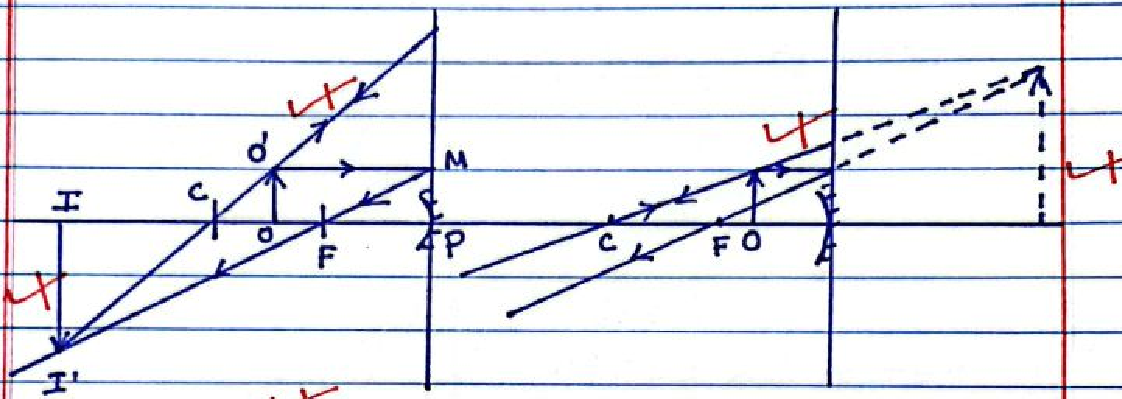
1 (a) The incident ray, the reflected ray, the normal, all at the point of incidence lie in the same plane.

The angle of incidence is equal to the angle of reflection.

(b) (i)



object, image rays

- Real images are formed by intersection of real rays while virtual images are formed by apparent intersection of rays.
- Real images can be formed on the screen while virtual images cannot.
- Real images are formed infront of the mirror while virtual images are formed behind the mirror.

(b)(ii) From Δs OCO' and CII'

$$\frac{OC}{CI} = \frac{OO'}{II'} \text{ -------- (i)}$$

From Δs FPM and FII'

$$\frac{FP}{FI} = \frac{MP}{II'} \text{ -------- (ii)}$$

But $MP = OO' \Rightarrow \frac{OC}{CI} = \frac{PF}{IF}$

Also $OC = CP - OP$

$CI = IP - CP$, $IF = IP - PF$

$$\therefore \frac{CP - OP}{IP - CP} = \frac{PF}{IP - PF}$$

$\Rightarrow \dfrac{v-u}{v-r} = \dfrac{f}{v-f}$, but $r = 2f$

$\therefore \dfrac{2f-u}{v-2f} = \dfrac{f}{v-f}$

$\Rightarrow (2f-u)(v-f) = (v-2f)f$

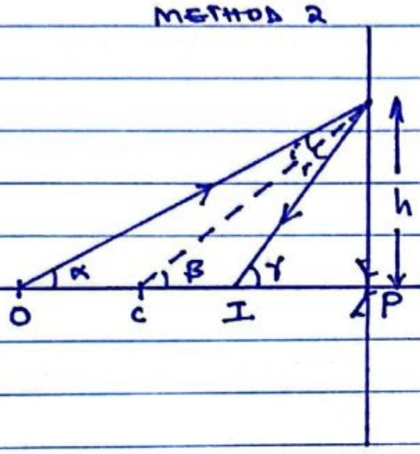
$2vf - 2f^2 - uv + uf = vf - 2f^2$

$vf - uv + uf = 0$

$vf + uf = uv$ Dividing through by uvf,

$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$ 04

METHOD 2



$i = r$

$\alpha + i = \beta$ and $\beta + r = \gamma$

$i = \beta - \alpha$, $r = \gamma - \beta$

$\Rightarrow \beta - \alpha = \gamma - \beta$

$\therefore 2\beta = \alpha + \gamma$

For small angles measured in radians,

$\alpha \simeq \tan\alpha = \dfrac{h}{OP}$, $\beta \simeq \tan\beta = \dfrac{h}{CP}$, $\gamma \simeq \tan\gamma = \dfrac{h}{IP}$

$\dfrac{2h}{CP} = \dfrac{h}{OP} + \dfrac{h}{IP} \Rightarrow \dfrac{2}{r} = \dfrac{1}{u} + \dfrac{1}{v}$ (04)

But $r = 2f$

$\dfrac{2}{2f} = \dfrac{1}{u} + \dfrac{1}{v} \Rightarrow \dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$

(c) $M = \dfrac{v}{u} = -3$, $v = -3u$

$\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$ $f = \dfrac{r}{2} = \dfrac{30}{2} = 15\text{cm}.$

$\dfrac{1}{15} = \dfrac{1}{u} + \dfrac{1}{-3u}$

$\dfrac{1}{15} = \dfrac{3-1}{3u} \Rightarrow \dfrac{3u}{15} = 2$ $\therefore u = 10\text{cm}.$ (03)

Method 2

$r = 30cm$, $m = 3$

$m = \frac{v}{u} = 3$ ⇒ $v = 3u$

$r = 2f$ ⇒ $f = 15cm$

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ ⇒ $\frac{1}{15} = \frac{1}{u} - \frac{1}{3u}$

$\frac{1}{15} = \frac{3-1}{3u}$ ⇒ $3u = 30$ ∴ $u = 10cm$ (03)

Method 3

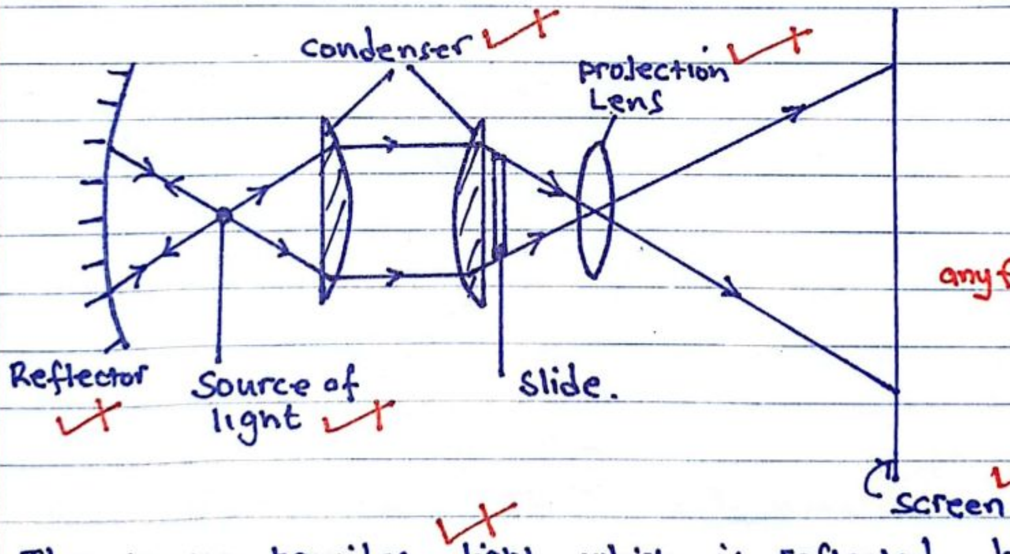
$\frac{1}{m} = \frac{u}{f} - 1$, $f = \frac{r}{2} = \frac{30}{2} = 15cm$.

