May 2022

[This question paper contains 8 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1134 **A**

Unique Paper Code : 32221201

Name of the Paper : Electricity and Magnetism

Name of the Course : **B.Sc. (Hons) Physics**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. **Question No.1** is compulsory
3. Answer **any four** of the remaining six question

P.T.O.

I. Attempt all parts of this question [5×5=25]

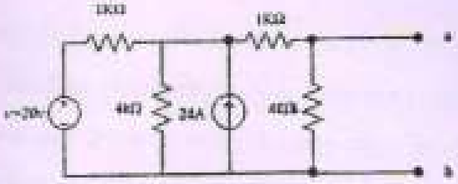
(a) A dielectric cube of side 'a' centered at the origin carries a polarization P=k r where k is a constant. Find the bound charges densities σ_b and ρ_b ?

(b) The electric field due to a static charge distribution has x component $E_x = k\,x^2\,y\,z$. Construct a valid functional form for the other two components.

(c) A point charge of +**Q** is at the origin of a spherical coordinate system, surrounded by a concentric uniform distribution of charge on a spherical shell at r=a for which the total charge is -**Q.** Find the flux Ψ crossing spherical surfaces at $r < a$ and $r > a$.

(d) A current sheet, **K**=10 a_z A/m, lies in the x = 5 m plane and a second sheet, **K**=– 10 a_z A/m, is at x =–5 m. Find **H** at all points.

(e) Obtain the Norton equivalent of the following circuit:



2. (a) A uniform surface charge density σ exists over the entire x--y plane except for a circular hole of radius R centered at the origin. Find the electric field along the z-axis. Plot the electric potential as a function of z in the range $-\infty < z < \infty$, indicating all the limiting values on the plot. [4+2]

(b) State Gauss's law of Electrostatics. A point charge Q is placed on the apex of a cone of semi vertex angle θ. Show that the electric flux through the base of the cone is q (1-cos θ) / 2 ε_0. [2+4.5]

3 (a) Calculate the electric field intensity due to a spherical charge distribution given by

P.T.O.

$$\rho(r) = \rho\,(1\text{-}r/R) \qquad r < R$$
$$= 0 \qquad r > R$$

Find the value of r at which electric field is maximum. (4+2)

(b) Find the potential due to a uniformly charged solid sphere at a point lying outside and inside the sphere. Compute the ratio of the potential at the centre of the sphere and the potential at the surface of sphere. Plot the potential. (3+2+1.5)

4. (a) A certain co-axial cable consists of a copper wire of radius 'a' surrounded by a concentric copper tube of inner radius b & outer radius c. The space between them is partially filled with a material of dielectric constant k. Find the capacitance per unit length of this cable? [5]

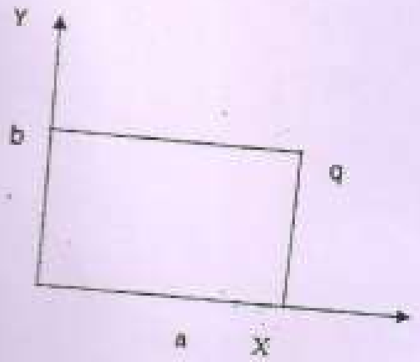
(b) A spherical shell of radius a carry a surface charge density σ. The shell rotates around the z-axis at an angular velocity w in an external magnetic field $\mathbf{B} = B_0\ \mathbf{a}_x$. Calculate the magnetic dipole moment m of the rotating spherical shell. Find the torque N exerted on the shell.

[4.5+3]

5. (a) Suppose current density in a wire of radius 'a' varies as $J = k r^2 a$, where k is a constant and r is the distance from the axis of the wire. Find magnetic field at a point distance r from the axis when r<a and r>a.

[4]

(b) Two semi-infinite grounded conducting planes meet at right angles. In the region between them there is a point charge q as shown in fig a X Calculate



Calculate

(i) Potential in the region at an arbitrary point

(ii) Induced charge densities and total induced charges on the two planes.

(iii) Total electrostatics energy of the system. [3+3+2.5]

6. (a) A series LCR circuit has R=5Ω2, L=1.0 H and V=100 cos πt. Find the value of C for resonance. Also determine the voltage across C. [3.5+3]

(b) The region between two concentric right circular cylinders contains a uniform charge density p. Use Poisson's equation to find potential V(r). [6]

7. (a) A coaxial capacitor with inner radius 5 mm, outer radius 6 mm, and length 500 mm has a dielectric for which r= 6.7 and an applied voltage 250 sin 377t (V). Determine the displacement current ip and compare with the conduction current i_c. [4+2]

(b) An emf ε= 100 sin 314t is applied across a pure capacitor of 637 μF. Find

(i) The instantaneous current i

(ii) The instantaneous power P

(iii) Maximum energy stored in the capacitor.

[2+2+2.5]

Helpful Formulas and Information

The vector derivatives in cartesian coordinates:

$$\nabla T = \frac{\partial T}{\partial x}\hat{x} + \frac{\partial T}{\partial y}\hat{y} + \frac{\partial T}{\partial z}\hat{z}$$

$$\nabla \cdot \mathbf{V} = \frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} + \frac{\partial V_z}{\partial z}$$

$$\nabla \times \mathbf{V} = \left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z}\right)\hat{x} + \left(\frac{\partial V_x}{\partial z} - \frac{\partial V_z}{\partial x}\right)\hat{y} + \left(\frac{\partial V_y}{\partial x} - \frac{\partial V_x}{\partial y}\right)\hat{z}$$

$$\nabla^2 T = \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2}$$

The vector derivatives in spherical coordinates:

$$\nabla T = \frac{\partial T}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial T}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial T}{\partial \phi}\hat{\phi}$$

$$\nabla \cdot \mathbf{V} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 V_r\right) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta V_\theta\right) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}V_\phi$$

$$\nabla \times \mathbf{V} = \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial \theta}(\sin\theta V_\phi) - \frac{\partial V_\theta}{\partial \phi}\right]\hat{r} + \frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial V_r}{\partial \phi} - \frac{\partial}{\partial r}(r V_\phi)\right]\hat{\theta} + \frac{1}{r}\left[\frac{\partial}{\partial r}(r V_\theta) - \frac{\partial V_r}{\partial \theta}\right]\hat{\phi}$$

$$\nabla^2 T = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial T}{\partial r}\right) + \frac{1}{r^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial T}{\partial \theta}\right) + \frac{1}{r^2\sin^2\theta}\frac{\partial^2 T}{\partial \phi^2}$$

The vector derivatives in cylindrical coordinates:

$$\nabla T = \frac{\partial T}{\partial s}\hat{s} + \frac{1}{s}\frac{\partial T}{\partial \phi}\hat{\phi} + \frac{\partial T}{\partial z}\hat{z}$$

$$\nabla \cdot \mathbf{V} = \frac{1}{s}\frac{\partial (s V_s)}{\partial s} + \frac{1}{s}\frac{\partial V_\phi}{\partial \phi} + \frac{\partial V_z}{\partial z}$$

$$\nabla \times \mathbf{V} = \left[\frac{1}{s}\frac{\partial V_z}{\partial \phi} - \frac{\partial V_\phi}{\partial z}\right]\hat{s} + \left[\frac{\partial V_s}{\partial z} - \frac{\partial V_z}{\partial s}\right]\hat{\phi} + \frac{1}{s}\left[\frac{\partial (s V_\phi)}{\partial s} - \frac{\partial V_s}{\partial \phi}\right]\hat{z}$$

$$\nabla^2 T = \frac{1}{s}\frac{\partial}{\partial s}\left(s\frac{\partial T}{\partial s}\right) + \frac{1}{s^2}\frac{\partial^2 T}{\partial \phi^2} + \frac{\partial^2 T}{\partial z^2}.$$

Vector Identities:

$$\nabla \cdot (f\mathbf{A}) = f(\nabla \cdot \mathbf{A}) + \mathbf{A} \cdot (\nabla f)$$

$$\nabla \cdot (\mathbf{A} \times \mathbf{B}) = \mathbf{B} \cdot (\nabla \times \mathbf{A}) - \mathbf{A} \cdot (\nabla \times \mathbf{B})$$

$$\nabla \times (f\mathbf{A}) = f(\nabla \times \mathbf{A}) - \mathbf{A} \times (\nabla f).$$

$$\nabla \times (\mathbf{A} \times \mathbf{B}) = (\mathbf{B} \cdot \nabla)\mathbf{A} - (\mathbf{A} \cdot \nabla)\mathbf{B} + \mathbf{A}(\nabla \cdot \mathbf{B}) - \mathbf{B}(\nabla \cdot \mathbf{A})$$

$$\nabla \times (\nabla \times \mathbf{A}) = \nabla(\nabla \cdot \mathbf{A}) - \nabla^2 \mathbf{A}.$$

Fundamental Constants:

$$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/Nm^2}$$

$$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{N/A^2}$$

[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1560 **A**

Unique Paper Code : 42221201

Name of the Paper : Electricity, Magnetism and EMT

Name of the Course : **B.Sc. (Prog.) – CBCS**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.

