বিদ্যাসাগর বিশ্ববিদ্যালয়

VIDYASAGAR UNIVERSITY

Question Paper

B.Sc. Honours Examinations 2022

(Under CBCS Pattern)

Semester - VI

Subject : PHYSICS

Paper : C 13 - T

Full Marks : 40

Time : 2 Hours

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

[ELECTROMAGNETIC THEORY]

Group - A

Answer any ***four*** questions : 5×4=20

1. (a) Suppose a wire of radius a, length l and resistance R is carrying a steady current I with a potential difference V across its length. Find $\vec{E}$ and $\vec{H}$ on the surface of the wire. Calculate the Poynting's vector $\vec{S}$ and show that it represents a flow of energy into the wire from the surrounding space. Interpret the result. 1+1+1+1

(b) What is wave impedance? 1

2. (a) Prove that the field energy in a good conducting medium is almost magnetic in nature. 3

   (b) Define 'skin depth'. Mention its application in transmission line. 1+1

3. (a) An electromagnetic wave of wavelength 653 nm in air is incident normally on a metal surface having complex refractive index $n = 0.17 + i\ 3.14$. Find the reflectivity of the surface. 2

   (b) What is radiation pressure? 1

   (c) What inductance is required with a 17-pF capacitor in order to construct an oscillator capable of generating 550 nm electromagnetic waves? Comment on your result. 2

4. (a) A green light at wavelength 500 nm is incident on quarter wave plate whose refractive indices corresponding to *E*-ray and *O*-ray are 1.5534 and 1.5443, respectively. Find the thickness of the quarter wave plate. 2

   (b) What is Malus law? 1

   (c) Unpolarized light passes through three polarizing filters. The angle between the first and second filters is 45º. The angle between the second and third filters is also 45º. What is the relationship between the intensity of light emerging from the third filter, I_3, and the incident intensity, I_0? 2

5. (a) The electric field intensity of a plane wave in air is given by

   $$\vec{E} = 4\times10^{-6}\times\cos\left(10^7\pi t - kz\right)\hat{i} + 4\times10^{-6}\times\sin\left(10^7\pi t - kz\right)\hat{j}\,\frac{v}{m}.$$

   Find the values of *k*, corresponding magnetic field and Poynting vector. 1+2+1

   (b) What is an evanescent wave? 1

6. (a) Consider a rectangular waveguide with the dimensions a = 3.33 cm and b = 2.50 cm. For the propagation of the TE_{11} mode find the range of frequencies. Which kind of filter does this waveguide behave like in this case? 2+1

   (b) A step-index fiber has a core index of refraction of n_1 = 1.425. The cut-off angle for light entering the fiber from air is found to be 8.50º. (i) What is the numerical aperture of the fiber? (ii) What is the index of refraction of the cladding of this fiber? 1+1

Answer any ***two*** questions : 10×2=20

7. (a) Write down the Maxwell equations in a conducting medium in case of propagation of electromagnetic waves through a conducting medium having permeability μ, permittivity ε, conductivity σ and free charge density ρ_f. Show why free charge cannot reside in a conducting medium with an appreciable period of time. 3

   (b) (i) Show that for a good conductor skin depth $\delta = \lambda_c / 2\pi$, where λ_c is the wavelength of EM waves in the conductor. (ii) Show that for EM wave incident on a good conductor the electric field reduces to 1% at a depth of $0.73\,\lambda_c$. 2+1

   (c) Deduce the expressions of amplitude coefficients for reflection and transmission for an s-polarized electromagnetic wave and discuss their variations. 4

8. (a) The intensity of sunlight reaching the earth's surface is about 1300 $W.m^{-2}$. Calculate the strength of electric and magnetic fields of the incoming light. 3

   (b) State and prove Poynting's theorem. 4

   (c) Consider the propagation of EM waves through diluted ionized gases such as the ionosphere. Hence, show that the critical frequency below which wave propagation through it is not possible is given by $f_c = 9\sqrt{n_0}$, where n_0 is the number of electrons per m^3. 3

9. (a) What is Brewster's angle? What should be the angle of seen above the horizon, so that the sunlight reflected from the surface of water (r.i.=1.33) of still lake is plane polarised. 1+2

   (b) Explain how the state of polarisation of the beam of light can be ascertained from three possibilities : (i) unpolarised, (ii) plane polarised, and (iii) circularly polarised with the help of a polaroid and a quarter wave plate. 5

   (c) What is meant by optical activity? 2

10. (a) Explain why and how Ampere's circuital law is modified to include displacement current. 3

    (b) Distinguish between polarised and unpolarised light. Describe the state of polarisation of an electromagnetic wave given by

$$\vec{E} = E_0 \cos(ky - \omega t)\hat{i} + E_0 \cos(ky - \omega t + \pi/4)\hat{k}$$ 2+2

(c) The dispersion equation of a waveguide is $k(\omega) = (1/c)\sqrt{\omega^2 - \omega_0^2}$, where $k(\omega)$ is the wavevector dependent on the angular frequency (ω), the speed (c) of light in free space, and ω_0 is a constant. Find the phase velocity when the group velocity is 2×10^8 m/s. 3