$m = \frac{v}{u} = -3$

$\frac{-1}{3} = \frac{u}{15} - 1$

$u = 10cm$. (03)

(d)



- The source provides light which is reflected by the concave reflector.
- The condenser concentrates light on the slide
- The projection lens focuses a magnified Image on the screen. (04)

(e) $m = \frac{300}{5} = 60$, $\frac{v}{u} = 60$, $u = \frac{2400}{60} = 40cm$.

$v = 2400cm$, $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{40} + \frac{1}{2400}$, $f = 39.3cm$. (03)

2(a) (i) The Incident ray, the normal and the refracted ray, at the point of incidence all lie in the same plane.

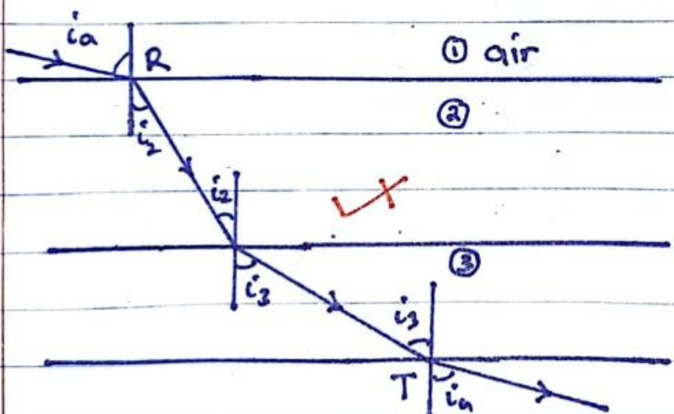
The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant for agiven pair of media. (02)

(ii) Refractive index of a medium is the ratio of the sine of angle of incidence to the sine of angle of refraction for a ray travelling from a vacuum or air to a medium. (01)

OR

It is the ratio of the speed of light in vacuum or air to the speed of light in a medium

(b) Consider aray travelling through different media as shown.



At R, $_a n_2 = \frac{\sin i_a}{\sin i_2}$, $\sin i_a = {_a n_2} \sin i_2$ ------(i)

At T, $_3 n_a = \frac{\sin i_3}{\sin i_a}$, $\sin i_a = \frac{1}{_3 n_a} \sin i_3$ But $_3 n_a = \frac{1}{_a n_3}$

$\therefore \sin i_a = {_a n_3} \sin i_3$ -------(ii)

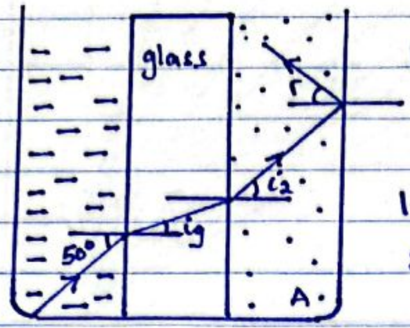
$\sin i_a = {_a n_2} \sin i_2 = {_a n_3} \sin i_3$ $n_a = 1$

$_a n_2 = n_2$ $_a n_3 = n_3$

$\therefore \sin i_a = n_2 \sin i_2 = n_3 \sin i_3$ (04)

$\therefore n \sin i = \text{constant}.$

(c)



Using $n \sin i$ = constant

At point X,

$n_w \sin i_w = n_g \sin i_g$

$1.33 \sin 50° = 1.50 \sin i_g$

$\sin i_g = \frac{1.33 \sin 50°}{1.5}$

$i_g = 42.78°$

At B, $1.5 \sin 42.28 = 1.25 \sin i_2$, $i_2 = 54.59°$

but $i_2 = r$, $r = 54.59°$ (05).

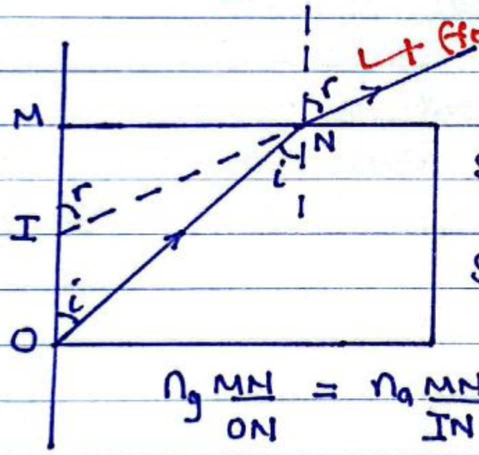
Method 2

$n_w \sin i_w = n_2 \sin i_2$

$1.33 \sin 50° = 1.25 \sin i_2$, $i_2 = 54.59°$

But $r = i_2$, $r = 54.59°$

(d)



(for angles).

$n_g \sin i = n_a \sin r$

$\sin i = \frac{MN}{ON}$

$\sin r = \frac{MN}{IN}$

$n_g \frac{MN}{ON} = n_a \frac{MN}{IN} = \frac{MN}{IN}$ $n_a = 1$

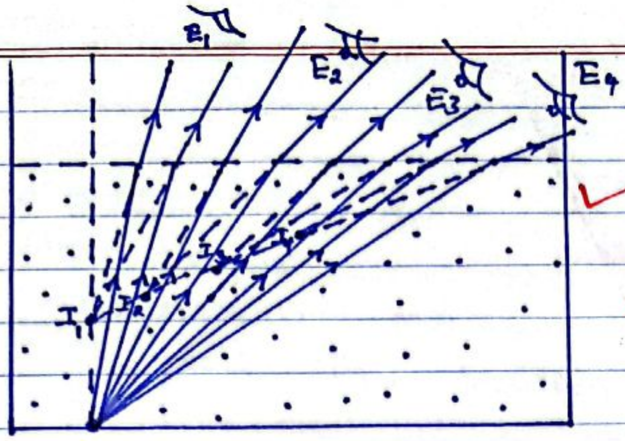
$n_g = \frac{NM}{IN} \times \frac{ON}{NM} = \frac{ON}{IN}$

Since i and r are small angles in radians,

$ON \approx OM$ and $IN \approx IM$ (04)

$\therefore n_g = \frac{OM}{IM} = \frac{\text{Real depth}}{\text{apparent depth}}$

(e)



Three diffrent positions of eye. (1 mark)

2 pts → $\frac{1}{2}$ mk

Light from the object O, is refracted away from the normal as it emerges from the water surface and the object appears displaced to I_1

As the eye moves away from E_1, the angle of incidence increases hence the angle of refraction leading to greater apparent displacement.

