the different control measures applied for the management of pests.

Learning Outcomes:

By studying this course, students will be able to:

- identify and differentiate among various types of pests.
- acquire knowledge of the damage caused by agricultural pests.
- better understand the methods of control for the management of the pests.

Unit 1: Introduction **(3 Hours)**

Classification, identification, distribution and host-range of agricultural pests; Overview of: bionomics, nature and extent of damage, seasonal abundance and management of insect pests.

Unit 2: Pests of Cereals **(2 Hours)**

Biology, nature, extent of damage and control: *Chilozonellus*, *Sesamia inferens*

Unit 3: Pests of Oilseeds **(4 Hours)**

Bionomics, lifecycle and management: *Lipaphis erysimi*, *Athalialugen sproxima*, *Achaea janata*, *Euproctis lunata.*

Unit 4: Pests of Fibre Crops **(5 Hours)**

Bionomics, life cycle and management*: Helicoverpa armigera, Earias vitella*, *Pectinophora gossypiella*, *Oxycarenus laetus*, *Dysdercus koenigii.*

Unit 5: Pests of Paddy and Sugarcane **(5 Hours)**

Biology, nature of damage and control: *Leptocorisa varicornis*, *Hispa (Dicladispa) armigera*, *Spodoptera exempta, Scirpophaga nivella*, *Pyrilla perpusilla*, *Emmalocera depressella, Aleurolobus barodensis.*

Unit 6: Stored Grain Pests **(6 Hours)**

Life cycle, nature of damage and control: *Sitophilus oryzae*, *Rhyzopertha dominica*, *Trogoderma granarium, Sitotroga cerealella*, *Callosobruchus chinensis, Atherigona varia*, *Calocorisan gustatus, Mythimna separate*, *Macrosiphum miscanthi /Sitobion avenae*.

Unit 7: **Polyphagus Pests** **(5 Hours)**

Lifecycle and control: grasshopper, locust, termite, white grub, hairy caterpillar, and non-insect pests (mites, birds, rodents, snails, slugs).

PRACTICAL **(60 Hours)**

1. Identification, life cycle and damage caused by following pests:

Chilozonellus, Sesamia inferens, Lipaphis erysimi, Helicoverpa armigera, Earias vitella, *Pectinophora gossypiella*, *Oxycarenus laetus*, *Dysdercus koenigii. Athalialugen sproxima, Achaea janata, Euproctis lunata, Hispa(Dicladispa) armigera, Spodoptera exempta, Pyrilla perpusilla*, *Emmalocera depresse, Sitophilus oryzae*, *Rhyzopertha dominica*, *Trogoderma granarium, Sitotroga cerealella*, *Callosobruchus chinensis, Atherigona varia*, *Calocorisan gustatus, Mythimna separate*, *Macrosiphum miscanthi /Sitobion avenae*.

2. Identification and life cycle of grasshoppers and locusts.
3. Study of life cycle and management of non-insect pests through specimens/photographs.
4. Collection and identification of stored grains pests and nature of damage caused by them.
5. Field visits to Central warehouse/FCI godowns/ CFTRI, IGSMRI.

Essential/recommended readings

1. Dhaliwal G.S. and Singh R. (2004) *Host Plant Resistance to Insects - Concepts and Applications*. Panima Publications., New Delhi.
2. Evans J.W. (2005). *Insect Pests and their Control.* Asiatic Publications., New Delhi.
3. Atwal A.S. and Dhaliwal G.S. (2018) *Agricultural Pests of South Asia and their Management,* 7th Edition Kalyani Publ., New Delhi.

Suggestive readings

1. Maxwell F.G. and Jennings P.R. (Eds). (1980) *Breeding Plants Resistant to Insects.* John Wiley and Sons, New York.
2. Sharma V. (2015) *Agricultural Pest Management*, Rajat Publications.

3. Awasthi V. B. (2017) Agricultural Insect Pest and their Control, 2nd edition, Scientific Publisher India.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

ZOOLOGY COMPONENT – DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 02)

Credits distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Developmental Biology of Animals ALS ZOO DSE 02	**4**	**2**	**0**	**2**	**Class 12th Pass with Science**	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to acquaint students of different phases of development and changes from embryonic to post-embryonic stage.
- to comprehend the basic principles and concepts underlying developmental processes at the cellular and molecular level.
- to learn about gametogenesis, cleavage patterns, morphogenetic movements and the importance of extraembryonic membranes.

- to apprise the students of the applications of this course in addressing the problems of developmental abnormalities and infertility in human.

Learning Outcomes:

By studying this course, students will be able to:

- understand the events that lead to the formation of a multicellular organism from a single cell.
- learn the general patterns and sequential developmental stages during embryogenesis.
- acquire better knowledge of the mechanisms involved in morphogenesis and interactions of cells during gastrulation, placentation, regeneration and metamorphosis.
- appreciate the importance of IVF and amniocentesis for tackling infertility and developmental abnormalities.

Unit 1: Introduction **(2 Hours)**

Historical background, phases of development, growth and differentiation, cytoplasmic determinants, teratogens.

Unit 2: Early Embryonic Development **(15 Hours)**

Gametogenesis: spermatogenesis, oogenesis; types of eggs, egg membranes; fertilization (External and Internal), blocks to polyspermy, planes and patterns of cleavage, types of blastula, fate maps, morphogenetic movements, gastrulation in frog and chick.

Unit 4: Late Embryonic Development **(5 Hours)**

Fate of germ layers, extraembryonic membranes in birds, placenta (structure, types and functions).

Unit 5: Post-embryonic Development **(5 Hours)**

Metamorphic changes in amphibians and insects; regeneration: modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration, limb regeneration in tailed amphibia.

Unit 6: Applications of Developmental Biology (3 Hours)

Embryonic stem cell; *in vitro* fertilization, amniocentesis.

PRACTICAL (60 Hours)

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Egg, cleavage stages, blastula, gastrula, neurula (neural plate, neural fold and neural tube stages), tailbud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton stages): Stage 3 (Intermediate Streak)-13 hours, stage 4 (Definitive streak)-18 hours, stage 5 (Head process)-21 hours, Stage 7- 24 hours, stage 8-28 hours, stage10-33 hours, stage 11- 40 hours, stage 13- 48 hours, stage 19- 72 hours and stage 24- 96 hours of incubation.
3. *In vivo* study of chick embryo development by windowing and candling methods. (Demonstration only).
4. Study of different stages of development of *Drosophila*.
5. Study of different types of placenta (photomicrographs/ slides).
6. Project report on *Drosophila* development/Visit to poultry farm/IVF Centre.

Essential/recommended readings:

1. Gilbert, S.F. (2016) *Developmental Biology*, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA.
2. Balinsky B. I. and Fabian B. C. (2006) *An Introduction to Embryology*. 8th Edition, International Thompson Computer Press.
3. Kalthoff, K. (2001) *Analysis of Biological Development*. 2nd Edition, McGraw Hill Publishers.