1. Answer any **five** of the following :

   (a) Determine the constant a so that the vector is $\vec{V} = (x + 3y)\hat{i} + (y - 2x)\hat{j} + (x + az)\hat{k}$ is solenoidal.

   (b) Prove that electrostatic field is conservative in nature.

P.T.O.

(c) Assuming the earth be a spherical conductor of radius 6400 km. Calculate its capacitance.

(d) Explain the physical significance of $\nabla.\vec{B}=0$. Define vector potential.

(e) Explain the difference between the properties of diamagnetic, paramagnetic and ferromagnetic materials.

(f) A current of 2 A flowing through a coil is cut-off completely in 0.2 sec. Calculate the e.m.f. induced in the coil if it has a self-induction of 0.06 H.

(g) What is displacement current? Give its physical significance. (5×3=15)

2. (a) Show that the vector field $\vec{V} = (x^2 + xy^2)\hat{i} + (y^2 + x^2y)\hat{j}$ is conservative and find the scalar potential ϕ such that the field $\vec{V} = \vec{\nabla}\phi$. (9)

(b) Find the unit vector normal to the surface $x^2 - 8y^2 + z^2 = 0$ at the point (8,1,4). (6)

3. (a) What is dipole moment? Show that the electric field due to a dipole at a point on its axis is twice as strong as that at a point at the same distance along the perpendicular axis. (8)

(b) Show that the capacitance of a parallel plate capacitor increases when the dielectric is inserted between the plates. A capacitor consists of two metallic discs, each of 1 m in diameter, placed parallel to each other at a distance 6 mm apart. The potential difference between the plates is 8000 V. Calculate the energy stored by the capacitor. (7)

4. (a) Using Ampere's circuital law, find the magnetic field due to a current, I carrying long cylindrical wire of radius R at a point distant r from the axis of the cylindrical wire for $r > R$ and $r < R$. (8)

(b) A wire shaped into a regular hexagon of side 2 cm carries a current of 2 A. Find the magnetic field at the centre of the hexagon. (4)

(c) Define the term (i) Magnetic Intensity (ii) Magnetic susceptibility and (iii) Hysteresis loss. (3)

5. (a) Explain the phenomenon of self-inductance. Obtain the expression for self -inductance of a long straight solenoid having N turns per unit length and volume V. (8)

(b) A solenoid having an air core and 12 cm long has 120 turns and its area of cross-section is 6 cm^2. Find the self-inductance of the solenoid. (4)

(c) A transformer of cross-sectional area 30 cm^2 has 60 turns per cm in the primary coil and 200 turns per cm in the secondary coil. Calculate the mutual inductance between the two coils. (3)

6. (a) Derive wave equations involving electromagnetic fields $\vec{E}$ and $\vec{H}$ in free space. Show that in free space, the electromagnetic waves travel with the speed of light. (8)

(b) Show that electromagnetic waves are transverse in nature and also establish the relationship between electric and magnetic field of the electromagnetic wave. (7)

7. (a) Write the Maxwell's equations. Explain the physical significance of every equation. (8)

(b) The magnetic field $\vec{B}$ in a material has value 0.013 T and the auxiliary magnetic field $\vec{H}$ has value 10^4 A/m. What are the magnetic permeability and susceptibility of the medium? (7)

Physical Constants:

$\varepsilon_0 = 8.854 \times 10^{-12} C^2/Nm^2$

$\mu_0 = 4\pi \times 10^{-7}$ Wb/Am

$e = 1.6 \times 10^{-19} C$

$c = 3 \times 10^8$ m/s

(100)

(g) A ball moving at a speed of 2.2 m/s strikes an identical stationary ball. After collision one ball moves at 1.1 m/s at 60^0 angle with the original line of motion. Find the velocity of the other ball.

$(5 \times 3 = 15)$

2. (a) Solve: $\cos(x+y)\,dy = dx$.

(b) Solve the equation $\frac{d^2y}{dx^2} - 8\frac{dy}{dx} + 16y = 0$.

(c) If $\vec{A} = \hat{i} + \ln(t^2+1)\hat{j} + e^{-2t}\hat{k}$ and $\vec{B} = 2\hat{i} + \hat{j} - 4\hat{k}$, find $(\vec{A}+\vec{B}) \times (\vec{A}-\vec{B})$.

(5, 5, 5)

3. (a) Show that any conservative force can be expressed as the negative gradient of potential energy.

(b) Find the centre of mass of a uniform solid hemisphere of radius 'R'.

(c) An empty rocket weighs 5000 kg and contains 40,000 kg fuel. If exhaust velocity of the fuel is 2.0 km/sec, calculate the maximum velocity gained by the rocket.

(5, 5, 5)

4. (a) Derive an expression for the acceleration of a rigid body rolling down an inclined plane without slipping.

(b) Calculate the moment of inertia of a hollow sphere about an axis through its centre.

(c) A solid sphere of mass 0.5 kg and diameter 1 m rolls without slipping with a constant velocity of 5 m/s along a smooth straight line. Calculate its total energy.

(5, 5, 5)

5. (a) What is the central force? Give an example of central force. Prove that the under the influence of a central force the motion of a particle is always confined in a plane.

(b) Shows that energy of a satellite of mass m moving round the earth in a circular orbit of radius r is given by $E = -\frac{J^2}{2mr^2}$, where, J is the angular momentum.

(c) A satellite revolves around planet of mean density $10^3\ kg/m^3$. If the radius of its orbit is only slightly greater than the radius of planet, find the time of revolution of the satellite. $[G = 6.67 \times 10^{-11}\ m^3kg^{-1}s^{-2}]$

(5, 5, 5)

6. (a) Deduce the differential equations of a damped harmonic oscillator and discuss the case of critical damping.

(b) What is meant by the term (i) logarithmic decrement and (ii) quality factor (Q) of a damped harmonic oscillator? Obtain the expression for them.

(c) Prove that the time average of total energy for simple harmonic motion is independent of time.

(7, 5, 3)

7. (a) State the postulates of Einstein's special theory of relativity. Derive the Lorentz transformation for space-time coordinates.

(b) Derive the relativistic formula for addition of velocities.

(c) What is proper interval of time? How fast should a rocket ship move relative to an observer in order that one year on it may correspond to two years on the earth?

(7, 5, 3)

[This question paper contains 3 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1835 A

Unique Paper Code : 32225201

Name of the Paper : Physics–I Mechanics

Name of the Course : B.Sc. (Hons.) – CBCS – GE

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any five questions in all, including Q. No. 1 which is compulsory.

1. Attempt any *five* of the following questions:

(a) What is the speed of a particle whose relativistic mass is twice its rest mass?

(b) Calculate period of revolution of an artificial satellite at a height h from surface of the earth, assuming that the satellite takes a circular orbit around earth.

(c) Let $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ and $\phi = \ln|\vec{r}|$. Find the value of $\vec{\nabla}.(\phi\vec{r})$.

(d) What are polar and axial vector? Give one example of each.

(e) Find the torque about the point $(1, 2, 3)$ of a force represented by $2\hat{i} + \hat{j} + 3\hat{k}$ acting through the point $(-2, 2, 1)$.

(f) Show that in the absence of external force, the velocity of the centre of mass remains constant.

P.T.O.

[This question paper contains 4 printed pages.]

Your Roll No..............

Sr. No. of Question Paper :	**1344**	**A**
Unique Paper Code	: 32221202	
Name of the Paper	: Wave and Optics	
Name of the Course	: **B.Sc. (Hons) Physics**	
Semester	: II	

Duration : 3 Hours — Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Q. No. **1** is compulsory.
3. Attempt any **four** questions of the remaining **six**.

Q 1 Attempt any five questions. Each question carries 3 marks.

a) A progressive wave of frequency 500 *Hz* is travelling with a velocity of 360 ms^{-1}. How far apart are two points 60° out of phase? [3]

b) The initial displacement of a particle of a travelling wave propagating in the negative direction of x-axis with a velocity $0.5ms^{-1}$ is $y = 8\sin(\pi x/50)$. Find the expression for the displacement at a time $t = 4s$. [3]

c) Distinguish between longitudinal and transverse waves.

d) What are achromatic fringes? How can they be obtained in principle?

e) Find out the number of orders visible if the wavelength of incident light is 5×10^{-5} cm and the number of lines on grating is 3000 per cm.

P.T.O.

f) Explain Rayleigh's criterion for resolution.

g) An exceedingly thin film appears to be perfectly black when seen by reflected light. Why?

Q.2

a) A particle is subjected to two simple harmonic motions in the same direction having equal amplitudes A, equal frequencies ω and a constant initial phase difference δ. Derive an expression for the resultant oscillation of the particle. If the resultant amplitude is equal to the amplitude of the component oscillations, what is the initial phase difference between the component oscillations.

[5+2]

b) A tuning fork A produces 4 beats with tuning fork B of frequency 256 Hz. When A is waxed, the beats are found to occur at shorter intervals. What was the frequency of A before it was waxed?