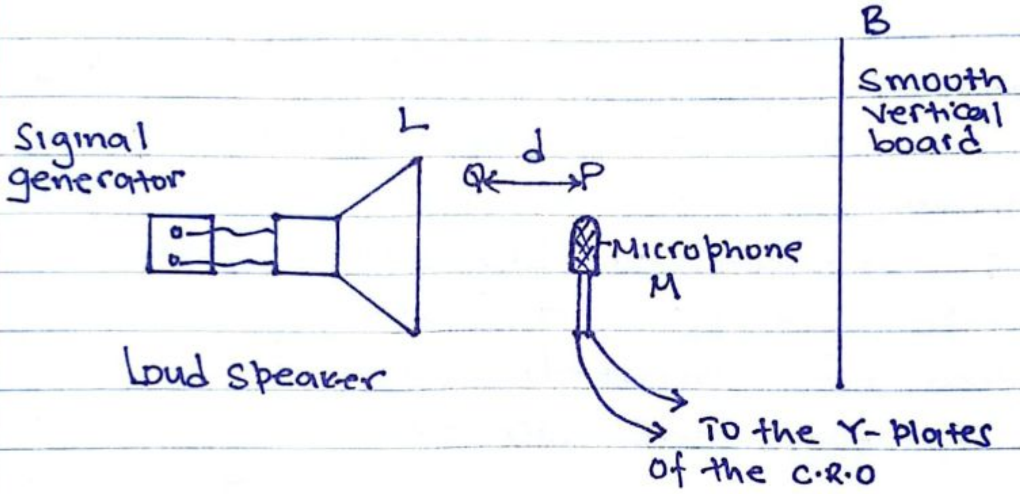
The position of the Image therefore moves along the curve as the eye moves away from E_1 (04)

3(a) (i) When two waves of equal frequency equal wavelength and equal amplitude travelling in the same medium in opposite directions meet, they superpose.
Where they arrive in phase, reinforcement takes place and maximum amplitude (Intensity) is observed. This position is the antinode.
Where they meet out of phase, cancellation takes place and amplitude (Intensity is zero. This position is the node.

Accept Identical waves. (coherent sources)

(04)

(ii)



. A Loud speaker L, microphone, M and a vertical metal sheet B are arranged as shown above
. The loud speaker is connected to a signal generator of known frequency, f
. The microphone is connected to Y-plates of a CRO with time base switched off.
. The microphone is moved slowly away from B towards L until the length of the vertical trace on the screen of the CRO is maximum.
. The position P of the microphone is noted and distance BP measured.
. The microphone is further moved away from B towards L until the length of the vertical trace again becomes maximum.

- The new position Q of the microphone is noted and the distance BQ measured and recorded.
- The distance between P and Q is calculated and recorded as d,

$$d = BQ - BP = \frac{\lambda}{2}$$

$$\lambda = 2d \;; \quad v = f\lambda$$
$$v = 2df$$

- The velocity of sound is determined from the above equation. (05)

(b). It is used in radar speed traps to measure the velocity of vehicles.
- Microwaves are sent from the gun towards approaching vehicle and get reflected.
- The machine detects the frequency of the reflected waves, determines the beat frequency and calculates the speed of the vehicles. (03)

(c) v- Velocity of the wave
u- velocity of the train.
f- frequency of the waves.

- The apparent wavelength of the waves recieved by the observer, $\lambda' = \frac{v-u}{f}$
- The apparent speed recieved by the observer due to echo, $v' = v+u$
- The apparent frequency of the waves recieved, $f' = \frac{v'}{\lambda'}$

$$= \left(\frac{u+v}{v-u}\right)f$$

(04)

(c) (ii) The apparent wavelength of the waves recieved $\lambda' = \frac{v+u}{f}$

The apparent speed of the waves recieved $v' = v - u$

Apparent frequency, $f' = \left(\frac{v-u}{v+u}\right) f$

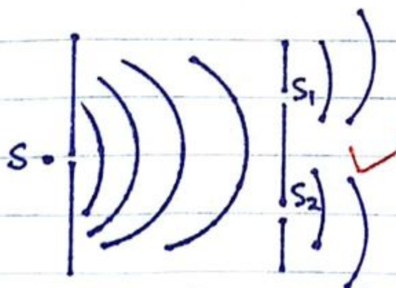
$$\Rightarrow f' = \left(\frac{330-25}{330+25}\right) \times 980 = 842\,Hz$$

OR $$f' = \left(\frac{340-25}{340+25}\right) \times 980 = 845.7\,Hz$$

4(a) Coherent sources are sources of waves of

- Equal frequency and equal wavelength.
- Equal or nearly equal amplitude.
- which superpose with constant phase relationship (03)

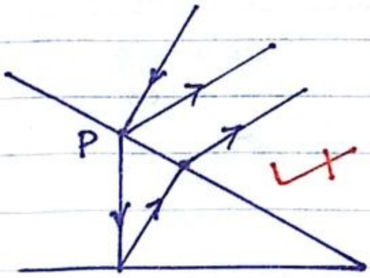
(b)(i)



- Suppose wave fronts diffracting through slit, S. Slits S_1 and S_2 are equidistant from S.
- The wave fronts diffracting through S_1 is from the same wavefront as that diffracting through S_2. Therefore sources S_1 and S_2 are created by division of wave front. (02)

- Consider athin beam of light incident almost normally on an air wedge above.
- It is partly reflected by the bottom surface of the upper slide at Y and partly transmitted light is reflected by the top surface of the lower glass slide at X.
- X and Y are sources created by division of the same wave energy.
- Since wave energy is proportional to the square of the amplitude, the sources are formed by division of amplitude. (02)

(c)(i)



- Monochromatic light is made incident almost normally onto the upper glass slide.
- It is partly reflected at the bottom surface of the upper glass slide and partly transmitted through the air film.
- The transmitted light is reflected at the top surface of the lower glass slide.
- The two wavetrains meet above the air wedge and Interfere.
- Where they meet with the optical path difference equal to an Integral multiple of a full wavelength a dark band is formed.

where they meet with geometrical path difference equal to an odd mutiple of half wavelength a bright band is formed. This is because reflection at the top surface of the lower plate occurs at boundary with a dense medium and hence the wave suffers a phase change of 180° equivalent to travelling an extra path length of $\frac{\lambda}{2}$. A series of straight alternate dark and bright fringes are formed which is an interference pattern. (05)

(ii) $\Delta x = \frac{\lambda s}{2t} \Rightarrow t = \frac{\lambda s}{2 \cdot \Delta x}$

But $\Delta x = \frac{5.0}{20} \times 10^{-3} m$

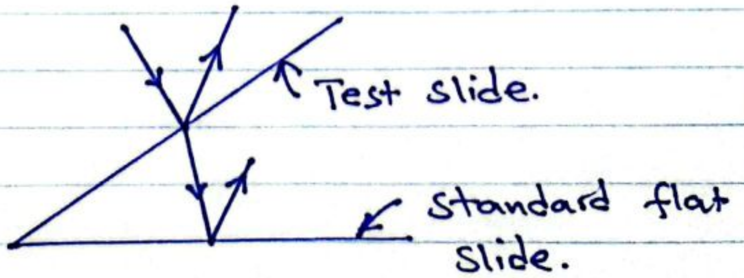
$\Rightarrow t = \frac{500 \times 10^{-9} \times 10.0 \times 10^{-2}}{2 \times \frac{5.0}{20} \times 10^{-3}}$

$\Rightarrow t = 1.0 \times 10^{-4} m.$

(d) (i) Constructive Interference is said to occur when two light waves superpose in phase form a bright band.

