WAKISO -KAMPALA TEACHERS' ASSOCIATION (WAKATA)
WAKATA EXAMINATIONS COMMITTEE
"Affordable Quality Assessment"

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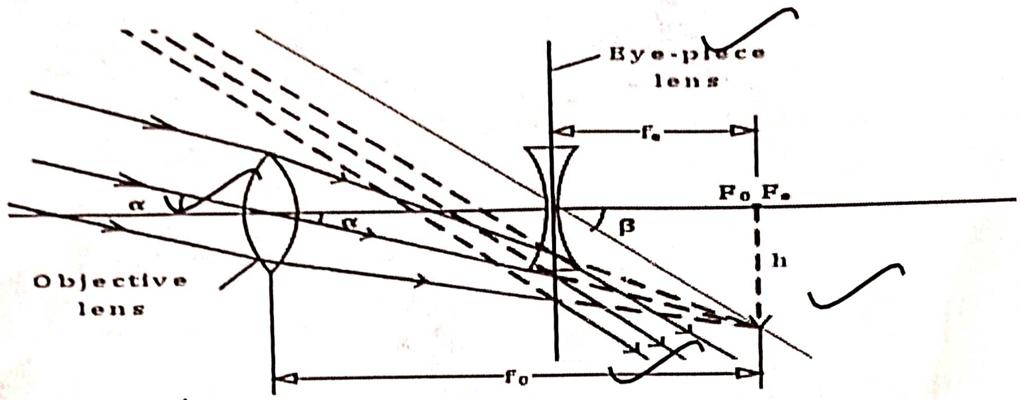
UACE MARKING GUIDE PHYSICS P1 P510/2 MOCK 2023

(a) (i) Visual angle is the angle subtended at the eye (naked or aided) by the Object (or image acting as the object). **(01)**

(ii) Accommodation is a process of focusing all objects of different sizes and at different distances into the retina of the eye by the elastic eye lens. **(01)**

(b) (i)



(04)

(ii) $M = \frac{\beta}{\alpha}$. For β and α being small angles in radians. $\beta \cong \tan\beta = \frac{h}{f_e}$

$\alpha \cong \tan\alpha = \frac{h}{f_o}$ $\therefore M = \frac{\beta}{\alpha} \Rightarrow M = \frac{h}{f_e} \div \frac{h}{f_o} = \frac{h}{f_e} \times \frac{f_o}{h}$

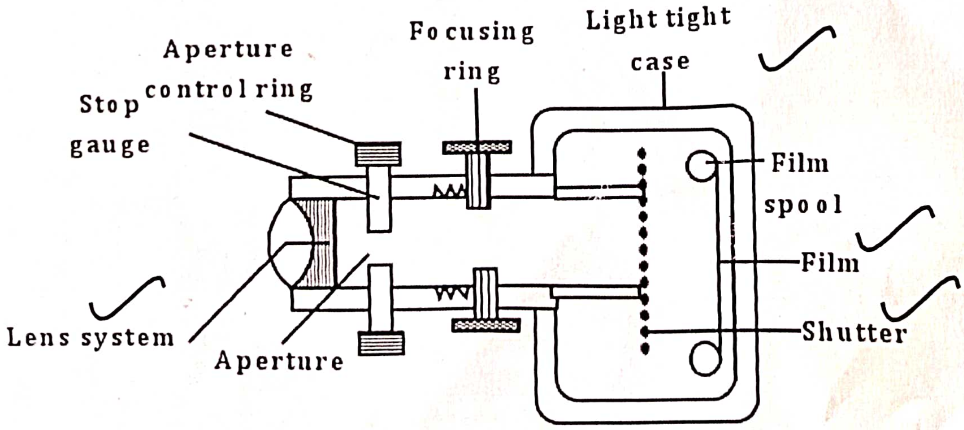
$\therefore M = \frac{f_o}{f_e}$ **(03)**

(c)

Advantages of a Galilean Telescope over Astronomical.	Disadvantages of Galilean Telescope.
- It is compact and portable, unlike Astronomical type which is bulky. - It produces final upright images making it suitable for observing objects on land and sea/ water bodies, unlike Astronomical type that produces final inverted images.	- It has a virtual eye ring. - It has a narrow or limited field of view.

(03)

(d) (i)



(04)

(ii) $f_1 = 15cm, L_1L_2 = 6.0cm, f_2 = -20cm, \; u = 15m = 1500cm.$

Action of lens L_1

$\frac{1}{U} + \frac{1}{V_1} = \frac{1}{f_1} \Rightarrow \frac{1}{1500} + \frac{1}{V_1} = \frac{1}{15} \quad \therefore V_1 = 15.2cm$

Action of lens L_2

$u_2 = 6 - 15.2 = -9.2cm$

$\frac{1}{U} + \frac{1}{V_1} = \frac{1}{f_1} \Rightarrow \frac{1}{1500} + \frac{1}{V_1} = \frac{1}{15} \quad \therefore V_1 = 15.2cm$

$\frac{1}{u_2} + \frac{1}{V_2} = \frac{1}{f_2} \Rightarrow \frac{1}{-9.2} + \frac{1}{V_1} = \frac{1}{-20} \quad \therefore V_1 = 17.04cm$

Distance of the film from $L_1 = 6.0 + 17.04 = 23.04cm$

Marker's note: *Object distance was typed as* **15cm** *instead of* **15m**. *So transfer the marks to part (b)(i) and part (d)(i)*

(e) (i) This is the formation of a series of **images with coloured edges** instead of one distinct white image when white light from an object is **refracted** by a **thick lens.** **(01)**

(ii) When the eye is placed close to the lens, all the coloured images produced due to dispersion of white light **subtend the same visual angle** at the aided eye.
The tips of all these images lie along one straight line and thus *superimpose on each other.*
The superposition and overlapping of these coloured images results into uniform white illumination thus nullifying the effect of distinct colours, on images which now appear like one white image. **(01)**

Total = 20 marks

2. (a) (i) This is the ratio of the speed of light in a vacuum to the speed of light in the given material. **(01)**

OR

This is the ratio of the sine of the angle of incidence to the sine of the angle of refraction as a ray of light travels from a vacuum to the given medium.