[3]

c) Graphically obtain the trajectory of a particle subjected to two perpendicular simple harmonic motions having equal frequencies, amplitudes in the ratio of 1:2 and an initial phase difference of $\pi/2$.

[5]

Q.3

a) Starting from an expression for a transverse harmonic wave travelling along a string, obtain an expression for total energy per wavelength propagated along the length of the given string.

[5]

b) Analytically discuss the normal modes of vibration of a longitudinally vibrating air column in a tube with both its ends open. What changes, if any, would occur in the existence of normal modes if one end of the tube is closed and also when both the ends are closed. Sketch the first two normal modes in all the above three cases.

[5+2]

c) Two cylindrical pipes of the same length, but one closed (at one end) and the other open (at both ends) are sounded together. The frequency of the second overtone in the closed pipe is 300 Hz higher than that of the first overtone of the open pipe. Calculate the fundamental frequency of the closed pipe. [3]

Q.4

a) Discuss Stoke's treatment of phase reversal and hence show that phase of an optical beam is changed by π when reflected from an optically denser medium. [5]

b) How can Michelson Interferometer be used to resolve close spectral lines in the spectrum of a source? Obtain an expression for difference in two wavelengths. [7]

c) In Llyod's single mirror interference experiment, the slit source is at a distance of 2 mm from the plane of the mirror. The screen is kept at a distance of 1.5 m from the source. Calculate the fringe width if λ=5890Å . [3]

Q.5

a) What are Newton's rings? Explain their formation and obtain the expression for diameters of these rings. [7]

b) In a Newton's rings experiment, the diameter of 15th ring was found to be 0.59 cm and that of the 5th ring was 0.336 cm. If the radius of plano-convex is 100 cm, calculate the wavelength of light used. [4]

c) Newton's rings are viewed with the space between lens and optical flat first empty and then filled with a liquid. Show that the ratio of the radii observed for a particular order fringe is very nearly the square root of the liquid's refractive index. [4]

Q.6

a) Illustrate the significance of Cornu's spiral. Explain the formation of diffraction pattern due to a single slit with the help of Cornu's spiral. [7]

b) What is meant by half-period elements and why they are called so? [4]

c) Consider a circular aperture of diameter 2 mm illuminated by a plane wave in case of Fresnel diffraction. The most intense point on the axis is at a distance of 200 cm from the aperture. Calculate the wavelength. [4]

P.T.O.

Q. 7

a) Derive the expressions of Fresnel Integrals and explain the significance. [7]

b) Derive an expression for intensity distribution in Fraunhofer diffraction due to a single slit. Find the positions of Maxima and Minima and the relative intensity of successive Maxima to discuss the intensity pattern. [8]

[This question paper contains 4 printed pages.]

Your Roll No..............

A

Sr. No. of Question Paper : 2305

Unique Paper Code : 32221202-OC

Name of the Paper : Wave and Optics

Name of the Course : **B.Sc. (Hons) Physics CBCS**

Semester : II

Duration : 3 hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Q. No. 1 is compulsory.
3. Answer any **four** questions of the remaining **six**.

Q.1 [15]

Attempt any five questions. Each question carries 3 marks.

a) The constituent waves of a stationary wave have amplitude, frequency and velocity as 8 cm, 30 Hz and 180 cm s^{-1} respectively. Determine the equation of stationary wave.

b) A sound wave in air is represented as $\vec{y} = 0.05 \sin(100t - 50x)$ m, where t is expressed in seconds and x in m. Determine the amplitude, frequency, wavelength and phase velocity of the wave.

c) What are beats? What are the necessary conditions to obtain them.

d) Explain what is meant by temporal and spatial coherence.

e) Distinguish between Haidinger and Fizeau fringes.

P.T.O.

f) What is the difference between positive Zone plate and negative Zone plate?

g) A plane transmission grating having 3000 line/cm gives an angle of diffraction equals to 60^0 in the 3rd order. Find the wavelength.

Q.2

a. Show analytically that the superposition of two perpendicular oscillations represented by

$x(t) = A\ sin\omega t$

$y(t) = -A\ cos\omega t$

results into circular motion traced in the anticlockwise sense. Also sketch the trajectory of a particle subjected to the given oscillations simultaneously. [5+2]

b. Two collinear simple harmonic oscillations are represented by the equations

$y_1(t) = 10\ \sin\ (3t + \pi/4)$

$y_2(t) = 5\ (\sin 3t + \cos 3t)$ [3]

Determine the ratio of their amplitudes.

c. Two collinear simple harmonic oscillations are described by equations

$x_1(t) = 0.03\ \cos(10\pi t)$

$x_2(t) = 0.03\ \cos\ (12\pi t)$ where x_1 and x_2 are in meters and t is in seconds. Obtain the equation of the resultant vibration obtained by superimposing the given oscillations and hence find the beat frequency. [5]

Q.3

a. Derive the classical wave equation using the model of a longitudinally vibrating air column. Hence deduce the expression for velocity of longitudinal harmonic waves propagating along the given air column. [5]

b. Obtain an expression for the frequencies of the normal modes of a transversely vibrating string which is rigidly fixed at its ends. Sketch the shape of the first two modes. [5+2]

c. Two strings A and B are made of same material. The cross-sectional area of A is half that of B while the tension on A is twice that on B. Determine the ratio of the velocities of transverse waves propagating along the two strings. [3]

Q 4.

a) Derive an expression for the resultant intensity when two coherent beams of light are superposed. Define Visibility of fringes and show that its value lies between 0 and 1. What is the physical significance of these extreme values of Visibility of fringes? [7]

b) In a two slit interference experiment determine the visibility of fringes when the two slits are of equal intensities. How would the visibility of fringes change if the intensity of one slit is two times the other? What will be the resultant intensity and the visibility of fringes when the sources are incoherent? [5]

c) When a thin film of transparent material of thickness 6.3×10^{-4} cm is introduced in path of one of the interfering beams, the central fringe shifts to a position occupied by the sixth fringe. If $\lambda=5460$ Å, find the refractive index of the sheet. [3]

Q 5.

a) Explain the principle of the Fabry Perot Interferometer. Prove that in case of a Fabry Perot Interferometer the intensity of the transmitted light

$I = I_{max} / (1 + F \sin^2(\delta/2))$ [8]

where symbols have their usual meaning.

b) Plot a graph of I against δ for F = 10, F=50 and F=80. Derive an expression for half width of fringes. [4]

c) Two Fabry Perot interferometers have equal plate separation. The coefficients of reflections are 0.8 and 0.9. Deduce the relative width of the maxima in two cases. [3]

P.T.O.

Q.6

a) Explain the formation of Zone Plates. How does a zone plate acts like a convergent lens? Deduce an equivalent formula for zone plate. [7]

b) Calculate the radii of the first three transparent zones of a zone plate whose first focal length is of 1m for a plane parallel incident light of wavelength 6000 Å. [4]

c) Distinguish between Fraunhofer and Fresnel diffraction. Compare the diffraction phenomenon in case of diffraction by a slit and a thin wire. [4]

Q.7

a) Derive an expression for intensity distribution due to N number of parallel identical slits and discuss the intensity pattern. [7]

b) How many minima and secondary maxima do we have between any two principle maxima in a grating having 8 number of slits? Draw the intensity distribution curve. [4]

c) A narrow circular aperture of radius 0.09 cm has been illuminated by an incident light of wavelength $6x10^{-5}$ cm. How far along the axis will the first maximum intensity be observed while considering the incident wavefront a plane wavefront? [4]

[This question paper contains 8 printed pages.]

Your Roll No.........

Sr. No. of Question Paper : 1397 **A**

Unique Paper Code : 32221403

Name of the Paper : Analog Systems and Applications

Name of the Course : **B.Sc. (Hons) Physics**

Semester : IV

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

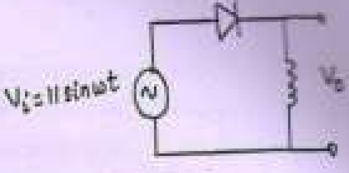
1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** is compulsory.
3. Attempt any **four** questions from the remaining **five** questions.
4. Non-programmable calculators are allowed.

1. Attempt any **five** of the following : (3×5=15)

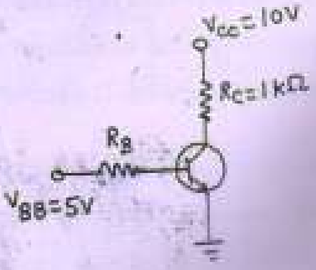
 (a) Find the conductivity of an intrinsic silicon at 300K. Mobility of electrons $\mu_n = 1350\ cm^2/V\text{-}s$ and that of holes $\mu_p = 480\ cm^2/V\text{-}s$. Intrinsic concentrations of electrons and holes $n_i = 1.5 \times 10^{10} cm^{-3}$.

P.T.O.

(b) The output of the circuit given below is connected to the dc voltmeter. What is the reading on it? (Assume ideal diode).



