2023

PHYSICS

(Honours Core)

Paper : PHY–HC–2016

(Electricity and Magnetism)

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 significance of electric susceptibility for a dielectric ?

   (b) How much electrostatic energy is stored by a solid sphere of radius R and total charge Q ?

   (c) Write Faraday's second law in differential form.

   (d) What is the capacitance of earth ? Given the radius of earth is 6400 *km*.

(e) If there is no damping in an L-C-R circuit with A.C, what will be the *Q*-factor ?

(f) Under what condition, a cell can act as a constant current source ?

(g) In a ballistic galvanometer :

(i) inertia of the coil is small and damping is also small

(ii) inertia of the coil is large and damping is critical

(iii) inertia of the coil is large and damping is small

(iv) both inertia of the coil and damping are large.

(Choose the correct option)

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

(a) In a region of space the electric field is given by $\vec{E} = 8\hat{i} + 4\hat{j} + 3\hat{k}$. Calculate the electric flux through a surface of area 100 units in $x-y$ plane.

(b) Write down Poisson's and Laplace's equation in electrostatics.

(c) Which one of the following will experience a maximum magnetic force, when projected with the same velocity (V) perpendicular to the magnetic field (B) ?

(i) α-particle

(ii) β-particle

(d) An electric dipole of moment $2 \times 10^{-8}\ Cm$ is placed in a uniform field of intensity $1.5 \times 10^{5}\ NC^{-1}$. How much work is done on turning the dipole end to end ?

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

(a) (i) Using Gauss' law, find the electric field outside a uniformly charged spherical shell of radius R and total charge q. 3

(ii) The potential of a certain charge configuration is expressed by $v = 2x + 3xy + y^2$ volts. Find the electric intensity at point (5,2). What acceleration does an electron experience in the x-direction ? Distances are in metre. 2

(b) What is meant by dielectric polarisation? Show how $\vec{E}, \vec{D}$ and $\vec{P}$ are related for an isotropic dielectric medium. Is water molecule a polar molecule ? If so, why ?
[Where the symbols have got their usual meaning.] 1+3+1=5

(c) State Ampere's circuital law of magnetic field. A toroid has a core made up of non-ferromagnetic material. The inner radius of the core is 19 *cm* and outer radius is 21 *cm*. Around this core 5000 turns of copper wire are wound. If the current in the wire is 10 A, what is the strength of the magnetic field

(i) outside the toroid;

(ii) inside the core of the toroid;

(iii) in the empty space surrounded by the toroid ? 1+4=5

(d) Two inductors of self inductances L_1 and L_2 with mutual inductances M are connected in series. Derive an expression for the equivalent inductance of the combination.

(e) Define charge sensitivity and current sensitivity of a ballistic galvanometer. Obtain an expression for charge sensitivity of a ballistic gavanometer. How is it related to the current sensitivity ? 2+2+1=5

4. Answer ***any three*** questions : 10×3=30

(a) (i) What is the principle of 'method of electrical images' ? A point charge *(Q)* is placed in front of an earthed conducting sphere of radius *(R)*. Calculate the potential and field at an external point $P(r, \theta)$. 1+4=5

(ii) What is electric dipole ? Derive an expression for electric potential at a point due to an electric dipole. 1+4=5

(b) Derive Gauss' law in a dielectric medium. Establish the boundary conditions satisfied by electric field $\vec{E}$ and electric displacement vector $\vec{D}$ at the boundary between the two dielectrics. 4+6=10

(c) (i) Derive an expression for magnetic field at a point on the axis of a circular current loop. Use it to prove that magnetic field at the ends of a long solenoid is one-half of that at the centre. 5+3=8

(ii) An electron circulates around a nucleus in an orbit of radius 5.1×10^{-1} metre at a frequency ν of 6.8×10^{15} rev./sec. Calculate magnetic field strength at the centre of the orbit. 2