(ii) *Real depth,* $t = 10.0cm, air = 1.0cm$

Apparent depth

$(t - d) = (12.0 - 4.5cm)$

$(t - d) = 7.5cm$

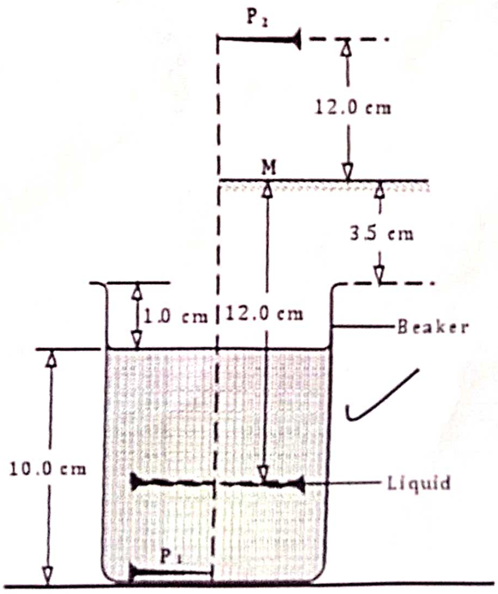
Refractive index, $n = \frac{t}{t-d}$

$n = \frac{10.0}{7.5} = 1.33$

$\therefore n = 1.33$

Apparent displacement, $d = 10.0 - 7.5$
$= 2.5\ cm$

(06)

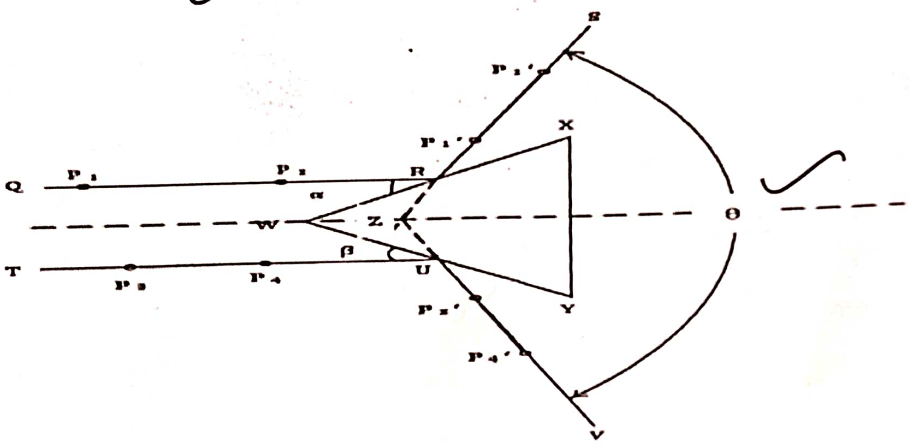


OR

$$Using\ the\ formula, d = t\left(1 - \frac{1}{n}\right)$$
$$= 10\left(1 - \frac{1}{1.33}\right)$$
$$= 10 \times \frac{1}{4}$$
$$= 2.5\ cm$$

(b) - A plain white sheet of paper is stuck onto the soft board using drawing pins or sellotape.

✓ A prism under test is then placed onto the sheet of paper and its outline WXY is traced using a pencil.



✓ The prism is removed from its outline.

✓ Two parallel lines QR and TU are drawn making small angles α and β with sides WX and WY of the prism outline respectively.

✓ Two optical pins P_1 and P_2 are stuck vertically on the soft board along line QR a distance apart.

✓ The prism is replaced on its outline WXY.

✓ While looking at S, the eye is slowly moved left and right until the images of P_1 and P_2 are seen appearing to be in a straight line.

✓ Optical pins P'_1 and P'_2 are stuck vertically on the soft board so as to appear in line with images of P_1 and P_2.

✓ The prism and all pins are now removed and a straight line drawn through P'_1 and P'_2 and extended backwards into the outline of the prism.

✓ The prism is now replaced on its outline and the same procedure is repeated for two other optical pins P_3 and p_4 stuck along line TU and their corresponding images P'_3 and P'_4 observed to be in line with images of P_3 and P_4 respectively.

✓ The prism and all the pins are removed and a straight line passing through P'_3 and P'_4 is drawn and extended backwards to meet the other line through P'_1 and P'_2 at Z. The angle SZV = θ is measured using a protractor from which 2A = θ and the

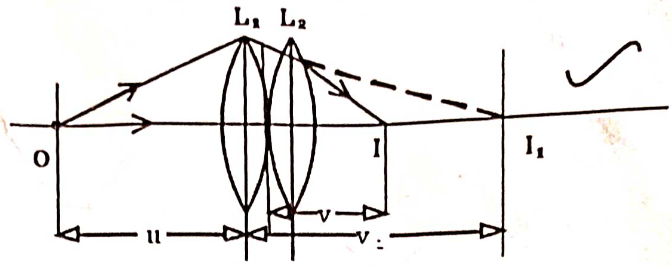
✓ refracting angle of the prism $A = \frac{\theta}{2}$ is determined. **(05)**

(c) (i) *Action of lens L_1*

$$\frac{1}{U}+\frac{1}{V_1}=\frac{1}{f_1} \quad \text{.................... (i)}$$

Action of lens L_2

$$-\frac{1}{V_1}+\frac{1}{V}=\frac{1}{f_2} \quad \text{.................... (ii)}$$



$eqn(1)+eqn(ii)$

$\frac{1}{U}+\frac{1}{V}=\frac{1}{f_1}+\frac{1}{f_2}$ but $\frac{1}{U}+\frac{1}{V}=\frac{1}{f}$ *where f is the combined focal length of L_1 and L_2*

$$\therefore \frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}$$

(04)

(ii) $u=15.0\text{cm}$, $v=60.0cm$, $f_1=10cm$, $f_2=?$

Using combined focal length, f, of the two thin lenses in contact,

$$\frac{1}{U}+\frac{1}{V}=\frac{1}{f} \Rightarrow \frac{1}{15}+\frac{1}{60}=\frac{1}{f} \quad \frac{1}{f}=\frac{5}{60}$$

$$\therefore f=12.0cm$$

$$\text{From } \frac{1}{f}=\frac{1}{10}+\frac{1}{f_2} \Rightarrow \frac{1}{f_2}=\frac{1}{12}-\frac{1}{10}$$

$$\therefore f_2=-60.0cm$$

(04)

$\therefore M = \frac{f_0}{f_e}$ [02]

(c)

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[03]

SECTION B

3. (a) (i) ***Wave length*** is the distance between two successive particles in the wave profile that are in phase

Or The distance between two successive crests or troughs, compressions or rarefactions.

