⑦ Your Roll No...............

Sr. No. of Question Paper : 4550

Unique Paper Code   : 32221201

Name of the Paper   : Electricity and Magnetism

Name of the Course   : **B.Sc. (Hons) Physics (CBCS – LOCF)**

Semester   : II

Duration : 3 Hours   Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.

2. Question No. **1** is compulsory.

3. Answer any **four** of the remaining **six** questions.

1. Attempt all parts of this question :   (5×5=25)

(a) A point charge 'q' is located at the centre of a cube having edge of length 'd'. What is the value of flux over one face of the cube? If the charge is placed at one corner of the cube, then what will be the value of electric flux through each face of the cube?

(b) Suppose the electric field in some region is found to be, $E = kr^3r$ in spherical coordinates where, is a constant with appropriate units.

    (i) Find the charge density.

    (ii) Find the total charge contained in a sphere of radius R centered at the origin.

(c) Find the magnetic field at origin corresponding to the vector potential $\vec{A} = \left(y \cos(ax) \right)\hat{i} + \left(y + e^x \right)\hat{k}$.

(d) What is displacement current? How is it different from the conduction current.

(e) State and prove maximum power transfer theorem. What is the maximum efficiency of any circuit.

2. (a) Find the electric field at a distance s from an infinitely long straight wire which carries a uniform line charge λ. (6)

(b) Derive the expression for the magnetic field at a point on the axis of a circular coil of radius a and carrying current I. Obtain an expression for the magnetic dipole moment of loop. (6.5)

3. (a) A spherical condenser consists of two concentric conducting spheres of radii a and b (a > b). The outer sphere is grounded and a charge Q is placed on the inner sphere. The outer conductor then contracts from radius a to c. Find the work done by the electric force? (6.5)

(b) The magnetic field intensity is H = 1200 Amp/m in a material when B = 2 Wb/m². When H is reduced to 400 Amp/m, B = 1.4 Wb/m², calculate the change in the magnetization M. (4)

(c) Explain why diamagnetism is temperature independent. (2)

4.   (a) A sphere of radius R, filled with material of dielectric constant k, have a small concentric spherical cavity of radius a. A free point charge q is placed at the center. Find the polarization vector P and bound charges σ_b and ρ_b.

                                                         (3.5,3)

   (b) Derive the expression for quality factor Q and bandwidth β of a series RLC circuit.   (3,3)

5.   (a) A point charge 'q' is placed inside a hollow grounded, conducting sphere of inner radius 'a'. Using the method of images,
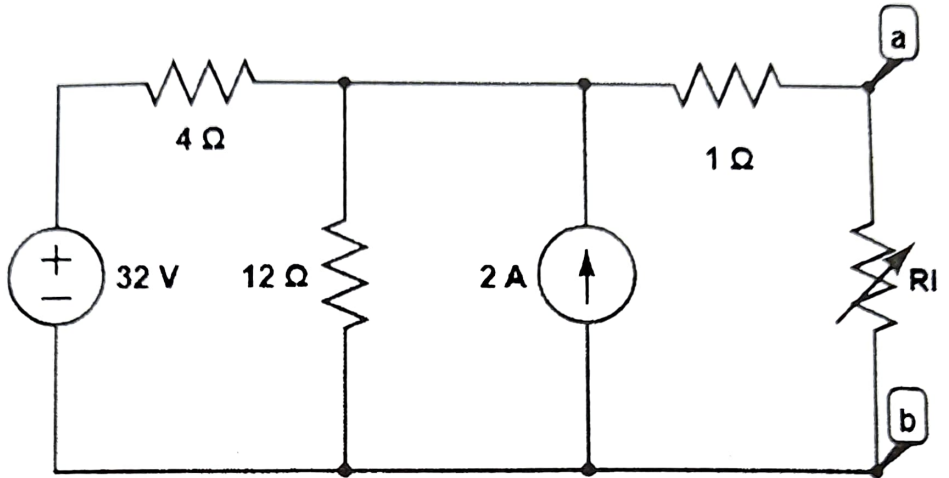
       (i) Find the potential inside the sphere.   (4)

       (ii) Find the induced surface-charge density.

                                                        (2)

(b) Find the Thevenin equivalent of the circuit below

and find the current through R1 = 6Ω.

