U.G. 6th Semester Examination-2024

PHYSICS

[HONOURS]

Course Code : PHY-H-CC-T-13

(Electro-magnetic Theory)

Full Marks : 40 Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks.
Candidates are required to give their answers in their own words as far as practicable.

(Treat all **bold** letters as a vector)

1. Answer any **five** questions: 2×5=10

a) What is displacement current? Write down the Maxwell's equation with displace current.

b) Explain the *step* and *graded indices* in fibre optics.

c) Write down the Biot's law of rotatory polarisation.

d) Explain the total internal reflection. A laser beam passing from ethanol (n_e=1.36) to air. Calculate the angle of incidence so that a laser beam reflected at the boundary of air and ethanol.

e) What is Brewster's law of reflection? Calculate the Brewster's angle for the two adjacent medium of refractive indices (n_1=1.33 and n_2=1.36).

f) An optical fiber has a core material of refractive index of 1.55 and cladding material of refractive index of 1.50. The light is launched it in air. Calculate its numerical aperture.

g) State the Poynting theorem.

h) What do you mean by *polarizer* and *analyzer*?

2. Answer any **two** questions: $5\times2=10$

a) Write down the Faraday's law of Induction. Show that the differential form of Faraday's law can be put in this form: $\nabla\times\mathbf{E}+1/c\,\partial\mathbf{B}/\partial t=0$ 2+3

b) What in Nicole prism? Construct a Nicole prism and explain the working principle of a Nicole prism as a polarizer and as a analyzer. $1+1+(1\frac{1}{2}+1\frac{1}{2})$

c) Write down the four Maxwell's equation in the case of polarised materials and explain each term. Derive the relations electric displacement vector **D** in terms of electric

field **E** and polarisation **P** as macroscopic magnetic field **H** in terms of magnetic field **B** and magnetization **M**. $2+(1\frac{1}{2}+1\frac{1}{2})$

d) Write down the continuity equation for charge-current. State whether Ampere's law for steady state current always true even for time varying case. If not derive the current form of Ampere's law. 1+1+3

3. Answer any **two** questions: $10\times2=20$

a) Show that the Maxwell stress energy tensor can be written as

$T_{ij} = \epsilon_0 (E_iE_j - 1/2\ \delta_{ij} E^2) + 1/\mu_0 (B_iB_j - 1/2\ \delta_{ij} B^2)$ and prove that the total electomagnetic force is $\mathbf{F} = \oiint \mathbf{T}.d\mathbf{a} - \epsilon_0 \mu_0 \frac{d}{dt} \iiint \mathbf{S}\, d\tau$, where **S** is the poynting vector. What will be the total electromagnetic force **F** in the static case? 5+4+1

b) Derive the wave equations for **E** and **B** inside matter where no free charge or free current. Assume the plane wave solution, $\mathbf{E} = \mathbf{E}_0 e^{i(kz-wt)}$. Find out the reflection (R) and transmission coefficients (T). Show that they obey the relation R+T=1. 3+6+1

c) Consider perfectly hollow conducting cylinder and electromagnetic wave propagating along z-axis. Find out the transverse electric (TE) and transverse magnetic waves. Show that transverse electric and magnetic (TEM) is not possible for perfectly hollow conducting cylinder. Find out the cut-off frequency and explain its significance. Calculate the energy and power flow for the case of TE. Show that the ratio of power and energy flow is exactly same as group velocity. 3+1+2+3+1.

d) Define the half-wave plate and quarter wave plate. Construct a Babinet's compensator and write down it's working principle. What is the advantage of Babinet's compensator over quarter plate? 2+3+3+2