Suggestive readings:

1. Arora, R. and Grover, A. (2018) *Developmental Biology: Principles and Concepts*. 1^{st} Edition, R. Chand & Company.
2. Baweja, V. and Misra, M. (2021) *E-book on Practical Manual of Developmental Biology*.
3. Carlson, B.M. (2007) *Foundations of Embryology*. 6^{th} Edition, Tata McGraw-Hill Publishers.

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Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER-V

BOTANY COMPONENT - DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 05)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Physiology and Biochemistry in Plant Development ALS BOT DSC 05	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to understand the fundamental concepts of plant physiology and metabolism.
- to identify the role of water, minerals, hormones, and light in plant growth and development.
- to understand the basic biochemical mechanisms and mineral nutrition of plants.
- to identify the criteria for the essentiality of elements.
- to understand the role of hormones in plant growth and development.
- to examine the commercial applications of growth regulators.
- to understand the physiology of flowering and senescence.
- to understand the mechanisms of photosynthesis and respiration.
- to examine the biological nitrogen fixation in plants.

Learning Outcomes:

By studying this course, students will be able to:

- comprehend the physiological processes that occur in plants, including the role of water, minerals, hormones, and light in plant growth and development.
- acquaint the basic biochemical mechanisms of plants, including photosynthesis, respiration, nitrogen metabolism, and chemical regulation of growth and development.
- comprehend the process of biological nitrogen fixation, reproductive physiology and senescence of plants.
- develop practical skills in plant physiology and metabolism.

Unit 1: Plant-water relations (3 Hours)

Water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation.

Unit 2: Mineral Nutrition (3 Hours)

Essential elements, Macro- and micronutrients, Criteria for essentiality of elements, Methods of studying mineral requirement (Hydroponics, Aeroponics)

Unit 3: Translocation in Phloem (3 Hours)

Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 3: Chemical Regulation of Growth and Development (3 Hours)

Role of hormones in plant growth and development, Commercial applications of growth regulators, Growth retardant and its usefulness

Unit 4: Reproductive Physiology and Senescence (3 Hours)

Photo-periodism and flowering response, Photo-perception and critical photoperiod, Phytochrome and its role in flowering, Vernalization and senescence.

Unit 5: Photosynthesis **(7 Hours)**

Historical contributions of Blackman, Emerson, and Hill, Photosynthetic pigments (chlorophyll-a and b, xanthophyll, carotene), Photosystem I and II, reaction center, antenna molecules, Electron transport and mechanism of ATP synthesis, C3 pathway, C4 and CAM plants (in brief, no pathways), Photorespiration.

Unit 6: Respiration **(5 Hours)**

Glycolysis, Anaerobic respiration, TCA cycle, Oxidative phosphorylation, Glyoxylate cycle, RQ

Unit 7: Nitrogen Metabolism **(3 Hours)**

Biological nitrogen fixation - nodulation in detail, Nitrate and ammonia assimilation.

PRACTICAL **(60 Hours)**

1. To determine the osmotic potential of plant cell sap by plasmolytic method.
2. Calculate stomatal index and stomatal frequency of a mesophyte and a xerophyte.
3. Study Hill's reaction.
4. To study the effect of the environmental factor light on transpiration by excised twig.
5. Study the effect of light intensity on O_2 evolution in photosynthesis.
6. Compare the rate of respiration in any two parts of a plant.
7. To study the activity of catalase and the effect of pH and heavy metals.
8. Demonstrate the effect of auxin on rooting.
9. Demonstration of Bolting.
10. Demonstration of root respiration.

11. Demonstration of suction due to transpiration
12. A field visit to Hydroponics and Aeroponics facilities.

Essential/ Recommended readings:

1. Hopkins, W. G., Huner, N. P. A. (2009) *Introduction to Plant Physiology*, 4^{th} edition. New Delhi, Delhi: Wiley India Pvt. Ltd
2. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018) *Plant Physiology and Development* International 6^{th} edition. New York, NY: Oxford University Press, Sinauer Associates.
3. Kochhar, S.L., Kaur, S. and Gujral, S.K. (2020) *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd.

Suggestive readings:

1. Bajracharya, D. (1999) *Experiments in Plant Physiology: A Laboratory Manual.* New Delhi, Delhi: Narosa Publishing House.
2. Bhatla S.C. and Lal, M.A. (2018) *Plant Physiology, Development and Metabolism*, Springer.
3. Salisbury F.B. and Ross C.W. (1992) Plant Physiology, 4^{th} edition, Wadsworth Publishing Company, California.

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BOTANY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Developmental Biology of Plants ALS BOT DSE 03	4	2	0	2	Class 12^{th} Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are follows:

- to acquaint the students with internal basic structure and cellular composition of the plant body.
- to correlate structure with important functions of different plant parts.
- to study of various tissue systems and their development and functions in plants
- to have knowledge of the flowering and fruiting, reproduction process, role of pollinators, ovule and seed development.

Learning Outcomes:

By studying this course, students will be able to:

- gain knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.

- get an insight of various aspects of growth, development of the tissues and differentiation of various plant organs.
- gain the knowledge of basic structure and organization of plant parts in angiosperms and its correlation with morphology and functions.
- get acquainted with pollen development and pollination, ovule development and fertilization, endosperm development and its importance.

Unit 1: Meristematic and permanent tissue: (4 Hours)

Meristems and derivatives- structural organization of shoot and root apices; permanent tissue: simple and complex tissues.

Unit 2: Dermal System (2 Hours)

Epidermis, stomata, trichomes and glands

Unit 3: Organs (4 Hours)

Structure of dicot and monocot root, stem and leaf

Unit 4: Secondary Growth (4 Hours)

Vascular cambium – structure and function, Secondary growth in root and stem, periderm.

Unit 5: Anther (4 Hours)

Structure and development, microsporogenesis, Pollen Development, structure of pollen and pollen wall (Basic Concepts).

Unit 6: Ovules (4 Hours)

Structure and types, megasporogenesis and mega gametogenesis, mature embryo sac.

Unit 7: Pollination and Fertilization **(4 Hours)**

Pollination mechanisms and adaptations; double fertilization; sexual incompatibility- basic concepts

Unit 8: Endosperm and Embryo **(3 Hours)**

Types and function of endosperm, embryogenesis, dicot and monocot embryo

Unit 9: Seed development **(1 Hours)**

Basic concepts of seed development

PRACTICAL **(60 Hours)**

1. Study of root and shoot apex through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma, sclerenchyma and their types); Macerated xylary elements, Phloem (Permanent slides/ Photographs/ Digital resources)
3. To cut transverse section of stem: Monocot: *Zea mays*; Dicot: *Helianthus*; Study of secondary growth in *Helianthus* stem.
4. To cut transverse section of root: Monocot: *Zea mays*; Dicot: *Cicer*; Study of secondary growth in *Helianthus* .
5. Study of structure of Dicot and Monocot leaf.
6. Study of anther structure (young and mature).
7. Calculation of percentage of germinated pollen in a given medium through hanging

drop/sitting drop method.

8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.

9. Female gametophyte: Mature embryo sac (photographs). Ultrastructure of mature egg apparatus cells through electron micrographs.