(c) The transistor of the figure given below is specified to have β in the range 100 to 300. Find the value of R_B that results in saturation with an overdrive factor of at least 10. Assume $V_{CEsat} = 0.2V$ and $V_{BE} = 0.7V$.



(d) Design a differentiator to differentiate an input signal that varies in frequency from 10Hz to 1KHz, using op-amp.

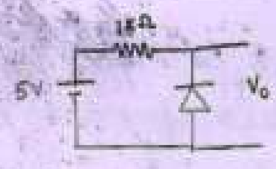
(e) Draw a circuit diagram of a 4-bit R-2R ladder type DAC and calculate its percentage resolution.

(f) Define slew rate and discuss why a high slew rate of an op-amp is desirable.

(g) Draw I-V characteristics of a Tunnel diode.

2. (a) A and B are two semiconductor materials. They have a band gap of 1.1 eV and 1.9 eV respectively. Which of these can be used for LED production? Support your answer by evaluating the wavelength of radiations emitted on recombination of electrons and holes in the two cases. Planck's constant $h = 6.626 \times 10^{-34}$ J s.

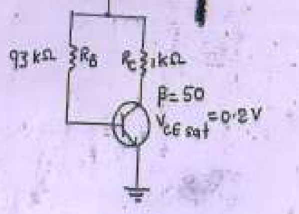
(b) For the circuit given below determine the voltage across the diode and the current flowing through it. Assume an ideal diode.



(c) Photodiodes and solar cells are both photovoltaic. What is the difference between the two?

(d) Explain Zener breakdown and discuss the main applications of Zener diode. (5,2,3,5)

3\. (a) For the circuit given below, draw the load line and determine whether the transistor in the figure is in the active region or saturation region. What significant change will happen if the transistor is replaced by the one with double the value of β. (V_{CC}=10V, V_{BE}=0.7V and V_{CEsat}=0.2V).



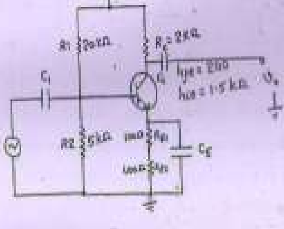
(b) In the circuit given below, evaluate :

(i) the operating point (V_{CE}, I_C)

(ii) mid frequency voltage gain

(iii) mid frequency voltage gain when bypass capacitor C_E is removed

(iv) mid frequency voltage gain when C_E is connected parallel to R_{E2}.



(5,10)

4\. (a) Derive an expression for the frequency of oscillations and the condition for sustained oscillations for phase shift oscillator constructed using BJT.

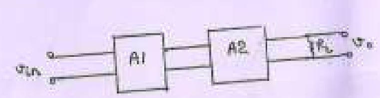
(b) A cascade connection of two voltage amplifiers A1 and A2 is shown in the figure given below. R_L=1kΩ. The open loop gain A_{V0}, input resistance

R_{IN} and output resistance R_o for A1 and A2 are as follows:

A1: A_{vo}=10; R_{IN}=10 kΩ; R_o=1kΩ

A2: A_{vo}=5; R_{IN}=5 kΩ; R_o=200Ω.

What is the overall voltage gain?



(10,5)

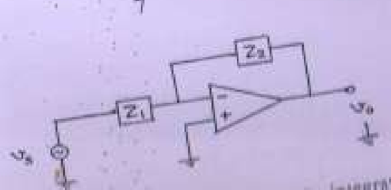
5. (a) The differential voltage gain and the common mode voltage gain of an operational amplifier are 100 dB and 2dB respectively. Calculate its CMRR. Why is it desirable to have high CMRR for an op-amp?

(b) Draw the frequency response of the gain for the circuit given below when:

(i) Z_1 and Z_2 are both resistors.

(ii) Z_1 is a resistor and Z_2 is a capacitor.

(iii) Z_1 is a capacitor and Z_2 is a resistor.



(c) Draw the circuit diagram of a basic integrator. Derive the expression for the output voltage. Discuss the problems associated with it. Also draw the circuit diagram of the practical integrator circuit that can integrate in the desired frequency range and rectify the problems associated with the basic circuit. (2,6,7)

6. (a) A silicon sample is doped with 10^{17} As atoms/cm^3. What is the equilibrium hole concentration p_o at 300K? (The intrinsic electron and hole concentrations for silicon is $n_i = 1.5\times10^{10} cm^{-3}$).

(b) Calculate ripple factor and efficiency of a full wave rectifier. What is the PIV of a bridge rectifier?

(c) An op-amp is used as a zero-crossing detector. The maximum output available from the op-amp is

+12V & -12V and the slew rate of the op-amp is 12V/ps. What is the maximum frequency of the input signal that can be applied without causing distortion in the output?

(d) What will be the output of a comparator circuit if the inverting input terminal of the op-amp is connected to the ground and a sinusoidal voltage is applied to the non-inverting input terminal.

(3,7,3,2)

[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1085 **A**

Unique Paper Code : 32223902

Name of the Paper : Computational Physics Skills

Name of the Course : **B.Sc. Hons. + Prog.– CBCS–SEC**

Semester : IV / VI

Duration : 3 Hours Maximum Marks : 50

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **four** questions in total. **All** questions cany equal marks.

1. (a) Define algorithm and flow chart. Discuss importance of algorithm and flow chart in a programming language.

   (b) Write all the steps of algorithm and draw flowchart for a programme to find maximum number among given three numbers. (6.5+6)

P.T.O.

2. (a) Write a fortran program to find the sum of a sine series for 15 terms of the series.

   (b) Write a fortran program to find addition and subtraction of two 3x3 matrices. (6.5+6)

3. (a) Write LaTeX code to input title in a document file. Write output of following LaTeX code.

```
$\Psi(x)=\sqrt{\frac{2}{a}}sin(\frac{\pix}{a})$
$0<x<a$
```

   (b) Write LaTeX code to insert figure in a document file. Write the output of the following LaTex code.

```
\ begin{table}[ ]
\ begin {tabular} {|c|c|c|}
Number of candidates & Height(cm) & Weight (kg)    \\ \hline
07                   & 167        & 65             \\ \hlipe
85                   & 175        & 85.6           \\ \hline
32                   & 173.5      & 83.5           \\ \hline
\end {tabular}
\end {table}
```

(6.5+6)

4. (a) Write LaTeX codes for following equations :

   (i) $\frac{d^2x}{dt^2} + \omega^2 x = 0$

   (ii) $F = \frac{-Gm_1m_2}{r^2}$

   (iii) $y = y_0 + tan\theta(x - x_0)\frac{g}{2v_0^2cos^2\theta}(x - x_0)^2$

   (b) Describe any method of bibliography and citation in a LaTeX document. Also describe any method to include index in the LaTeX document. (6.5+6)

5. (a) Explain with an example how to fit a curve to given data in gnuplot.

   (b) Given the functions $f_1(x) = \sin\pi x$; $f_2(x) = \cos\pi x$; $f_3(x) = e^{-x}$. Write a gnuplot script to plot $f_1(x) + f_2(x) + f_3(x)$ as a function of x. (6.5+6)

6. (a) Write the gnuplot statements to plot $f(x) = x^2$ and $f(x) = x^3$ on a same plot for the range $0 \le x \le 10$. with proper title of graph, title of axis, also show the legends. Save the plot with ".pdf" extension.

   (b) Describe the use of any three of the following gnuplot statements

   (i) "save" and "load"

(ii) set parametric

(iii) set pm3d

(iv) set samples 3000

(v) unset key (6.5+6)

[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1379 A

Unique Paper Code : 32221402

Name of the Paper : Elements of Modern Physics

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : IV – CBCS Part–II

Duration : 3.5 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question no. **1** is compulsory.
3. Attempt **five** questions in all.
4. **All** questions carry equal marks.
5. Symbols have their usual meanings.

1. Attempt any **five** parts :

(a) If $f = x^n$, show that f is an eigen function of the operator $x\left(\frac{d}{dx}\right)$. Also find the eigenvalue.

P.T.O.

(b) David Beckham takes a free-kick of a football of mass 400 g. The curving ball moves with a velocity of 170 km/hr while reaching the goalpost. Find the deBroglie wavelength associated with the ball at that time. Will this wavelength have any physical significance for the goalkeeper facing the free-kick?

(c) Can the following two functions be physically acceptable solution of the Schrödinger wave equation

(i) (A/2) tan (x)

(ii) (3/2C) sin (x),

where A and C are non-zero constants.

(d) A 60 pm X-ray is incident on a calcite crystal. Find the wavelength of the X-rays scattered through an angle of 30°. What is the largest shift in wavelength that can be expected in this experiment?

(e) Find the combined kinetic energy of an electron and an antineutrino, when a free neutron decays into proton, electron and antineutrino. Given $m_n = 1.008984$ u, $m_p = 1.00759$ u, $m_e = 0.00055$ u, $1u = 1.673 \times 10^{-27}$ kg

(f) If ^{235}U loses 0.1% of its mass on undergoing fission, then how much energy is released when 1 Kg of ^{235}U undergoes fission?

