C – 102.

[This question paper contains 6 printed pages.]

May 2013

877 *Your Roll No. .....*

B.Sc. (Hons.) / III C

PHYSICS – Paper XVIII

(Electromagnetic Theory)

Time : 3 Hours *Maximum Marks : 38*

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

Attempt **all** *questions.*
The use of non-programmable calculators is permitted.

1. Attempt any **five** parts :

(a) For a plane electromagnetic wave propagating through free space show that the ratio of the time average Poynting vector to the time average energy density is equal to the velocity of the wave i.e. 'c'.

(b) Using Maxwell's equations show that the free space impedance is equal to 377 Ω.

(c) The electric field of a plane electromagnetic wave

P.T.O.

propagating in a non-magnetic medium with $\epsilon_r = 9$ is given by :

$$\vec{E} = 3\cos\left(\pi \times 10^7 t + kx\right)\hat{j} - 2\cos\left(\pi \times 10^7 t + kx\right)\hat{k}\ V/m$$

Determine :

(i) Direction of wave propagation

(ii) Velocity of the wave

(iii) State of polarization of the wave

(iv) Propagation constant k

(d) Calculate the skin depth for silver at 50 GHz, given that $\sigma = 6 \times 10^7$ mho/m, $\mu = 3 \times 10^{-7}$ H/m.

(e) Give reasons as to why graded index optical fibre is better than a step index fibre.

(f) Calculate the Numerical Aperture (NA) and acceptance angle for an optical fibre given that refractive indices of the core and the cladding are 1.45 and 1.40 respectively.

(g) Write dielectric tensor for (a) uniaxial and (b) biaxial crystals.

(h) For an air filled square wave guide of side 2 cm, find the cut-off frequency for TM_{11} mode. (5×2)

a) Starting from Maxwell's equations in homogeneous, isotropic dielectric non-magnetic medium derive the wave equations for electric and magnetic field vectors. What is the velocity of the wave through this medium if dielectric constant is 9? (4)

b) Assuming plane wave solutions show that electromagnetic waves are transverse in nature. Write $\vec{H}$ in terms of $\vec{E}$. (3)

OR

a) What are gauge transformations? What is Lorentz Gauge and what are its advantages? (4)

b) Why does Ampere's circuital law need modification in electrodynamics? What is the Maxwell's correction to modify this law? (3)

a) Discuss the propagation of electromagnetic waves through dilute plasma. Obtain expressions for electrical conductivity, frequency and refractive index of plasma. (4)

b) Calculate plasma frequency for a plasma containing 10^{16} electrons/m^3. For such plasma, what is the

P.T.O.

penetration depth of the wave having frequency of 600 MHz. (3)

OR

(a) Starting from Maxwell's equations for a conducting medium, obtain expressions for skin depth, refractive index and phase difference between the electric and magnetic field vectors for a good conductor. (4)

(b) For an electromagnetic wave propagating through a conducting medium

$$\vec{E} = 16\, e^{-0.05x} \cos(2 \times 10^8\, t - 2\, x)\ \hat{k}\ V/m\ .$$

Determine (i) direction of wave propagation and (ii) skin depth. (3)

4. (a) A plane electromagnetic wave with polarization parallel to the plane of incidence is incident at an angle θ on the interface between two dielectrics. Derive Fresnel's relations for reflection and transmission of the wave. (4)

(b) Define Brewster's angle. Why is it called polarizing angle ? (3)

OR

(a) Derive Fresnel's equation for phase velocities for plane wave propagation in an anisotropic medium. How does this law lead to phenomenon of double refraction ? (4)

(b) Show that in an anisotropic medium energy is not propagated along the direction of wave propagation. (3)

(a) What is a cavity resonator ? Derive expressions for electric and magnetic fields for the TE mode in a rectangular cavity bounded by perfectly conducting walls. (4)

(b) Find what TE modes will propagate in a rectangular cavity resonator of dimensions 2 cm × 2 cm × 3 cm operating at 2 GHz frequency. (3)

OR

(a) Derive expressions for electric and magnetic fields for TE mode of an electromagnetic wave propagating in a rectangular waveguide. Obtain expression for cut off frequency. (4)

(b) What TE modes will propagate in a rectangular waveguide of dimensions 2.28 cm × 1.01 cm at an operating frequency of 1.70×10^{10} Hz ? (3)

This question paper contains 3 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 6228

Unique Paper Code : 2221502

F-5

Name of the Paper : Electromagnetic Theory

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

Semester : V

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.