10. Dissection of embryo and endosperm from developing seeds.

Essential/ Recommended readings:

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.

2. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjamin/Cummings Publisher.

3. Franklin, E. R. (2006). *Esau's Plant Anatomy: Meristems, Cells, And Tissues of the Plant Body: Their Structure, Function, and Development.* New Jersey, U.S.: John Wiley & Sons, Inc., Hoboken.

4. Shivanna, K.R. (2003). *Pollen Biology and Biotechnology.* Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Suggestive readings:

1. Raghavan, V. (2000). *Developmental Biology of Flowering plants*. Netherlands, Europe: Springer.

2. Johri, B.M. (1984). *Embryology of Angiosperms.* Netherlands, Europe: Springer-Verlag.

3. Bhojwani S.S., Dantu P.K. and Bhatnagar, S.P. (2015) The Embryology of Angiosperms, 6th edition. Vikas Publication House Pvt. Ltd. New Delhi.

4. Tayal, M.S. (2021). Plant Anatomy, 4th Edition. Meerut, U.P.: Rastogi publications.

5. Crang, R., Lyons-Sobaski, S., and Wise, R., (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants, 1st Edition, Springer Nature Switzerland AG.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CHEMISTRY COMPONENT - DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 05)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Physical Chemistry; ALS CHEM DSC 05	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The Learning Objectives of this course are as follows:

- to make students able to understand thermodynamic concepts, properties of thermodynamic systems, laws of thermodynamics and thermochemistry.
- to introduce the basic concept of chemical equilibrium, ionic equilibria and conductance and their correlation among themselves and with other branches of chemistry.
- to provide basic understanding of the behavior of electrolytes and their solution.

Learning Outcomes:

By studying this course, students will be able to:

- understand the laws of thermodynamics, thermochemistry and equilibria.
- explain the concept of pH and its effect on various physical and chemical properties of the compounds.
- use the concepts learnt to predict feasibility of chemical reactions and to analyse the behaviour of reactions in equilibrium.
- apply classroom knowledge to local environmental phenomena and interpret them in relation to the chemistry involved in both conceptual and experimental aspects.

Unit 1: Chemical Energetics **(8 Hours)**

Review of thermodynamics and the laws of thermodynamics

Thermochemistry: Important principles and definition of thermochemistry, *Conventions* about the *thermochemical equation,* Enthalpy of reactions: standard states; enthalpy of neutralization, enthalpy of ionization, enthalpy of hydration, enthalpy of formation, *enthalpy of solution: integral and differential enthalpies of solution and dilution, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data,* the effect of temperature (Kirchhoff's equations) on the enthalpy of reactions.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 2: Chemical Equilibrium **(6 Hours)**

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and $\Delta G^{\ominus}$, Le Chatelier's principle, relationship between Kp, Kc and Kx for reactions involving ideal gases.

Unit 3: Ionic Equilibria **(10 Hours)**

Strong, moderate, and weak electrolytes, degree of ionization, factors affecting the degree of ionization, Ostwald's dilution law, ionization constant, and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, Buffer solutions, Henderson- Hasselbach equation, salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH of different salts, solubility and solubility product of sparingly soluble salts-applications of solubility product principle. Qualitative treatment of acid-base titration curves (calculation of pH at various stages).

Unit 4: Conductance **(6 Hours)**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolytes, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

PRACTICAL **(60 Hours)**

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of the enthalpy of ionization of ethanoic acid.
4. Determination of integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of enthalpy of hydration of copper sulphate.

Ionic equilibria:

6. Preparation of buffer solutions:

    (i) Sodium acetate-acetic acid

    (ii) Ammonium chloride- ammonium hydroxide.

    Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

7. pH metric titration:

    (i) Strong acid vs strong base

    (ii) Weak acid vs strong base

    Determination of dissociation constant of a weak acid.

Conductance

8. (i) Determination of cell constant

    (ii) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

9. Conductometric titration:

(i) Strong acid vs strong base

(ii) Weak acid vs strong base

(iii) Mixture of strong and weak acid vs strong base

Essential/Recommended readings:

1. Peter, A., Paula, J. de. (2011), "*Physical Chemistry*", Fifth Ed., Oxford University Press.
2. Castellan, G. W. (2004), "*Physical Chemistry*", Fourth Ed., Narosa.
3. Kapoor, K. L. (2015), "*A Textbook of Physical Chemistry*", Vol 1, 6th Edition, McGraw Hill Education.
4. Kapoor, K. L. (2015), "*A Textbook of Physical Chemistry*", Vol 2, 6th Edition, McGraw Hill Education.
5. Puri, B.R; Sharma, L.R; Pathania, M.S. (2017), "*Principles of Physical Chemistry*", Vishal Publishing Co.

Suggestive readings:

1. Khosla, B. D., Garg, V. C., Gulati, A. (2011), "*Senior Practical Physical Chemistry* ", R. Chand & Co., New Delhi.
2. Athawale, V. D., Mathur, P. (2001), "*Experimental Physical Chemistry*", New Age International: New Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CHEMISTRY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanotechnology in Agriculture; ALS CHEM DSE 03	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The Learning objectives of this course are as follows:

- to create foundational knowledge of Nanotechnology.
- to educate students about the current green and sustainable methods of preparation of nanomaterials.
- to teach difference between conventional and modern agriculture.
- to give idea about the importance of nanomaterials in agriculture.
- to impart knowledge on toxicity of nanomaterials.

Learning Outcomes:

By studying this course, students will be able to:

- identify the different types of nanomaterials and their properties.
- understand the role of nano- agrochemicals in enhancing crop productivity.
- articulate the study of nanomaterials in the treatment of soil.
- summarize the toxicity risks of nanomaterials on soil and environment.

Unit 1: Introduction **(6 Hours)**

Basics of nanoscience and technology: Definition, Classification of nanoparticles based on dimension and origin, Quantum confinement, properties of nanoparticles (optical only).

Synthesis of nanoparticles: Overview of physical and chemical routes, green methods of nanoparticles synthesis.

Introduction to agriculture: Limitations of conventional farming, role of nano- agrochemicals in modern agriculture. Benefits of nanomaterials in agriculture (plant growth, crop protection, crop nutrients, etc.).

Unit 2: Application of Nanomaterials in Agriculture (14 Hours)

Nano fertilizers: Types and synthesis: Nitrogen-based, Phosphate based and Iron based. Role towards enhancement of crop productivity. Molecular mechanism of nano- fertilizer for plant growth and mechanism.

Advantages over conventional fertilizers, limitations, optimization of nutrient use efficiency (NUE) and environment sustainability.

Nano pesticides: Brief discussion about nano- insecticides, nano- herbicides and nano-fungicides, role in agriculture. Advantages over conventional pesticides and limitations.

Unit 3: Treatment of Soil using Nanomaterials (6 Hours)

Treatment of polluted soil by nanoremediation. Utilization of nanoparticles like nanoclay and zeolites in soil boosting. Smart pest control.

