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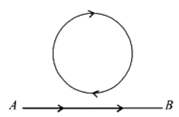
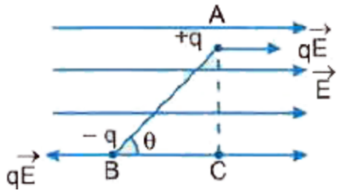
LUCKNOW REGION

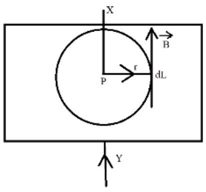
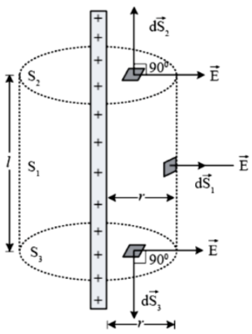
MONTHLY TEST OCTOBER-2024

SUBJECT – Physics **CLASS- 12th**

M.M. 40 **TIME: 90min**

Q. No.	**SECTION A**	**Marks**
1	(a) $F = \frac{1}{4\pi\epsilon_r} \cdot \frac{Q_1Q_2}{r^2}$ where ϵ_r is the dielectric constant of the medium. $F = \frac{1}{4\pi(5\epsilon_0)} \cdot \frac{Q_1Q_2}{r^2}$ $F' = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q_1Q_2}{r^2}$ $F' = 5F$	**1**
2	(c) I=6t mA. $Q = \int_0^3 6t\,dt$ $Q = 6\int_0^3 t\,dt = 6\left[\frac{t^2}{2}\right]_0^3 = 6\left(\frac{3^2}{2} - \frac{0^2}{2}\right) = 6\left(\frac{9}{2}\right) = 27\text{ mC}$	**1**
3	(b)ferromagnetic material becomes paramagnetic material.	**1**
4	**(a)**50 V ∵ ε=−Mdi/dt ∵ ε=−0.5×(7−3)/(0.04) =−0.5×40.04 =−50 V ∴ |ε|=50 V	**1**
5	(a)As the current increases, the number of magnetic lines of force passing through the loop increases in the outward direction. To oppose this change, the current will flow in the clockwise direction. 	**1**
6	(b)At lower temperature, resistance of metallic wire is less or slope of I-V graph is more. Hence, $T_1 < T_2$.	**1**
7	(a) $[\phi] = [BS] = [MT^{-2}A^{-1}][L^2] = [ML^2T^{-2}A^{-1}]$	**1**
8	B. Both (A) and (R) are true, but (R) is not the correct explanation of (A) Diamagnetic materials do not have a net magnetic moment in the absence of an external magnetic field. When an external magnetic field is applied, diamagnetic materials exhibit a weak repulsion to the field. This is because a small induced magnetic dipole moment is created in the opposite direction of the applied field Therefore, while diamagnetic substances do interact with magnetic fields, they do not have a permanent magnetic moment. This means that the reason (R) does not fully explain the assertion (A).	**1**