Destructive Interference is said to occur when two light waves superpose completely to form a dark band. (02)

(ii)



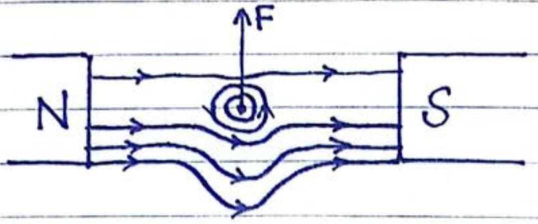
- The test slide is placed in contact with a standard flat slide to form an air wedge. Monochromatic light is directed almost normally onto the wedge and Interference pattern formed are viewed from above.
- If regular fringes parallel to the line of contact is observed, the test slide is flat. Any areas showing irregular patterns correspond to the areas on the surface that are not flat. (03)

Accept Newton's ring experiment

20

5(a)(i) Magnetic field line. Direction of the path which an Isolated N-pole of a magnet would take when placed in magnetic field. (01)

(ii)



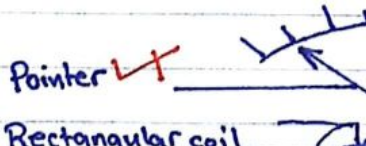
Magnetic field due to current in the wire interacts with the applied field to form the resultant pattern which is stronger on the lower side and weaker on the upper side.
A force therefore develops which acts on the wire from direction of strong to weak field. (04)

(b) Mechanical power = Electrical power
Mechanical power = FV
Electrical power = EI but E = BLV

$$FV = BLVI$$
$$F = BIL$$ (04)

(c)(i) $B = \frac{\mu_0 I}{2\pi a}$

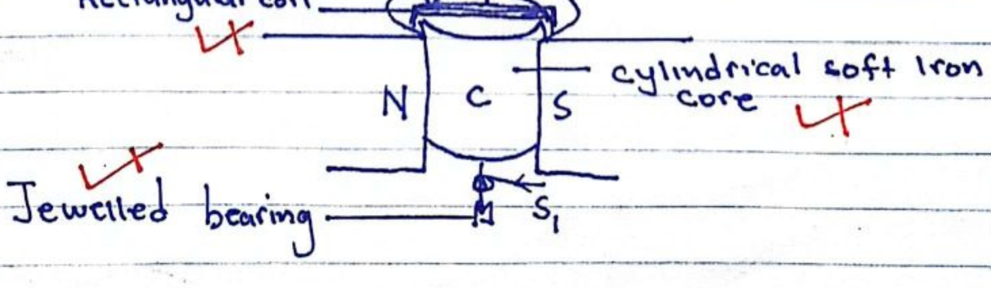
(ii)



$B_B - B_A = 0$
$\Rightarrow B_B = B_A$

$$\frac{\mu_0 5}{2\pi(x+0{\cdot}2)} = \frac{\mu_0 3}{2\pi x}$$

$\Rightarrow x = 0{\cdot}3m.$ (03)



(02)

- The current to be measured is let in and out by the hair springs.
- The coil experiences a magnetic torque $\tau = BANI$ and turns together with the pointer until they are stopped by the restoring torque of the hair spring $\tau = k\theta$
- At this point $BANI = k\theta$

$$\Rightarrow \theta = \frac{BNAI}{k}$$

- Since $\frac{NBA}{k}$ is constant $\theta \alpha I$ hence linear scale. (03)

(ii) The coil is made heavier to Increase the period of oscillation.
- The suspension is made fine to reduce rigidity and Increase sensitivity Any 2 (02)
- The coil is wound on Insulating former to minimise damping due to eddy currents.

(6)(a)(i) Magnitude of Induced emf is proportional to the rate of change of magnetic flux linkage.
- The direction of the Induced emf is such as to oppose the change causing it.

(ii) Let total flux linking the N-turns of the coil be $N\phi$

Induced emf $E = -N\frac{d\phi}{dt}$

Induced current $I = \frac{E}{R} = -\frac{N}{R}\frac{d\phi}{dt}$ but $I = \frac{dQ}{dt}$

$$\Rightarrow dQ = -\frac{N}{R}d\phi$$

When the flux changes from ϕ_1 to ϕ_2

$$\text{Then } Q = \int_{\phi_1}^{\phi_2} \frac{-N}{R} d\phi = \frac{-N}{R}(\phi)\Big|_{\phi_1}^{\phi_2}$$

$$Q = \frac{N}{R}(\phi_1 - \phi_2)$$ (04)

(b) The coil is made heavier to Increase the period of oscillation.
The ~~sub~~ suspension is made fine to reduce rigidity and Increase sensitivity.
The coil is wound on Insulating former to minimise damping by eddy currents.

Any two. (04)

(c) $B_s = \mu_0 n I$

$= 4\pi \times 10^{-7} \times 500 \times 5$

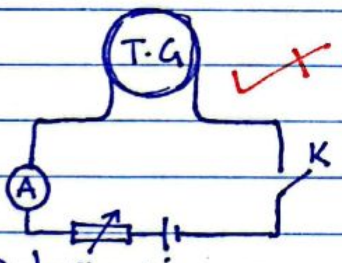
$= 3.142 \times 10^{-3} T$

$B = \frac{\theta R}{\alpha N A} \Rightarrow \theta = \frac{B \alpha N A}{R}$

$\theta = \frac{3.142 \times 10^{-3} \times 4 \times 2000 \times 6 \times 10^{-4}}{10 \times 10^{-6}}$

$\theta = 1507.97$ Divisions. (04)

(d)



A deflection magnetometer is mounted in a Search coil to form a tangent galvanometer which is connected in a circuit as shown
- The coil is placed vertical and perpendicular to the horizontal component of the field Intensity
Switched K is closed and the deflection θ_1 and θ_2 of the tangent galvanometer is recorded

- The average deflection θ is recorded together with the ammeter reading I.
- The experiment is repeated for other values of I and the result recorded in a table including values of $\tan\theta$.
- A graph of $\tan\theta$ against I is plotted and the slope S determined

$$B_H = \frac{\mu_0 N}{2RS}$$

Where N and R are number of turns and radius of the coil respectively (06)

Accept the reverse switch method.

