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| **Name:**<br>**Enrolment No:** | |

**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**
**End Semester Examination, May 2024**

**Course: Electricity & Magnetism** — **Semester: II**
**Program: BSc (H) Physics by Research** — **Time : 03 hrs.**
**Course Code: PHYS 1013** — **Max. Marks: 100**

**Instructions:**

- There are 3 Sections such as Section A, B & C.
- Section A is compulsory, however, Section B & Section C have internal choices.
- Scientific calculator is allowed

**SECTION A**
**(5Qx4M=20Marks)**

| S. No. | | Marks | CO |
|---|---|---|---|
| Q1 | If the electric flux density ($\vec{D}$) is given as $$\vec{D} = \frac{2\cos\theta}{r^3}\hat{r} + \frac{\sin\theta}{r^3}\hat{\theta}\ \mathrm{C/m^2}$$ Find the charge density. The divergence of a vector field in spherical coordinates is given as: $$\vec{\nabla}\cdot\vec{A} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 A_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(A_\theta \sin\theta) + \frac{1}{r\sin\theta}\frac{\partial A_\varphi}{\partial\varphi}$$ | **4** | **CO1** |
| Q2 | Differentiate between diamagnetic and paramagnetic materials. | **4** | **CO2** |
| Q3 | Discuss briefly the concept of resonance in an LC circuit. | **4** | **CO1** |
| Q4 | For a magnetized material, considering magnetic flux density as $\vec{B} = \mu_0(\vec{H} + \vec{M})$, prove $$\vec{B} = \mu_0\mu_r\vec{H}$$ where $\vec{H}$, $\vec{M}$ and $\mu_r$ are magnetic field intensity, magnetization vector and relative permeability, respectively. | **4** | **CO2** |
| Q5 | Using the concept of electromagnetic induction, find an expression for transformer EMF in integral form. | **4** | **CO2** |

**SECTION B**
**(4Qx10M= 40 Marks)**

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| Q6 | What is a phasor diagram? | **10** | **CO3** |

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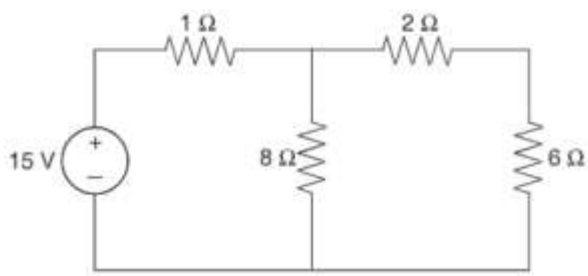
| | Using phasor algebra, find out the following for an LR circuit with an external voltage source $v(t) = 10\sin 10^6 t$:<br>• Impedance of the circuit<br>• The current flowing in the circuit ($i(t)$).<br><br>Prepare a plot of $i(t)$ Vs $\omega t$ considering $R = 10$ ohms and $L = 0.2$ henry. | | |
| Q7 | What are the characteristics of an ideal solenoid?<br><br>Considering a solenoid of length $l$, total number of turns as $N$, and current flowing in the solenoid as $I$, derive the magnetic field at the center of the solenoid. If the solenoid is kept in a medium having permeability as $\mu_m$, find the magnetic flux density due to the solenoid | **10** | **CO2** |
| Q8 | Explain Norton's theorem for solving electrical circuits. Using Norton's theorem, find the current through the 6Ω resistor in the given circuit below:<br><br> | **10** | **CO3** |
| Q9 | In a coaxial solenoid of length $l$, a current $i_2$ is flowing in the outer solenoid of radius $r_2$ and number of turns $N_2$. The inner solenoid of radius $r_1$, number of turns $N_1$ carries a current $i_1$. Find the mutual inductance of both the coils and prove that reciprocity theorem holds in this case.<br><br>**OR**<br><br>Discuss the significance of displacement current density in electromagnetics. Derive an expression for it and show how it completes Ampere's law. | **10** | **CO2** |
| **SECTION-C**<br>**(2Qx20M=40 Marks)** | | | |
| Q10 | A finite conductor carrying a current $I$ is placed along $z - a$xis. The length of the conductor is $l = z_2 - z_1$, where $(0,0,z_1)$ and $(0,0,z_2)$ are the coordinates of bottom and top most points of the conductor, respectively (see the figure below). Prove that the magnetic field intensity at any point P in space is given as:<br><br>$$\vec{H} = \frac{I}{2\pi\rho}(\sin\varphi_1 - \sin\varphi_2)\hat{\varphi}$$<br><br>The symbols are shown in the given diagram; $\varphi_1, \varphi_2$ are the angular positions of bottom and top most points of the finite conductor w.r.t. $\rho$, where $\rho$ is radial coordinate. | **20** | **CO4** |

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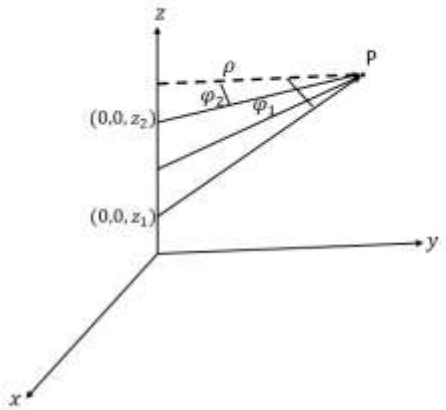
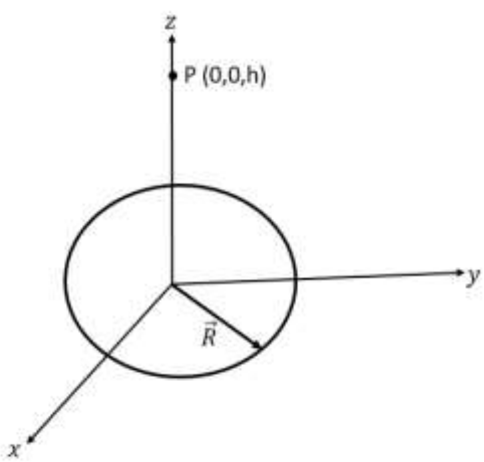



Using the expression for the magnetic field intensity for finite current carrying conductors, derive the magnetic field intensity for an infinite current conductor.

**OR**

State Ampere’s circuital law in integral and differential forms.

Using Biot-Savart Law, find the magnetic field intensity at point P (0,0,h) along $z-$ axis due to a circular loop of radius $R$ placed in the plane $z = 0$. The loop is carrying a current $I$. Find the magnetic field at the center of the circular loop and discuss.



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<td>Q11</td>
<td>Derive the current flowing in an LR circuit powered by ac voltage source $v(t) = V_0 \sin \omega t$ with the help of EMF equation.<br><br>Using the phasor diagram also, derive the resultant current in the circuit.</td>
<td>20</td>
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