3 (Sem–6/CBCS) PHY HC 1

2023

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 ***all the seven*** questions : 1×7=7

   (a) What do you mean by isotropic medium ?

   (b) What is a half wave plate ?

   (c) Write the expression for Lorentz gauge.

   (d) How is refractive index related with dielectric constant ?

   (e) Write momentum of a photon in terms of its frequency.

   (f) Write down the intrinsic impedance for free space.

(g) What is cladding in di-electric waveguide ?

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

(a) What is Nicol prism ? Draw a neat diagram of it.

(b) Find numerical aperture of a step index fibre.

(c) Calculate the Skin depth for an EM wave of frequency 100 *MHz* in copper. Given, conductivity for

$Cu = 6.25 \times 10^7\ mho/m$ and

$\mu_0 = 4\pi \times 10^{-7}$ henry/meter

(d) Find expression of electric field in terms of scaler and vector potentials.

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

(a) Using the concept of displacement current density, derive the expression for EM wave in free space.

(b) Show that EM waves are transverse in nature.

(c) How will you use Babinet's compensator to analyse polarisation of light ?

(d) Explain the terms Levo-rotatory and Dextro-rotatory. A 15 *cm* tube containing sugar solution of sp. rotation 66° shows optical rotation 7°. Find strength of the solution. 1+1+3=5

(e) What is a dielectric waveguide ? Find the condition of internal reflection at the two boundaries of the waveguide. 2+3=5

4. Answer ***any three*** of the following : 10×3=30

(a) Derive the expression for EM energy flux coming out of a surface. What is the significance of Poynting vector ? 8+2=10

(b) (i) Derive the expression for total internal reflection using EM wave equation where $\vec{E}$ is parallel to the plane of incidence.

(ii) An EM wave in free space has electric field given by

$\vec{E} = 20\ cos(3y + 4z - 0.5ct)\,\hat{i}$.

What is its propagation vector ?

Given $c = 3 \times 10^8\ m/sec$. 8+2=10

(c) Using Fresnel equations, show that the amplitude reflection coefficient for $\vec{E}$ parallel to the plane of incidence is equal to zero if sum of angle of incidence and polarising angle is $\pi/2$ and hence derive Brewster's law. Also sketch the variation of amplitude reflection co-efficients for both perpendicular and parallel components of $\vec{E}$. 3+4+3=10

(d) What is meant by rotatory polarisation? Describe the theory and working of Laurent's half-shade polarimeter. 2+3+5=10

(e) Equations of two electric field vectors oscillating in perpendicular direction are given by $\vec{E}_1 = \hat{i}\, a_1 \cos(kz - \omega t)$ and $\vec{E}_2 = \hat{j}\, a_2 \cos(kz - \omega t + \theta)$, assuming time variation of the resultant field at $z = 0$, find the state of polarisation (SOP) of the resultant at different values of θ.

(f) Using Maxwell's equation, derive the Fresnel's wave equation in anisotropic medium.

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3 (Sem–6/CBCS) PHY HC 2

2023

PHYSICS

(Honours Core)

Paper : PHY–HC–6026

(Statistical Mechanics)

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

   (a) What is the number of microstates if 8 distinguishable particles are distributed in two compartments ?

   (b) What is ensemble in statistical mechanics ?

   (c) Define phase space.

   (d) What is the importance of Kirchhoff's law of radiation ?

   (e) Give *one* example of bosons.

(f) What is Chandrasekhar mass limit ?

(g) Under what condition quantum statistics approaches the classical statistics ?

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

(a) Write *two* properties of thermal radiation.

(b) Black body radiation is white. Explain.

(c) To what temperature must an ideal black body be raised in order to double the total radiation if original temperature is 127 °C ?

(d) Write *one* similarity and *one* difference between B-E and F-D statistics.

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

(a) State law of equipartion of energy. Using this law find an expression of the ratio of two specific heat of a gas. 1+4=5

(b) 6 distinguishable particles are to be arranged in 3 compartments of a box. Find the total number of microstates corresponding to the macrostate (0,2,4) and (2,3,1). [There is no restriction of number of particles that can go into any compartment]. 2½+2½=5

(c) In a metal there are 3.14×10^{27} free electrons per cubic metre. Calculate the Fermi energy.

(d) Write a note on Bose-Einstein condensation.

(e) Write the Saha's ionisation formula. Write the assumptions considered to derive the formula. 2+3=5

4. Answer the following : 10×3=30

(a) Write the statistical definition of entropy. What is its unit ? State the physical significance of entropy giving *one* example. Derive the relation between entropy and thermodynamic probability. 2+1+2+5=10

Or

Derive Maxwell-Boltzmann law of energy distribution. 10

(b) What is radiation pressure ? Prove that the diffuse radiation exerts a pressure on the walls of the container, equal to $\frac{1}{3}$rd of its energy density. 2+8=10

Or

From Planck's law of blackbody radiation, derive : 3+7=10

(i) Rayleigh-Jeans law

(ii) Wien's displacement law

(c) Derive Bose-Einstein's distribution law. 10

Or

Derive the expression of total internal energy of a Fermi-Dirac gas.