- Coil placed perpendicular to B_H
- K is closed, I recorded
- Deflection θ_1 & θ_2 noted
- K is reversed. θ_3 & θ_4 noted.
- Average θ is noted.

$$H_m = \frac{NI}{2R\tan\theta}.$$

(06)

7(a) (i) Reactance is the non resistive opposition to the flow of alternating current in a circuit (01)

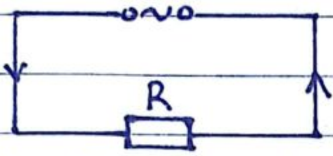
OR

Reactance is the non resistive opposition to the flow of alternating current in a capacitor or Inductor. (01)

(ii) Frequency is the number of cycles made by the current per second. (01)

Note [cycles not oscillations]

(b)



$I = I_0 \sin \omega t$

Instantaneous power dissipated $P = I^2 R$

$P = I_0^2 \sin^2 \omega t \, R$

$\langle P \rangle = \langle I_0^2 \sin^2 \omega t \, R \rangle$

$= I_0^2 R \langle \sin^2 \omega t \rangle$

but $\langle \sin^2 \omega t \rangle = \frac{1}{2}$

$\langle P \rangle = \frac{1}{2} I_0^2 R$

let I_{rms} be the steady current that dissipates heat in the resistor at the same rate as the a.c then

$\langle P \rangle = I_{rms}^2 R$

$I_{rms}^2 R = \frac{1}{2} I_0^2 R$

$I_{rms}^2 = \frac{I_0^2}{2}$

$I_{rms} = \frac{I_0}{\sqrt{2}}$ (04)

(c) $X_L = 2\pi f L$

$I_0 = \frac{V_0}{X_L} = \frac{20}{157.0796} = 0.1273 A$

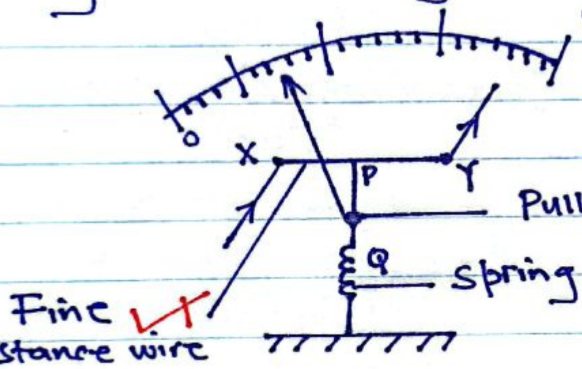
$I_{rms} = I_0/\sqrt{2} = \frac{0.1273}{\sqrt{2}} = 0.09003 A$ (03)

(d)(i) The bulb lights continuously
This is because, when switch K is closed the capacitor charges and discharges continiously and in so doing, current flows (02)

(ii) The brightness of the bulb Increases. This is because when the capacitance Increases, the reactance reduces and the current in the circuit Increases. When the current Increases, the brightness also Increases. (02)

(iii) The brightness of the bulb reduces. This is because reducing frequency increases reactance in the circuit thus reducing current making the bulb go dim.

(e)

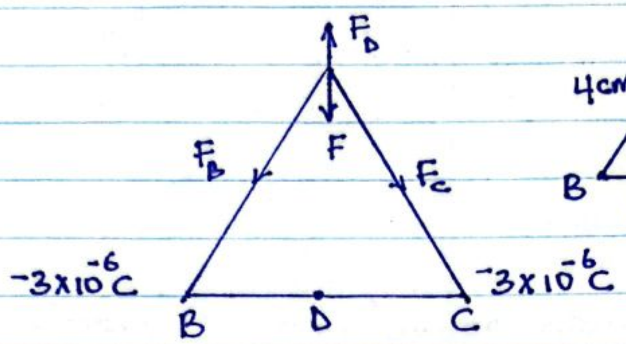


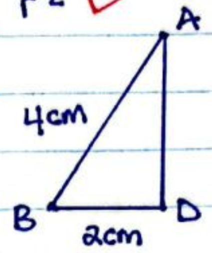
(02)

- current to be measured is passed through the fine resistance wire XY as shown above.
- The wire heats up, expands and sags
- The sag is taken up by the fine rod PQ which rotates the pulley as it moves causing the pointer to turn over the scale.
- The deflection of the pointer is proportional to the sag
- Hence the deflection is proportional to the square of the average current. (03)

Coulomb's law of electrostatics states that the force between two point charges is directly proportional to the product of the magnitude of the charges and Inversely proportional to the square of their distance apart.

(ii) Electric force, $F = \frac{KQ_1Q_2}{r^2}$





$AD = \sqrt{4^2 - 2^2}$

$= \sqrt{12}$ cm.

$F_B = \frac{9\times10^9 \times 3\times10^{-6} \times 2\times10^{-6}}{(4\times10^{-2})^2} = 33.75N.$

$F_C = \frac{9\times10^9 \times 3\times10^{-6} \times 2\times10^{-6}}{(4\times10^{-2})^2} = 33.75N$

Let Q be the charge at D

$F_D = \frac{9\times10^9 \times Q \times 2\times10^{-6}}{(\sqrt{12}\times10^{-2})^2}$

$\rightarrow$, the resultant force is zero.

$\uparrow$, $F_B\cos30 + F_C\cos30 = F_D$

But $F_B = F_C$

$\frac{9\times10^9 \times Q \times 2\times10^{-6}}{(\sqrt{12}\times10^{-2})^2} = 2\times 33.75\cos30$

$Q = \frac{2\times33.75\cos30 \times (\sqrt{12}\times10^{-2})^2}{(9\times10^9)\times2\times10^{-6}}$

$Q = 3.89\times10^{-6}C.$ (05)

b(i) Capacitance is the ratio of the magnitude of charge on either plate of the capacitor, to the potential difference between the plates.

(ii) $I = Qf$

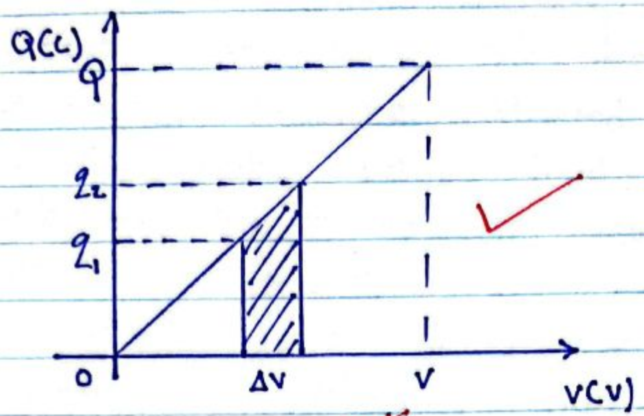
$I = CVf$

$C = \frac{I}{fV}$ ✓

$C = \frac{10\times10^{-6}}{50\times25} = 8\times10^{-9}F$ ✓ ✓

(03)

C(i)



(ii) Energy = Area under graph $= \frac{1}{2}QV$

but $Q = CV$

$C = \frac{\varepsilon A}{d}$ also $V = Ed$

$\therefore Q = \frac{\varepsilon A E d}{d} = \varepsilon AE$

$\text{Energy} = \frac{1}{2}\varepsilon AE \cdot Ed$

$= \frac{1}{2}\varepsilon E^2 Ad$

$\text{Volume} = A \times d$

$\text{Energy per unit volume} = \frac{1}{2}\frac{\varepsilon E^2 Ad}{Ad}$

$= \frac{1}{2}\varepsilon E^2$

(04)

d(i) A dielectric is an Insulating material placed between the plates of a capacitor ✓ (01)

(ii) When a dielectric is placed between the plates of a charged capacitor. It's molecules get polarized. Charges inside the Insulator cancel each other's effect and those on the sides remain.
An electric field Intensity develops between the two surfaces in opposition to the applied field
The resultant electric field Intensity between the plates is thus reduced.
From $E = \frac{V}{d}$ where V is the p.d between the plates and d is the plate separation, V reduces, but $C = \frac{Q}{V}$
therefore when V reduces, C Increases. (04).