(g) Why stimulated emission is necessary for lasing action?

(5×3)

2. (a) The work function of potassium is 2.30 eV. UV light of wavelength 3000 Å and intensity $2Wm^{-2}$ is incident on the potassium surface.

(i) Determine the maximum kinetic energy of the photo electrons.

(ii) If 40% of incident photons produce photo electrons, how many electrons are emitted per second if the area of the potassium surface is 2 cm^2?

(b) The energy of a free electron including its rest mass energy is 10 MeV. Calculate the group velocity and the phase velocity of the wave packet associated with the motion of this electron.

(c) Deduce the Heisenberg's uncertainty principle for position and momentum from gamma ray microscope thought experiment. (5+5+5)

3. (a) Explain why it is plausible to define probability current density in quantum mechanics by the following expression

$$J = (-i\hbar/2m)\,(\psi^* \text{ grad } \psi - \psi \text{ grad } \psi^*)$$

The symbols have usual meaning.

(b) Name and explain an electron diffraction experiment. Give the physical significance of this experiment in relation to the wave particle duality. (10+5)

4. (a) Explain nuclear binding energy and packing fraction. Discuss graphically the variation of average binding energy per nucleon with mass number, A and hence explain nuclear stability and phenomena of fusion and fission.

(b) Calculate the binding energy per nucleon of $_{26}Fe^{56}$ in MeV using semi-empirical mass formula. Given a_1 = 14.1 MeV, a_2 = 13.0 MeV, a_3 = 0.595 MeV, a_4 = 19.0 MeV, a_5 = 33.5 MeV. (10+5)

5. A particle of mass m is confined in a field free region between impenetrable walls at x=0 and x=L.

(a) Obtain an expression for energy of the particle.

(b) Obtain and draw the first three normalized wave functions.

(c) Find the minimum energy of the particle with mass 9.1×10^{-31} kg for L=1 Å. (5+5+5)

6. (a) Given the half life of ^{210}Po is 138 days, find

(i) the decay constant of Po.

(ii) the activity of 1 g of Po.

(iii) how many decays per second occur when the sample is one week old.

(b) What are the main differences among alpha, beta and gamma decay?

(c) Name and explain which conservation laws seemed to be violated in beta decay. How did Pauli resolve these discrepancies? (5+5+5)

7. (a) What are the assumptions made in liquid drop model of atomic nucleus? How do asymmetry and pairing of the nucleons affect the nuclear stability?

(b) How are decay constant, half-life and average life time of a radioactive nuclide related with one another? Derive the equations connecting them. (10+5)

Some Physical Constants

Planck constant, $h = 6.626 \times 10^{-34}$ Js

$\hbar = 1.055 \times 10^{-34}$ Js

Boltzmann constant, $K_B = 1.38 \times 10^{-23}$ JK^{-1}

Mass of electron, $m_e = 9.1 \times 10^{-31}$ kg

Charge of electron, $e = 1.6 \times 10^{-19}$ C

Speed of light in vacuum, $c = 3 \times 10^8$ ms^{-1}

Stefan-Boltzmann constant, $\sigma = 5.67 \times 10^{-8}$ $Wm^{-2}K^{-4}$

Rest mass energy of electron = 512 KeV

Velocity of electron in free space = 3×10^8 ms^{-1}

[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1152 **A**

Unique Paper Code : 32221401

Name of the Paper : Mathematical Physics – III

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question No. **1** is compulsory.

1. Attempt any **five** parts : (5×3=15)

   (a) Find the cube root of $z = 1 + i$ and locate them in the plane.

   (b) Show that $u(x, y) = x^2 - y^2$ is a harmonic function in the whole complex plane, find its harmonic conjugate, $v(x, y)$.

P.T.O.

(c) Evaluate

$$\oint_C \frac{e^{3z}}{(z - i\pi)}\, dz \qquad C : |z - 1| = 4.$$

(d) If a complex function f(z) is analytic in a domain D and |f(z)| = Const. K in D, then show that f(z) is also constant in D.

(e) Show that the Laplace Transform of Dirac delta function is 1, ie, $L\{\delta(t)\} = 1$.

(f) If Laplace Transform of a function $L\{f(t)\} = F(s)$, show that

$$L\{t^n f(t)\} = (-1)^n F^{(n)}(s),$$

where $F^{(n)}$ represents n-th derivative of F(s).

(g) If Fourier Transform of f(x) is $F(\omega)$, find Fourier Transform of f(x) cos ax, where a > 0.

(h) Evaluate the following integrals

(i) $\int_0^\infty e^{3t}\, \delta(t-4)\, dt$

(ii) $\int_0^\infty \sin 2t\, \delta(t - \pi/4)\, dt$.

2. (a) Find all values of $\sin^{-1} 2$. (5)

(b) Expand $f(z) = e^{z/(z-2)}$ in the Laurent series about z = 2 and determine the region of convergence of this series. Also classify the singularity. (6)

(c) Evaluate (4)

$$\oint_C \frac{z}{z^2+9}\, dz, \quad \text{where} \quad C : |z - 2i| = 4$$

3. Using Contour Integration, solve any **two** of the followings : (7.5×2=15)

(a) $\int_0^\infty \frac{dx}{x^4+1}$

(b) $\int_0^\pi \frac{a}{a^2+\sin^2\theta}\, d\theta \quad a > 0$

(c) $\int_0^\infty \frac{\cos x\, dx}{(x^2+a^2)(x^2+b^2)} \quad a \,\&\, b > 0$

(d) $\int_0^\infty \frac{\sin^2 x}{x^2}\, dx$

4. (a) Obtain Fourier Integral representation of the function (4)

$$f(x) = \begin{cases} 0 & x < 0 \\ a & 0 \leq x \leq 3 \\ 0 & x > 3 \end{cases}$$

(b) Find the Fourier Transform of the function (4)

$$f(x) = \frac{x}{x^2 + 1}$$

(c) Find Fourier sine transform of e^{-mx}, $m > 0$ and hence evaluate the integral (7)

$$\int_0^\infty \frac{\omega \sin \omega x}{a^2 + \omega^2}\, d\omega.$$

5. (a) For a periodic function f(t) having periodicity T, such that f(t + T) = f(t), show that the Laplace Transform is given by (7)

$$L\{f(t)\} = \frac{\int_0^T e^{-st} f(t)\, dt}{1 - e^{sT}}.$$

(b) If a function is piece-wise continuous on $0 < t \leq T$ and is of exponential order for $t > T$ then show that (8)

$$\lim_{s \to \infty} L\{f(t)\} = \lim_{s \to \infty} F(s) = 0,$$

and hence further show that

$$\lim_{t \to 0} f(t) = \lim_{s \to \infty} sF(s)$$

where F(s) represents the Laplace Transform of f(t).

6. (a) Plot the given function (5)

$$f(x) = \begin{cases} 1 & |x| < 2 \\ 0 & |x| > 2. \end{cases}$$

Finding its Fourier Transform, F(s), plot it.

(b) Solve the differential equation

$y''(t) + 4y(t) = 9t$ with initial condition $y(0) = 0$ and $y'(0) = 7$. (10)

7. (a) Show that the Dirac delta function can be expressed as the derivative of Heaviside's unit step function. (5)

(b) For the Dirac delta function $\delta(x)$, prove that

$$\delta(x^2 - a^2) = \frac{1}{2|a|}\left[\delta(x + |a|) + \delta(x - |a|)\right].$$ (5)

(c) If a continuous function f(t) is an even function, then show that its Fourier Transform F(ω) will also be an even function. (5)

8. (a) Find the Fourier Transform of the function

$$f(x) = e^{-\alpha|x|}, \quad \alpha > 0$$

and hence show that

$$\int_{-\infty}^{\infty} \frac{e^{-ikx}}{(\alpha^2 + k^2)}\, dk = \frac{\pi}{\alpha}\, e^{-\alpha|x|}. \qquad (7)$$

(b) For a function

$$h(t) = \begin{cases} e^{-xt} g(t) & t > 0 \\ 0 & t < 0, \end{cases}$$

show that F{h(t)} = L{g(t)}. (3)

(c) For the equation $z^4 - 3z^2 + 1 = 0$, find the sum of its roots. (5)

[This question paper contains 3 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1950 A

Unique Paper Code	: 32225415
Name of the Paper	: Thermal Physics and Statistical Mechanics
Name of the course	: B.Sc. (Hons.) – CBCS_GE
Semester	: IV
Duration	: 3 Hours
Maximum Marks	: 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt **five** questions in all, including Question No. 1 which is compulsory.

All questions carry equal marks.

(Symbols have their usual meanings.)

1. Answer any *five* of the following: $3 \times 5 = 15$

(a) Based on the zeroth law of thermodynamics, introduce the concept of temperature.

(b) Prove that it is impossible to attain absolute zero of temperature.

(c) Derive the expression for efficiency of Carnot's engine with the help of T-S diagram.