All questions carry equal marks.

Question No. 1 is compulsory.

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

(a) Calculate the displacement current through a parallel plate air filled capacitor having plates of area 10 cm^2 separated by a distance of 2 mm and connected to 360 V, 1 MHz source.

(b) Explain the significance of loss tangent when electromagnetic wave travels in different media.

(c) Calculate the skin depth for a conductor at 1 GHz given that $\sigma = 3.8 \times 10^7$ mho/m, $\mu = 2.57 \times 10^{-7}$ H/m.

P.T.O.

(*d*) What is meant by Attenuation Constant ? Write the relation between neper and decibel.

(*e*) Discuss the phenomena of total internal reflection on the basis of electromagnetic theory.

(*f*) How would you optically distinguish between circularly polarized light and unpolarized light ?

(*g*) On the basis of scattering of light explain the colour of sky.

2. (*a*) Define scalar and vector potentials. Show that the Maxwell's equations can be expressed as two coupled second order deferential equations in terms of scalar and vector potentials. What is Lorentz condition ? How do the above equations get simplified using Lorentz condition ?

(*b*) Show that for electromagnetic fields the average energy density is given by $U = \frac{1}{2}(\varepsilon_0 E^2 + \mu_0 H^2)$. 12,3

3. (*a*) State and prove Poynting theorem. Explain the physical significance of each term in the theorem.

(*b*) Show that the expression for time average Poynting vector for time varying fields is given by $\langle S \rangle = \frac{1}{2}\mathrm{Re}(E \times H^*)$. Where H^* is the complex conjugate of vector H. 8,7

4. (*a*) What is plasma ? Obtain an expression for plasma oscillation frequency.

(*b*) Show that the critical frequency for propagation of electromagnetic waves in plasma is given by $9\sqrt{N}$. Where N is the electron density in plasma.

(*c*) Obtain an expression for refractive index of the ionosphere. 7,4,4

6228

(a) Derive Fresnel's relations for reflection and transmission of plane electromagnetic waves at an interface between two dielectric media when an electric vector of the incident wave is parallel to the plane of incidence.

(b) Find the expression for the Brewster's angle at which the reflected wave is completely extinguished. Why this angle is called polarizing angle ? 9,6

(a) Derive an expression for power radiated by an oscillating electric dipole.

(b) What is retarded potential ? Explain the significance of retarded potential. 10,5

(a) Derive the transformation laws for the electric and magnetic fields in the case of parallel plate capacitor.

(b) Do static electromagnetic fields possess linear and angular momentum ? Give reasons. 10,5

This question paper contains 4 printed pages]

Roll No.

S.No. of Question Paper : 955

Unique Paper Code : 222601

Name of the Paper : Electromagnetic Theory [PHSDT-601]

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

Semester : VI

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.

All questions carry equal marks.

Question number 1 is compulsory.

The use of non-programmable calculator is permitted.

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

(a) *The relative permittivity of distilled water is 81. Calculate the refractive index and velocity of light in it.*

(b) *The conduction current density in a dielectric is given by* $\vec{J} = 0.02 \sin(10^9 t)$ *Amp/m*^{2}. *Find the displacement current density if* $\sigma = 10^{-2}$ *mho/m and* $\varepsilon_r = 6.5$.

P.T.O.

(c) A plane polarized light is incident perpendicularly on a Quarter Wave Plate. Find its thickness which introduces a phase difference of 60° between *e*- and *o*-rays. (Given $\mu_e = 1.553$, $\mu_0 = 1.544$, $\lambda = 5400 \times 10^{-10}$ m.) 3

(d) Derive Maxwell's divergence equations from Maxwell's curl equations.