Unit 4: Nanotoxicity in Agriculture (4 Hours)

Toxicity of nanoparticles. Toxic effects of metal nanoparticles on soil ecosystem. Toxicity of nanoparticles to crop production. Health and environmental concerns related to nanomaterials.

PRACTICAL (60 Hours)

1. Basic introduction to the characterization of nanoparticles employing the following techniques (Data and/or images for few reference compounds will be provided for analysis):
   i. UV-Visible spectroscopy

ii. Fourier transform infrared spectroscopy (FT-IR)
iii. Powder X-ray diffraction (PXRD)
iv. Scanning electron microscopy (SEM)
v. Transmission electron microscopy (TEM)

2. Sol-gel synthesis of nanoparticles.
3. Synthesis of metal and metal oxide nanoparticles by green methods:
   i. Silver nanoparticles and their characterization using UV-visible spectrophotometer.
   ii. Zinc oxide nanoparticles.
   iii. Iron oxide nanoparticles using potato extract.
4. Synthesis of Nano urea.
5. Analysis of soil:
   i. Comparative study of pH of untreated and nano fertilizer treated soil
   ii. Estimation of composition of zinc in nano fertilizer treated soil using complexometry.

Essential/Recommended readings:

1. Varghese, T., Balakrishna, K.M., (2020) *Nanotechnology- An Introduction to synthesis, properties and applications of nanomaterials.* Atlantic Publishers & Distributors (P) Ltd; ISBN: 9788126916375.

2. Shah, M.A.; Shah, K.A., (2019) *Nanotechnology-The Science of Small*. Wiley; ISBN: 9788126579976.

3. Swayam (MHRD) Portal online: Nanotechnology in Agriculture (https://nptel.ac.in/course/102104069); Book download link: 102104069.pdf - Google Drive .

4. Axelos, M. A., & Van de Voorde, M. (Eds.). (2017). *Nanotechnology in agriculture and food science*. John Wiley & Sons, ISBN: 3527339892.

5. Chattopadhyay K.K., Banerjee A.N., (2009) *Introduction to Nanoscience and* Technology; PHI Learning Pvt. Ltd. ISBN: 9788120336087.

6. Jogaiah, S., Singh, H. B., Fraceto, L. F., & De Lima, R. (Eds.). (2020). *Advances in Nano-Fertilizers and Nano-Pesticides in Agriculture: A Smart Delivery System for Crop Improvement*. Woodhead Publishing; ISBN: 978-012-820092.

7. Singh, H. B., Mishra, S., Fraceto, L. F., & De Lima, R. (Eds.). (2018). Emerging trends in agri-nanotechnology: fundamental and applied aspects; CABI Publishing, ISBN: 9781786391445.

8. Mallick, M. A., Solanki, M. K., Kumari, B., & Verma, S. K. (Eds.). (2021). *Nanotechnology in Sustainable Agriculture*. CRC Press; ISBN: 9780367369408.

9. Subramanian, K. S., Gunasekaran, K., Natarajan, N., Chinnamuthu, C. R., Lakshmanan, A., & Rajkishore, S. K. (2015). *Nanotechnology in Agriculture*. New India Publishing Agency; ISBN: 9789383305209

10. Tarafdar, J. C. (2021). Nanofertilizers: challenges and prospects.; Scientific Publishers (India); ISBN: 978938889696931.

11. Fraceto, L. F., De Castro, V. L. S., Grillo, R., Ávila, D., Oliveira, H. C., & Lima, R. (2020). *Nanopesticides*. Springer International Publishing. ISBN: 978-3-030-44873-8.

Suggestive readings:

1. Craig, E. (2019) Nanomaterials: An Introduction to Properties, Synthesis and Applications. Larsen and Keller Education (New York). ISBN: 1641721065.
2. Fraceto, L. F. (2022). *Inorganic Nanopesticides and Nanofertilizers: A View from the Mechanisms of Action to Field Applications*. Springer Nature; ISBN: 9783030941543.
3. Prasad, R., Kumar, M., & Kumar, V. (Eds.). (2017). *Nanotechnology: an agricultural paradigm*. Springer.ISBN:9789811045721.
4. Kumar, V., Guleria, P., Ranjan, S., Dasgupta, N., & Lichtfouse, E. (Eds.). (2021). *Nanotoxicology and Nanoecotoxicology Vol. 1* (Vol. 59). Springer International Publishing; ISBN: 978-3-030-63241-0.

E-contents:

1. E-content on e-PG Pathshala portal of Government of India: (**P08**) Nanoscience and Nanotechnology (**33**) (https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=5VgWkgm+I3FGq9cGlsbNmQ==).
2. Swayam (MHRD) Portal online: Nanotechnology in Agriculture (https://nptel.ac.in/course/ 102104069); study material, videos and other material link for course (NPTEL).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

ZOOLOGY COMPONENT – DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 05)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Animal Physiology and Metabolism ALS ZOO DSC 05	**4**	**2**	**0**	**2**	**Class 12th Pass with Science**	**NIL**

Learning Objectives:

The learning objectives of this course are as follows:

- to impart knowledge about the functions of organs and organ systems of the body.
- to distinguish between normal and diseased states of the body functions.
- to apprise the students about correlation of the structure of organs with their functions.
- to enable the students to learn the working of different metabolic pathways of the body.

Learning Outcomes:

By studying this course, students will be able to:

- understand the physiology of different systems of the human body.
- comprehend and analyse problem-based questions on physiological aspects.
- recognize and explain the working of physiological systems in unison to maintain homeostasis in the body.

Unit 1: Nerve and Muscle **(5 Hours)**

Types of muscles, ultrastructure of muscle, characteristics of muscle twitch. Structure of neuron, action potential, propagation of nerve impulse (myelinated and non-myelinated nerve fibre).

Unit 2: Digestion **(5 Hours)**

Digestion and absorption of carbohydrates, fats and proteins.

Unit 3: Respiration **(4 Hours)**

Ventilation, external and internal respiration, transport of oxygen and carbon dioxide in blood.

Unit 4: Heart **(4 Hours)**

Structure of heart, origin and conduction of heart beat, cardiac cycle.

Unit 5: Excretion **(3 Hours)**

Structure of nephron, mechanism and regulation of urine formation.

Unit 6: Endocrine Glands **(2 Hours)**

Structure and function of endocrine glands.

Unit 7: Metabolism of Carbohydrates, Proteins and Lipids **(7 Hours)**

Glycolysis, TCA cycle, electron transport chain (respiratory chain), Urea cycle, β-oxidation of fatty acids.

PRACTICAL **(60 Hours)**

1. Preparation of temporary mount of neuron and striated muscle.
2. Estimation of haemoglobin using Sahli's Haemoglobinometer.
3. Preparation of haemin crystals.
4. Study of oesophagus, stomach, duodenum, ileum, liver, pancreas, trachea, lung,

kidney (of mammals) through permanent slides.