(d) Derive the equation :

$$TdS = C_v\, dT + T\left(\frac{\partial P}{\partial T}\right)_V dV$$

(e) Calculate the surface temperature of the sun and moon, given that $\lambda_m = 4753$ Å and 14×10^{-6} m respectively and Wein's constant $b = 0.2898$ cm-K, λ_m being wavelength of maximum intensity of emission.

(f) What do you mean by degrees of freedom of a particle? Give degrees of freedom of a monoatomic, diatomic and triatomic molecule in the absence of vibratory motion.

(g) Calculate the average kinetic energy of a molecule of a monoatomic gas at a temperature 300 K. Given that $R = 8.3 \times 10^7$ ergs K^{-1} $mole^{-1}$ and $N = 6.02 \times 10^{23}$ $(gm\text{-}mole)^{-1}$.

P.T.O.

2. (a) Give the Kelvin-Planck and Clausius statement of the second law of thermodynamics. Are these statements equivalent to each other? Justify your answer. 10

   (b) Using first law of thermodynamics, find the value of C_P-C_V for a perfect gas. 5

3. (a) What is Entropy? Show that the entropy remains constant in reversible process but increases in irreversible process. 9

   (b) Calculate the change in entropy when 5 kg of water at 100°C is converted into steam at the same temperature. Given Latent heat of steam = 540 cal/gm. 6

4. (a) Prove for a perfect gas

$$\left(\frac{\partial U}{\partial V}\right)_T = 0$$

5

   (b) Define Helmholtz function and derive related Maxwell's thermodynamic relation. 5

   (c) Prove that

$$C_P\text{-}C_V = TE\alpha^2 V$$

   where T is absolute temperature, E the modulus of isothermal elasticity, α the coefficient of volume expansion and V the specific volume. 5

5. Derive Maxwell Boltzmann's distribution law of molecular velocities for an ideal gas. Show the distribution graphically for various temperatures. Describe any one method to verify this law experimentally. 15

6. (a) Derive an expression for coefficient of viscosity on the basis of kinetic theory of gases. How does the coefficient of viscosity of a gas depend upon the pressure and temperature of the gas? 12

   (b) Calculate the mean free path of a gas molecule, given that the molecular diameter is 2×10^{-8} cm and the number of molecules per cc is 3×10^{19}. 3

7. (a) What are the basic assumptions of Plank's theory of black body radiation? Derive Plank's radiation formula for the distribution of energy in the spectrum of a black-body. 10

   (b) Derive Wein's distribution law and Rayleigh Jean's law from the Plank's radiation formula. 5

8. (a) Obtain the expression for thermodynamic probability and the most probable distribution function for a system obeying Maxwell Boltzmann statistics. 9

   (b) Three particles are to be distributed in four energy levels. Calculate all possible ways of this distribution when particles are (i) Oxygen molecules (ii) Electrons (iii) Photons. 6

[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1224 **A**

Unique Paper Code : 32227626

Name of the Paper : Classical Dynamics

Name of the Course : **B.Sc. (Hons) Physics-DSE-4**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** which is compulsory.
3. Attempt any **three** questions from the remaining.

1. Attempt any **four** of the following : (4×6=24)

(a) Show that phase of an electromagnetic wave is Lorentz invariant.

(b) Write the Hamiltonian of a one-dimensional harmonic oscillator.

(c) Define pathlines, streamlines and streaklines.

(d) A particle of mass m is constrained to move on the boundary of an ellipse $x^2 + 2y^2 = 2$. Identify the generalized coordinates of this system.

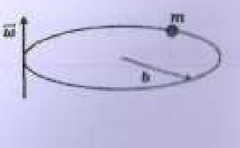
(e) An alpha-particle ($q = 3.2 \times 10^{-19}$ C) moves through a uniform magnetic field whose magnitude is 1.5 T. The field is directly parallel to the positive z-axis of the rectangular coordinate system. What is the magnitude and direction of the magnetic force on the alpha- particle when it is moving with a velocity $\vec{v} = (2.0\hat{i} - 3.0\hat{j} + 1.0\hat{k}) \times 10^4\ m/s$.

(f) Given the fluid velocity components

$v_x = -\alpha y/(x^2 + y^2)$, $v_y = \alpha x/(x^2 + y^2)$, $v_z = 0$.

Verify that the fluid is incompressible.

2. (a) A bead of mass m slides freely on a frictionless circular wire of radius b. The wire itself rotates in a horizontal plane about an axis passing through a point on perimeter of the wire with a constant angular velocity ω.



Find the Lagrangian of the system with a suitable choice of generalized coordinates. Deduce the Euler- Lagrange's equation of motion of the bead. Show that the bead oscillates as a pendulum of length $l = g/\omega)^2$.

(10)

(b) For a time independent holonomic system, show that the Hamiltonian of the system represents total energy.

(7)

3. (a) Using cylindrical coordinates, write the Hamiltonian and Hamilton's equations for a particle of mass m moving on the inside of a frictionless cone $x^2 + y^2 = z^2 \tan^2 \alpha$.

(10)

(b) Show that the energy conservation is nothing but a consequence of the time-shifit invariance of a system.

(7)

4. (a) An observer A stands 1 light-second away from a tunnel of length L = 1 light-second. A high-speed train speeds through the tunnel at constant velocity $\beta = 0.5$. An observer inside the train measures the length of the train to be L = 2 light-second.

(i) Draw a spacetime diagram for observer A showing the worldlines of the front and rear of the train and the tunnel. Assume that at $t = 0$ the rear of the train has just crossed the observer.

(ii) Label the event at which the front end of the train emerge from the tunnel and the rear end of the train enter the tunnel. Using the spacetime diagram, show that the train fits the tunnel as observed by A.

(iii) In the train frame, label the event along the worldline of the rear which is simultaneous to the event when the front end emerges from the tunnel and label the event along the worldline of the front which is simultaneous to the event when the rear end of the train enters the tunnel. (10)

(b) Show that in units such that $c = 1$, the 4-acceleration is given by $A = \gamma(d\gamma/dt,\ v d\gamma/dt + \gamma a)$ where α is the 3-acceleration. Prove that $v^{\mu}a_{\mu} = 0$ where v^{μ} is 4-velocity and a_{μ} is 4-acceleration. (7)

5. (a) A particle of mass m moving at speed v collides with another particle of the same mass at rest. They stick together and move with speed V. What is V in terms of v? What is the mass of the final combined particle? (10)

(c) Let an observer B move relative to an observer A with fractional velocity v. For a photon moving in the v direction, show that energy $E' = E\sqrt{(1-\beta)/(1+\beta)}$ where $\beta = v/c$. Also derive the relativistic Doppler shift. (7)

6. (a) Three masses m each, initially located equidistant from one another on a horizontal circle of radius R. They are connected in pairs by three springs of force constant k each and of unstretched length $2\pi R/3$. The spring threads the circular tract so that the mass is constrained to move on the circle. Find the normal modes with their frequencies and normalized coordinates. (10)

(b) Define stable and unstable equilibrium. In case of a simple pendulum, find the point of stable and unstable equilibrium. (7)

7. (a) Show that motion of a particle with mass m and charge q moving at a speed $\vec{v}$ in a magnetic field of strength $\vec{B}$ is helical. A proton enters a uniform magnetic field of with a speed of $v = 1.0 \times 10^{-4}$ T. At what angle must the magnetic field be from the velocity so that the pitch of the resulting helical motion is equal to the radius of the helix? (10)

(b) Show that the pressure at a point in an inviscid fluid is independent of direction. (7)

[Ths question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1305 **A**

Unique Paper Code : 32227613

Name of the Paper : Communication System

Name of the Course : **B.Sc. (Hons.) Physics – CBCS-DSE**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **FIVE** questions in all.
3. All questions carry equal marks.
4. Question No. **1** is compulsory.
5. Scientific (non-programmable) calculators are allowed.

1. Answer any **five** of the following questions : (5×3=15)

   (a) Discuss the need of modulation in electronic communication system.

P.T.O.

(b) An FM transmitter has a frequency deviation of 20 kHz. Determine the percentage modulation of this signal if it is broadcasted in 88-108 MHz band.

(c) What is the advantage of Flat Top Sampling over Natural Sampling?

(d) Distinguish between Time Division and Frequency Division Multiplexing.

(e) Define the terms quantization error and coding efficiency.

(f) What do you understand by ASK and FSK. Explain using wave forms.

(g) List out the frequency bands used for satellite services.

(h) Explain how cell splitting improves the capacity in a cellular network.