(e) In a homogeneous region, where $\mu_r = 1$ and $\varepsilon_r = 50$,

$$\vec{E} = 20\pi e^{j(\omega t - \beta z)}\hat{a}_x \text{ Volts/m}, \quad \vec{H} = H_0 e^{j(\omega t - \beta z)}\hat{a}_y \text{ Tesla.}$$

Here $\hat{a}_x$, $\hat{a}_y$ are unit vectors in the x and y directions. Find ω and H_0 if the wavelength is 1.78 m.

(f) Starting from the boundary condition satisfied by the electromagnetic fields at an interface between two dielectric media, deduce the Snell's law.

(g) For an optical fibre with refractive index of the core 1.47 and of its cladding 1.46, calculate the pulse dispersion per km.

2. (a) Define scalar and vector potentials. Show that the Maxwell's equations can be expressed as two coupled second order differential equations in terms of scalar and vector potentials. How do the above equations get simplified using Lorentz condition ? Discuss the significance of Gauge Transformations.

(b) Show that the time averaged Poynting vector for electromagnetic time-varying fields is given by :

$$\left\langle \vec{S} \right\rangle = \frac{1}{2} Re\left(\vec{E} \times \vec{H}^* \right)$$

where $\vec{H}^*$ is the complex conjugate of the vector $\vec{H}$. 11,4

3. (*a*) A plane electromagnetic wave propagating in a conducting medium is characterized by the parameters ε, μ and σ. Show that propagation constant is complex in this case and is given by :

$$\beta = \omega\sqrt{\varepsilon\mu\left(1 + i\sigma/(\omega\varepsilon)\right)}.$$

Hence discuss the propagation of electromagnetic waves in a good and a bad conductor. Here ε, μ and σ are the permittivity, permiability and conductivity of the medium.

(*b*) Calculate the skin depth for a conductor at 1 GHz, given that $\sigma = 3.8 \times 10^7$ mho/m, $\mu = 2.57 \times 10^{-7}$ H/m.

12,3

4. (*a*) Derive Fresnel's relations for reflection and refraction of plane electromagnetic waves at an interface between two dielectric media when the electric field vector of the incident wave is parallel to the plane of incidence.

(*b*) Discuss the phenomenon of total internal reflection on the basis of electromagnetic theory. Determine the change of phase in the reflected ray when it suffers a total internal reflection.

7,8

5. (*a*) Show that in an electrically anisotropic dielectric medium the permittivity tensor is symmetric.

(*b*) Show that in an anisotropic dielectric medium the electric field, the magnetic field and the Poynting vector on one hand and the electric displacement, the magnetic field and the wave normal on the other hand form orthogonal triplets.

(*c*) On putting a polarimeter tube 25 cm long containing a sugar solution of unknown strength, the plane of polarization is rotated through 10 degrees. Given the specific rotation of sugar is 60° per decimetre/(gm/cc), find the concentration of the sugar solution.

4,8,3

P.T.O.

6. (*a*) Derive Fresnel's laws of phase velocities in an electrically anisotropic medium. Show that it leads to the phenomenon of double refraction.

(*b*) Describe the construction of Babinet Compensator and explain how it is used to determine the direction of major and minor axes. How is this compensator used to determine the ratio of these axes for an elliptically polarized light ? 7,8

7. (*a*) Starting with the Maxwell's equations obtain the wave equations for the propagation of an electromagnetic wave in a symmetric planar wave guide. Derive the appropriate eigenvalue equations and show that there exists only one Symmetric TE mode for $0 < V < \pi$, 'V' being the dimensionless wave guide parameter.

(*b*) Obtain an expression for the Numerical Aperture of an optical fibre in terms of the refractive indices of the core and cladding. 11,4

Value of constants :

$\mu_0 = 4\pi \times 10^{-7}$ H/m

$\varepsilon_0 = 9.0 \times 10^{-12}$ F/m

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

$m_e = 9.11 \times 10^{-31}$ kg

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

[This question paper contains 3 printed pages.] 11 MAY 2016

Sr. No. of Question Paper : 5788 **F** **Your Roll No.....**

Unique Paper Code : 222601

Name of the Paper : Electromagnetic Theory [PHHT - 619]

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

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 number **1** is compulsory.
5. The use of non-programmable calculator is permitted.

