FIRST TERMINAL EXAMINATION-AUGUST 2025

HSE II **PHYSICS**

	Answer Any 5 from 1 to 7	
1	Quantisation of charge	1
2	Zero	1
3	Infinity	1
4	(iii)Electric field between the plates	1
5	Remains the same	1
6	Ω m	1
7	a)Circular	1
	Answer any 5 questions from 8 to 14	
8	1. Field lines start from positive charges and end at negative charges. 2. In a charge-free region, electric field lines can be taken to be continuous curves without any breaks 3. Two field lines can never cross each other 4. Electrostatic field lines do not form any closed loops	2
9	a)$\phi_E = \frac{q}{\varepsilon_0} = \frac{8.85x}{8.85x}\frac{10^{-6}}{10^{-12}} = 10^6\ Nm^2/C$ b) $10^6\ Nm^2/C$ (No change)	1 1
10	1. There is no potential difference between any two points on the surface 2. no work is required to move any charge on the surface from one point to another 3. The electric field must be normal to the equipotential surface at every point.(Any 2)	2
11	Statement of Ohm's law Limitations(Any one) *1)*V ceases to be proportional to I 2) The relation between *V* and *I* depends on the sign of *V*.	1 1

12

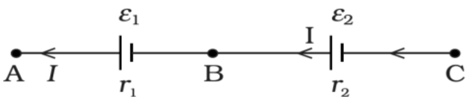
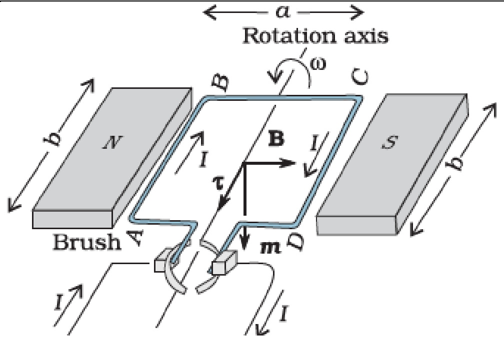
Polar	Non polar
Positive and negative charge centre does not coincide	Positive and negative charge centre coincide
Have permanenet dipole moment	Zero dipole moment
Eg: H_2O, HCl	Eg: O_2, H_2

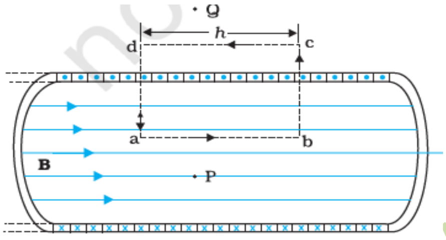
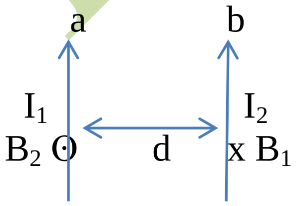
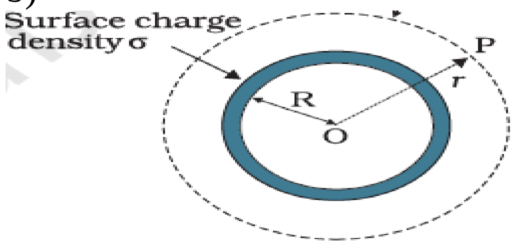
Any 1 difference

1

1

13	Magnitude of the drift velocity per unit electric field $\mu = \frac{\mathbf{|v_d|}}{\mathbf{E}}$ $[\mu] = [M^{-1}T^2A]$	1 1
14	$I_g = 3x10^{-3}A$; $R_G = 12\ \Omega$; V=18V Resistance to be connected in series to galvanometer,R = $\frac{V}{I_g}$ - R_G = $\frac{18}{3x10^{-3}}$ -12 =5988Ω	

