U.G. 6th Semester Examination - 2022

PHYSICS

[HONOURS]

Course Code : BPHSCCHC601

Course Title : Electromagnetic Theory

Full Marks : 30 Time : 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.

1. Answer any **ten** questions: 1×10=10

a) What are the advantages and disadvantages of Coulomb Gauge?

b) Write down the expression of magnetic flux in terms of vector potential $\vec{A}$.

c) Find out the skin depth of a medium with conductivity 2×10^{7} mho-m^{-1} at frequency 1 MHz. $\left(\mu \simeq \mu_0 = 4\pi\times10^{-7}\ \mathrm{H/m}\right)$

d) Show that for a good conductor, the phase lag of $\vec{H}$ behind $\vec{E}$ is $\frac{\pi}{4}$.

e) How does displacement current density differ from free current density?

f) What is 'attenuation constant'?

g) What do you mean by 'Maximum usable frequency'?

h) Using Cauchy's formula of normal dispersion, show that dispersion is inversely proportional to the cube of wavelength of electromagnetic wave.

i) Mention two features of Evanescent wave.

j) What is graded index optical fibre?

k) What is the difference between TE mode and TM mode of a waveguide?

l) Describe the state of polarization of the wave represented by

$$\vec{E}(x,\ t) = \hat{i}E_0\cos\left(\omega t - kx + \frac{\pi}{2}\right) + \hat{j}E_0\cos(\omega t - kx).$$

m) How can you distinguish between an elliptically polarized light and a mixture of plane polarized light and unpolarized light?

n) A halfwave plate is fabricated for a wavelength 3200Å. For what wavelength does it work as quarter-wave plate?

o) What will be the Brewster angle for a glass slab (n=1.5) immersed in water (n=1.33)?

2. Answer any **five** questions: $2\times5=10$

a) A parallel plate capacitor with plate area $5cm^2$ and plate separation 5mm has a voltage $50\sin10^3t$ V applied to its plates. Calculate the displacement current assuming $\in=2\in_0$. $\left(\in_0=8.854\times10^{-12}\,F/m\right)$

b) Given the total electromagnetic energy

$$W=\frac{1}{2}\int\left(E.D+H.B\right)dv.$$

show from Maxwell's equations that

$$\frac{\partial W}{\partial t}=-\oint_s\left(E\times H\right).ds-\int_v E.J\,dv.$$

(Symbols have their usual meanings)

c) A plane electromagnetic wave travelling in positive t-direction in an unbounded lossless dielectric medium with relative permeability $\mu_r=1$ and relative permittivity $\in_r=3$. Find

i) The speed of the wave

ii) The intrinsic impedance of the wave medium.

$\left(\mu_0=4\pi\times10^{-7}\,H/m,\ \in_0=8.854\times10^{-12}\,F/m\right)$

d) Establish that, the displacement of electron in an atom, from its equilibrium position under the influence of EM waves consists of two parts: one in phase with $\vec{E}$ and another with 90^o phase difference with $\vec{E}$.

e) Prove that the frequency of incident wave does not change on reflection.

f) Consider a waveguide of square cross-section having side 'a'. It is to transmit an EM wave of wavelength λ in TE_{10} mode but not in TE_{11} or TM_{11} modes. Find the limiting range of values of a.

g) Obtain an expression for numerical aperture for a step index fibre.

h) Show that in a linear dielectric medium electromagnetic energy is equally shared between electric and magnetic field.

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

a) Derive differential form of Poynting Theorem. Brass waveguides are often silver-coated to reduce the material cost. If the thickness of the silver required for this purpose is at least five times the skin depth,

find the minimum thickness of silver coating required for a waveguide operating at 10 GHz. Assume for silver, $\mu = \mu_0$ and $\sigma = 6 \times 10^7$ S/m. 3+2

b) Deduce expression for amplitude reflection coefficient and amplitude transmission coefficient for incident EM wave having $\vec{E}$ perpendicular to the plane of incidence. Calculate the percentage of light energy reflected back for air-water interface. 3+2

c) Describe the construction and working of a Laurent half-shade polarimeter. 2+3

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