1. Attempt any **Five** of the following : 5 x 3 = 15

(a) Compute the velocity and wavelength of light of frequency 0.5×10^{15} Hz when travelling through glass having refractive index 1.5.

(b) In free space the electric field of the electromagnetic wave is given by

$$\vec{E}(z,t) = 1.0\,\hat{\imath}\sin(\omega t - \beta z)\,(V/m)\,.$$

Find the average power crossing a circular disk of radius 15.5 m in z = constant plane.

(c) Calculate the thickness of a calcite plate that would convert plane polarized light to circularly polarized light. Given: $\lambda = 5890\ A^0$, $\eta_0 = 1.568$, $\eta_e = 1.486$. (where η_0 & η_e are the refractive indices of the medium for ordinary and extra-ordinary waves ly)

(d) A tube of sugar solution 20 cm long is placed between crossed Nicol Prisms and is illuminated with light of wavelength $6000\ A^0$. If the optical rotation produced is 13^0 and the specific rotation is 65^0, determine the concentration of the solution.

P.T.O.

(e) A radio wave of frequency 20 MHz is incident on the ionosphere at an angle of 60^0 and is completely reflected. What is the Plasma Frequency of the reflecting layer.

(f) Starting from the boundary conditions satisfied by the electromagnetic fields at an interface between two dielectric media, deduce the laws of reflection of light.

(g) Draw the wavefronts of an electromagnetic wave inside a positive and a negative uniaxial crystal. Also indicate the optic axis in the diagram.

2. a) State and prove Poynting's theorem. Explain the physical significance of each of the terms.

b) The expression for the electric field vector of a uniform plane wave propagating in the negative x direction in a medium is given by

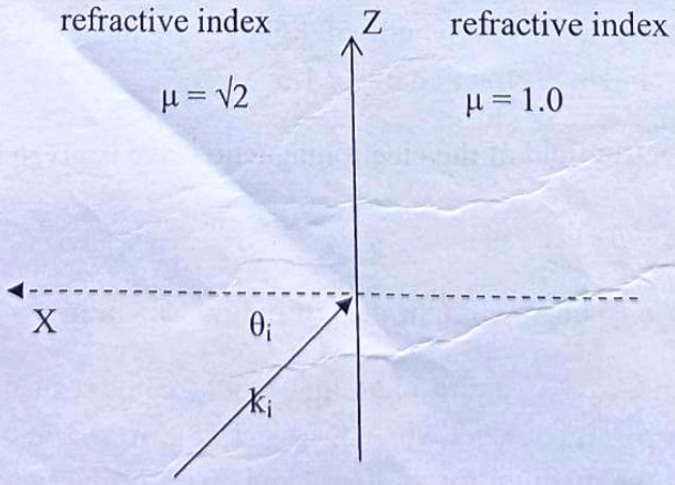
$$\vec{E} = (2 \times 10^{-3}\hat{j}) \exp[\, i\, 2\pi\, (9\times 10^{15} t + 6 \times 10^{7}\, x\,)] \text{ Volts/m}$$

What is i) phase velocity of the wave ii) wavelength of the wave iii) refractive index of the medium and iv) The direction of the magnetic field.

9,6

3. a) Derive the Fresnel's relations for reflection and transmission of a plane electromagnetic wave at a boundary separating two dielectric media when the incident Electric vector is perpendicular to the plane of incidence. Plot the reflection and transmission coefficients as a function of the angle of incidence when the wave is going from air into the medium of refractive index 1.5.

b)



In the diagram if the electric vector is given by

$\vec{E} = (10\hat{j}) \exp[i\, (10^8\, t - 0.5\, x + (\sqrt{3}/2)\, z)]$ then show that the wave will undergo total internal reflection at the $x = 0$.

10,5

4. a) What is plasma? Obtain expressions for electrical conductivity and frequency of a collisionless plasma.

b) Discuss the propagation of electromagnetic waves in an ionized medium and obtain an expression for refractive index of the ionosphere.

9,6

5. a) Derive Fresnel's Laws for the phase velocities in an electrically anisotropic medium and prove that in this medium the displacement vectors $\vec{D}_1$, $\vec{D}_2$ associated with the two modes of propagations are normal to each other.

b) Discuss the principle and working of the Laurent's Half-shade polarimeter.