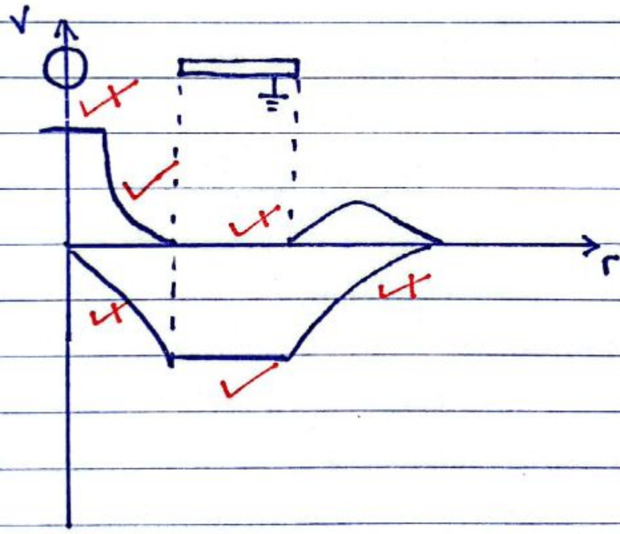
9(a) (i) The material is lowered near the cap of a neutral gold leaf electroscope using an Insulating thread.
The leaf of the electroscope is seen ~~to~~ to diverge. The material is then earthed. If the leaf collapses then the material is a conductor. If it remains diverged, the material is an Insulator. (03)

(ii) There is always a high charge concentration on sharp points on a charged conductor.
The electric field Intensity around the sharp points is therefore high. Air around the sharp points is therefore high.

Air around the sharp points is therefore ionised. and charge similar to that on the conductor is repelled while that of opposite charge is attached and neutralised. This loss of charge is reffered to as corona discharge. (03)

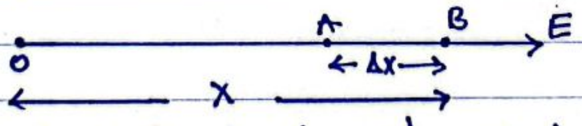
(b) Negative charge is induced on the surface of the conductor at B. The potential at A is the sum of potential due to charge at A and charge at B Since the potential due to charge at B is negative, the resultant potential is lower (reduces) (04)

(c)



(04)

(d)

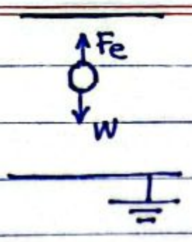


- Potential at B is V and at A is V+ΔV
- workdone to transfer 1C of +ve charge from B to A is $(V+\Delta V) - V = \Delta V$
- workdone to move a charge on a small distance Δx to-wards O is $E \times 1 \times (-\Delta x)$

$$= -E\Delta x$$

$$\therefore \Delta V = -E\Delta x \Rightarrow E = \frac{-\Delta V}{\Delta x}$$ (03)

d(ii)



$W = F_e$ (at equilibrium)

But $W = mg$

$$\frac{qV}{d} = mg$$

$$q = \frac{4.8\times10^{-15}\times 9.81 \times 12\times10^{-3}}{1800}$$

$$= 3.14\times10^{-19}\,C.$$ (03)

ALT $mg = F_e$ and $E = \frac{V}{d} = \frac{1800}{12\times10^{-3}}$

$mg = QE$ $= 150{,}000\,NC^{-1}$

$\therefore Q = \frac{mg}{E}$

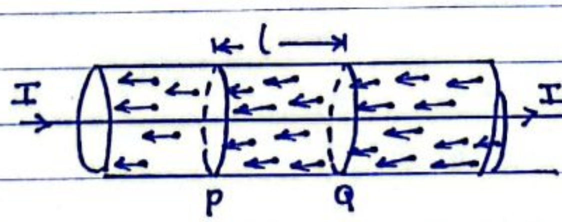
$$= \frac{4.8\times10^{-15}\times 9.81}{150{,}000}$$

$$= 3.14\times10^{-19}\,C$$ (03)

10(a) E.m.f of a cell is the p.d between the terminals of a cell in an open circuit.

OR: E.m.f is the ratio of power generated to the current it delivers.

OR: The workdone to convey 1C of charge round in a complete circuit in which a cell is connected. (01)



Volume of the section PQ of the conductor $= lA$

Total number of charge carriers in the section $= nlA$

Total charge in the section = enlA
Suppose in 1 second all charge in section PQ is swept through section Q then charge swept persecond is nelA
But charge flow per second is current I, and distance covered persecond is velocity, v.

$$\therefore \quad I = nevA$$

$$\Rightarrow v = \frac{I}{neA}$$

(04).

where v is the drift velocity.

(c) When e.m.f of the driver cell is less than the test p.d. In this case, the test p.d drives current through the slide wire for all points when the cells are not connected in opposition to each other. In this case the test cell only supports the driver cell. (04)

(d) $I_d(R_Q + r \times 32.0) = 1.018$

$$r = 4/100$$

$$I_d \times r \times 68.5 = E_x$$

$$I_d\left(40 + \frac{4}{100} \times 32.0\right) = 1.018 \quad \text{—— (i)}$$

$$I_d \times \frac{4}{100} \times 68.5 = E_x \quad \text{—— (ii)}$$

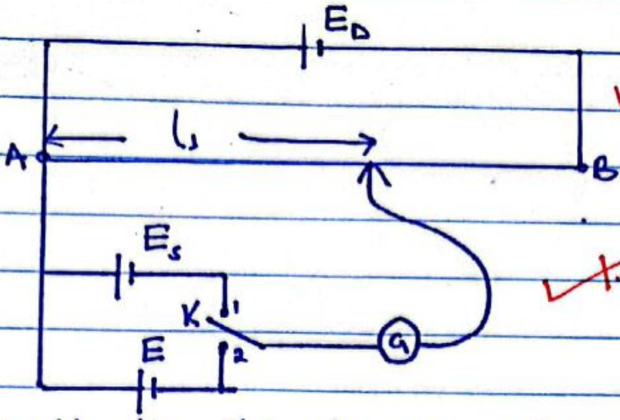
$$\frac{ii}{i} \Rightarrow \frac{0.04 \times 68.5}{40 + 0.04 \times 32.0} = \frac{E_x}{1.018}$$

$$E_x = \frac{0.04 \times 68.5 \times 1.018}{40 \times 0.04 \times 32.0}$$

(06)

$$E_x = 0.067577\,V$$

(e)



- The circuit is set up as above, where AB is a uniform wire, E_s and E are emfs of standard and test cells respectively.
- Switch K is connected to position (1) and the Jockey tapped at different points along the uniform wire until where the galvanometer G shows no deflection.
- The balance length, l_1 is measured and recorded. K is now connected to position (2) and the balance position located.
- The balance length l is measured and recorded.