2. (a) Explain the generation of FM wave using VCO. (6)

(b) Explain the mathematical analysis of AM wave using frequency spectrum. A 50 MHz carrier signal with a voltage of 5 V is amplitude modulated by a sine wave of 5 kHz with a voltage of 2.5 V. Draw the frequency spectrum of AM wave. (9)

3. (a) With the help of circuit diagram explain the working of emitter modulator to obtain an amplitude modulated wave. (10)

(b) Find the power in each side band of a DSB-SC signal with the carrier at 1 MHz and of a peak signal voltage of 100V modulated simultaneously by three different signals. The frequency of the modulating signals are 2 kHz, 3 kHz and 5 kHz respectively and the peak modulating voltages are 10 V, 20 V and 30 V respectively. Assume a resistance of 100Ω. (5)

4. (a) What is alising explain how it can be removed. Explain PWM using waveform and its importance in modulation. (5)

(b) Explain the theory of TDM in a PAM signal by using a block diagram. (10)

5. (a) Explain uniform quantization and derive the expression for signal to quantization Noise ratio. (9)

(b) For a minimum line speed with an 8-bit PCM speech signal ranging up to IV

(i) Calculate the resolution and quantization error

(ii) Calculate the coding efficiency for a resolution of 0.0 IV with 8 bit PCM. (6)

6. (a) Explain Geosynchronous satellites. Write advantages and disadvantages of geosynchronous satellites. Draw and explain the simplified block diagram of an earth station. (10)

(b) Explain the operation of GPS. (5)

7. (a) With the help of a block diagram explain Global System for Mobile Communication. Describe in detail about different components and the interfaces between them. Briefly explain various frequency bands used for satellite communications and frequency allocations for mobile satellite service. (8)

(b) What do you understand by look angles and range for a geostationary satellite with respect to an earth station? Explain limits of visibility of a satellite with respect to an earth station and explain the method for its calculation? (7)

[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1361 **A**

Unique Paper Code : 32221602

Name of the Paper : Department of Physics & Astrophysics

Name of the Course : **B.Sc. (Hons) Physics – CBCS**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **four** questions in all.
3. **All** questions carry equal marks.
4. Non-programmable Scientific calculators are allowed.

1. (a) Given a system of 5 weakly interacting distinguishable particles which can occupy any of the three energy levels of energy 0, ε, and 2ε. Let the total energy of the system be 5ε. Write

P.T.O.

all possible macrostates and their corresponding number of microstates. Find the entropy of this system.

(b) Consider equal amount of two identical ideal gases at the same temperature T but at different pressure P_1 and P_2 in two different containers of volume V_1 and V_2 respectively which are joined by the partition. Starting with Sackur-Tetrode relation, prove that If gases are allowed to mix each other by removing the partition between them, the change in the entropy is given by :

$$\Delta S = Nk \ln [(P_1 + P_2)^2 / (4 P_1 P_2)]$$

where N denotes the number of atoms in each container. Assume that the temperature remain the same after mixing of the ideal gases.

(c) The partition function, Z (V, T), for some physical system is given as:

$$Z(V, T) = \exp[(8\pi^5 k^3 V T^3) / (45 h^3c^3)]$$

where the symbols have their usual meaning. Calculate the internal energy and pressure for such system. (6.75,6,6)

2. Consider an isolated system of N distinguishable particles. Each particle can occupy only one of two energy levels of energy ε_1 and ε_2 (where $\varepsilon_1 < \varepsilon_2$). Particles are distributed in such a way that n_2 particles resides in energy level ε_2 and n_1 particles are present in level of energy ε_1. (Assume N is very large and $N = n_1 + n_2$)

(a) Find the entropy and energy of this system. Show that entropy of such system is maximum when n2 = N/2.

(b) Find the maximum and minimum value of the entropy.

(c) Obtain the general expression of temperature for the above mentioned isolated system and explain how is it possible to attain negative temperature in it. (6.75,6,6)

3. (a) Consider a spherical enclosure whose wall are moving outward with speed v (v << c) and are perfectly reflecting. Suppose that an electromagnetic wave of wavelength λ incident at an angle θ to the normal on the wall. Show that

change in the wavelength after one reflection during adiabatic expansion of blackbody radiation is $d\lambda = (2 v \lambda/c) \cos\theta$.

(where c is velocity of light)

(b) Obtain the value of Wien's constant by using the Planck's radiation formula.

(c) A radiating cavity has the maximum of its radiating power per unit area at $(\lambda_1)_{max} = 24$ μm at temperature T_1. Now the temperature of the cavity is changed to T_2 such that total power radiated per unit area by the cavity is 81 times higher than its previous value. Calculate the wavelength $(\lambda_2)_{max}$ where the maximum emission of radiation occur. (6.75,6,6)

4. (a) At what temperature would you expect a trapped gas of hydrogen atoms with peak density 1.8×10^{14} atoms/cm^3 to show the signs of Bose- Einstein Condensation.

(Given $m_H = 1.66 \times 10^{-27}$ kg)

If the number density of bosons become 8 times of its previous value, find the change in the condensation temperature.

(b) Consider a photon gas enclosed in a Volume V. The photons are in equilibrium at temperature T. The average number of photons in equilibrium is given as $N = \gamma V^{\alpha} T^{\beta}$. Obtain the value of constants α, β and γ.

(c) Plot the pressure of strongly degenerate bosons with temperature. Show explicitly the T < Tc and T > Tc regions in the graph. Compare it with classical gas. (6.75,6,6)

5. (a) Calculate the internal energy possessed by the non-relativistic and strongly degenerate ($T < T_F$) electrons moving in 3-dimensions.

(b) Derive an expression for Fermi velocity of electrons at T = 0 K and hence show that the de Broglie wavelength associated with the electrons is given by

$$\lambda_{dB} = 2\ (\pi/3n)^{1/3}$$

where n is the number density (N/V) of the electron gas.

(c) Prove that for a system consisting of fermions at temperature T ($T << T_F$), the probability that a filled state ΔE lying above Fermi level is the same as the probability of an empty state ΔE lying below the Fermi level. (6.75,6,6)

Useful constants and Integrals :

$h = 6.6 \times 10^{-23}$ Js

$k_B = 1.38 \times 10^{-23}$ J/K

$c = 3 \times 10^8$ m/s

$\int_0^\infty x^2/(e^x - 1)\, dx = 2.404$

10

[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1670 **A**

Unique Paper Code : 42227637

Name of the Paper : DSE: Solid State Physics

Name of the Course : **CBCS: B.Sc. (Prog.) – DSE**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Answer **five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.
5. Non-programmable scientific calculator is allowed.

1. Attempt any **five** : (3×5)

(a) Mention the lattice type and bases in CsCl structure with diagram.

(b) Obtain the Miller indices of a plane which makes an intercepts at a/2, b/2 and 3c along the primitive axes of the simple cubic unit cell. Draw a neat diagram of the plane.

(c) Determine the number of normal modes of vibration in a linear mono-atomic lattice of finite length in first Brillouin zone.

(d) Describe low temperature behavior of Einstein's theory of specific heat of solids.

(e) Calculate the Hall Coefficient when number of holes in a semiconductor is 10^{20} m^{-3}. Given that $e = 1.6 \times 10^{-19}$ coulomb.

(f) Distinguish between dia, para and ferro-magnetic materials on the basis of magnetic susceptibility.

(g) Discuss the variation of polarizability with frequency.

(h) Differentiate a superconductor with a perfect conductor.

2. (a) Mention the names of seven crystal systems in three dimensions with fourteen Bravais lattices included in them. Mention the unit cell characteristics of each system. (10)

(b) For a bcc lattice, determine the diffraction angle for 1st order diffraction maximum from the (220) set of planes with interplanar spacing 1.013 Å with monochromatic X- rays of wavelength 1.790 Å. (5)

3. (a) Discuss the importance of reciprocal lattice space in understanding the structure of a crystal. (5)

(b) Prove that the reciprocal lattice vector $\vec{G}_{hkl}$ is perpendicular to the crystal plane (hkl) of a cubic crystal and that the interplanar spacing d_{hkl} is given as

$$d_{hkl} = \frac{2\pi}{|\vec{G}_{hkl}|} \quad (5)$$

(c) A direct lattice has the following primitive translation vectors: $\vec{a} = 2(i + j)$, $\vec{b} = 2(j + k)$, $\vec{c} = 2(k + i)$. Find out the reciprocal lattice vectors and type of lattice. (5)

4. The dispersion relation for the vibrational modes of diatomic linear lattice having masses m and M(m < M) is

$$\omega^4 - 2\alpha\left(\frac{1}{M}+\frac{1}{m}\right)\omega^2 + \frac{4\alpha^2}{mM}\sin^2 Ka = 0$$

where the symbols have their usual meanings.

(a) Obtain expressions for acoustical and optical curves. Draw the dispersion curves. (4,2)

(b) Explain its behaviors observed in acoustical and optical branches when

(i) m becomes equal to M.

(ii) m reduces to zero.