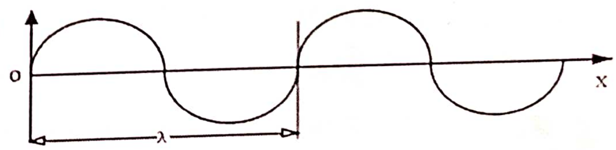
Frequency is the number of complete cycles performed by a wave particle in one second

Or Number of complete waves produced by the source of the waves in one second. [02]

(ii) Suppose T is the periodic time taken by the wave profile to describe on cycle.

Distance by one cycle = λ

Time to cover on cycle = T



Using Speed = $\frac{\text{Distance}}{\text{Time}}$

$v = \frac{\lambda}{T} = \lambda \times \frac{1}{T}$ but $\frac{1}{T}$ = f(frequency)

$\therefore$ Velocity of progressive wave $V = \lambda f$ [03]

Alternatively: If a source of waves is producing f waves per second, after a time t second, it would have produced ft, complete waves or cycles. If λ is the distance between the successive wave fronts, then after t, seconds.

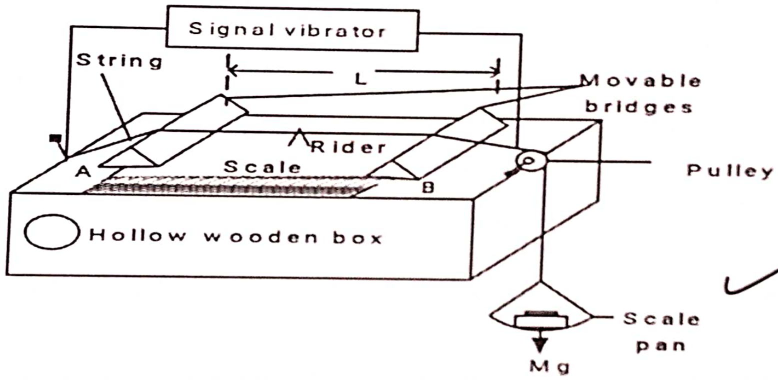
The leading wave front would be at a distance of $D = ft\lambda$ metres away

Using Speed = $\frac{\text{Distance}}{\text{Time}}$ $\Rightarrow$velocity of the wave V = $\frac{ft\lambda}{t}$

$\therefore$ Velocity of progressive wave V = λf

(b) (i) The frequency of oscillation or vibration of the string is inversely proportional to the length of the string provided, tension and mass per unit length of the string are kept constant.
The frequency of vibration of the string is directly proportional to the square root of the tension in the string provided length and mass per unit length of the string are kept constant.
The frequency of vibration of the string is inversely proportional to the square root of the mass per unit length provided the length and tension in the string are kept constant. **[03]**

(ii) Tuning forks of different frequencies may be used, or using a signal vibrator.



Using the set up shown with the test wire fixed between two knife edges or bridges A and B, an inverted "V" shaped paper cone is placed on the wire.

Starting with a known mass M in the scale pan, the signal vibrator is switched on and its frequency adjusted using a calibrated knob until the paper cone just jumps off.

The frequency, f, on the knob of the signal generator is noted together with the total weight Mg in the scale pan.

The ***experiment is repeated*** using several other different masses M in the scale pan and in each case the total weight Mg in the scale pan together with the frequency f are noted, for the same length L and thickness d, of the wire under test.

The results are tabulated in a suitable table including values f^2 and Mg.

A graph of f^2 against Mg is plotted and gives a straight line through the origin.

$\Rightarrow f^2 \propto Mg$ but $Mg = T$ thus $f^2 \propto T$ hence, $f \propto \sqrt{T}$ as required. **[06]**

(c) (i) End correction is the length of the vibrating air column just beyond the open end of the tube that compensates for the missing part of the pipe/tube needed to attain an allowed mode of vibration. **[01]**

(ii) For a stopped pipe, $f_2 = 3f_0 = \frac{3V}{2(L_1 + 2e)}$ for a wire $f_1 = f_0 = \frac{1}{2L_2}\sqrt{\frac{T}{\mu}}$

But, $\frac{3V}{2(L_1 + 2e)} = \frac{1}{2L_2}\sqrt{\frac{T}{\mu}} \Rightarrow \frac{3 \times 330}{2(0.60 + 2e)} = \frac{1}{2 \times 0.5}$

$$\sqrt{\frac{4 \times 150}{\pi \times 1780 \times (0.34 \times 10^{-3})^2}}$$

where $\mu = \frac{\rho \times V}{L} = \frac{\rho \times A \times L}{L} = \rho A = \frac{\rho \pi d^2}{4}$

$\Rightarrow e = -4.31 \times 10^{-2}$ m ** **[04]**

** NB: there was error in length of pipe instead of 0.6m it was meant to be 0.3m

(d) Unstopped pipes vibrate with all the harmonics unlike stopped pipes that produce only odd harmonics. Thus open ended pipes produce ***better quality sound output*** than closed piped instruments owing to the larger number of overtones they produce. **[01]**

4. (a) (i) Doppler effect is the apparent change in the frequency of waves received by the observer due to relative motion between the source of the waves and the observer. **[01]**

(ii) Apparent wave length of received waves $\lambda' = \frac{\omega V_s}{f} = \frac{(v - u_s)}{f} = \frac{(v + u_s)}{f}$

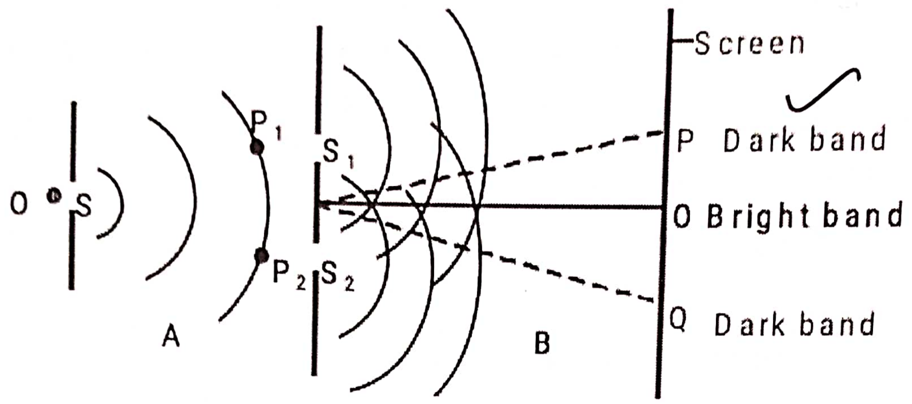
Apparent speed of the waves received by observer $v' = \omega V_s = (v + u_0)$

