Total number of printed pages–7

1 (Sem–3/FYUGP) PHY41 MJ

2025

PHYSICS

(Major)

Paper : PHY4300104 MJ

(Waves and Optics)

Full Marks : 45

Time : 2 hours

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

1. Answer the following questions : 1×5=5

   (a) "There is loss of energy in interference of light." It –

   (A) is true

   (B) is false

   (C) may be true

   (D) none of the above

(b) In which of the following phenomena the division of wave front phenomenon is applied ?

(A) Fresnel's biprism

(B) Newton's ring

(C) Michelson interferometer

(D) Thin film

(c) The dispersive power of a grating in diffraction is

(A) Directly proportional to the order of the spectrum

(B) Inversely proportional to the order of the spectrum

(C) Directly proportional to the square root of the spectrum

(D) Inversely proportional to the square root of the spectrum

(d) Principal of superposition is applicable only for oscillations

(A) Who govern exponential equation of motion

(B) Complex equation of motion

(C) Linear equation of motion

(D) None of the above

(e) The velocity of sound in a gas is

(A) Proportional to its density

(B) Inversely proportional to its density

(C) Inversely proportional to the square of root of its density

(D) Inversely proportional to the square of its density

2. Answer the following equations : ***(Any five)***

$2 \times 5 = 10$

(A) What is the principal of superposition of harmonic oscillations ?

(B) Compare between progressive and stationary waves.

(C) Define constructive and destructive interference.

(D) State the factors that affect the velocity of sound in a gas.

(E) Write the laws of length and tension of transverse vibration in a stressed string.

(F) Two strings are joined together and stretched with a certain force. If the linear mass density of the second string is four times that of the first string, then calculate ratio of wave velocity in two strings.

(G) State Huygen's principal of wave theory of light.

(H) What is wavefront? Write the name of different types of wavefronts.

(I) How coherent sources of light waves are produced ?

(J) What is a plane diffraction grating? Resolving power of plane diffraction grating depends on which factors.

3. Answer the following questions : ***(any four)*** 5×4=20

(A) Find out the expression of resultant displacement for superposition of two oscillations having equal frequencies. If the two osciliations are in same phase, what will be the resultant displacement ? 4+1=5

(B) Write the differential equation of S.H.M and solve it. 1+4=5

(C) Write about half wave plate and quarter wave plate.

(D) Define phase velocity and group velocity. Find out the relation between phase velocity and group velocity. 2+3=5

(E) Discuss the phenomenon of Fraunhofer diffraction at a single slit. Find the expression for the width of the central maximum.

(F) What do you mean by plane -polarized, circularly polarized and elliptically-polarized light? Mention how these three types of light can be produced. 3+2=5

(G) In a Fraunhoffer diffraction light a wavelength 6000 passes through a narrow circular aperture of radius 0.9mm. At what distance along the axis will the first maximum intensity be observed? Assume focal length of focusing lens to be 20cm.

(H) Newton's rings are formed by reflection of light of wavelength 600nm. The diameter of 10^{th} dark ring is 0.4cm. Calculate the radius of curvature of the lens used.

(I) Write short notes : ***(any one)***

(1) Zone plate

(2) Resolving power of a grating.

4. Answer ***only one*** : $10 \times 1 = 10$

(A) Describe the working principle of a Michelson's interferometer. Discuss how you would determine the separation of two close spectral lines with the help of a Michelson interferometer.

(B) Derived the Newton's formula of velocity of sound in air and discuss Laplace's correction.

(C) What do you mean by progressive waves? Derived the equation of a progressive wave.

(D) What are Lissajous figures? How will you trace graphically the Lissajous figures when (i) the periods are equal and phase difference is $\pi / 4$ and (ii) the periods are in the ratio of 2:1 and phase difference is zero.

Total number of printed pages–7

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. 2

(ii) At what frequencies may sea water be considered as a good conductor ? Given $\sigma = 4\Omega^{-1}m^{-1}$ and $\sigma \geq 0.01\ \omega\varepsilon$. 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 $E(z,t) = E_\circ \sin(kz - \omega t)\hat{x}$, 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}.

2½+2½=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 Å 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 *Hz*. Hence, show that radio communication becomes difficult with submarines at large depths. Show that metals are opaque to visible light.

2½+2½=5

(viii) The electric field component of a plane monochromatic *em* wave propagating through free space along the z-direction is given by $E = E_{\circ} \sin(kz - \omega t)\hat{x}$. 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