5. Study of endocrine glands of mammal using permanent slides: pituitary, thyroid parathyroid, pancreas, adrenal, ovary and testis.
6. Study of the activity of salivary amylase under optimal conditions.
7. Interpret the recording of frog's heartbeat (*in situ)* under normal conditions.
8. Study of muscle twitch through videos/photographs and interpret the recording of muscle twitch.

Essential/recommended readings:

1. Tortora, G.J. and Derrickson, B. H. (2017) *Principles of Anatomy and Physiology*. 15th Edition, Wiley Publishers.
2. Campbell and Reece (2020). *Biology.* Pearson Education, (Singapore) Pvt. Ltd.

Suggestive readings:

1. Vander A., Sherman J. and Luciano D. (2017) *Vander's Human Physiology: The Mechanism of Body Function*. 7th Edition, McGraw Hills.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

ZOOLOGY COMPONENT – DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 03)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Integrated Pest Management ALS ZOO DSE 03	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to familiarize the students with the ecology of pests and the damage caused by them.
- to acquaint the students of the concept of Integrated Pest Management (IPM) using different models.
- to apprise the students of various components of IPM *viz*. chemical, biological and genetic control.
- to impart knowledge about the various pest surveillance techniques and forecasting of pest outbreaks.

Learning Outcomes:

By studying this course, students will be able to:

- better understand the effects of insecticides on the environment and need for ecofriendly approach for management of insect pests.
- learn the management of agricultural ecosystem using effective pest control strategies and techniques.
- appreciate the role of IPM in sustainable agriculture.

Unit 1: Concept of Pest and its Ecology **(5 Hours)**

Pest population dynamics, Economic Injury Level (EIL), Economic Threshold Level (ETL), carrying capacity, secondary pest outbreak.

Unit 2: Overview of Integrated Pest Management **(4 Hours)**

Concept of IPM and its components, major IPM strategies.

Unit 3: Insect Pest Management **(6 Hours)**

Types of pest management: cultural, physical and mechanical; pest survey (types) and surveillance: factors affecting surveys; forecasting; pest and pesticide risk analysis; political, social and legal implications of IPM; case studies of successful IPM programmes.

Unit 4: Chemical Control **(5 Hours)**

Classification of insecticides, insecticide adjuvants and formulations, mechanism of insecticide action with reference to chlorinated hydrocarbons, organophosphates, carbamates, plant products, synthetic pyrethroids, fumigants, IGR compounds and pheromones.

Unit 5: Biological Control **(6 Hours)**

Principle; biocontrol agents: parasitoids, predators and pathogens (NPV, bacteria, fungi and nematodes).

Unit 6: Genetic Control and Legislation **(4 Hours)**

Sterile Insect Release Method (SIRM): radio and chemo sterilization, hybrid sterility; other strategies of genetic control; quarantine laws.

PRACTICAL **(60 Hours)**

1. Study of damage caused by the common insect pests of stored grains and crops (any 6).
2. Study of life history of important insect pests and non-insect pests.
3. Study of common natural enemies of crop pests (parasitoids, predators, microbes).

4. Study of IPM model for control of *Leptocorisa acuta* and *Scirpophaga nivella.*
5. Learn algorithm (flow chart) of IPM strategies for the sustainable agriculture.
6. Study of tools and techniques of IPM: mechanical, physical, cultural control.
7. Study of the equipments used for spraying and dusting of insecticides.
8. Determination of LD50/LC50 of insecticides based on assessment of SIT efficacy through data.
9. Submission of project report on visit to IARI, IPFT, Hindustan Insecticides Ltd., FCI complex.

Essential/recommended readings:

1. Atwal A.S. and Dhaliwal G.S. (2018) *Agricultural Pests of South Asia and their Management,* 7th Edition Kalyani Publ., New Delhi.
2. Dhaliwal G.S. and Singh R. (2004) *Host Plant Resistance to Insects – Concepts and Applications.* Panima Publ., New Delhi.
3. Hill, Dennis S (2012) *Agricultural insect pests of the tropics and their control*, 2nd Edition; Permission of Cambridge University, printed at Shree Maitrey Printech Pvt.
4. Horowitz, A. Rami and Ishaaya, Isaac. (2009) *Insect Pest Management - Field and Protected Crops* by Mary Lou Flint and Robert van den Bosch**,** (1981).
5. Flint MC & Bosch RV. (2012). *Introduction to Integrated Pest Management.* Springer, New York.

Suggestive readings:

1. Pedigo, L.P. (1996) *Entomology and pest management*, prentice hall, New Delhi
2. Raymond A. Cloyd, Philip L. Nixon and Nancy R. Pataky. 2004. *IPM for Gardeners: A Guide to Integrated Pest Management*, Timber Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Bachelor of Science (Hons.) in Applied Life Sciences with Agrochemicals and Pest Management

SEMESTER-VI

BOTANY COMPONENT - DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 06)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Biotechnology: Concepts and Applications ALS BOT DSC 06	**4**	**2**	**0**	**2**	**Class 12th Pass with Science**	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to give students knowledge of techniques used in plant biotechnology and its applications.
- to explore the use of biotechnology to generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.
- to understand the biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals, food industry, agriculture, horticultural and ecology. This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.
- to perform the techniques currently used to generate information and detect genetic variation.

Learning Outcomes:

By studying this course, students will be able to:

- comprehend the basic concepts, principles and processes of plant biotechnology.
- apply the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural fields.
- use the basic biotechnological techniques to explore molecular biology of plants.
- explain the use of biotechnological techniques for plant improvement and biosafety concerns.

Unit 1: Introduction to Biotechnology (2 Hours)

Historical timeline; Brief overview of techniques and methods in Biotechnology, sectors of Biotechnology.

Unit 2: Plant Tissue Culture (8 Hours)

Historical perspective (Haberlandt, Laibach, White, Reinert and Steward, Murashige, Cocking, Guha and Maheshwari, Bhojwani, Morel and Martin); Composition of media; Nutrients (major and minor), vitamins and hormones; Plasticity and Totipotency; Regeneration: Organogenesis (Direct and Indirect) and Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, haploids, triploids, cybrids, production of virus-free plants).

Unit 3: Recombinant DNA Technology and Genetic Transformation (12 Hours)

Restriction Endonucleases (History, Types I - IV, biological role and applications); Modifying enzymes and their applications (nucleases, ligases, alkaline phosphatase, polynucleotide kinase) Introduction to prokaryotic and eukaryotic cloning vectors: pBR322, pUC 18, pUC19, BACs, Lambda phage, YACs. Gene Cloning: Restriction digestion of DNA, ligation, bacterial transformation and selection of recombinant clones; Methods of gene transfer to plants: *Agrobacterium*-mediated transformation (Ti plasmids), Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenic plants: selectable marker genes (Positive selection markers – antibiotic- and herbicide-resistance conferring genes) and reporter genes (Luciferase, GUS, GFP).

Unit 3: Applications of Transgenic Technology (8 Hours)

Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); Edible vaccines; Introduction to genome editing; Biosafety of transgenic plants.

