[This question paper contains 10 printed pages.]

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Your Roll No.....

2019

Sr. No. of Question Paper : 2262A **IC**

Unique Paper Code : 32221201

Name of the Paper : Electricity and Magnetism

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

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

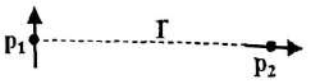
1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** with all its parts is compulsory.
3. Attempt any **four** questions from the remaining questions.
4. Each of the question nos. **2** to **7,** carries **14** marks.
5. Out of the **three** parts of question Nos. **2–7**, attempt any **two** parts.

1. (a) A constant electric field $\vec{E}$ passes through the surface of an open hemisphere, perpendicular to its base. Calculate the flux through the curved surface. (3)

P.T.O.

(b) Find the force per unit area on the surface of a charged conductor. (3)

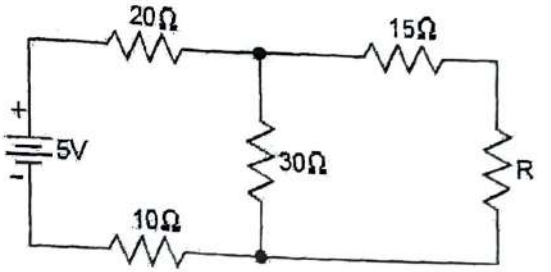
(c) Consider $\vec{p}_1$ and $\vec{p}_2$ are perfect dipoles a distance r apart as shown in figure given below. What is the torque on $\vec{p}_1$ due to $\vec{p}_2$? (3)



(d) A sphere of radius R carries a polarization $\vec{P}=k\vec{r}$ where k is a constant and $\vec{r}$ is the radial vector from the center. Find bound charge densities σ_b and ρ_b. (3)

(e) Suppose a uniform magnetic field in some region has the form $\vec{B}=B\hat{i}$. Find the force on a circular loop of radius a, lying in the yz plane, centered at the origin, which carries a current I in clockwise direction, when you look down the x-axis. (3)

(f) Determine Thevenin's equivalent circuit for the given network external to load resistance R. (3)



(g) What is displacement current? (1)

2. (a) State and prove first uniqueness theorem. Also derive Poisson's equation. (7)

(b) The electric field in a cubical region ($0 \le x, y, z \le a$) of space is given by the following expression:

$$\vec{E}=k\left[y^2\hat{i}+\left(2xy+z^2\right)\hat{j}+2yz\hat{k}\right]$$

(i) Verify that this expression represents an electrostatic field or not.

(ii) Find charge density and

(iii) Total charge that gives rise to this electric field. (7)

(c) A hollow spherical shell inner radius a and outer radius b carries charge density $\rho=\frac{k}{r^2}$ in the region

$a \leq r \leq b$. Find the electric field in the three regions :

(i) $r < a$

(ii) $a < r < b$

(iii) $r > b$

(7)

3. (a) Evaluate the electrostatic energy of sphere of radius R and having uniform distribution of total charge Q for the following configuration

(i) Non-conducting sphere

(ii) Conducting sphere

Show that their ratio is 6/5. (7)

(b) There are two cavities of spherical shapes inside spherical conductor of radius R. The charges q_1 and q_2 are placed inside at the centers of each cavity. Then

(i) Find the surface charge densities σ_1, σ_2 and σ_R.

(ii) Find the electric field in each cavity.

(iii) What is the force on q_1 and q_2? (7)

(c) A point charge q is placed at a distance d from the centre of a grounded conducting sphere of radius a. Using the method of images, find

(i) The potential outside the sphere.

(ii) The magnitude and direction of the force acting on q. (7)

4. (a) Show that the potential due to a polarized dielectric material is given by

$$V = \frac{1}{4\pi\varepsilon_0}\left(\oint_S \frac{\sigma_b}{r} dS + \iiint_\tau \frac{\rho_b}{r} d\tau\right)$$

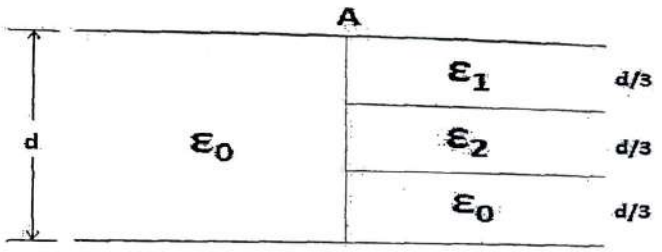
where σ_b and ρ_b are bound surface charge density and bound volume charge density respectively. Also, show that the net charge in a polarized dielectric material is zero. (7)