Emf E is then calculated from

$$E = \frac{E_s}{l_s} \cdot l$$

05

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SECTION A

1. (a) State the **laws of reflection of light**. (*02 marks*)

(b) (i) With the aid of ray diagrams distinguish between virtual and real images formed by a concave mirror. (*04 marks*)

(ii) Using any of the diagrams in (b) (i), derive the mirror formula. (*04 marks*)

(c) Find the position of a finite object placed on the axis of a concave mirror of radius of curvature 30 cm, if the mirror forms a virtual image three times the height of the object. (*03 marks*)

(d) With the aid of a ray diagram, describe the working of a projection lantern. (*04 marks*)

(e) A projector consists of a slide 5 cm by 5 cm which produces an image 3 m by 3 m on a screen placed 24 m from the projection lens. Calculate the focal length of the projection lens. (*03 marks*)

2. (a) (i) State the **laws of refraction of light**. (*02 marks*)

(ii) Define **refractive index** of a medium. (*01 mark*)

(b) Show that when a ray of light passes through different media separated by plane boundaries,

$$n \sin i = \text{constant},$$

where n is the absolute refractive index of a medium and i is the angle made by the ray with the normal in the medium. (*04 marks*)

(c) A glass block separates water and liquid A in a trough as shown in Figure **1**.

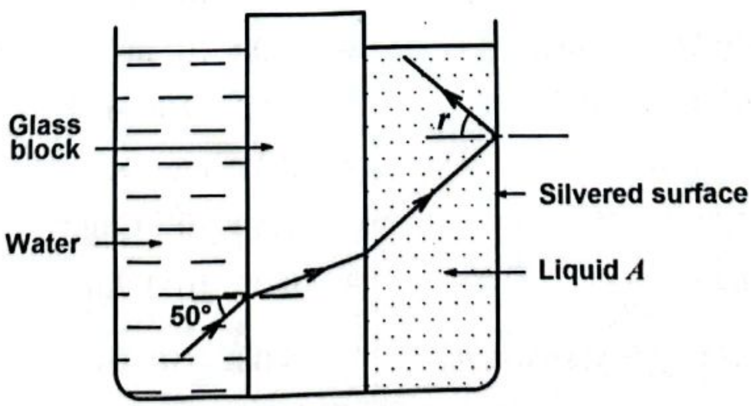

Fig. 1

Monochromatic light from water is incident on the glass block at an angle of 50^0. The opposite side of the trough is silvered.

Determine the value of angle, r, if the refractive indices of water, glass and liquid **A** are 1.33, 1.50 and 1.25 respectively. (*05 marks*)

(d) Show that the refractive index, n_g, of a glass block is given by

$$n_g = \frac{\text{Real depth}}{\text{Apparent depth}}.$$ (*04 marks*)

(e) With the aid of a ray diagram explain the observation made on a small object at the bottom of a pool of water as the observer above the surface successively shifts position from the vertical to oblique positions. (*04 marks*)

SECTION B

3. (a) (i) Explain how **stationary waves** are formed. (*04 marks*)

(ii) Describe an experiment to determine the speed of sound in air using a speaker, a microphone and a smooth wooden board. (*05 marks*)

(b) Describe **one** application of Doppler effect. (*03 marks*)

(c) A train approaching a high wall with a velocity of 25 ms^{-1} makes a sound of frequency 980 Hz.

(i) Derive an expression for the apparent frequency of the echo a passenger in the train receives. (*04 marks*)

(ii) Find the apparent frequency of the sound, the passenger receives as the train passes the wall. (*04 marks*)

4. (a) State **three** characteristics of coherent sources of light. (*03 marks*)

(b) With the aid of sketch diagrams, explain the following:

(i) Division of wavefront. (*02 marks*)
(ii) Division of amplitude. (*02 marks*)

(c) An air wedge is formed by placing two glass slides of length 10.0 cm in contact at one end and a wire between them at the other end. Viewing from vertically above, 20 dark fringes are observed to occupy a distance of 5.0 mm when the slides are illuminated with light of wavelength 500 nm.

(i) Explain how the fringes are formed. (*05 marks*)
(ii) Determine the diameter of the wire. (*03 marks*)

(d) (i) What is meant by **constructive interference** and **destructive interference** as applied to light waves. (*02 marks*)

(ii) Describe how interference of light can be used to test for the flatness of a surface. (*03 marks*)

SECTION C

5. (a) (i) Define **magnetic field line**. (*01 mark*)

(ii) A wire carrying current out of the paper is placed between two opposite poles of a permanent magnet. Sketch the resultant magnetic field pattern and explain what is observed. (*04 marks*)

(b) A conductor of length, l, carrying current, I, perpendicular to a magnetic field of flux density, B, is moved in the field. Using the principle of conservation of energy, show that the force, F, acting on the conductor is given by;

$$F = BIl.$$

(*04 marks*)

(c) (i) Write down the expression for the magnetic flux density at a perpendicular distance, a, from a straight conductor carrying current, I, in air. (*01 mark*)

(ii) Two straight parallel wires A and B carry currents of 3 A and 5 A respectively in opposite directions. Given that the wires are 0.2 m apart in air, find the distance from wire A where the resultant magnetic flux density is zero. (*03 marks*)

(d) (i) With the aid of a labelled diagram, describe how a moving coil galvanometer works. (*05 marks*)

(ii) How can the moving coil galvanometer be converted to measure charge instead of current? (*02 marks*)

6. (a) (i) State the **laws of electromagnetic induction**. (*02 marks*)

(ii) Show that the induced charge Q is given by;

$$Q = \frac{N}{R}(\phi_1 - \phi_2),$$

when the magnetic flux threading a coil of N turns and resistance R changes from ϕ_1 to ϕ_2. (*04 marks*)

(b) Explain **two** essential features of a ballistic galvanometer. (*04 marks*)

(c) A long air-closed coil of wire has 500 turns of wire per metre and cross-sectional area of 6.0 cm^2. A secondary coil of 2000 turns is wound around its centre and connected to a ballistic galvanometer. The total resistance of the coil and the galvanometer is 10 Ω and the sensitivity of the galvanometer is 4.0 divisions per micro coulomb. If a current of 5.0 A in the long coil of wire is switched off, find the deflection of the galvanometer. *(04 marks)*

(d) Describe an experiment to determine the horizontal component of the earth's magnetic field intensity using a deflection magnetometer. *(06 marks)*

7. (a) Define the following as applied to an alternating current circuit:

(i) Reactance. *(01 mark)*

(ii) Frequency. *(01 mark)*

(b) A sinusoidal voltage is applied across a resistor of resistance, R, in which an alternating current $I = I_0 \sin \omega t$ flows. Derive an expression for the root mean square value of the alternating current. *(04 marks)*

(c) A sinusoidal alternating potential difference of peak value 20 V and frequency 50 Hz is connected across an inductor of inductance 0.5 H. Calculate the root mean square value of the current which flows through the inductor. *(03 marks)*

(d) An alternating current source is connected across a capacitor which is connected in series with a bulb as shown in Figure **2**.