Apparent frequency of waves reaching the observer

$$f' = \frac{v'}{\lambda'} = \frac{(v + u_0)}{\frac{(v + u_s)}{f}} = \frac{(v + u_0)}{(v + u_s)} f$$ **[04]**

(b) (i) Whenever two waves are travelling in the same region, the total (or resultant) displacement at any point is equal to the vector sum of their individual displacements at that point. [01]

(ii) When two coherent waves emerging from two adjacent parallel slits S_1 and S_2 having a common plane, travel into the same region, B.



The diffracted waves from the two coherent sources into region B, overlap and superimpose on each other.

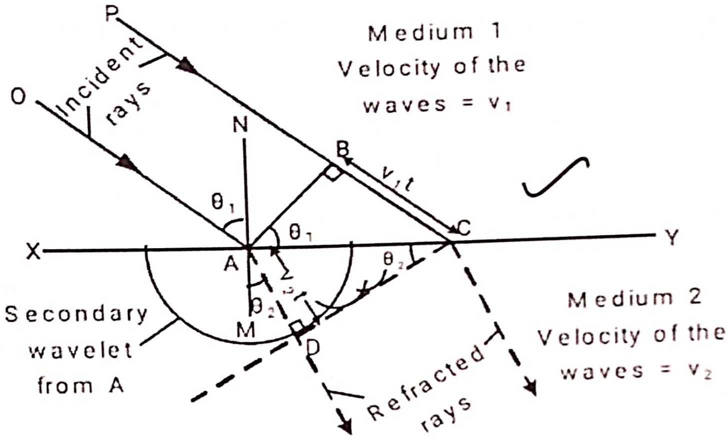
At positions where the two wave trains from the sources S_1 and S_2 arrive in phase, such as O, *reinforcement occurs* and bright bands or fringes are obtained at all such points where the path difference is an integral multiple of a full wave length.

At positions where the two wave trains from the sources S_1 and S_2 arrive when they are *completely out of phase*, *cancellation occurs* and dark bands or fringes are obtained at all such points as P and Q, where the path difference is an odd number multiple of half the wave length.

This then leads to formation of alternate permanent regions of maximum and minimum intensity called interference patterns. [04]

(c) (i) ***Huygens's principle*** states that every point on a wave front can be regarded as a source of secondary spherical wavelets and that the line or tangent to all these wavelets is a new secondary wave front. [01]

(ii) AB is the plane wave front arriving at the interface between two media of refractive indices n_1 and n_2. Wave front at A produces wavelet AD by the time B reaches C in time t seconds later.
Ray at A begins to bend and in the same time t, it covers distance AD = v_2t.



From the geometry of the diagram above, ΔABC has angle CAB = angle OAN = θ_1, while from ΔACD, angle ACD = angle MAD = θ_2
From Snell's law of refraction n sin i = a constant, using ΔABC and ΔACD

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ where, $\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$

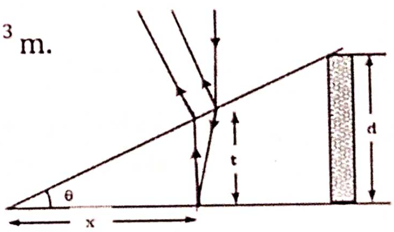
$$\frac{n_1}{n_2} = \frac{AD}{AC} \div \frac{BC}{AC} = \frac{AD}{AC} \times \frac{AC}{BC} = \frac{AD}{BC}$$

$$\frac{n_1}{n_2} = \frac{AD}{BC} = \frac{v_2 \times t}{v_1 \times t} = \frac{v_2}{v_1}$$

$$\frac{n_1}{n_2} = \frac{v_2}{v_1} \Rightarrow v \propto \frac{1}{n}$$ **[03]**

∴ velocity of light is inversely propotional to absolute refractive index

(d) (i) $\lambda = 5.60 \times 10^{-7}$m $y = 1.20\text{mm} = 1.20 \times 10^{-3}$ m.



Path difference $2t = n\lambda$

But for very small angle θ in radians

$\theta \approx \tan\theta = \frac{t}{x} \Rightarrow t = x\theta$

$\Rightarrow 2t = 2x\theta = n\lambda$ where n = 0,1,2,3...

∴ Fringe separation, $y = \frac{\lambda}{2\theta}$ ∴ $\theta = \frac{\lambda}{2y} = \frac{5.60 \times 10^{-7}}{2 \times 1.20 \times 10^{-3}} = 2.33 \times 10^{-4}$ rad.

[03]

(ii) Considering the entire Length L of the wedge and thickness d of the foil,

$$\theta \approx \tan\theta = \frac{d}{L} \Rightarrow d = L\theta = 75 \times 10^{-3} \times 2.33 \times 10^{-4}$$

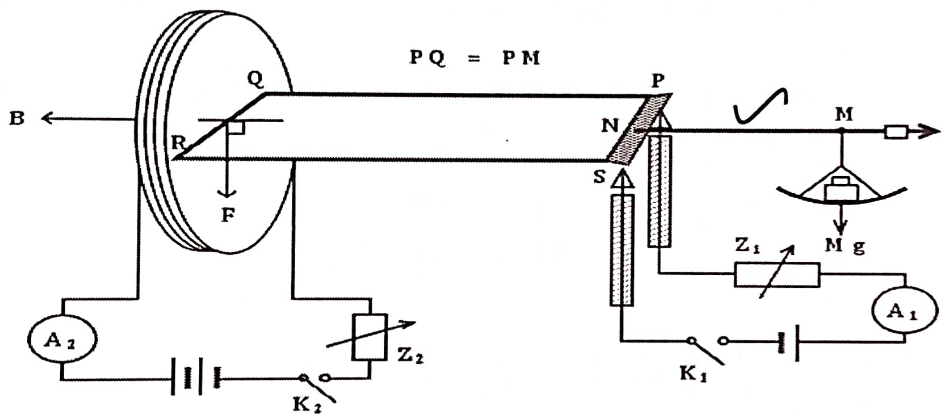
$\therefore$ Thickness of the foil $d = 1.75 \times 10^{-5}$ m **[02]**

(iii) Testing for the flatness of plane surfaces. **[01]**

SECTION C

(a) (i) Magnetic flux density is the force exerted on a conductor of length 1m carrying a current of 1A in a direction normal to the magnetic field. **[01]**

(ii) A plane circular coil of known number of turns N is connected to a d.c source via a rheostat Z_2 and an ammeter.