(5,1.5)

6. (a) In a parallel plate air capacitor having plate

separation 0.04 mm, an electric field of 4×10^4 V/

m is established between the plates. The battery

is then removed and a metal plate of thickness

0.03 mm is inserted between the plates of the

capacitor. Determine the potential difference

across the capacitor,

(i) before the introduction of metal plates

(2)

(ii) after the introduction of metal plates (2)

(iii) if dielectric slab with dielectric constant 2.5 and same thickness is inserted instead of the metal plates   (2)

(b) Find the emf induced in a rectangular loop due to a current carrying long wire placed in the plane of the loop. Also find the induced emf when the loop moves away from the wire with a constant speed v so that it's orientation w.r.t. the wire does not change.   (3,3.5)

7.   (a) A thin metal sphere of radius b has a charge Q.
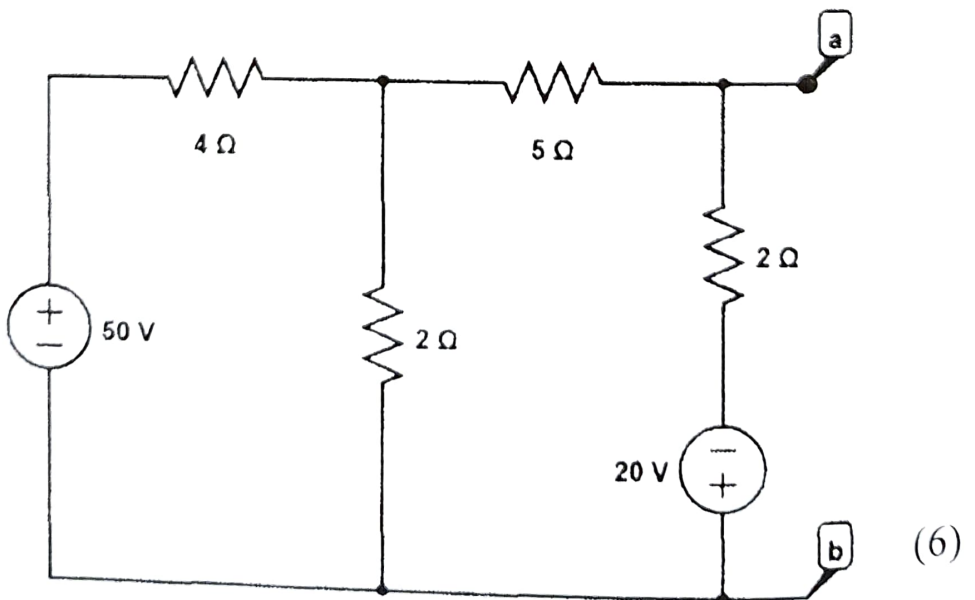
(i) What is its capacitance?   (2)

(ii) What is the E-field energy density at a distance r from the center of the sphere?   (1)

(iii) What is the total energy of the field?

(2)

(iv) Compute the work expended in charging the sphere by carrying infinitesimal charge from infinity.   (1.5)
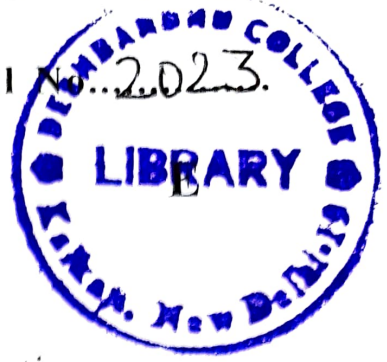
(b) Using the node voltage method, find V_{oc} and I_{sc} at the terminal ab of the following network :

(200)

[This question paper contains 6 printed pages.]

Sr. No. of Question Paper : 4670

Unique Paper Code : 32221202

Name of the Paper : Wave and Optics

Name of the Course : **B.Sc. (Hons) Physics CBCS**

Semester : II

Duration : 3 Hours   Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.

2. Answer any **five** questions in all.

3. Q. No. **1** is compulsory.

1. Attempt any **five** questions. Each question carries **3** marks.   (3×5=15)

    (a) Two pendulums, P and Q, are set up alongside each other. The period of P is 1.90 s and the period of Q is 1.95 s. How many oscillations are made by pendulum Q between two consecutive instants when P and Q move in phase with each other?

P.T.O.

(b) A Llyod's mirror of length 5 cm is illuminated with monochromatic light ($\lambda = 5460$ A°) from a narrow slit 0.1 cm from its plane, and 5 cm measured in that plane, from its near edge. Find the separation of the fringes at a distance of 120 cm from the slit & the total width of the pattern observed.

