WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 2nd Semester Examination, 2022

PHSACOR03T-PHYSICS (CC3)

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Answer Question No. 1 and *two* questions from the rest

1. Answer any ***ten*** questions from the following: 2×10 =20

(a) Show that the mutual inductance between two coils of self-inductance L_1 and L_2 cannot exceed $\sqrt{L_1 L_2}$.

(b) A coil of radius 1.5 cm and of 500 turns links with a magnetic field of 50 G. If the magnetic field is reversed in 0.01 sec, calculate the average e.m.f. induced in the coil.

(c) Show that, $\delta(ax) = \frac{1}{a}\delta(x)$, $a > 0$.

(d) Find the electric field at $(2, \pi/2, 0)$, if the potential is given by $V = \frac{10}{r^2}\sin\theta\cos\phi$.

[Components of gradient in spherical polar coordinates are given by $\left(\frac{\partial}{\partial r}, \frac{1}{r}\frac{\partial}{\partial \theta}, \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}\right)$.]

(e) Find the force on a square loop of side *s*, lying on the *y*-*z* plane, centered at the origin, if the loop carries a current *I* and the magnetic field is $\vec{B} = kz\,\hat{i}$, *k* is a constant.

(f) Consider a point charge *q* situated at the origin and a dipole of moment $\vec{p}$ is situated at $\vec{r}$ with $\vec{p}$ oriented along $\vec{r}$. Find the force on the dipole due to *q*.

(g) State Gauss's law in presence of dielectric.

(h) At each corner of a square is a particle with charge *q*. Fixed at the centre is a point charge of opposite sign, of magnitude *Q*. What value must *Q* have to make the total force on each of the four particles zero?

(i) The electrostatic potential in free space is given by

$$\phi = \alpha - \beta(x^2 + y^2) - \gamma \ln\sqrt{x^2 + y^2}$$

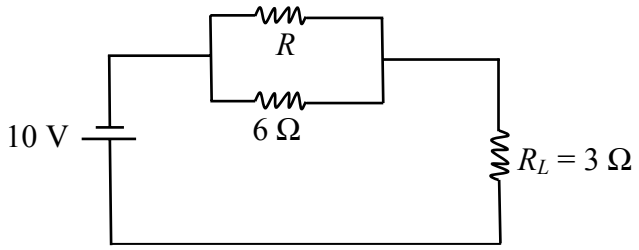
where α, β, γ are constants. Find the charge density in the region.

(j) A dielectric cylinder is defined by $x^2 + y^2 = r^2$, $z = 0$ and $z = h$. The polarization at a point (x, y, z) in the cylinder is $\vec{P} = x^2\hat{i} + y^2\hat{j}$. Determine the surface densities of polarization charge.

(k) Using the magnetic vector potential $\vec{A} = e^{-x}\sin y\hat{i} - (1+\cos y)\hat{j}$, determine the magnetic induction.

(l) Write a short note on the reciprocity theorem in electromagnetic induction.

(m) In the following circuit the value of R for maximum power transfer to the load $R_L = 3\ \Omega$ is :



(n) In a series RLC circuit, L = 10 mH, C = 1 μF, calculate the value of R for which the capacitor discharge is critically damped.

2. (a) A point charge 'q' is placed at a distance 'd' from the centre of a grounded conducting sphere of radius R, with $d > R$. Determine the position and magnitude of the image charge and also the distribution of charge over the surface of the sphere such that the net potential on the surface of the sphere is zero. $1\frac{1}{2}+1\frac{1}{2}+2$

(b) A point charge +6 esu is located 6 cm from the centre of a grounded conducting sphere of radius 5 cm. Determine the force of attraction experienced by the point charge. 2

(c) Consider a magnetized material with magnetization $\vec{M}$. Show that the magnetic vector potential is equivalent to that produced by a volume current $\vec{J} = \vec{\nabla}\times\vec{M}$ and a surface current $\vec{K} = \vec{M}\times\vec{n}$. 3

3. (a) Two insulating planar dielectric slabs having permittivity ε_1 and ε_2 respectively, are bonded together. Slab 1 has electric field $\vec{E}_1$ making an angle θ_1 to the surface normal. Find corresponding electric field $\vec{E}_2$ and angle θ_2 in absence of surface charge at the boundary. 2

(b) What are the components $\vec{E}_2$ and angle θ_2 in presence of surface charge at the boundary? 2

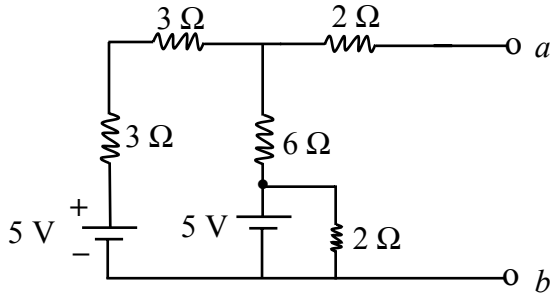
(c) The electric potential inside a dielectric sphere of radius a and permittivity ξ is $\phi(r, \theta) = kr\theta$, where k is a constant. Determine the volume density of polarization charge. 3

(d) A conducting wire of length 2 m and parallel to the y-axis is located at $z = 0$, $x = 1$ m in a region of uniform magnetic field of induction $\vec{B}$. The wire carries a current of 10 A in the negative y direction and experiences a force $\vec{F} = \frac{10^{-2}}{\sqrt{2}}(-\hat{i} + \hat{k})$ N. Find the x and z-components of $\vec{B}$. 3

4. (a) Show how a small current loop can be treated as a magnetic dipole. What is its dipole moment? 2+1

(b) A straight conducting wire of length $l = 1\hat{k}$ m moves with a velocity $\vec{v} = (2\hat{i} - 3\hat{j} + \hat{k})$ m/s in a region of uniform magnetic induction $\vec{B} = (2\hat{i} + \hat{j})\ T$. Find the voltage induced between the ends of the wire. 3

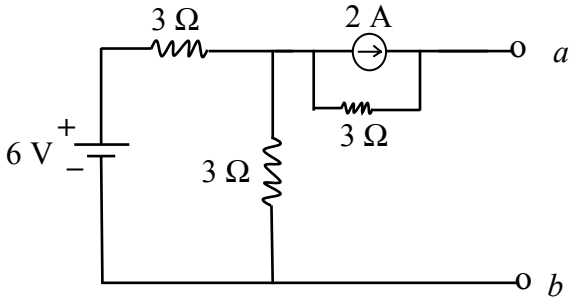
(c) 3+1



Find the Thevenin equivalent circuit of the above circuit diagram. Draw the Norton equivalent circuit also.

5. (a) A series combination of a resistance R and a capacitance C is connected in parallel to an inductance L. Determine the parallel resonant frequency. 3

(b) For the circuit below, determine the Norton equivalent source current and resistance with respect to the terminals a, b: 4



(c) An alternating source of 200 volt, 50 Hz is connected in series with a resistance of 20 Ω and an inductance of 1 Henry. What capacitance should be put in series with the combination to obtain maximum current? Find the potential difference across resistance, inductance respectively under the maximum current condition. 3

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within* 1 *hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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