When switches K_1 and K_2 are both open, the plane of the rigid rectangular copper wire frame PQRS is made horizontal.

Switches K_1 and K_2 are then closed and current I_1 through wire QR is noted on ammeter A_1. Current through the coil is also adjusted using rheostat Z_2 until a reasonable downward deflection on wire QR is registered.

The ammeter reading I_2 is noted.

Small masses are added into the scale pan until the wire frame PQRS balances horizontally.

The length l of wire QR is measured and the total weight mg in the scale pan is noted.

i.e $BI_2l = Mg$ where $B = \dfrac{\mu_0 N I_2}{2r}$

Keeping currents I_1 and I_2 constant, the experiment is **repeated** using different number N of turns of the coil and in each case, the total weight Mg in the scale pan is noted.

The results are tabulated in a suitable table including values of N and mg.

A graph of N against mg is then plotted and gives a straight line through the origin.

$\Rightarrow$ $N \propto mg$ but $Mg = F = BIl \Rightarrow mg \propto B$

$\therefore N \propto B$ **[05]**

(b) (i) Wire XY will move to the right when switch K is closed.

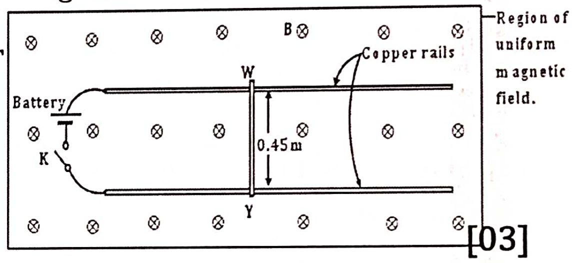
A current I flows through the wire from end W to end Y.

The wire placed perpendicularly across a magnetic field B experiences a

magnetic force F = BIl by Flemings left hand rule.
The force causes the wire to move to the right. **[03]**

(ii) From $F = BIL$ and $F = ma$

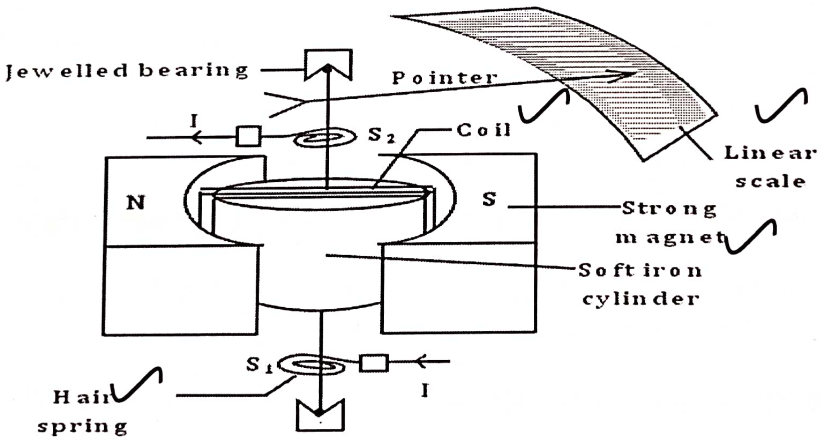
$\Rightarrow$ $ma = BIL$, $L = 0.450m$, $B = 0.80T$



$\therefore$ $a = \dfrac{BIl}{m} = \dfrac{0.80 \times 2.0 \times 0.450}{50 \times 10^{-6}}$

$\therefore$ $a = 1.44 \times 10^{4} ms^{-2}$ to the right. **[03]**

(c) (i) **The moving coil galvanometer**



[02]

(ii) Concave pole pieces provide a radial magnetic field.

The plane of the coil will always be parallel to the magnetic field lines at all times and hence experiences the maximum torque. **[02]**

(d) (i) An electric motor converts electrical energy into mechanical energy

while a generator converts mechanical energy into electrical energy. **[02]**

(ii) During the start/ *switching on* of a motor back e.m.f. ε is zero.

From, $V - \varepsilon = Ir_a \Rightarrow I = \frac{V}{r_a}$ when $\varepsilon = 0$ where V is the applied voltage

The starting current I is very large that it can easily burn off the coil, hence the need for a starting resistant to limit this current.

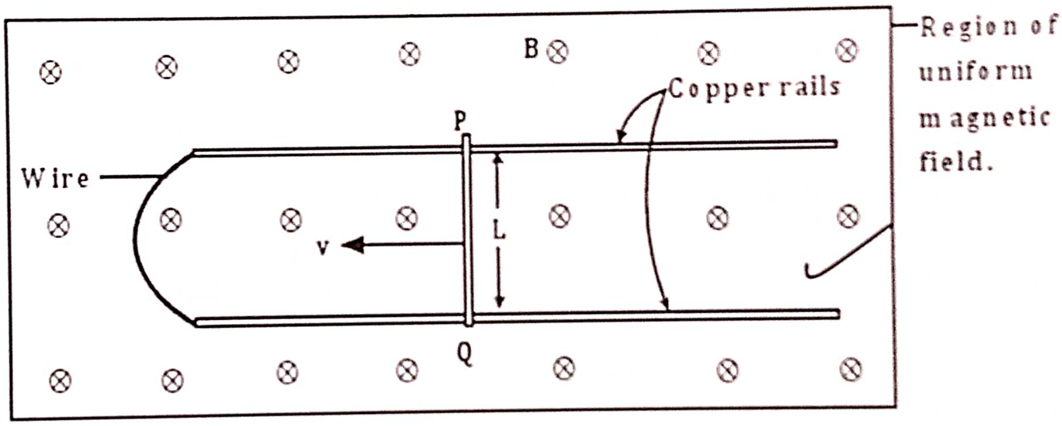
As the motor speeds up, back e.m.f is generated which limits the current flowing in the armature and thus protects the coil. **[02]**

(a) (i) **Laws of electromagnetic induction.**

-The magnitude of the e.m.f. induced in a coil or circuit is directly proportional the rate of change of magnetic flux linked with it.