9,6

6. a) Starting from the wave equation for an inhomogeneous dielectric medium, find the TE modes of a symmetric step index planar waveguide. Explain pulse dispersion in a step index optical fibre.

b) An optical fibre has a core of refractive index 1.48 and a cladding of refractive index 1.46. Calculate the acceptance angle and the numerical aperture of the fibre.

10,5

7. Explain the construction and working of a Nicol Prism. Give a brief account of the production of circularly and elliptically polarized light from plane polarized light.

b) How would you distinguish between i) elliptically polarized light and a mixture of plane polarized and unpolarized light ii) unpolarized and circularly polarized light.

9,6

Value of constants:

$\mu_0 = 4\pi \times 10^{-7}$ H/m

$\varepsilon_0 = 9.0 \times 10^{-12}$ F/m

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

$m_e = 9.11 \times 10^{-31}$ kg

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

(300)

This question paper contains 6 printed pages.]

Your Roll No.....

r. No. of Question Paper : 122 G

nique Paper Code : 222463

ame of the Paper : Physics – IV : Electricity, Magnetism and Electromagnetic Theory (PHPT-404)

ame of the Course : **B.Sc. (Physical Science)**

emester : IV

uration : 3 Hours Maximum Marks : 75

nstructions for Candidates

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

Attempt **Five** questions in all.

Question No. **1** is compulsory. Attempt **four** questions from the rest of the paper.

Use of non-programmable scientific calculator is allowed.

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

(a) What is Lenz's law ?

P.T.O.

(b) When does magnetic forces do no work on a movi point charge ?

(c) How Maxwell modified Ampere's Law ?

(d) What is the difference between circular and elliptic polarisation ?

(e) Why do the electric field lines never cross ? Explain

(f) For the electrostatic potential $V = \frac{1}{r} + 2$ determi whether $\vec{E}$ is rotational or irrotational.

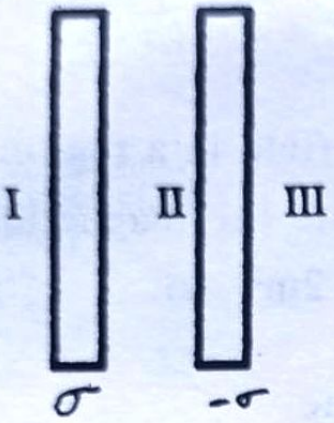
(g) What is the critical damping resistance in a ballis Galvanometer ?

(h) A magnetic vector potential $\vec{A}$ is given by $3x^3\,\hat{i} + yz$ Obtain $\vec{B}$, the magnetic field at the point (1,3,5,).

2. (a) State and prove Gauss's theorem of electrostatics fo spherical surface.

(b) Find the electric field inside a sphere which carries charge density proportional to the distance from the ori given by $\rho = k\,r$, for some constant k.

(c) Two infinite parallel planes carry equal but opposite uniform charge densities $\pm \sigma$. Find the electric field in the three regions shown. (4)



(a) A thin spherical shell of radius R carries a uniform charge density. Find the expression of electric field at a point lying inside and outside this spherical shell. Use these values to calculate the electric potential at an arbitrary point inside and outside the shell. (7+3)

(b) Find the electric-energy associated with an electric field for a uniformly charged solid sphere of total charge Q and radius R. (5)

(a) State the Biot Savart Law. Using the Biot Savart Law find the magnetic field at a distance a due to long straight wire carrying a current I along the positive y-axis. (7)

P.T.O.

(b) A circular loop of radius r = 2 cm carries a stea current, I = 16 A in anti-clockwise direction. W magnetic field will be observed at the center of t loop.

(c) The magnetic field in a region is given by $\vec{B} = 3\hat{\imath} +$ Tesla. Calculate the magnetic flux across the surfa each of area $2m^2$ in

(i) x – y plane

(ii) y – z plane

(iii) z – x plane.

5. (a) List the various torques that act on the coil of a mov coil galvanometer. Using them write the equation motion of the coil. Under what conditions does it sh 'ballistic' behaviour. (2+2+3

(b) Using Ampere's Circuital Law find the magnetic fi (i) inside and (ii) outside a very long solenoid, consist of n closely wound turns per unit length on a cylinde radius R and carrying a current i.