9	(A)The assertion states that "The direction of induced e.m.f. is always such as to oppose the change that causes it." This is a statement of Lenz's Law.The assertion is **correct**. The reason states that "The direction of induced e.m.f. is given by Lenz's Law." This is also true. The reason is also **correct**. In this case, the reason does explain the assertion	**1**
10	Consider an electric dipole AB placed in a uniform electric field $\vec{E}$ oriented at an angle θ with the field. As shown, forces q$\vec{E}$ and q$\vec{E}$ act on the two charges in mutually opposite directions. As the two forces act at two different points non-linearly, they constitute a couple whose torque is given by:  torque $\tau = (qE)$. Normal distance between the forces $=qE2a\sin\theta = pE\sin\theta$ $[\therefore p = q(2a)]$ The torque has a tendency to align the dipole along the direction of electric field. In vector notation, we can write that, $\vec{\tau} = \vec{p} \times \vec{E}$. When electric dipole is parallel to the electric field $\vec{E}, \theta = 0°$ and so the torque $\vec{\tau} = \vec{0}$. Moreover, potential energy of dipole [U= -pE sin θ] is minimum having a value U = -pE. So this represents the stable equilibrium position of dipole.	**0.5** **1** **0.5**
11	Net capacitance=$1\mu F = 10^{-6}F$ if $C_1 = C_2 = C_3 = C$ Let be the capacitance of each of three capacitors and C_3 and C_R be the capacitance of series and parallel combination respectively. then, $\frac{1}{C_s} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C} \Rightarrow C_1 = \frac{C}{3}$ $[C_1 = 1\mu F]$ $1\mu F = \frac{C}{3}$ $C = 3\mu F$ Also in $C_P = C + C + C + = 3 + 3 + 3 \Rightarrow C_P = 9\mu F$ Energy stored in capacitor $E = \frac{1}{2}CV^2 \Rightarrow \frac{E_S}{E_P} = \frac{\frac{1}{2}C_S V^2}{\frac{1}{2}C_P V^2} = \frac{C_S}{C_P} = \frac{1}{9} = 1{:}9$	**0.5** **0.5** **0.5** **0.5**
12	Total emf of three cells in series (3ε) = pot. Diff. corresponding to zero current $\therefore 3\varepsilon = 6V$ or $\varepsilon = \frac{6}{3} = 2V$ The internal resistance of each cell $r = \frac{\varepsilon}{I_{\max}} = \frac{2}{1} = 2\Omega$ OR Circuit (a) and (b) both show balanced Wheatstone.s bridge. Hence, we have $\frac{4}{R_1} = \frac{6}{9} \Rightarrow R_1 = 6\Omega$ and $\frac{6}{12} = \frac{R_2}{8} \Rightarrow R_2 = 4$ Ω $\therefore \frac{R_1}{R_2} = \frac{6}{4} = \frac{3}{2} \Rightarrow R_1 : R_2 = 3:2$	**1** **1** **1** **1**

13	Ampere's circuit law state that the line integral of the magnetic field B around a closed path is equal to the product of magnetic permeability of that space and the current through the area bounded by the path. That is $\oint B\cdot dL=\mu_0 I$ Where B is the magnetic field, μ_0 the magnetic permeability and I is the current through the area bounded by the path. Let us find the magnetic field at a point due to long straight wire carrying current I. Let an Ampereian loop of radius r which is circular and the wire carrying current pass through its centre P $\therefore \oint B\cdot \mathrm{d}\,L=\mu_0 I$ $\Rightarrow B\oint \mathrm{d}\,L=\mu_0 I$ $\Rightarrow B\cdot 2\pi r=\mu_0 I$ $\Rightarrow B=\frac{\mu_0 I}{2\pi r}$ $\Rightarrow B=\frac{\mu_0}{4\pi}\cdot\frac{2I}{r}$ 	**0.5** **1** **0.5**
14	An emf is induced in a single isolated coil due to change of flux through the coil by means of varying the current through the same coil. This phenomenon is called self-induction. In this case, flux linkage through a coil of N turns is proportional to the current through the coil and is expressed as $N\Phi_B \propto I$ $N\Phi_B = L\,I$ where constant of proportionality L is called self-inductance of the coil. Self-inductance of a coil is numerically equal to the amount of magnetic flux linked with the coil when unit current flows through the coil. The S.I. unit of self-inductance is henry (H). The self-inductance of an air core coil depends on the geometry of the coil that is (i) Number of turns (ii) area of cross section and intrinsic material properties (permeability of core material)	**0.5** **0.5** **1**
15	 Electric field $\vec{E}$ due to a straight uniformly charged infinite line of charge density λ : Consider a cylindrical Gaussian surface of radius r and length l coaxial with line charge. The cylindrical Gaussian surface may be divided into three parts : (1) curved surface S_1 (ii) flat surface S_2 and (iii) flat surface S_3 . By symmetry, the electric field has the same magnitude E at each point of curved surface S_1 and is directed radially outward. We consider small elements of surfaces S_1 , S_2 and S_3 . The surface element vector d $\vec{S}_1$, is directed along the direction of electric field (i.e., angle between $\vec{E}$ and d $\vec{S}_1$, is 0°); the elements d $\vec{S}_2$, and d $\vec{S}_3$, are directed perpendicular to field vector E (i.e., angle between d $\vec{S}_2$ and $\vec{E}$, and d $\vec{S}_3$, and $\vec{E}$ is 90°).	**1**