-The direction of the induced e.m.f. in a coil or closed circuit acts in such a way as to oppose the change (of magnetic flux) that caused it. **[02]**

(ii)



A mechanical force F_1 applied to move PQ from left to right at a speed v

Causes an e.m.f. to be induced across the rod and an induced current I flows from P towards Q by Flemings' Right Hand Rule.

Mechanical power on the rod $P_1 = F_1 v$ ....(i)

A magnetic force $F_2 = BIL$ the acts on the rod from left to right.

Electrical power dissipated in the circuit $P_2 = EI$ ....(ii)

When the rod attains a constant velocity, $F_1 = F_2 = BIL$ and by conservation of energy , Mechanical energy = Electrical energy i.e $F_1 v t = EIt$

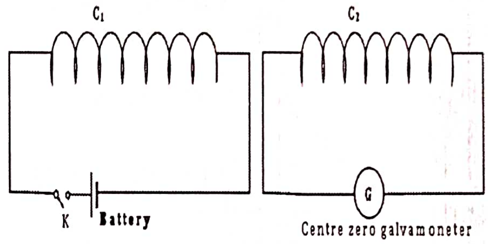
$BILv = EI$ $\Rightarrow E = BLv$ **[04]**

(b) Mutual induction is the induction of e.m.f in a neighbouring coil when the current flowing in the nearby primary coil changes,

A change of current in the primary coil causes a changing magnetic flux in and around the coil and links the secondary coil.
A changing magnetic flux in the secondary coil causes an e.m.f. to be induced in it by mutual induction.

[02]

(c) (i) When K is just closed Galvanometer G deflects in one direction.



The rapidly increasing current growing through coil 1 produces a changing magnetic flux in it and links coil 2
the change of magnetic flux in coil 2 causes an e.m.f. to be induced in coil 2.
When switch K is opened, G deflects in the opposite direction,
e.m.f. is induced by a reducing magnetic field linking coil 2 from coil 1.

[03]

(ii) Inserting a bunch of soft iron rods enhances the magnetic flux linkage between the two coils.
Larger deflections of G are noted when soft iron rods are placed inside coil 1.
The galvanometer G deflects in two opposite directtions when the switch is jused closed when itts just opened.

[03]

(d) (i) The speed at the axle $u_1 = 0 \text{ ms}^{-1}$ at the rim speed $u_2 = v \text{ ms}^{-1}$

$\therefore$ the average speed of the disc $v_a = \frac{u_1 + u_2}{2} = \frac{v}{2}$

Induced e.m.f. $E = BLV$ where $L = r$, $v_a = \frac{v}{2}$, but $v = r\omega$

Thus induced e.m.f. $E = Br\left(\frac{r\omega}{2}\right) = \frac{1}{2}Br^2\omega$

[03]

(ii) $r = 7.0 \text{ cm} = 0.07\text{m}$, frequency $f = \frac{300}{60} = 5.0 \text{ Hz}$, $B = 18 \times 10^{-6}\text{T}$

Induced e.m.f. $E = \frac{1}{2}Br^2\omega = B\pi r^2 f$

$E = \frac{1}{2} \times 18 \times 10^{-6} \times 0.07^2 \times 2\pi \times 5$

$E = 1.39 \times 10^{-6} \text{ V}$

[03]

7. (a) (i) **Peak value** – is the *maximum* value of the alternating voltage,

While, **Root mean square value** – is the steady voltage that causes (heat) or energy dissipation when connected across a resistor at the same rate as the alternating voltage.

[02]

(ii) $V = V_0 \sin \omega t$, a.c. power in a resistance R, $P_a = I^2R$

$$P_a = \frac{V_0^{\ 2}}{R} \sin^2 \omega t$$

Average a.c. power over one complete cycle

$$\langle P_a \rangle = \frac{V_0^{\ 2}}{R} \langle \sin^2 \omega t \rangle$$

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

$$\therefore \langle P_a \rangle = \frac{V_0^{\ 2}}{2R} \text{..................................(i)}$$

While steady power dissipated over the same resistor

$$P_d = \frac{V_d^{\ 2}}{R} \text{..................................(ii)}$$

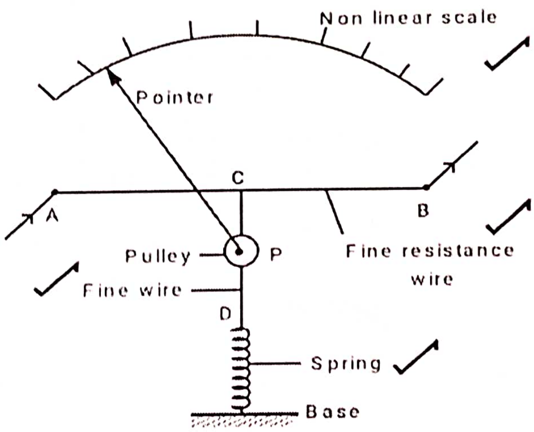
Thus from (i) and (ii) $P_d = \langle P_a \rangle_T$

$$\Rightarrow \frac{V_d^{\ 2}}{R} = \frac{V_0^{\ 2}}{2R}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

Or $V_o = V_{rms}\sqrt{2} = 1.4142\ V_{rms}$ **[03]**

(b) (i) **The Hot wire Ammeter**



- Current to be measured is passed through the fine resistance wire AB.
- The wire heats up, expands and sags.
- The sag is taken up by the fine wire, which *passes round* a grooved pulley P

attached to the pointer.

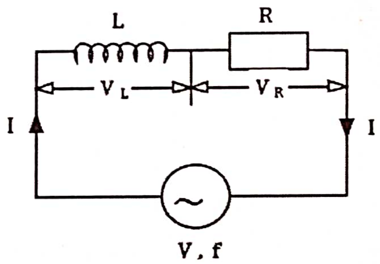
- The pulley rotates and causes the pointer to rotate over the scale, and the deflection is proportional to the sag, and is therefore proportional to the square of the average current. i.e $\theta \propto \langle I^2 \rangle$
- Hence, the non-linear or square scale of the instrument **[05]**

(ii) **Advantage:**
The instrument measures both a.c. and d.c unlike the moving coil type that measures only direct current.
Disadvantage:
Estimation of a given reading is not easy since it has a non-linear scale.
Not suitable for rapidly changing values. Unlike moving coil ammeters that give direct readings.