PRACTICALS 60 hours

1. Preparation of nutrient media for plant cell cultures- Murashige & Skoog's (MS) medium and B5 medium.
2. Initiation of axenic cultures (seed sterilisation and inoculation)
3. Micropropagation (shoot induction) using leaf and/or nodal explants of tobacco/*Datura*/ *Brassica* etc.
4. Study of anther culture, embryo and endosperm culture, somatic embryogenesis using digital resources/ photographs.
5. Preparation of artificial seeds.
6. Isolation of plasmid DNA.
7. Induction of callus and analysis of effects of growth regulators on *in vitro* regeneration using tobacco as a model plant
8. Preparation of competent cells and transformation of *E. coli* by heat shock method.
9. Restriction digestion and gel electrophoresis of plasmid DNA.
10. Construction of restriction map of circular and linear DNA from the data provided.
11. Visit to a Research laboratory.

Essential/recommended readings:

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). The Embryology of Angiosperms, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Bhojwani, S.S., Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.
3. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6th edn. Washington, U.S.: ASM Press.
4. Brown, T. A. 2020. Gene Cloning & DNA Analysis: An Introduction. 8th edn. UK: Wiley Blackwell.
5. Slater, A., Scott, N. W. & Fowler, M. R. (2010) Plant Biotechnology: The Genetic Manipulation of Plants. 2nd edn. New York, USA: Oxford University Press Inc.
6. Primrose, S. B. and Twyman, R.M. (2013) Principles of Gene Manipulation and Genomics. 7th edn. Wiley-Blackwell Publishing.

Suggested Readings :

1. Stewart, C.N. Jr. (2008). Plant Biotechnology and Genetics: Principles, Techniques and Applications. New Jersey, U.S.: John Wiley & Sons Inc.
2. Snustad, D.P., Simmons, M.J. (2010). Principles of Genetics, 5th edition. Chichester, England: John Wiley and Sons.
3. Bhojwani, S.S. and Dantu, P.K. (2013). Plant Tissue Culture: An Introductory Text. Springer New Delhi Heidelberg New York Dordrecht London

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

BOTANY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Systematics ALS BOT DSE 04	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to gain knowledge about the basics of plant systematics.
- to get an insight into the interrelationships of plant systematics and allied subjects.

Learning Outcomes:

By studying this course, students will be able to:

- understand technical terminology used in plant taxonomy.
- apply the terminologies to describe, identify and classify the flowering plants.
- search and analyze taxonomic information from internet-based scientific databases and other resources.
- comprehend and compare various systems of classification.
- recognize diversity in local/regional flora.

Unit 1: Introduction **(1 Hour)**

Plant identification, Classification, Nomenclature, Biosystematics.

Unit 2: Identification **(4 Hours)**

Field inventory, Herbarium Techniques, Functions of Herbarium, Important herbaria and botanical gardens of the world and India, Virtual Herbarium, E-flora: Flora, Monographs, Journals.

Unit 3: Systematics-An Interdisciplinary Science **(5 Hours)**

Evidence from cytology, phytochemistry [Alkaloids, Phenolics, Glycosides, (in brief)] and molecular data (cp.DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis)

Unit 4: Taxonomic Hierarchy **(2 Hours)**

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological & evolutionary)

Unit 5: Botanical Nomenclature **(7 Hours)**

Principles and rules (ICN); Ranks and names; Typification, Author citation, Valid publication, Rejection of names, Principle of priority and its limitations; Names of hybrids and cultivated plants.

Unit 6: Basic Terms and Concepts of Phylogeny **(4 Hours)**

Cladistics: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly, clades and grades). Methodology of Cladistics, Methods of illustrating evolutionary relationships (phylogenetic tree, cladogram).

Unit 7: Systems of Classification **(7 Hours)**

Major contributions of Parasara, Charaka, Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan, Cronquist, Bremer and MW Chase; Classifica tion systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Angiosperm Phylogeny Group (APG IV) Classification (major clades).

PRACTICAL **(60 Hours)**

1. To prepare at least 2 herbarium specimens and identify them using available resources (Literature, herbaria, e-resources, taxonomic keys) and classify up to family level (according to Bentham and Hooker's classification).
2. Description of taxa using semi-technical terms and identification of the families according to Bentham and Hooker's classification.

Note: Any twelve families from the following list to be studied with at least two specimens (or one where limitations exist).

List of Suggested Families (*mandatory)

Acanthaceae, Rubiaceae, *Apiaceae, Apocynaceae, *Asteraceae, *Brassicaceae, *Euphorbiaceae, *Fabaceae, *Lamiaceae, Liliaceae, *Malvaceae, Moraceae, *Poaceae, *Ranunculaceae, *Solanaceae.

Essential/recommended readings:

1. Simpson, M. G. (2019). *Plant systematics*. 3rd Edition, Academic press.
2. Singh, G. (2019). *Plant Systematics- An Integrated Approach.* 4th edition. CRC Press, Taylor and Francis Group.
3. Pandey, A. K., Kasana, S. (2021). *Plant Systematics*. 2nd Edition. CRC Press Taylor and Francis Group
4. *http://www.mobot.org/MOBOT/research/APweb/*
5. Maheshwari, J. K. (1963). *The flora of Delhi.* Council of Scientific & Industrial Research.
6. Maheshwari, J. K. (1966). *Illustrations to the Flora of Delhi.* Council of Scientific & Industrial Research.
7. Harris, J. G., Harris, M. W. (2001). *Plant Identification Terminology: An Illustrated Glossary.* Spring Lake, Utah: Spring Lake Pub. Spring Lake, Utah.

Suggestive Readings:

1. The Angiosperm Phylogeny Group, Chase, M.W., Christenhusz, M.J.M, Fay M.F., Byng, J.W., Judd, W.S., Soltis, D.E., Mabberley, D.J., Sennikov, A.N., Soltis, P.S., Stevens, P.F. (2016). *An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV.* Botanical journal of the Linnean Society 181 (1): 1-20.
2. https://www.mobot.org/MOBOT/research/APweb/treeapweb2s.gif
3. https://www.digitalatlasofancientlife.org
4. http://apps.kew.org/herbcat/navigator.do
5. https://efloraofindia.com/
6. https://powo.science.kew.org/
7. Page, R.D.M., Holmes, E.C. (1998). *Molecular Evolution: A Phylogenetic Approach*. Blackwell Publishing Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

CHEMISTRY COMPONENT – DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC 06)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Analytical Techniques in Chemistry ALS CHEM DSC 06	4	2	0	2	Class 12^{th} Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to make students aware of the concept of accuracy, precision, Statistical test data-F, Q and t test.
- to expose students to the laws of spectroscopy and selection rules governing the possible transitions in the different regions of the electromagnetic spectra.
- to familiarize students to different electroanalytical methods of analysis.
- to make students familiar to important separation methods like solvent extraction and chromatography.

Learning Outcomes:

By studying this course, students will be able to:

- analyse various sources of errors in chemical analysis.
- apply methods to minimize error.

- understand basic principle of instrumentation (UV-VIS spectrophotometer, Infrared spectrometer, Mass spectrometer, NMR Spectrometer).
- apply basic principles of separation techniques (chromatography and solvent extraction) and apply them to separate mixtures.
- analyse samples independently in the laboratory.