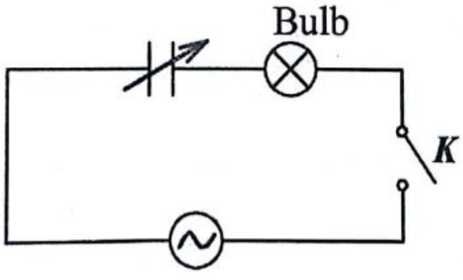

Fig. 2

Explain what is observed when;

(i) switch, ***K***, is closed. *(02 marks)*

(ii) the capacitance of the capacitor is increased while switch ***K***, is still closed. *(02 marks)*

(iii) the frequency of the source is decreased while switch ***K***, is still closed. *(02 marks)*

Turn Over

(e) With the aid of a labelled diagram, describe how the hot wire ammeter is used to measure alternating current. (*05 marks*)

SECTION D

8. (a) (i) State **Coulomb's law of electrostatics**. (*01 mark*)

(ii) Charges of +2 μC, −3 μC and −3 μC are placed at the corners A, B and C of an equilateral triangle of side 4.0 cm as shown in Figure **3**.

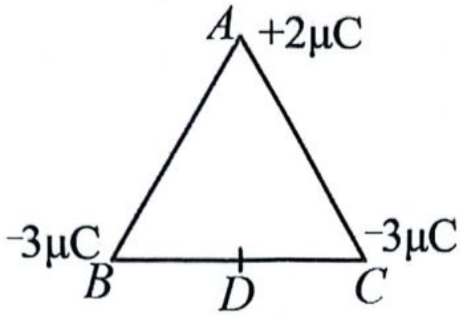

Fig. 3

Find the charge that should be placed at D, the mid-point of BC so that the net force on the charge at A is zero. (*05 marks*)

(b) (i) Define **capacitance** of a capacitor. (*01 mark*)

(ii) A vibrating reed switch charges and discharges a capacitor 50 times per second. The d.c supply is 25 V and the discharge circulates through a galvanometer and produces an average current of 10 μA. Find the capacitance of the capacitor. (*03 marks*)

(c) (i) Sketch a graph of variation of charge on a capacitor with the potential difference across the plates of the capacitor. (*01 mark*)

(ii) Use the graph in (c)(i) to show that the energy per unit volume in a parallel plate capacitor is given by $\frac{1}{2}\varepsilon_0 E^2$ where ε_0 is the permittivity of free space and E is the electric field intensity. (*04 marks*)

(d) (i) What is meant by a **dielectric** material? (*01 mark*)

(ii) Explain why the capacitance of a charged capacitor increases when a dielectric material is placed between its plates. (*04 marks*)

9. (a) (i) Describe an experiment to determine whether a given charged material is a conductor or an insulator. (*03 marks*)

(ii) Explain what is meant by **corona discharge** in electrostatics. (*03 marks*)

(b) A neutral conducting rod **BC**, earthed at **C** is placed near a positively charged sphere **A** as shown in Figure **4**.

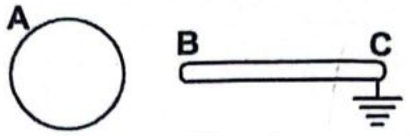

Fig. 4

Explain how the potential of **A** changes due to the presence of the rod **BC** near it. (*04 marks*)

(c) With reference to Figure **4**, on the same axes, show the variation of potential with position;

(i) along **ABC**. (*02 marks*)

(ii) when both **A** and the earthing are removed. (*02 marks*)

(d) (i) Derive the relationship between electric field intensity and electrical potential in an electric field. (*03 marks*)

(ii) Two parallel conducting plates 12 mm apart are held horizontally with one above the other in air. When the upper plate is maintained at a positive potential of 1800 V, and the lower one is earthed, a charged smoke particle of mass 4.8×10^{-15} kg is held stationary between the plates. Find the charge of the particle. (*03 marks*)

10. (a) Define **e.m.f** of a cell. (*01 mark*)

(b) Show that the drift velocity, v, of electrons in a conductor of cross sectional area, A, having, n, charge carriers per unit volume is given by;

$$v = \frac{I}{nAe}.$$

where, I, is the current through the conductor and, e, is the charge of each charge carrier. (*04 marks*)

(c) Explain the circumstances under which a galvanometer connected to a potentiometer may fail to give a two-way deflection when the sliding contact is made to touch the terminals of the slide wire of a potentiometer. (*04 marks*)

(d) Figure **5** shows a resistance box, P, a coil Q of resistance 40 Ω and an accumulator X connected to the slide wire potentiometer AB.

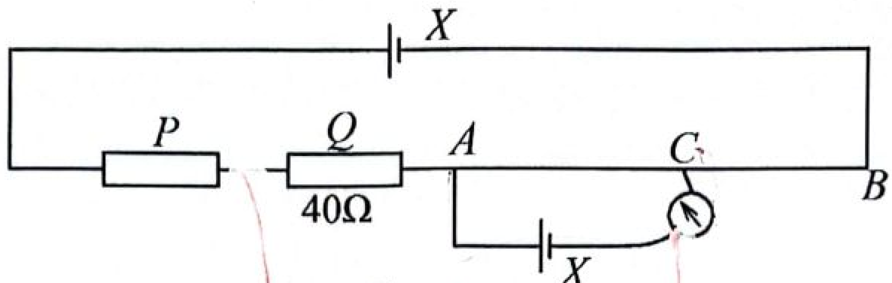

Fig. 5

The slide wire is 1.0 m long and has a resistance of 4.0 Ω. For a certain value of P, the potential drop across Q plus 32.0 cm of the slide wire is enough to balance an e.m.f of 1.018 V. For the same value of P, a potential drop across 68.5 cm of the slide wire is required to balance the e.m.f of cell X. Calculate the e.m.f of cell X. *(06 marks)*

(e) With the aid of a diagram, describe an experiment to measure the e.m.f of a cell using a potentiometer. *(05 marks)*

END