(c) The first and the eleventh throw of a ballis galvanometer are 20 cm and 16 cm respective Calculate the value of the logarithmic decrement.

22

(a) Define self inductance. Does it have dependence on the geometry of the circuit ? Find the self inductance of a solenoid of radius R and n number of turns per unit length. (7)

(b) Prove that curl $\vec{E} = -\frac{\overrightarrow{\partial B}}{\partial t}$. (5)

(c) A 50 mH coil carries a current of 2A. Find the energy stored in the magnetic field. (3)

(a) Obtain the wave equation for electric and magnetic field vectors in free space and show that electromagnetic waves are transverse in nature. (7)

(b) Write Maxwell's equations for electromagnetic field in integral form and explain their physical meaning. (8)

(a) Derive the boundary conditions for the $\vec{D}$, $\vec{B}$, $\vec{E}$ and $\vec{H}$ fields using Maxwell's equations at the interface between two dielectrics. (8)

(b) Deduce Brewster's law on the basis of Fresnel's equations and explain the concept of polarisation by reflection. (7)

P.T.O.

[This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 6685

10 MAY 2018

Unique Paper Code : 32221601 HC

Name of the Paper : Electromagnetic Theory

Name of the Course : B.Sc. (H) Physics-CBCS

Semester : VI

Duration : 3 Hours Maximum Marks : 75

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

Attempt total **5** questions.

All questions carry equal marks.

Question No. **1** is compulsory

Scientific calculator is allowed.

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

(*a*) Write the boundary conditions satisfied by the electric and magnetic field vectors at the boundary of the two dielectrics.

(*b*) Explain the terms loss tangent and intrinsic impedance.

P.T.O.

(c) Explain why in high frequency circuits current flows only on the surface of conductors.

(d) What do you understand by homogenous and isotropic medium ?

(e) A parallel polarized wave propagates from air into dielectric at Brewster angle of 75°. Find relative permittivity.

(f) For an optical fibre with refractive index of the core 1.47 and of its cladding 1.46. Calculate the pulse dispersion per kilometre.

(g) Given $\vec{E} = E_0 \sin(\omega t - \beta z)\hat{a}_y$ V/m in free space. Find H.

(h) Write constitutive relations in electrodynamics.

2. (a) State and prove Poynting's theorem. 2,5

(b) What are Lorentz and Coulomb gauges ? Show that Lorentz transformation remains invariant if gauge function ϕ satisfies :

$$\nabla^2\phi - \mu_0 \epsilon_0 \frac{\partial^2\phi}{\partial t^2} = 0 .$$ 2,6

3. (*a*) Derive em wave equation satisfied by E field using Maxwell's equation in an isotropic, linear and homogenous dielectric material (no free charges or free currents).

(*b*) Show that the em waves are transverve in nature.

(*c*) Calculate the characteristic impedance of the medium.

(*d*) Show that the energy is equally shared between the electric and magnetic fields in free space. 4,4,3,4

4. (*a*) Derive Fresnel's formula for the case of propagation of em waves in an anisotropic medium. 9

(*b*) Show that critical frequency for the propagation of em waves in plasma is $f_c = 9\sqrt{n_0}$, where n_0 is number of electrons/m^3. 6

5. (*a*) Derive Fresnel's relations for reflection and refraction of plane em waves at an interface between two dielectric media when electric vector of the incident wave is parallel to the plane of incidence. Also find the expressions for R and T. 8,4

(*b*) Find the expression for the Brewster's angle at which the reflected wave is completely extinguished. 3

P.T.O.

6685

6. (*a*) State Biot's laws for rotatory polarization.

(*b*) Using the Fresnel's theory of optical rotation, obtain the formula for the angle of rotation of plane of vibration.