Unit 1: Qualitative and Quantitative Aspects of Analysis (4 Hours)

Errors, Accuracy and Precision. The Gaussian distribution, mean and standard deviation, confidence intervals. Normal law of distribution of indeterminate errors, statistical test of data; F, Q and t test.

Unit 2: Optical Techniques of Analysis (8 Hours)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, Verification of Beer's-Lambert Law by using colorimeter for different solutions and its limitations. UV-Visible Spectrometry: Basic principles of instrumentation for single and double beam instruments. Determination of concentration of unknown compounds, composition of metal complexes using Job's method of continuous variation and mole ratio method.

Unit 3: Electroanalytical Techniques (6 Hours)

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values. Application of conductance measurement: i) Ionic product of water ii) Solubility and solubility product of sparingly soluble salts.

Unit 4: Separation Techniques (6 Hours)

Solvent extraction: Classification, principle and efficiency of the technique. Chromatography: Principles of Chromatographic separations, Classification of Chromatographic techniques, Paper

Chromatography, Thin Layer Chromatography, Column Chromatography, efficiency of separation (Resolution, Efficiency of Resolution, Plate Height) Application of these techniques in analysis of biological samples.

Unit 5: Spectroscopy **(6 Hours)**

Basic principle of IR and NMR spectroscopy, interpretation of IR spectra of simple organic molecules with functional groups amine, amide, carbonyl, hydroxy. Chemical shift and low-resolution spectra, factors affecting chemical shift, interpretation of ^{1}H-NMR spectra of simple organic molecules like methanol, ethanol, acetaldehyde, acetone, acetic acid, aromatic protons and pesticide. Elementary discussion on Mass Spectrometry.

PRACTICAL **(60 Hours)**

1. Verification of Lambert-Beer's law and determination of concentration of a coloured species ($KMnO_4$, $K_2Cr_2O_7$).
2. Determine the concentration of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture by using colorimeter.
3. Spectrophotometric analysis of Co^{2+} and Ni^{2+} ions in a mixture.
4. Perform the following conductometric titration

   i) Strong acid vs strong base

   ii) Weak acid vs strong base

5. Perform the following potentiometric titration

   i) Strong acid vs strong base
   ii) Weak acid vs strong base

6. Determination of isoelectric point of amino acids.

7. Separation of Co^{2+} and Ni^{2+} mixture by paper chromatography and to determine their R_f values.

8. Separation of amino acids present in the given mixture by paper chromatography and to determine their R_f values.

9. Interpretation of simple organic compounds by IR spectra. (Spectra to be provided).

10. Study and interpretation of ^{1}H-NMR spectra of simple organic compounds (Spectra to be provided).

11. Interpretation of the structure of simple pesticide molecule (two examples) from the given IR and NMR data/spectra

Essential/ Recommended readings:

1. Willard, H.H. (1988), *Instrumental Methods of Analysis*, 7th Edition, Wardsworth Publishing Company.
2. Christian, G.D. (2004), *Analytical Chemistry, 6th Edition*, John Wiley & Sons, New York.
3. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley and Sons.
4. Skoog, D.A.; Holler F.J.; Nieman, T.A. (2005), *Principles of Instrumental Analysis*, Thomson Asia Pvt. Ltd.
5. Donald L. Pavia, Gary M. Lampman, George S. kriz (2014), *Introduction to Spectroscopy*, Thomas Press Ltd.
6. Singh, Pradeep Pratap; Ambika (2018), *Organic Spectroscopy,* Viva Books

Suggestive readings:

1. Harris, D. C. (2007), *Quantitative Chemical Analysis,6th Edition*, Freeman.
2. Khopkar, S.M. (2008), *Basic Concepts of Analytical Chemistry*, New Age International Publisher.

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CHEMISTRY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Medicinal Chemistry; ALS CHEM DSE 04	4	2	0	2	Class 12^{th} Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to impart fundamental knowledge on the structure, chemistry, and therapeutic value of drugs.
- to familiarize the structure activity relationships (SAR) of drugs.
- to understand the importance of physicochemical properties and metabolism of drugs.
- to study chemical synthesis of important drugs under each class.

Learning Outcomes:

By studying this course, students will be able to:

- understand the chemistry of drugs with respect to their pharmacological activity.
- explain the drug metabolic pathways, adverse effect and therapeutic value of drugs.
- analyze the Structural Activity Relationship (SAR) of different class of drugs.
- write the chemical synthesis of some drugs.

Unit 1: Basic Principles of Medicinal Chemistry (10 Hours)

History and development of medicinal Chemistry. Stereochemical aspects: optical, geometrical, conformational, Isosterism. Physiochemical properties: solubility, acid-base, chemical bond, partition coefficient. Drug receptor interaction and International Nonproprietary Names (INNs) of drugs.

Unit 2: Pharmacokinetics **(4 Hours)**

ADME: Drug absorption, drug distribution, drug metabolism - Phase 1, Phase 2 metabolism, drug excretion, Drug Half Life.

Unit 3: Medicinally Important Classes of Compounds **(10 Hours)**

Introduction, Structure, Synthesis, Therapeutic value and elementary SAR of representative drugs of the following classes:

- Analgesics agent: Ibuprofen
- Antipyretic agent: Paracetamol
- Anti-inflammatory agent: Aspirin
- Antibacterial and antifungal agents: Sulphonamides; Sulphanethoxazol, Sulphacetamide
- Antiviral agent: Acyclovir
- Antibiotics agents: Penicillin, Cephalosporin, Chloromycetin and Streptomycin
- Antileprosy agent: Dapsone

Unit 4: Drugs Acting on Central Nervous System **(6 Hours)**

Introduction, structure, therapeutic value and elementary SAR of representative drugs of the following classes:

- Central Nervous System agents: Phenobarbital, Diazepam
- Morphine and related drugs
- Narcotic antagonists: Nalorphine hydrochloride
- Miscellaneous: Cardiovascular (Glyceryl trinitrate), HIV-AIDS related drugs (AZT-Zidovudine)

PRACTICAL **(60 Hours)**

1. Preparation of aspirin and its analysis.

2. Preparation of paracetamol and its analysis.

3. Preparation of sulphacetamide of sulphonamide and its analysis.

4. Determination of alcohol contents in liquid drugs/galenical.

5. Determination of ascorbic acid in vitamin C tablets by iodometric or coulometric titrations.

6. Assay of drugs (any two)

1. Chlorpromazine
2. Phenobarbitone
3. Atropine
4. Ibuprofen
5. Aspirin

Essential/ Recommended Readings:

1. Patrick, G. (2017), *Introduction to Medicinal Chemistry*, Oxford University Press.
2. Lemke, T. L.; William, D.A.; Roche, V. F.; Zito, S. W. (2012), *Principles of Medicinal Chemistry*, 7th Edition, Wolter Kluwer I Lippincott Williams and Wilkins.
3. Burger, (2021) *Medicinal Chemistry, Drug Discovery and Development*, Vol I to VIII, 8th Edition, Wiley.