Electric flux through the cylindrical surface,

$$\oint_S \vec{E}.\vec{dS} = \oint_{S_1} \vec{E}.\vec{dS_1} + \oint_{S_1} \vec{E}.\vec{dS_2} + \oint_{S_1} \vec{E}.\vec{dS_3}$$

$$= \oint_{S_1} Ed\,S_1 \cos 0^0 + \oint_{S_1} Ed\,S_2 \cos 90^0 + \oint_{S_1} Ed\,S_3 \cos 90^0$$

0.5

$$= E\int dS_1 + 0 + 0$$

$= E \times$ area of curved surface $= E \times 2\pi rl$

Charge enclosed, $q = \lambda l$

0.5

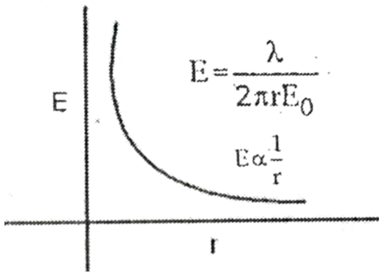
By Gauss' theorem, $\phi_E = \frac{q}{\varepsilon_0}$

$E.\ 2\pi rl = \frac{\lambda l}{\varepsilon_0}$

or $E = \frac{\lambda}{2\pi\varepsilon_0 r}$

0.5

b)



0.5

16

Force on charge q due to the charge -4q

$$F_1 = \frac{1}{4\pi \in_0 \alpha}\left(\frac{4q^2}{l^2}\right) \text{ along AB}$$

0.5

Force on the charge q. due to the charge 2q

$$F_2 = \frac{1}{4\pi n \in_0}\left(\frac{4q^2}{l^2}\right) \text{along CA}$$

0.5

the forces F_1 and F_2 are inclined to each other at an angle of 120°

Hence , resultant electric force on charge q

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

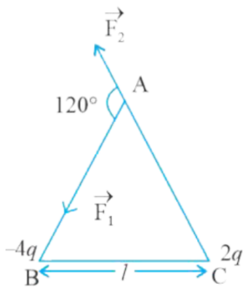
$$= \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta 120^\circ}$$

$$= \sqrt{F_1^2 + F_2^2 - F_1F_2}$$

$$= \left(\frac{1}{4\pi \in_0}\frac{q^2}{l^2}\right)\sqrt{16 + 4 - 8}$$

$$= \frac{1}{4\pi \in_0}\left(\frac{2\sqrt{3}\,q^2}{l^2}\right)$$

0.5



0.5

b) The amount of the work done to separate the charges at infinite distance is equal to the potential energy of the system.

The potential energy between two charges separated by a distance 'r' is

$$U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$$

Here the potential energy of the system is,

$$U = \frac{1}{4\pi\varepsilon_0 \times l}[(q \times -4q) + (q \times 2q) + (-4q \times 2q)]$$