(d) An instantaneous e.m.f $E = E_0 \sin\omega t$ is applied to LCR circuit due to which the instaneous circuit is $I = I_0 \sin(\omega t - \phi)$. What is the average power consumed during one complete cycle ? If the circuit contains only capacitor, then what will be the average power ? 8+2=10

(e) (i) State and prove maximum power transfer theorem. 5

(ii) An AC source of internal resistance R_s is used to drive a load consisting of a capacitor (C) in parallel with a series combination of an inductor (L) and a resistor (R) Find the condition for maximum power transfer. 5

(f) What is hysteresis ? Derive an expression for work done per unit volume during cycles of magnetisation. What are the factors on which hysteresis loss depends ? Draw hysteresis curves for the material suitable for its use *(i)* in a transformer, and *(ii)* as a permanent magnet. 2+4+2+2=10

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3 (Sem–2/CBCS) PHY HC 2

2023

PHYSICS

(Honours Core)

(Waves and Optics)

Paper : PHY–HC–2026

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 relation between group velocity v_g and wave velocity v in a dispersive medium ?

   (b) What is the nature of wavefront emitted by a point source ?

(c) Which method is used for producing two coherent sources from one single source in Newton's rings experiment?

(d) What is the grating element for a plane diffraction grating having 5,00,000 *lines/cm*?

(e) What do you mean by a positive zone plate?

(f) What is the velocity of a particle at the nodes of a standing wave?

(g) Which assumption was considered by Newton while formulating the velocity of sound as incorrect?

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

(a) Fundamental frequency of a stretched string of length 50 *cm* and mass 10 *gm* is 300 *Hz*. What is the tension applied?

(b) What are the conditions essential to obtain sustained interference of light?

(c) In Fraunhofer diffraction pattern formed by a single slit, suppose that the slit width is 0·03 *cm* and the wavelength of light used is 6×10^{-5} *cm*. Find the diffraction angle for the first dark band.

(d) Show that two perpendicular SHMs of equal frequency and equal amplitude but having a phase difference of $\pi/2$ can produce a circular motion.

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

(a) Deduce an expression for the velocity of transverse vibrations in a stretched string.

(b) Explain the phenomenon of refraction of a plane wave at a plane surface using Huygens' principle.

(c) Illustrate Stokes treatment for explanation of the change of phase when reflection takes place at the denser medium.

(d) Mention three differences between Fresnel and Fraunhofer diffraction. A zone plate behaves like a convex lens of focal length 50 *cm*. If the wavelength of light is 5000 Å, calculate the radius of first half period zone. 3+2=5

(e) What do you mean by standing (stationary) waves ? Deduce an equation illustrating the relationship between phase and group velocities. 1+4=5

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

(a) Determine the resultant of two perpendicular SHMs having frequency ratio 2:1 and a phase difference zero. Obtain a representation of the resultant path graphically. 6+4=10

(b) Discuss the phenomenon of Fraunhofer diffraction at a single slit. Find an expression for the width of the central maximum. Fraunhofer diffraction pattern due to a narrow slit of width 0·2 *mm* is observed in a screen placed on the focal plane of a lens having focal length 2 *m*. If the first minima is at 5 *mm* on either side of central maximum, calculate the wavelength of the incident light. 7+3=10

(c) Describe Fresnel's biprism experiment for interference. How can you determine the wavelength of light by this method? Light of wavelength 5896 Å falls normally on a thin wedge-shaped air film forming fringes that are 3 *mm* apart. Find the angle of the wedge.

2+5+3=10

(d) Find the expression for intensity due to a plane diffraction grating. Why cannot the secondary maxima be observed? What is its resolving power?

5+2+3=10

(e) Elucidate the construction and working principle of a Michelson's interferometer. Under what conditions are circular fringes formed in Michelson's interferometer? How are localized fringes formed in Micheleson's interferometer?

6+2+2=10

(f) Write short notes on ***any two*** of the following: 5×2=10

(i) Ripple and gravity waves

(ii) Vibrations in a plucked string

(iii) Haidinger fringes

(iv) Holography

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