(b) A spherical conductor of radius a carries a charge Q and it is surrounded, out to radius b, by linear dielectric material of permittivity ε. Find the potential at the center (relative to infinity) and polarization vector $\vec{P}$. (7)

(c) Calculate the capacitance for the configuration given below, where A is the cross-sectional area

of the square metallic parallel plates separated by total distance d. One half of the volume within the plates is free space with permittivity ε_0, while the other half is filled with equal slabs of different dielectrics with permittivities ε_1, ε_2, and ε_0.

(7)



5. (a) Starting from Biot-Savart law, show that $\vec{\nabla}.\vec{B}=0$ and explain its physical significance. Hence prove that the magnetic flux through any closed surface is zero. (7)

(b) Two long coaxial solenoids each carrying current I in the same direction having number of turns per unit length n_1 (inner solenoid) and n_2 (outer solenoid). The radii of the inner and outer solenoids are a and b respectively. Find the magnetic field in the following regions with r being the radial distance from the axis :

(i) $r < a$

(ii) $a < r < b$

(iii) $r > b$ (7)

(c) Determine the magnetic field due to a long current carrying straight wire at a distance r from it. Consider two long parallel conducting wires 1 and 2 carrying currents I in same direction. One wire is placed at $x = +a$ and another at $x = -a$. Determine the magnetic field for the point $x > a$ on positive x-axis. (7)

6. (a) Show that for a system of two coils C_1 and C_2, the mutual inductance is given by

$$M = \frac{\mu_0}{4\pi} \oint_{C_1} \oint_{C_2} \frac{\overrightarrow{dl_1}.\overrightarrow{dl_2}}{r}$$

where $\overrightarrow{dl_1}$ and $\overrightarrow{dl_2}$ are the elements of coils C_1 and C_2 respectively and r is the distance between them. (7)

(b) Let the internal dimensions of a coaxial cylindrical capacitor be a = 1.2 cm, b = 4 cm, and L = 40 cm.

The homogeneous material inside the capacitor has the parameters $\epsilon = 10^{-11}$ F/m and $\sigma = 10^{-5}$ S/m. If this capacitor is connected to the source $V_S = V_0 \sin(\omega t)$ and the electric field inside this capacitor is

$$\vec{E}(r) = \frac{V_S \hat{r}}{r \ln(b/a)}$$

find

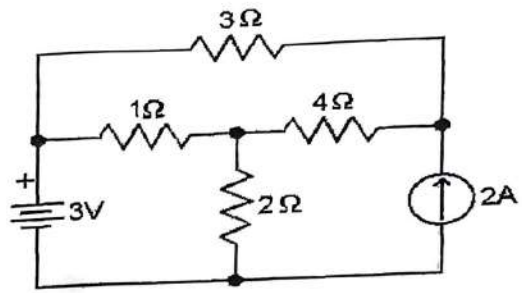
(i) The displacement current density, $\vec{J}_D$ and displacement current I_D

(ii) the conduction current density, $\vec{J}_C$ and conduction current I_c

$$\left[C = \frac{2\pi \epsilon L}{\ln(b/a)} \text{ Farad} \right] \quad (7)$$

(c) Given $\vec{E} = E_o \sin(\omega t - kz)\hat{y}$ V/m in free space. Find $\vec{D}$, $\vec{B}$ and $\vec{H}$. (7)

7. (a) Use Mesh-Analysis to find the voltage across 1Ω resistance



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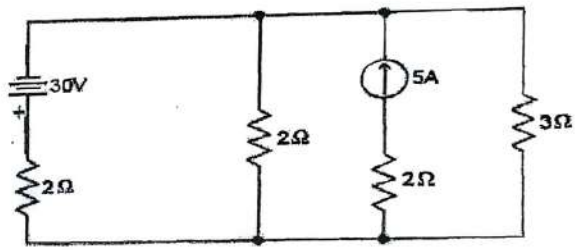
(b) Obtain Norton equivalent circuit for the network external to the 3Ω resistance for the given network. Further determine the current through 3Ω resistor.