$$U = \frac{1}{4\pi\varepsilon_0 \times l}[-4q^2 + 2q^2 - 8q^2]$$

$$U = \frac{1}{4\pi\varepsilon_0 \times l} \times (-10q^2)$$

0.5

therefore,

work done is

$$\frac{5q^2}{2\pi\varepsilon_0 l}$$

0.5

17	Current density is the amount of electric current that flows through a unit area (taken normal to the current) of a conductor, relaxation time is the average time between Relation between the resistivity and relaxation time : We know that drift velocity of electron is given by $v_d = \frac{eE}{m}\tau \text{but} E = \frac{V}{l}$ $\therefore V_d = \frac{e}{m}.\frac{V}{l}.Tau \Rightarrow V = \frac{v_d.ml}{e\tau}$ $\therefore$ According to Ohm's law $R = \frac{V}{I} = \frac{v_d ml/e\tau}{I} = \frac{v_d ml/e.\tau}{neAv_d} \Rightarrow R$ $= \frac{v_d ml}{e\tau.neAv_d} = \frac{m}{ne^2\tau}.\frac{l}{A}...(i)$ But the resistivity is given by $R = \rho\frac{l}{A}$ Comparing (i) and (ii), we get $\rho = \frac{m}{ne^2\tau}$ successive collisions of electrons in a conductor	**1** **1** **0.5** **0.5**
18	We know radius of circular path $r = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2mk}}{qB}$ (1) $\frac{r_p}{r_\alpha} = \frac{\frac{P}{qB}}{\frac{P}{qB}} = 2(\because P_p = P_\alpha)$ $\Rightarrow r_p : r_\alpha = 2:1$ (2) $\frac{r_p}{r_\alpha} = \frac{\frac{\sqrt{2mk}}{qB}}{\frac{\sqrt{2\times 4mk}}{2qB}} = \frac{2}{2} = 1$ $\Rightarrow r_p : r_\alpha = 1:1$ OR Magnetic field B at a distance x along the axis of a circular coil is given by: $B = \frac{\mu_0 NIR^2}{2(R^2+x^2)^{3/2}}$ - Here, μ_0 is the permeability of free space. Magnetic field B_1 at the midpoint due to Coil 1 is: $B_1 = \frac{\mu_0 NIR^2}{2(R^2+R^2)^{3/2}} = \frac{\mu_0 NIR^2}{2(2R^2)^{3/2}} = \frac{\mu_0 NIR^2}{2(2\sqrt{2}R^3)} = \frac{\mu_0 NI}{4\sqrt{2}R}$ Magnetic field B_2 at the midpoint due to Coil 2 is: $B_2 = \frac{\mu_0 NIR^2}{2(R^2+R^2)^{3/2}} = \frac{\mu_0 NI}{4\sqrt{2}R}$	**1** **1** **1** **1**

<table>
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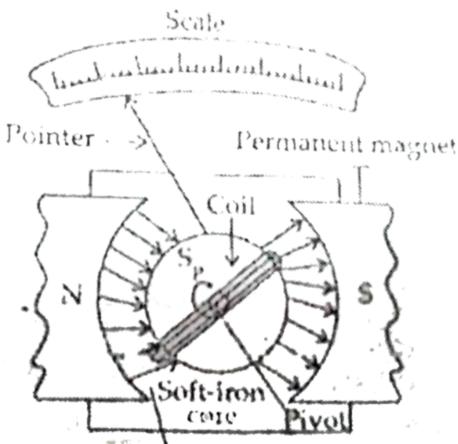
<td>Since both coils carry current in the same direction, the magnetic fields B_1 and B_2 at the midpoint will be in the same direction (using the right-hand rule).

The net magnetic field B_{net} at the midpoint is the sum of the two magnetic fields:
$$B_{net} = B_1 + B_2 = \frac{\mu_0 NI}{4\sqrt{2}R} + \frac{\mu_0 NI}{4\sqrt{2}R} = \frac{2\mu_0 NI}{4\sqrt{2}R} = \frac{\mu_0 NI}{2\sqrt{2}R}$$
The direction of the net magnetic field is along the axis of the coils, in the direction determined by the right-hand rule based on the current flow.</td>
<td>1

0.5

0.5</td>
</tr>
<tr>
<td>19</td>
<td>Moving coil galvanometer: It is a device used for the detection and measurement of small electric current.
Principle: The working is based on the fact that a current carrying coil suspended in a magnetic field experiences a torque.


Uniform radial magnetic field
Construction: It consists of a coil having a large number of turns of insulated copper wire wound on a metallic frame. The coil is suspended by means of a phosphorbronze strip and is surrounded by a horse shoe magnet NS. A hair spring is attached to lower end of the coil. The other end of the spring is attached to the scale through a pointer.
Working: When current is passed, say along ABCD, the couple acts on it. Since the plane remains always parallel to the magnetic field in all position of the coil (radial field), the force on the vertical arms always remains perpendicular to the place of the coil.
Let I = the current flowing through coil.
B = magnetic field supposed to be uniform and always parallel to the coil.
A = area of the coil
Deflecting torque acting on the coil is
τ=NIBAsin90∘=NIBA[∵sin90∘=1]
Due to deflecting torque, the coil rotates and suspension wire gets twisted . A restoring torque is set up in the suspension fibre. If ϕ is angle through which the coil rotates and K is the restoring torque per unit angular twist, then restoring torque, τ=kϕ.
In equilibrium
Deflecting torque = Restoring torque
NIBA=kϕ
$$\phi = \left(\frac{NAB}{k}\right) \text{ is the galvanometer constant}$$
∴ ϕ∝1
This provides a linear scale for the galvanometer.</td>
<td>1
1