(c) (i) ***Inductive Reactance*** – is the non – resistive (or dissipative) opposition offered by a pure inductor of the reactive circuit to the passage of changing current (a.c) through it.
Impedance – is the ***total opposition*** offered by a reactive circuit (containing at least more than one different component) to the passage of changing current (e.g. a.c) through it. **[02]**

(ii) $L = 4.0\ H$, $R = 2\ \Omega$, $V_{rms} = 20V$, $f = 50\ Hz$

$$X_L = 2\pi fL = 2\pi \times 50 \times 4.0 = 1.26\times10^3 V$$



$$I_{rms} = \frac{V_{rms}}{\sqrt{X_L^{\ 2} + R^2}}$$

$$\Rightarrow I_{rms} = \frac{20}{\sqrt{(1.26\times10^3)^2 + (4.0)^2}}$$

$$\therefore I_{rms} = 1.59\times10^{-2} A$$

[03]

(d) At the resonant frequency, $X_C = X_L \Rightarrow \frac{1}{2\pi fC} = 2\pi fL$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \Rightarrow C = \frac{1}{(2\pi f_0)^2 L} = \frac{1}{(100\pi)^2 \times 4.0}$$

$\therefore C = 2.53\times10^{-6}$ F [03]

SECTION D

8. (a) (i) Electric field intensity is *force exerted on a +1C* charge placed in an electric field. [01]

(ii) $Mg \times d_1 = F \times d_2$ but $F = EQ$ and $E = \dfrac{V}{d}$

$90 \times10^{-6} \times 9.81 \times 0.350 = EQ \times 0.150$, but $E = \dfrac{V}{d}$

$$3.09 \times 10^{-4} = \frac{0.150 \times 12.0 \times Q}{2.0 \times 10^{-2}}$$

$$\therefore Q = \frac{3.09 \times 10^{-4} \times 2.0 \times 10^{-2}}{0.150 \times 12.0}$$

$\therefore$ Charge, $Q = 3.43 \times 10^{-6}$C [04]

(b) (i) This is the apparent loss of charge from a sharp, pointed, charged conductor.

There is a high charge density at such points.

A strong electric field around the sharp points ionized the air around.

Charges of the same sign as that on the conductor are repelled

while opposite charges are attracted to the conductor and *neutralize* some of the charges leading to apparent reduction of charge known as Corona discharge. [03]

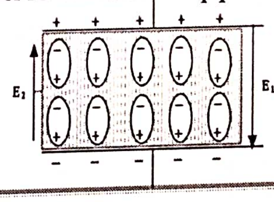
(ii) A smooth and circular cap of a GLE – ensures uniform charge distribution throughout the cap.

It also ensures there are no sharp point where charge is apparently lost due to the action of corona discharge. [02]

(c) (i) When a dielectric is inserted between the plates of a charge capacitor, the molecules of the dielectric get *polarized*.

An *opposite electric field* E_2 is set up across the dielectric material opposing due to charge on the plates.

The net Electric field $E = E_1 - E_2$ reduces.



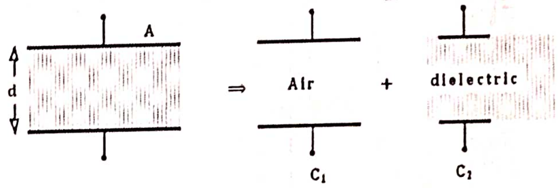
Since $E = \frac{V}{d}$ the p.d across the plates reduces.

From $C = \frac{Q}{V}$ a reduction in the p.d causes the capacitance to increase.

Hence, inserting a dielectric causes the capacitance of the capacitor to increase.

[03]

(ii) $C_1 = \dfrac{\varepsilon_0 \frac{2A}{3}}{d} = \dfrac{2\,\varepsilon_0 A}{3d}$ while $C_2 = \dfrac{\varepsilon_0 \varepsilon_r \frac{1A}{3}}{d} = \dfrac{\varepsilon_0 \varepsilon_r A}{3\,d}$

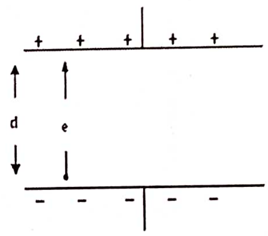


$C = C_1 + C_2$

$= \dfrac{2\,\varepsilon_0 A}{3\,d} + \dfrac{\varepsilon_0 \varepsilon_r A}{3d} = \dfrac{\varepsilon_0 A}{3\,d}(2+\varepsilon_r)$

[03]

(d) Using $ut + \frac{1}{2}at^2 = S$ $u = 0\text{ ms}^{-1}$, $S = d$



$d = \dfrac{at^2}{2}$ but $a = \dfrac{F}{m} = \dfrac{Ee}{m}$ but $E = \dfrac{V}{d}$

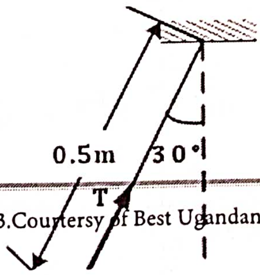
$a = \dfrac{V\,e}{d\,m}$ $\quad\therefore d = \dfrac{V\,e\,t^2}{2m}$

$t = \sqrt{\dfrac{2dm}{Ve}} = \sqrt{\dfrac{2d}{V\left(\frac{e}{m}\right)}}$

$\therefore t = \sqrt{\dfrac{2 \times 2.0 \times 10^{-2}}{2400 \times 1.8 \times 10^{11}}} = 9.62 \times 10^{-9}\text{ s}$ **[03]**

9. (a) (i) The force between two point charges is directly proportional to the product of the *magnitudes* of the charges and inversely proportional to the square of their distance of separation. **[01]**

(ii) $F = T\sin 30°$ ....(i)
$Mg = T\cos 30°$ ....(ii)



(i) ÷ (ii) $\Rightarrow \dfrac{F}{mg} = \tan 30°$

$\therefore F = mg \tan 30°$

$$\frac{Q^2}{4\pi\varepsilon_0 x^2} = mg \tan 30°$$

$$\frac{x}{2} = 0.5 \sin 30°$$

$x = 1.0 \sin 30°$

$x = 0.5$ m

$\therefore q = \sqrt{4\pi\varepsilon_0 x^2 mg\tan 30°}$

$= \sqrt{4\pi \times 8.85\times10^{-12} \times (0.5)^2 \times (20\times10^{-3}) \times 9.81 \times \tan 30°}$

[04]

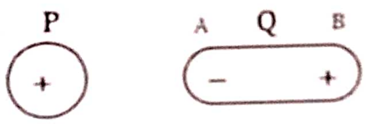
$\therefore Q = 1.77 \times 10^{-6}$ C

(b) (i) P induces *a negative charge* to the side of Q next to P, leaving *a positive charge* at the remote end of Q.