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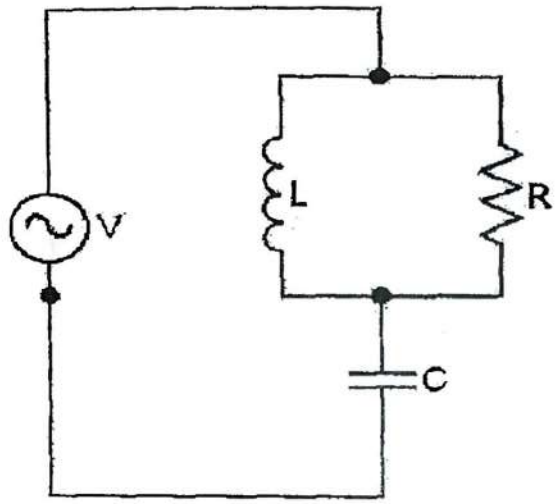
(c) A resistor 50Ω which is connected in parallel with an inductor of 30 mH, is connected in series with a capacitor C. An ac voltage of 220 V, with frequency 50 Hz is applied to the circuit. Find

(i) The value of C to give unity power factor

(ii) Total current in the circuit

(iii) The current in the inductor



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2019

Your Roll No. : .....

Sl. No. of Q. Paper : **2263** **IC**

Unique Paper Code : 32221202

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

Name of the Paper : Waves and Optics

Semester : II

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt any **five** questions in all.

(c) Question **No. 1** is compulsory.

1. Answer any **five** of the following questions :

3×5=15

(a) What are Spatial and Temporal coherence ?

(b) A simple progressive wave is expressed by $y = 0.5 \sin (6.28t - 12.56x)$, where y and x are in meters and t is in seconds. Find (i) wavelength, (ii) maximum velocity and (iii) frequency of the wave.

P.T.O.

(c) Give **three** essential conditions to obtain sustained interference.

(d) Write **two** similarities and **two** differences between zone plate and convex lens.

(e) Distinguish between Fizeau's and Haidinger's fringes. Give **one** example of an experiment where each of them can be obtained.

(f) Which order will be missing for a grating having opacity b=2a, where 'a' is the slit width ? Explain.

(g) Draw a labelled ray diagram illustrating the phenomenon of interference due to a Fresnel's bi-prism.

2. (a) Draw graphically the Lissajous figure for the following : 6

$$x = 5\cos\omega t$$

$$y = 10\cos\left(\omega t + \frac{\pi}{3}\right)$$

(b) Two simple harmonic waves expressed by $y_1 = a_1\cos\omega_1 t$ and $y_2 = a_2\cos\omega_2 t$ are superimposed collinearly. How the resulting motion leads to formation of beats ? Also find the beat frequency. 9

3. (a) Derive differential equation of motion for the transverse vibration of a stretched string and establish an expression for the velocity. 6

(b) Obtain an expression for the path difference between two successive reflected rays in the case of a parallel thin film of refractive index μ and thickness t, and hence obtain conditions for bright and dark fringes. 9

4. (a) Explain with suitable diagram the formation of circular rings in Newton's rings experiment. Obtain an expression for the radius of the n^{th} ring and hence show that the rings get closer as their order increases. 9

(b) In Newton's rings experiment, the diameter of 20^{th} ring changes by 0.05 cm when a liquid is introduced between the lens and the plane glass plate. Find the refractive index of the liquid. 3

(c) In a bi-prism experiment, the eye piece is 120 cm apart from the source. The two virtual images of the source are separated by a distance of 0.075 cm. Find the wavelength of the light used if the cross-wire of the eye piece moves through a distance 1.888 cm for 20 fringes. 3

5. (a) What is Cornu's spiral and how it is formed ? Discuss Fresnel's diffraction at a straight edge using the concept of Cornu's spiral. 9

(b) What do you mean by resolving power of an optical instrument ? Obtain an expression for resolving power of a diffraction grating. 6

6. (a) With the help of necessary theory, derive expression for the intensity distribution pattern in Fraunhofer diffraction at double slit. 12

(b) Calculate the radius of the third half period element of a zone plate behaving as a convex lens of focal length 100 cm. The wavelength of light used is 4800 Å . 3

7. (a) Draw a labelled diagram showing interference due to Lloyd's single mirror. Why is the central fringe dark ? 5

(b) Explain the concept of Fresnel's half period elements and show that every zone has approximately the same area. 7

(c) Draw the intensity pattern for Fresnel's diffraction due to thin and thick wire, mentioning the difference between them. 3