(iii) M increases to infinity. (2,2,2)

(c) Determine the smallest possible wavelength allowed by this diatomic lattice in the first Brillouin zone. (3)

5. (a) Describe qualitatively the Einstein's theory of specific heat of solids. Describe its shortcomings. (5,2)

(b) Describe how Debye improved the Einstein's theory? Discuss qualitatively Debye's theory of specific heat. (6)

(c) The Debye temperature for Aluminum is 418 K. Calculate the frequency of the highest possible lattice vibration in Aluminum. (2)

6. (a) Describe in detail n- type and p- type semiconductors. (6)

(b) Define conductivity and mobility. Obtain expressions for conductivity and mobility for a highly doped n-type semiconductor. (6)

(c) What will be the mobility of electrons in Cu if it has 9×10^{28} valence electrons per cubic meter and its conductivity is 6×10^{7} ohm^{-1}meter^{-1}? (3)

7. (a) Describe Langevin theory of paramagnetism and hence, obtain expression of magnetic susceptibility. (10)

(b) Assuming the existence of Weiss molecular field, obtain modified expression of magnetic susceptibility for a paramagnetic substance. (5)

8. (a) Obtain an expression for the local electric field at an atom in a dielectric medium. (8)

(b) Explain Meissner effect in superconductors. (5)

(c) For a given specimen of a superconductor, the critical fields are 1.4×10^5 A/m and 4.2×10^7 A/m respectively for 14K and 13 K. What will be the critical field at 4.2 K? (2)

[This question paper contains 6 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1116 **A**

Unique Paper Code : 32221601

Name of the Paper : Electromagnetic Theory

Name of the Course : **B.Sc. (Hons) Physics–CBCS**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** is compulsory.
3. Answer any **four** of the remaining **six**.
4. Use of non-programmable calculator is allowed.

1. Attempt any 5 parts of this question. (5x3)

(a) A conductor of square cross section and having conductivity 3.8×10^7 S/m is 50 m long. It measures 0.5 cm on either side. Calculate the skin depth if conductor carries current at 150 kHz.

(b) The conduction current density in a material is given as $\overline{J_C} = 0.02 \sin(10^9 t)$ A/m². Find the displacement current density if $\sigma = 10^5$ mho/m, $\epsilon_r = 6.5$.

(c) What is plasma frequency and minimum penetration depth for collision free plasma having 10^{12} electrons/m³.

(d) A 300 mm long tube containing 56 cm³ of sugar solution produces an optical rotation of 12° when placed in a polarimeter. If the specific rotation of sugar solution is 66°, calculate the quantity of sugar contained in the tube.

(e) For glass air interface ($n_1 = 1.5$, $n_2 = 1.0$), find the reflection and transmission coefficients for normal incidence.

(f) A left circularly polarized wave (λ = 5893 A) is incident normally on calcite crystal of thickness 0.00514 mm. Find the state of polarization of the emergent beam. Take $n_o = 1.65836$ and $n_e = 1.48641$.

(g) A circularly polarized electromagnetic wave is propagating in the z-direction in free space and is described by the following equation

$$\overline{E} = 5\cos(\omega t - kz)\hat{x} + 5\sin(\omega t - kz)\hat{y}\ \text{Vm}^{-1}$$

The wavelength is 6×10^{-7}m. Find the corresponding magnetic field and the average of the Poynting vector.

(a) State and establish the Poynting theorem for conservation of energy for electromagnetic fields. Explain the physical significance of each term in the equation. (6)

(b) Using electromagnetic scalar and vector potentials, show that the four Maxwell equations can be written as two coupled second order differential equations. (6)

(c) What is the ratio of amplitudes of conduction current density and displacement current densities density if applied field is $\overline{E} = \overline{E}_0 e^{-t/\tau}$, where τ is real. (3)

(a) Discuss the propagation of high frequency electromagnetic wave in plasma. Show that the critical frequency for the propagation of electromagnetic wave in plasma is given by $f_c = 9\sqrt{n_0}$, where n_0 is the electron density. (8)

(b) A material has $\sigma = 6.0 \times 10^{-2}\ \Omega^{-1}/m$, $\mu = \mu_0$ and $\varepsilon_r = 7.0$. A plane wave of frequency 10^9 Hz with amplitude 200V/m is propagating along positive z direction. Find (a) E_x at (x = 0 cm, y= 0 cm, z = 3 cm, t = 0.16 ns) (b) H_y at (x = 0 cm, y = 0 cm, z = 3 cm, t = 0.16 ns). (7)

4. (a) Derive the Fresnel's equation for reflection and transmission of a plane electromagnetic wave at the boundary separating between two dielectric media when electric field vector is perpendicular to the plane of incidence. (9)

(b) An electromagnetic wave propagating in a dielectric medium with $\varepsilon = 16\varepsilon_0$ along the z direction. It strikes another dielectric medium with $\varepsilon = 4\varepsilon_0$ at z = 0. If the incoming wave has a maximum value of 0.2 V/m at the interface, and its angular frequency is 300 M rad/s, determine the power densities of the incident, reflected, and transmitted waves. (6)

5. (a) Derive Fresnel's formula for the propagation of light in Anisotropic crystals. Also explain how this leads to the phenomenon of double refraction. (9)

(b) Discuss the propagation of light in uniaxial crystals. Explain the difference between a positive uniaxial crystal and a negative uniaxial crystal. Also give one example of each. (6)

6. (a) Explain the construction and working of a Babinet Compensator. How is it used to analyze the elliptically polarized light? (9)

(b) A right-handed circularly polarized plane wave with electric field magnitude of 3 mV/m is travelling in the +Y direction in a dielectric medium with $\varepsilon = 4\varepsilon_0$ and $\mu = \mu_0 = 0$. If the frequency is 100MHz, obtain expressions for $\bar{E}(y,t)$ and $\bar{H}(y,t)$. (6)

7. (a) Starting with Maxwell's equations, derive the wave equations for a symmetric planar dielectric waveguide with refractive index profile as :

$n = n_1 \quad -d/2 < x < d/2$

$n = n_2 \quad -d/2 > x > d/2$

Using the boundary conditions, obtain the eigenvalue equation for symmetric TE modes. (9)

(b) Consider a symmetric planar waveguide with the following parameters.

$$n_1 = 1.5 \,;\, n_2 = 1.48 \,;\, d = 3.912 \ \mu m$$

How many TE modes exist for $\lambda_0 = 1 \ \mu m$? Determine the corresponding propagation constants. (6)

Value of Constants:

$\varepsilon_0 = 8.85\times10^{-12}$ farad/m $= \frac{10^{-9}}{36\pi}$ farad/m

$\mu_0 = 4\pi\times10^{-7}$ henry/m

$c = 3 \times 10^8$ m/s

$\eta_0 = 120\ \pi\Omega = 377\ \Omega$

Mass of electron= 9.11×10^{-31} kg

[This question paper contains 4 printed pages.]

Your Roll No...............

Sr. No. of Question Paper : 1622 **A**

Unique Paper Code : 42224412

Name of the Paper : Waves and Optics

Name of the Course : **B.Sc. Prog. – CBCS–Core**

Semester : VI

Duration : 3.5 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **five** questions in all.
3. Question no. 1 is compulsory.

1. Attempt any **FIVE** parts from the following :

(a) The time period of tuning fork is $\frac{1}{256}$ and it produces 4 beats/second, when sounded with another fork. Calculate the frequency of the second fork.

(b) If the phase velocity is given by, $v_p = \left(\frac{2\pi S}{\rho\lambda}\right)^{1/2}$

(Here, S and ρ are constant), then derive the relation between group velocity and phase velocity.

(c) Give three differences between travelling waves and stationary waves.

(d) Explain why the reverberation time is larger for an empty hall than for a crowded hall.

(e) What do you understand by wave front? Name one experiment each, which is based on division of wave front.

(f) Why do thin films appear colored in white light?

(g) How many orders will be visible if the wavelength of incident radiation is 4800 Å and the number of lines on a diffraction grating is 2500 per inch.

(5×3=15)

2. (a) What are Lissajous Figures? For the cases mentioned below, give the graphical as well as analytical representation of the Lissajous Figures

(with direction) for the motion of a particle which is subjected to two perpendicular simple harmonic motions given by,

$$x = 3\cos(\omega t)$$

$$y = 2\cos(2\omega t + \alpha), \text{ where } \alpha = 0$$

(b) Prove that the principle of superposition holds only for linear homogenous differential equation.

(10+5=15)

3. (a) Explain the formation of standing waves on a stretched string.

(b) For a stationary wave, the displacement (in cm) is given by,

$$y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$$

What is the distance between a node and the next anti-node? (10+5=15)

4. (a) What do you mean by Fresnel's half period zones? What are the radii of zones of a zone plate?

(b) Explain with the help of a diagram, the intensity distribution due to diffraction at a straight edge. (7+8=15)

5. (a) State the principle of reversibility of light. Determine the Stokes' relation for reflection of light from an optically denser medium.

(b) Discuss the theory of interference due to two slits and find the expression for fringe width.

(5+10=15)

6. (a) Derive the expression for intensity distribution in case of Fraunhofer diffraction due to single slit.

(b) Show that the relative intensities of the successive maxim are in the ratio of,

$$1:\left(\frac{2}{3\pi}\right)^2:\left(\frac{2}{5\pi}\right)^2\cdots$$ (10+5=15)

7. (a) Show that electromagnetic waves are transverse in nature.

(b) Explain any two methods of polarizing an un-polarized beam of light. (9+6=15)