0.5

0.5

0.5</td>
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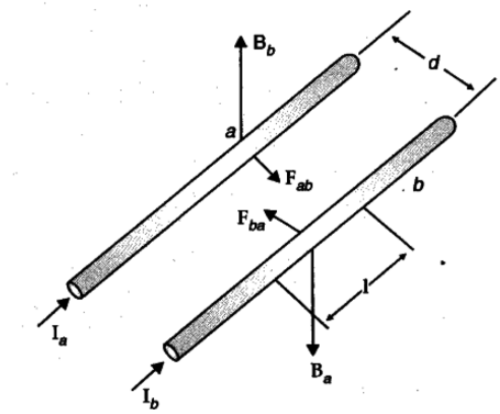
</table>

	The current sensitivity of a galvanometer is defined as the deflection per unit current. ∴ Current sensitivity $\phi/I = NAB/k$, where k= restoring torque per unit deflection. The voltage sensitivity of a galvanometer is defined as the deflection per unit voltage. ∴ Voltage sensitivity $\phi/V = NAB/k \cdot 1/R$, where R is the resistance of the galvanometer. Increase in current sensitivity may not necessarily increase the voltage sensitivity. To explain it let us double the number of turns N of galvanometer coil. So as to double the current sensitivity. However, on doubling the number of turns the resistance of galvanometer coil is also doubled from R to 2R consequently voltage sensitivity remains unchanged.	**0.5** **0.5** **0.5**
	OR	
	F_{ab} = Force experienced by wire 'a' of length 'l' due to magnetic field of wire 'b'. F_{ba} = Force experienced by wire 'b' of length 'l' due to magnetic field of wire 'a'. B_a = Magnetic field due to wire 'a'. B_b = Magnetic field due to wire 'b'. $B_a = \frac{\mu_0 I_a}{2\pi d}$ since $\vec{F} = i(\vec{l} \times \vec{B})$ $F_{ba} = I_2 l \frac{\mu_0 I_1}{2\pi d}$ Similarly, $F_{ab} = I_1 l \frac{\mu_0 I_2}{2\pi d}$ The direction of force experienced by the wire 'a' is toward the wire 'b'. (As shown in the diagram). Similarly the direction of force experienced by the wire 'b' is toward the wire Thus, the force is attractive.	**1** **1** **1**
	 	
	The ampere is the value of that steady current which, when maintained in each of the two very long straight parallel conductors of negligible cross-section and placed 1m apart in vacuum, would produce on each of these conductors force equal to 2×10^{-7} N/m of length.	**1** **1**

20	(i) Ans: (c) According to Joule law of heating Heat produced in a conductor, $H=I^2Rt$ where, I = Current flowing through the conductor R = Resistance of the. conductor t = Time. for which current flows through the conductor. $\therefore H \propto I^2$ (ii) Ans:(a) Doubled **Total heat** generated by the full length of wire is- $H = \frac{V^2}{R} t$ After cutting it in **two equal** part- We know that, $R \propto l$ So, it means **resistance becomes half**. $H = \frac{V^2}{\frac{R}{2}} t$ So, $H = 2\frac{V^2}{R} t$ Hence, **Heat generated** will be **double**. (iii) Ans: (b) Assuming the mains voltage V is 220V, we can calculate the resistance of each bulb. **For the 25W bulb:** $R_{25} = \frac{220^2}{25} = \frac{48400}{25} = 1936\,\Omega$ **For the 100W bulb:** $R_{100} = \frac{220^2}{100} = \frac{48400}{100} = 484\,\Omega$ In a series circuit, the same current flows through both bulbs. The power consumed by each bulb can be expressed as: $P = I^2R$ Since the current I is the same for both bulbs, the power is directly proportional to the resistance: $P \propto R$ From our calculations: - The resistance of the 25W bulb is $1936\,\Omega$. - The resistance of the 100W bulb is $484\,\Omega$. Since the 25W bulb has a higher resistance, it will consume more power when the same current flows through it. (iv) (d) Power(P) =Energy consumed(E)/time(t) E = P×t= 100×60= 6000 J	**1** **1** **1** **1**