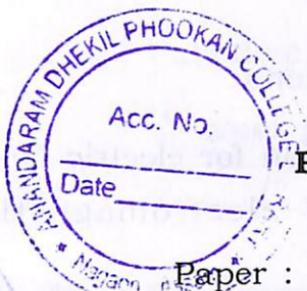


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1 (Sem-3/FYUGP) PHY42MJ

2025



**PHYSICS**

(Major)

Paper : PHY4300204 MJ

**(Electromagnetic Theory)**

Full Marks : 45

Time : 2 hours

***The figures in the margin indicate full marks for the questions.***

1. (i) Write the expression for electric field vector, where the magnetic field is polarized along y-direction. 1
- (ii) Express the Poynting's theorem in differential form. 1
- (iii) Define the term birefringence. 1
- (iv) What is the function of the Fresnel rhomb? 1

(v) Write Maxwell's equations for harmonically varying fields. 1

2. Answer **any five** questions:

(i) Derive the expression for electric field in terms of the electromagnetic potentials.

(ii) At what frequencies may sea water be considered as a good conductor? Given  $\sigma = 4\Omega^{-1}m^{-1}$  and  $\sigma \geq 0.01 \omega\epsilon$ . 2

(iii) Under what situation do the o-ray and e-ray move with the same velocity? 2

(iv) Why is calcite said to be a negative crystal? 2

(v) For an electric field expressed as  $E(z,t) = E_0 \sin(kz - \omega t)\hat{x}$ , draw the plane of polarization of E-field. 2

(vi) Explain the physical basis of optical rotation. 2

(vii) Does an unpolarized light be polarized by reflection? Justify your answer. 2

(viii) Calculate the minimum thickness of a  $\frac{\lambda}{4}$  plate made of calcite for Na-yellow light  $\lambda = 589nm$ . 2

(ix) Write two significance of Displacement current. 2

(x) Define specific rotation for an optically active solution. What happens if a plane-polarized white light is allowed to pass through an optically active substance? 1+1=2

3. Answer **any four** questions

(i) Show that in free space, the electric and magnetic fields vectors are perpendicular to the propagation vector. 5

(ii) Draw a neat diagram of a section of Nicol prism parallel to the principal section. What should be the length-to-breadth ratio of a Nicol prism?

$$4+1=5$$

(iii) Write the characteristics of a lossless dielectric medium. For an  $em$  wave propagating in such a medium, find

- (i) the phase constant,
- (ii) velocity of the  $em$  wave, and
- (iii) the Phase difference.

$$2+3=5$$

(iv) Consider a plane  $em$  wave where the amplitudes of the electric field components are  $E_{ox}$  and  $E_{oy}$ . Explain the formation of linear and circularly polarized light in relation to the orientation of  $E_{ox}$  and  $E_{oy}$ .

$$2\frac{1}{2}+2\frac{1}{2}=5$$

(v) List one difference between transmission lines and waveguides. Define the terms TE, TM and TEM associated with the propagation of  $em$  waves through a waveguide. Why is the TEM mode of vibration not allowed in a rectangular waveguide? 5

(vi) A parallel beam of plan polarized light of wavelength  $5896 \text{ \AA}$  in air is incident on a quartz crystal. Find the wavelength of  $o$ -ray and  $e$ -ray in the crystal, given that  $\mu_o = 1.5418$ ,  $\mu_e = 1.5508$  5

(vii) For sea water, calculate skin depth if conductivity  $\sigma = 4.3 \Omega^{-1}m^{-1}$  and frequency is  $100 \text{ Hz}$ . Hence, show that radio communication becomes difficult with submarines at large depths. Show that metals are opaque to visible light.  $2\frac{1}{2}+2\frac{1}{2}=5$

(viii) The electric field component of a plane monochromatic  $em$  wave propagating through free space along the  $z$ -direction is given by  $E = E_o \sin(kz - \omega t) \hat{x}$ . Calculate the corresponding  $H$  field.  $1+3+1=5$

4. Answer **any one** question :

(i) Show that for an *em* wave propagating in a conducting medium the propagation vector is a complex parameter. Show how this leads to the attenuation of the *em* wave. Define skin depth.

6+3+1=10

(ii) Describe, with proper diagram, the construction and working of Laurent's half-shade polarimeter.

6+4=10

(iii) If the electric field vector is perpendicular to the plane of incidence of an *em* wave propagating from one medium to another medium then show with a diagram the incident, reflected and transmitted waves with properly denoting the direction of the electric field, magnetic field and the propagation vector. Derive the expression for amplitude reflection coefficient.

3+7=10

(iv) For a uniaxial crystal, derive the expression for the refractive index of *e*-rays in any direction in terms of the refractive index of *o*-ray and principal refractive index of *e*-ray. Describe with diagram the polarization by double refraction.

6+4=10