(*c*) Discuss the construction and working of Laurent's half shade device. 4,6,5

7. (*a*) Determine the change of phase in the reflected ray when it suffers a total internal reflection for the case when E is parallel to the plane of incidence. 5

(*b*) What is step index optical fibre ? Derive relation between the numerical aperture and the angle of acceptance. 6

(*c*) An optical fibre has a core of refractive index 1.48 and cladding of refractive index 1.46, calculate the acceptance angle and the numerical aperture of the fibre. 4

8. (*a*) For the case of propagation of em waves in conducting medium, derive an expression for complex intrinsic impedance and the ratio u_e/u_m, where u_e is electric energy density and u_m is magnetic energy density. 8,4

(*b*) What is the significance of the equation : 3

$$\vec{\nabla} . \vec{B} = 0 .$$

This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2267** **IC**

Unique Paper Code : 32221601

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

Name of the Paper : Electromagnetic Theory

Semester : VI

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

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

(b) Attempt any **five** questions.

(c) Question **No.1** is compulsory.

(d) **All** questions carry equal marks.

(e) Scientific calculator is allowed.

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

(a) In a lossy dielectric of relative permittivity 12 the displacement current is 25 times greater than the conduction current at 100MHz. Calculate the conductivity of dielectric.

(b) Mention any two differences between half and quarter wave plates.

P.T.O.

(c) Calculate the minimum thickness of calcite plate which would convert plane polarized light into circularly polarized light. Given $n_0 = 1.568$, $n_e = 1.468$ and $\lambda = 5890$ Å^0.

(d) In an optical fibre the core refractive index is 1.5 and cladding refractive index is 1.47. Determine critical angle at core clad interface and numerical aperture.

(e) Using Faraday's law, find the intrinsic impedance of free space.

(f) In what respect does an electrically anisotropic medium differ from an isotropic medium. Mention at least **two** points.

(g) Show that in plasma electron current lags the electric field by $\pi/2$.

(h) Can perfectly static fields possess momentum and angular momentum ?

2. (a) Show how Maxwell modified Ampere's law to make it consistent with the equation of continuity. 3

(b) Show that the Maxwell's equations can be expressed as two coupled second order differential equations in term of scalar and vector potentials. How does these two equations get modified after Lorentz gauge ? 8,4

3. (a) Derive wave equation for E of an em wave in a conducting medium. 4

(b) Show that the amplitude of electric field of em wave attenuates as it propagates in a conducting medium. 8

(c) Find the expression for skin depth. 3

4. (a) Show that in an electrically anisotropic dielectric medium the permittivity tensor is symmetric. 6

(b) Show that in anisotropic dielectric medium the electric field, magnetic field and the Poynting's vector on one hand and the electric displacement, magnetic field and the wave normal on the other hand form orthogonal triplets. 9

5. (a) Derive Fresnel's relations for reflection and refraction of plane em wave at an interface between dielectric media when the electric field vector of the incident wave is normal to the plane of incidence. Also find the expressions for R and T. 8

(b) If a parallel polarized em wave is incident from air onto distilled water with $\mu_r = 1$ and $\epsilon_r = 81$, find the Brewster angle θ_B. 3

6. (a) How would you optically distinguish between circularly polarized light and plane polarized light ? 4

(b) Explain the construction and working of a Nicol prism. 8

(c) What is graded index optical fibre ? Give its one advantage over step index fibre in optical communication. 3

P.T.O.

7. (a) Derive wave equation for E of em wave in a symmetric planar dielectric wave guide whose refractive index [$n^2 = n^2(x)$] profile is :

$n = n_1$, $-d/2 < x < d/2$

$= n_2$, $x < -d/2, x > d/2$.

Using the boundary conditions, obtain the eigenvalue equation for symmetric TE modes. 8,4

(b) Show that there exists only one symmetric TE mode for $0 < V < \pi$, where V denotes the dimensionless wave guide parameter. 3

8. (a) A long straight conducting wire of radius b and conductivity σ is kept along z-axis and it carries a direct current I in +z-direction. Calculate the Poynting's vector on the surface of this wire. 5

(b) Calculate the reflection coefficient at normal incidence for a plane em wave incident on silver from vacuum ($f = 10^{15}$ Hz, $\sigma = 6 \times 10^7$ mho/m). 5

(c) Find the maximum usable frequency for em waves to be transmitted through a distance of 1.5×10^6m by reflection from the ionosphere at a height of 300 km. (number of electrons per unit volume in ionosphere is $6 \times 10^{11} m^{-3}$) 5