	Answer any 6 questions from 15 to 21	
15	a)Statement of Coulomb's law b) $F=9x10^9\ x\ \frac{q_1q_2}{r^2}$ $= 9x10^9\ x\ \frac{2x10^{-6}\ x\ 3x10^{-6}}{(30x10^{-2})^2} = 0.6N$	1 2
16	a)Energy density is the energy stored per unit volume of space b) Energy U= $\frac{1}{2}CV^2$ $C = \frac{\varepsilon_0 A}{d}$ $\frac{1}{2}\frac{\varepsilon_0 A}{d}\ x\ E^2d^2$ V= Ed volume = Ad Energy density = $\frac{Energy}{volume} = \frac{1}{2}\frac{\varepsilon_0 A}{d}\frac{E^2d^2}{Ad}$ $\boxed{Ud\ = \frac{1}{2}\varepsilon_0 E^2}$	1 2
17	 $V_{AB} = V_B - V_A = \varepsilon_1 - Ir_1$ ....(1) $V_{BC} = V_C - V_B = \varepsilon_2 - Ir_2$ ....(2) Effective p.d, $V_{AC} = V_C - V_A = V_{AB} + V_{BC}$ $= \varepsilon_1 - Ir_1 + \varepsilon_2 - Ir_2$ $= \varepsilon_1 + \varepsilon_2 - I(r_1 + r_2)$ ...(3) Equivalent p.d V= $V_{AC} = \varepsilon_{eq} - Ir_{eq}$.(4) From (3) and (4) $\boxed{\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2}$ $\boxed{r_{eq} = r_1 + r_2}$	3
18	a)Drift speed is the average speed with which electrons are drifted in the presence of electric field through a conductor b) I = neAV$_d$ --> $V_d = \frac{I}{neA}$ $= \frac{10}{\mathbf{10^{30}}\ X\ 1.6X10^{-19}X2X10^{-4}}$ $=0.3125x10^{-6}A$ = 0.3125μA	1 2
19	 Let a rectangular loop ABCD is placed in a uniform magnetic field B making an angle ϴ with normal to the loop	3

	The forces on the two arms AD and BC are equal and opposite and along the axis of the loop cancel out. The forces on arms AB and CD are **F_1** and **F_2** are equal and opposite, with magnitude $F_1=F_2$ = IbB but not collinear produces torque given by Torque $\tau= F_1\mathrm{x}\frac{a}{2}\sin\theta + F_2\mathrm{x}\frac{a}{2}\sin\theta$ $= I\,b\,B\frac{a}{2}\sin\theta += I\,b\,B\frac{a}{2}\sin\theta$ $= I\,b\,B\,a\sin\theta$ $= I\,A\,B\sin\theta$ $\boxed{\tau = m\,B\sin\theta}$	
20	a)Statement of Ampere's circuital law b) The field between two neighbouring turns vanishes since magnetic field due to one circular loop is opposite to that due to nearby loop. Also the field at the exterior mid-point Q is very weak and for a long solenoid the field approaches zero.  For the rectangular Amperian loop abcd, along cd the field is zero and along bc and ad, component of field is zero. Let the field along ab be *B* and thus the relevant length of the Amperian loop is, *L = h.* Let *n* be the number of turns per unit length, then the total number of turns is *nh*. The enclosed current is, $I_e = I\,n\,h$, where *I* is the current in the solenoid. Now, Ampere circuital law $\int\vec{B}.d\vec{l} = \mu_0 I_e \rightarrow BL = \mu_0 I_e$ $B\,h = \mu0I\,n\,h$ $\boxed{B = \mu_0\,n\,I}$	1 2
21	 The conductor 'a' produces a magnetic field $B_1 = \frac{\mu_0 I_1}{2\pi d}$ away from observer. Now conductor 'b' will experience a force in a segment L is, $F_{ba} = I_2 l_2 B_1 = I_2 l_2\,\mathrm{x}\,\frac{\mu_0 I_1}{2\pi d} = \frac{\mu_0 I_1 I_2}{2\pi d}L$ Force per unit length $f_{ba} = \frac{\mu_0 I_1 I_2}{2\pi d}$ …(1) towards left The conductor 'b' produces a magnetic field $B_2 = \frac{\mu_0 I_2}{2\pi d}$ towards the observer. Now conductor 'a' will experience a force in a segment L is, $F_{ab} = I_1 l_1 B_2 = I_1 l_1\,\mathrm{x}\,\frac{\mu_0 I_2}{2\pi d} = \frac{\mu_0 I_1 I_2}{2\pi d}L$ Force per unit length $f_{ab} = \frac{\mu_0 I_1 I_2}{2\pi d}$ …(2) towards left From (1) and (2) it is clear that magnitudes… $f_{ba} = f_{ab} = \frac{\mu_0 I_1 I_2}{2\pi d}$	3
	Answer any 3 questions from 22 to 25	
22	a) Electric field intensity is the electric force per unit charge. E = F/q b) N/C or V/m c) Intensity $E = \frac{F}{q}$ For a point charge Q, the force acting on a charge q at a distance r is, $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ Now intensity $E = \frac{F}{q} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$	1 1 2
23	a)Statement of Gauss' law b) 	1