(c) What are coherent sources? How spatial and temporal coherence are different?

(d) A convex lens of focal length 20 cm is placed after a slit of width 0.6 mm. If a plane wave of wavelength 600 nm falls on the slit normally, calculate the separation between the second minima on either side of central maximum.

(e) Define Fizeau's and Haidinger's fringes. Give one example for each.

(f) A telescope of aperture 3 cm is focused on a window at 80 m distance fitted with a wire mesh of spacing 2 mm. Will the telescope be able to observe the wire mesh with an illuminating light of wavelength 550 nm?

(g) State and explain Huygen's principle.

(h) A wave is represented by $y(x, t) = (0.5)$ $\sin[(314t - 12.56x)]$; where y and x are in meters and t in seconds. Determine the amplitude, wavelength, angular frequency, wave number, time period and the velocity of the wave.

2. (a) A particle is subjected to two simple harmonic motions at right angle to each other, of equal amplitudes A, equal frequencies ω and a constant initial phase difference $\pi/2$. Derive an expression and trajectory for the resultant oscillation of the particle.

(b) Graphically construct the Lissajous figures traced by a particle subjected to two simple harmonic motions at right angle to each other, of unequal amplitudes, frequencies in the ratio 1:2, and a constant initial phase difference of (i) $\pi/2$ (ii) $-\pi/4$.

(c) The dispersion relation for surface waves propagating in a fluid is given $\omega^2 = \alpha k + \beta k^3$ where α and β are constants. Evaluate the value of propagation constant when the phase velocity is equal to the group velocity.   (7+5+3)

3. (a) Derive the classical wave equation using the model of a longitudinally vibrating air column. Hence deduce the expression for velocity of longitudinal harmonic waves propagating along the given air column.

(b) Obtain the frequencies of the normal modes of vibration of a longitudinally vibrating air column in a tube closed at one end and open at the other. Hence show that all the even harmonics of fundamental mode frequency are absent in this case. Sketch the first two normal modes of this case.

(c) A 2m long wire having a linear mass density of 0.0025 kg/m is stretched between two fixed supports such that two adjacent harmonic frequencies are 252 Hz and 336 Hz.

   (i) Calculate the fundamental frequency of the wire.

   (ii) Determine the tension in the wire.

   (7+5+3)

4. (a) Discuss the theory of interference due to a parallel thin film. Show that the result obtained in reflected and transmitted components are complementary to each other.

(b) Schematically show the experimental arrangement to obtain interference pattern due to Fresnel's biprism.

(c) In a bi-prism experiment bands of width 0.0195 cm are observed at 100 cm from the slit. On introducing a convex lens 30 cm away from the slit, two images of slit are seen 0.7 cm apart at 100 cm distance from the slit. Calculate the wavelength of light used.   (7+5+3)

5. (a) Give the theory of Michelson interferometer. How different types of fringes are formed in it. How can Michelson interferometer be used to determine the difference between two close wavelength?

(b) Define Visibility of fringes. How can it be used to check whether a source of light is monochromatic or composite?

(c) A thin transparent plate of refractive index 1.5 displaces 10 fringes when introduced in one of the arms of Michelson's interferometer. Calculate the thickness of the plate. Wavelength of light is 6000 A°.   (7+5+3)

6. (a) Using the expression for intensity distribution in Fraunhofer Single Slit Diffraction Pattern, obtain the intensity distribution in the far-field pattern

for an array of N equally spaced identical slits under normal monochromatic illumination. Discuss the characteristic features of the given diffraction pattern.

(b) Distinguish between resolving power and dispersive power of a plane transmission grating. Explain how a grating having higher dispersive power than another does not necessarily have a higher resolving power.

(c) Two distant stars subtend an angle of one second of an arc 4.84×10^{-6} radians and the wavelength of the light used be 5000 A⁰, Calculate the diameter of the objective of the telescope required to just resolve the stars.   (7+5+3)

7.   (a) Using Fresnel's integral how Comu's spiral can be constructed? What are its properties?

(b) Explain how Cornu's spiral can be used to obtain intensity distribution in the Fresnel diffraction pattern due to a straight edge.

(c) For a wavelength of light $\lambda = 6 \times 10^{-7}$ m and the radius of the first half period zone is 6×10^{-4} m, a zone plate brings rays to focus at its brightest spot. Find the focal length of the equivalent lens.   (7+5+3)