Suggestive Reading:

1. Beale, J. M.; Block, J. H. (2010), *Organic Medicinal and Pharmaceutical Chemistry*, 12th Edition, Wolters Kluwer India Pvt. Ltd.
2. Singh H.; Kapoor V.K. (1996), *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan.

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ZOOLOGY COMPONENT - DSC

DISCIPLINE SPECIFIC CORE COURSE (DSC-06)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Immunology and Immunotechnology ALS ZOO DSC 06	4	2	0	2	Class 12th Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to acquaint the students about cells of innate and acquired immune system and their interactions.
- to learn the structure of antibody, different isotypes and their biological functions.
- to acquire knowledge of different types of vaccines.
- to apprise the students of the mechanisms of antigen processing and presentation.
- to train the students in various immunotechniques applied in diagnostics and therapeutics.

Learning Outcomes:

By studying this course, students will be able to:

- have better understanding of the concepts of innate and acquired immunity.
- acquire knowledge of antigenicity and immunogenicity of biomolecules.
- comprehend and analyse different cellular and humoral components of the immune system.

- appreciate the applications of immunotechniques used in diagnostics and therapeutics.

Unit 1: Overview of Immune System **(3 Hours)**

Historical perspectives of immunology, clonal selection theory, brief outline of immune dysfunctions (hypersentivity, autoimmunity and immunodeficiency).

Unit 2: Innate and Adaptive Immunity **(7 Hours)**

Anatomical barriers, inflammation, cells of immune system; adaptive immunity: cell-mediated and humoral, active and passive, natural and artificial.

Unit 3: Antigens **(4 Hours)**

Antigenicity and immunogenicity; Immunogens:factors influencing immunogenicity; adjuvants and haptens; properties of B and T-cell epitopes.

Unit 4: Immunoglobulins and Vaccines **(7 Hours)**

Structure and functions of different classes of immunoglobulins, different types of vaccines.

Unit 5: Major Histocompatibility Complex **(4 Hours)**

Structure and functions of MHC molecules (MHC I and II), endogenous and exogenous pathways of antigen processing and presentation.

Unit 6: **Immunotechniques** **(5 Hours)**

Double immunodiffusion assay, haemagglutination assay (ABO typing), immunoeletrophoresis, immunofluorescence, ELISA, hybridoma technology: monoclonal antibodies in therapeutics and diagnosis.

PRACTICAL **(60 Hours)**

1. Demonstration of lymphoid organs of rat/mouse. (Subject to UGC guidelines).
2. Study of primary and secondary lymphoid organs through slides/photographs/videos.
3. Preparation of stained blood film to study various types of cells.
4. Preparation of serum using rat /mouse (Subject to UGC guidelines).
5. Perform Ouchterlony's double immunodiffusion (DID) to study immunoprecipitation and interpretation of patterns of identity, non-identity and partial identity.
6. Identification of ABO blood group by heamagglutination using antisera.

7. Cell counting and viability test of splenocytes from farm bred animals/cell lines.
8. Demonstration of ELISA and Immunoelectrophoresis.
9. Project on any topic related to theory.

Essential/ Recommended Readings:

1. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006*). Immunology,* VI Edition, W.H. Freeman and Company.
2. David, M., Jonathan, B., David, R. B. and Ivan, R. (2006). *Immunology*, VII Edition, Mosby, Elsevier Publication.
3. Punt, J., Stranford, S., Jones, P., Owen J., A. (2018) Kuby Immunology, W H Freeman Publications.

Suggestive readings:

1 Abbas, K. Abul and Lechtman H. Andrew (2017) *Cellular and Molecular Immunology*. IX Edition, Saunders Publication.

2 Kaur, H., Toteja, R., and Makhija, S. (2021). *Textbook of Immunology*. IK International Publishing House and Wiley India Ltd.

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ZOOLOGY COMPONENT - DSE

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Social and Beneficial Insects ALS ZOO DSE 04	4	2	0	2	Class 12^{th} Pass with Science	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to acquaint students of the social organization found in insects.
- to apprise them of beneficial aspects of insects.
- to impart knowledge about the techniques involved in culturing and rearing of bees, silkworms and lac insect.

Learning Outcomes:

By studying this course, students will be able to:

- identify different types of social and beneficial insects.
- differentiate the various castes and their role in the social life of insects.
- acquire skill for mass rearing of beneficial insects and their products.

Unit 1: Social Insects (7 Hours)

Characteristics and systematic position. Social organization: caste determination, communication, social parasitism and symbioses, social insect pathogens. Life cycle, social organisation and types of ants, bees, wasps and termites.

Unit 2: Apiculture **(7 Hours)**

Habit and habitat of honey bee (*Apis),* bee keeping techniques, bee pasturage, artificial bee hives. Economic importance of bee. Bee enemies, bee diseases and their control.

Unit 3: Sericulture **(6 Hours)**

Life cycle of silkworm *Bombyx mori.* Types of silkworm species and their salient features. Rearing techniques of mulberry, muga, eri and tassar silkworms. Enemies and diseases of silkworms and their management.

Unit 4: Lac Culture **(5 Hours)**

Habit, habitat and biology of *Laccifera lacca.* Host trees of lac insect, pruning, inoculation and lac harvesting. Enemies of lac insect and their control.

Unit 5: Ecological aspects of beneficial insects **(5 Hours)**

Ecological role of insects: pollination, weed control, improving soil fertility and as scavengers. Medicinal use of insects and insect products. Entomophagy.

PRACTICAL **(60 Hours)**

1. Study of life cycle of ants, bees, termites, silk worm and lac insect through museum specimens/photographs.
2. Study of different nests build by ants, bees and termites.
3. Construction and maintenance of artificial bee hives and study of equipments related to apiculture.
4. Rearing techniques of mulberry, muga, eri and tassar silkworms.
5. Study of different types of enemies and diseases of silkworms.
6. Study of lac culture technique: pruning, inoculation, cropping and harvesting.
7. Study of economically important insect products.

Essential/Recommended readings:

1. Watson, J. A. L., Okot-Kother, B. M. and Noiroh C. (1985) *Caste differentiation in social insects.* Pergamon Press.
2. Dunston AP. (2007) *The Insects: Beneficial and Harmful Aspects*.Kalyani Publishers., New Delhi.
3. Brian, M. V. (1983) *Social insects: ecology and behavioural biology*. Chapman and Hall, London, New York.
4. D. B. Tembhare (2017) *Modern Entomology.* Himalaya Publishing House.
5. Dokuhon, Z.S. (1998) *Illustrated Textbook on Sericulture.* Oxford & IBH publishing Co., Pvt. Ltd. Calcutta.
6. Shukla, G.S. and Upadhyay, V.B. (2014) *Applied and Economic Zoology*, Rastogi Publications.

Suggestive readings:

1. Maxwell F.G. and Jennings P.R. (Eds). (1980) *Breeding Plants Resistant to Insects*. John Wiley & Sons, New York.
2. *Encyclopedia of Social Insects* (2021) Springer International Publishing.

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