Let σ be the uniform surface charge density of a thin spherical shell of radius *R*. 3

(i) Field outside the shell

Let P be appoint at distance r (r >R). The gaussian surface is a sphere with O as the centre. Electric field E and area ds are in the same direction. Then electric flux through the small area ds is ,$d\varphi = \vec{E}.d\vec{s}$

Total electric flux through the Gaussian sphere, $\varphi = \int_s \vec{E}.d\vec{s} = \int_s E\, ds \cos 0 = E \int_s ds$

But $\int_s ds = 4\pi r^2$

$\varphi = E \times 4\pi r^2$ …… (1)

Gauss law→ $\varphi_0 = \frac{q}{\varepsilon_0} = \frac{\sigma\, 4\pi R^2}{\varepsilon_0}$ …. (2)

(1) & (2) gives $E \times 4\pi r^2 = \frac{q}{\varepsilon_0}$

ie , $\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}}$ or $\boxed{E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2}}$ …(3)

(i) Field on the surface r= R

(3) → $\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}}$ or $\boxed{E = \frac{\sigma}{\varepsilon_0}}$

(i) Field inside the shell(r<R)

The gaussian surface is a sphere with O as the centre and r <R. No charge inside the Gaussian surface. $\varphi = E \times 4\pi r^2 = \frac{1}{\varepsilon_0} \times 0 = 0$ → E = 0

24 a) medium between the plates, area of each plate, distance between the plates. **(1 ½)**

b) $U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{\varepsilon_0 A}{d}V^2$ **(2 ½)**

$$U = \frac{1}{2}\frac{\varepsilon_0 A}{d}V^2 = \frac{8.85X10^{-12}X\,0.2}{2X\,0.01}X\,10^6$$

$$= 8.85 \times 10^{-5}\,J$$

$$d' = d - \frac{10}{100} \times d = 0.01 - 0.1 \times 0.01 = 0.009m$$

$$U' = \frac{1}{2}\frac{\varepsilon_0 A}{d'}V^2 = \frac{8.85X10^{-12}X\,0.2}{2X\,0.009}X\,10^6$$

$$= 9.833 \times 10^{-5}\,J$$

Change in U = U'-U $= 0.983 \times 10^{-5}$ J

25 a) Magnetic Lorentz force or Lorentz force 1

b) We have $F_m = q\,v\,B\,\sin\Theta$ 1

When charge is at rest, v=0 Then $F_m = 0$

c) Consider a rod of a uniform cross-sectional area A and length *l*. Then total number of charge is *nAl* and total charge is *q=nAle*. When this conductor is placed in a magnetic field B, it experience a force given by, 2

$F = q\,v\,B\sin\Theta$

$= nAle\, v_d \sin\Theta$ ……(1)

But we have $I = neAv_d$ or $v_d = \frac{I}{neA}$

(1) → $F = nAle \frac{I}{neA}\sin\Theta$

$\boxed{F = I\,l\,B\sin\Theta}$

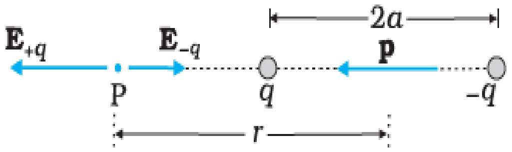
Or $\boxed{\vec{F} = I(\vec{l} X \vec{B})}$

Answer any 3 questions from 26 to 29

26 a) Electric dipole 1

b) For stable equilibrium, angle between $\vec{p}$ and $\vec{E}$ is 0^0 . For unstable equilibrium, angle between $\vec{p}$ and $\vec{E}$ is 180^0 . 1

c) consider an electric dipole of magnitude of charge q , separation 2a and dipole moment p. Let the point P be at a distance r from the centre of dipole on its axial line. 3



Now electric field due to –q charge and +q at P are ,

$E_{-q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$ ….(1) towards right

$E_{+q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2}$ ….(1) towards left

Resultant intensity at P is

$E = E_{+q} - E_{-q}$

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$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)^2} - \frac{1}{4\pi\varepsilon_0}\frac{q}{(r+a)^2}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{4rl}{(r^2-a^2)^2}\right]$$

Since $a^2 <<< r^2$ $(r^2 - a^2)^2 = r^4$

$$E = \frac{q}{4\pi\varepsilon_0} x \frac{4l}{r^3}$$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}}$$

27

a) Zero. 1

Work done = Potential difference =0

b) i. $\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} \rightarrow \frac{1}{4} = \frac{1}{20} + \frac{1}{C}$ 1

