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3 (Sem–6/CBCS) PHY HC 1

2025

PHYSICS

(Honours Core)

Paper : PHY–HC–6016

(Electromagnetic Theory)

Full Marks : 60

Time : Three hours

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

1. Answer the following questions : 1×7=7

   (i) Write the basic difference between the propagation of electromagnetic waves through conducting and non-conducting mediums.

   (ii) $\vec{\nabla} \times \vec{A} =$ __ ?

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(iii) Write down the boundary condition of $\vec{H}$.

(iv) Define phase retardation plate.

(v) Write the expression for group-velocity dispersion.

(vi) What does the imaginary part of the propagation vector signify ?

(vii) What is the function of cladding in optical fibre ?

2. Answer the following questions : 2×4=8

(i) Show that the ratio of conduction current density (J_C) and displacement current density (J_D) is equal to $\frac{\sigma}{\omega\varepsilon_0}$.

(ii) Draw the variation of amplitude reflection coefficients $r_{||}$ and $r_{\perp}$ with respect to the incident angle.

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(iii) Define optic axis. What types of crystal possess only one optic axis ?

(iv) Write down the mathematical expression and unit of energy flux density.

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

(i) Show that the critical frequency for propagation of electromagnetic waves in plasma is given by $f_C = 9\sqrt{n_0}$, where n_0 is the number of electrons per cubic meter. Comment on the propagation of em wave incident on plasma with frequency less than the plasma frequency. 4+1=5

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(ii) A uniform plane wave propagating in a medium is expressed by $E = 2e^{-\beta x} \sin\left(10^8 t - \alpha x\right)\hat{y}\, V/m$, where the medium is characterized by $\varepsilon_r = 1$, $\mu_r = 20$ and $\sigma = 3$ *mhos/m*. Show that the medium is a good conductor. Also find the value of α. α and β denotes the real and imaginary part of propagation vector. 2½+2½=5

(iii) Write the Poynting theorem in differential form. What does the Poynting vector signify ? Consider the propagation of an em wave with electric field vector given by $E = E_0 \sin(kz - \omega t)\hat{x}$. Calculate the Poynting vector. 1+1+3=5

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(iv) What is rotatory polarization ? Draw a neat diagram of the Laurent half-shade polarimeter, labeling each part of it.

2+3=5

(v) Show that for an em wave in a conducting medium, the ratio between H and E vectors is a complex quantity. What does this complex value signify ?

4+1=5

4. Answer ***any three*** of the following questions :

10×3=30

(i) Using Fresnel equation, prove Brewster's law and explain the total internal reflection phenomenon. 5+5=10

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(ii) Can a poor conductor be made a good conductor ? Explain. Why is radio communication with submarine difficult ? Ocean water can be assumed to be a non-magnetic dielectric with $k = \varepsilon/\varepsilon_0 = 80$ and $\sigma = 4.3$ *mho/m*.

(a) Calculate the frequency at which the penetration depth will be 10 *cm*. *(b)* Show that for frequencies less than 10^8 *Hz*, it can be considered as a good conductor. 2+2+3+3=10

(iii) Write the Maxwell equations for a non-conducting medium. Derive the em wave equations for the medium and show how these equations lead to the fact that light is an electromagnetic wave. 2+5+3=10

(iv) Discuss with a neat diagram the construction of Babinet compensator. Explain how Babinet compensator can be used to analyze elliptically polarized light. 4+6=10

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(v) Explain how optical fibres are classified on the basis of the refractive index profile. From the consideration of parabolic relation of refractive index, derive the ray path in graded index fibres. Write the *two* types of fibre optic sensors. 2+6+2=10

(vi) What are wave guides ? List *one* difference between transmission lines and wave guides. Draw a neat diagram of the propagation of waves between two parallel conducting plates. Define the term TE, TM and TEM associated with the propagation of electromagnetic waves through a wave guide.

1+1+5+3=10
