Name:

Enrolment No:

UPES

End Semester Examination, May 2025

Course: Electricity and Magnetism **Semester:** II

Program: B.Sc. (H) Physics / B.Sc. (H) Physics by Research **Time:** 03 hours

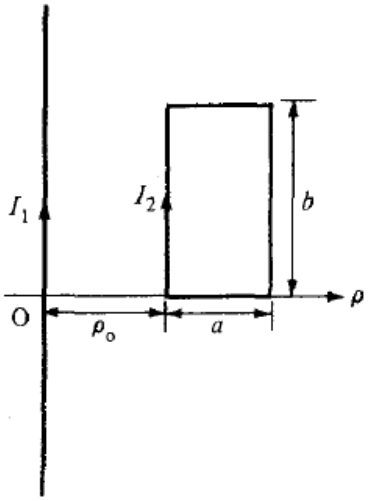
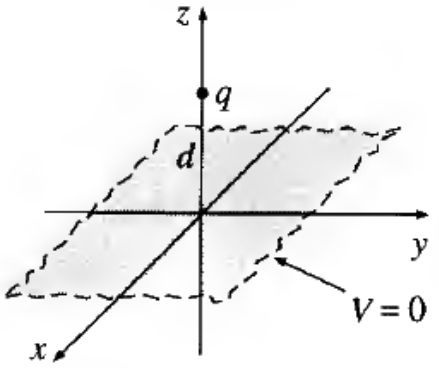
Course Code: PHYS1013 **Max. Marks:** 100

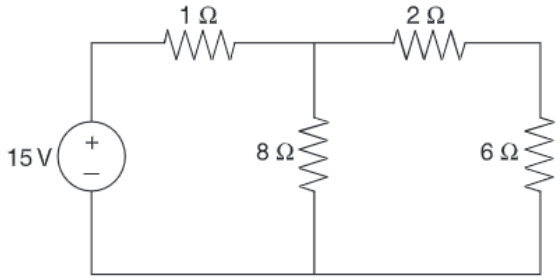
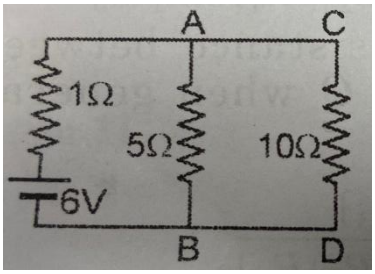
No. of pages: 3

Instructions: *Use of scientific calculators is permitted. All symbols have their usual meaning. Use appropriate diagram/schematic wherever necessary.*

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q1	State True or False: **(a)** For time varying fields, the divergence of $\vec{B}$ is non-zero. **(b)** For a conductor, any *net* charge always resides on the surface. **(c)** Magnetic forces cannot perform work. **(d)** Diamagnetic materials have positive susceptibility.	**4**	**CO1**
Q2	The magnetic flux through a coil is given as $\Phi = (4t^2 + 5t + 12)$ milliwebers. What would be the magnitude of the induced current in the coil at $t = 3$ seconds if the resistance in the loop is 29 mΩ?	**4**	**CO1**
Q3	Discuss in brief ferromagnetic and anti-ferromagnetic materials (with one example for each).	**4**	**CO1**
Q4	Prove that for time varying electromagnetic fields, $\vec{E}$ is non-conservative.	**4**	**CO2**
Q5	Using the Ampere's Circuital Law, derive an expression for the magnetic flux density $\vec{B}$ due to a solenoid.	**4**	**CO2**
	SECTION B **(4Qx10M= 40 Marks)** **Question 9 has an internal choice.**		
Q6	Using the Biot-Savart law, derive an expression for the magnetic field $\vec{H}$ at an arbitrary point due to a current carrying straight wire of finite length.	**10**	**CO2**
Q7	Using the continuity equation ($\frac{\partial \rho_v}{\partial t} = -\vec{\nabla}.\vec{J}$), prove that there is an exponential decay of the volume charge density with time in a material (assume that at $t = 0$, $\rho_v = \rho_v^0$).	**10**	**CO2**
Q8	A rectangular loop carrying current I_2 is placed parallel to an infinitely long straight wire carrying current I_1 as shown in the figure below. Illustrate that the force experienced by the rectangular loop is given by	**10**	**CO4**

	$\vec{F} = -\frac{\mu_o I_1 I_2 b}{2\pi}\left[\frac{1}{\rho_o} - \frac{1}{\rho_o + a}\right]\widehat{a_\rho}$  		
Q9	Apply the 'method of images' to determine the potential $V\ (x, y, z)$ in the region $z > 0$ for the charge distribution given in the figure (point charge q held a distance d above an infinite grounded conducting plane lying on the x-y plane).  **OR** In the case of two different dielectric materials, demonstrate that the tangential component of the electric field intensity $\vec{E}$ and the normal component of the electric flux density $\vec{D}$ are both continuous across the boundary between the two dielectrics (assume that there is no free charge present at the boundary).	**10**	**CO3**
SECTION-C (2Qx20M=40 Marks) Question 11 has an internal choice.			
Q10	Analyze a series LCR circuit to obtain **(i)** the current, **(ii)** phase difference between current and applied voltage, **(iii)** impedance, and **(iv)** resonance frequency. Hence plot X_L, X_C, R, and Z as a function of log ω.	**20**	**CO4**

Q11	**(a)** For the circuit given below, sketch the Thevenin's equivalent circuit considering the 6Ω resistor to be the load and hence calculate the current through the load resistance.  	**10**	**CO3**
	(b) A coil of resistance 60 Ω and inductance 3 henry is connected in series with a capacitor of 4μF and an A.C. supply of 200 volts (RMS value) and frequency 50 Hz. Calculate the **(i)** impedance, **(ii)** phase difference between the current and voltage, and **(iii)** the potential difference across the inductor and capacitor.	**10**	
	OR		
	(a) A 6-volt battery is connected to the resistances 1 Ω, 5Ω and 10Ω as shown in the figure below. Using Norton's theorem, calculate the current through the resistance 10Ω.  	**10**	
	(b) A series LCR circuit containing a resistor R_1, inductor L_1 and capacitor C_1 gives resonance at the same frequency (say *f*) as a different series LCR circuit having resistor R_2, inductor L_2 and capacitor C_2. If the two LCR circuits are connected in series, demonstrate that the whole circuit will also resonate with the same frequency *f*.	**10**	