$\frac{1}{C} = \frac{1}{4} - \frac{1}{20} \rightarrow C = \frac{20X4}{20-4} = \frac{80}{16} = 5\mu F$

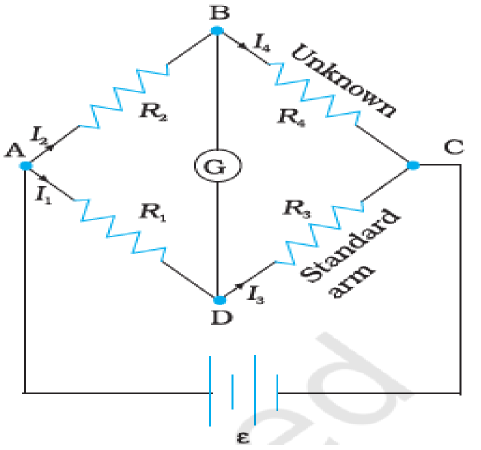
b) ii. Since the capacitors are connected in series charge on both capacitors are same. 3

$Q = \frac{C_{eff}}{V} = \frac{5X10^{-6}}{12} = 0.416\ \mu C$

28

a) Statement of junction rule and Loop rule 2

b) 2



For the loop ABDA, loop rule becomes,

$I_2R_2 + I_gR_G - I_1R_1 = 0$ ….(1)

For the loop BCDB, loop rule becomes,

$I_4R_4 - I_3R_3 - I_gR_G = 0$ ….(2)

28 2

By adjusting the values of resistors, make the value of $I_g = 0$, then the wheatstones bridge is said to be balanced, then $I_2 = I_4$ & $I_1 = I_3$ 2

Now (1) and (2) becomes

$I_2R_2 + 0 - I_1R_1 = 0$ OR $I_2R_2 = I_1R_1$ …(3)

$I_2R_4 - I_1R_3 - 0 = 0$ OR $I_2R_4 = I_1R_3$ …(4)

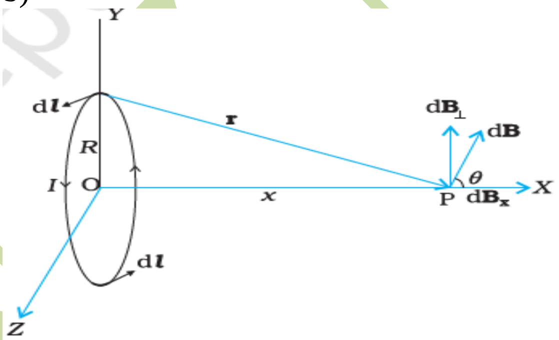
Then $\frac{(3)}{(4)} \rightarrow \frac{R_2}{R_4} = \frac{R_1}{R_3}$ OR $\boxed{\frac{\boldsymbol{R_1}}{\boldsymbol{R_2}} = \frac{\boldsymbol{R_3}}{\boldsymbol{R_4}}}$

c) No change 1

29

a) statement of Biot- Savert law 1

b) 4



Consider circular loop carrying a steady current I having radius R in YZ plane. Let P be a point at a distance x from the centre of the loop.

The magnitude dB of the magnetic field due to dl is given by the Biot-Savart law,

$dB = \frac{\mu_0}{4\pi}\frac{I\,dl\sin\theta}{r^2}$ here $\theta = 90^0$

Now, $dB = \frac{\mu_0}{4\pi}\frac{I\,dl}{r^2}$ ….(1) in the XY plane as shown in figure

A current element diametrically opposite to above dl produces dB of same magnitude in the XY plane. The Vertical components dB sin θ cancel out but horizontal components dBCosθ adds up

Now Total Magnetic field due to entire loop is

$B = \Sigma\, dB \text{ Cos } \theta$

$= \Sigma \frac{\mu_0}{4\pi}\frac{I\,dl}{r^2} \text{ Cos } \theta = \frac{\mu_0}{4\pi}\frac{I}{r^2} \text{ Cos } \theta\ \Sigma dl$

But $r^2 = x^2 + R^2$ and $\text{Cos } \theta = \frac{R}{(x^2+R^2)^{\frac{1}{2}}}$

Also $\Sigma dl = 2\pi R$

Now $B = \frac{\mu_0}{4\pi}\frac{I}{(x^2+R^2)^{\frac{3}{2}}} 2\pi R^2$

$$\boxed{B = \frac{\mu_0}{2}\frac{IR^2}{(x^2+R^2)^{\frac{3}{2}}}}$$