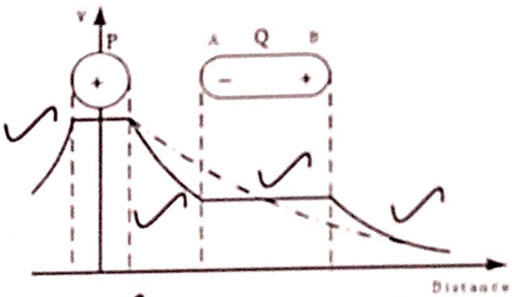
The potential at end A of conductor Q gets *lowered* while the potential at end B is *increased*.

Between extremes A and B of conductor Q, the electric *potential is constant.*

[03]



(ii) A sketch graph of Potential against distance.

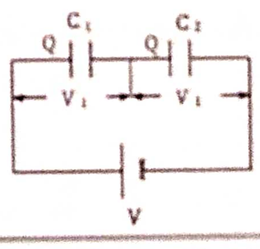


[02]

(c) <u>Same charge</u> is induced on all the plates of the capacitor

Net p.d $V = V_1 + V_2$

But $V_1 = \dfrac{Q}{C_1}$, and $V_2 = \dfrac{Q}{C_2} \Rightarrow V = \dfrac{Q}{C_1} + \dfrac{Q}{C_2}$



$$V = Q\left(\frac{1}{C_1} + \frac{1}{C_2}\right) = Q\left(\frac{C_1 + C_2}{C_1C_2}\right)$$

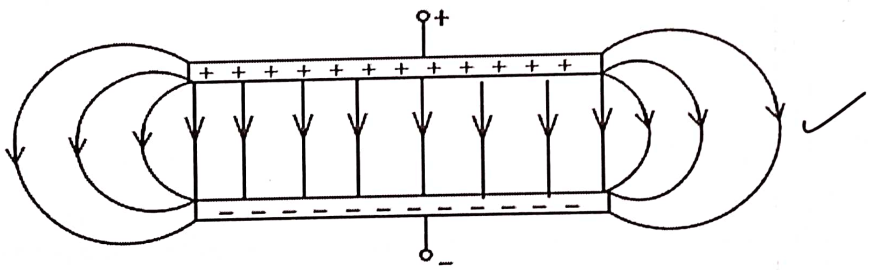
$$\therefore \text{charge, } Q = \left(\frac{C_1C_2}{C_1 + C_2}\right)V$$ [04]

(ii) - The distance between the plates.
- The area of overlap of the plates of the capacitor.
- The dielectric material placed to fill the space between the plates. [03]

(d) (i) - Storing large quantities of charge for nuclear research.
- Tuning in the radio/ TV receivers.
- Preventing sparking in large switches.
- Smoothing rectified alternating currents.

Any two @ 1 mark ***but only mark the first two for the candidates.*** [02]

(ii) Electric pattern for a charged parallel plate capacitor.

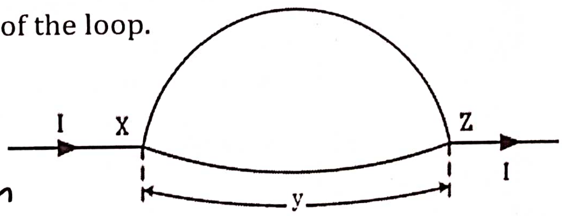


[01]

10. (a) (i) This is the resistance across opposite faces of a cube of the material of side 1 m. [01]

(ii) Let R_1 = resistance of length y of the loop.

Let R_2 = resistance of length (L – y) of the loop.



Using $R = \rho\frac{L}{A}$,

$$R_1 = \rho\frac{y}{A} \quad \text{and} \quad R_2 = \rho\frac{(L-y)}{A}$$

$$R_1R_2 = \left(\frac{\rho}{A}\right)^2 y(L-y) \text{ ....(i) and } R_1 + R_2 = \rho\frac{L}{A} \text{ ....(ii)}$$

The loop has 2 resistors in parallel, whose effective resistance

$$R = \frac{R_1 R_2}{R_1 + R_2} = \frac{\left(\frac{\rho}{A}\right)^2 y(L-y)}{\left(\frac{\rho}{A}\right) L} = \frac{\rho y (L-y)}{A L}$$

Hence $\rho = \dfrac{R A L}{y(L-y)}$ **[04]**

(b) $L_1 : L_2 = 4 : 5$, $d_1 : d_2 = 4 : 3$, and $R_1 : R_2 = 3 : 20$, $\rho_1 : \rho_2 = ??$

using, $\rho = \dfrac{R A}{L}$ $\therefore$ $\rho_1 = \dfrac{R_1 A_1}{L_1}$ and $\rho_2 = \dfrac{R_2 A_2}{L_2}$

$$\therefore \frac{\rho_1}{\rho_2} = \frac{R_1 A_1}{L_1} \div \frac{R_2 A_2}{L_2} = \frac{R_1}{R_2} \times \frac{L_2}{L_1} \times \left(\frac{d_1}{d_2}\right)^2 \text{ where } A = \frac{\pi d^2}{4}$$

$$\frac{\rho_1}{\rho_2} = \frac{3}{20} \times \frac{5}{4} \times \left(\frac{4}{3}\right)^2 = \frac{1}{3}$$

Hence, $\rho_1 : \rho_2 = 1 : 3$ **[03]**

(c) (i) An ***accumulator*** acting as the driver cell provides ***a steady current*** through ***a uniform resistance slide wire*** for a relatively longer time before running down.

This sets up ***a constant p.d per unit length*** across the slide wire.

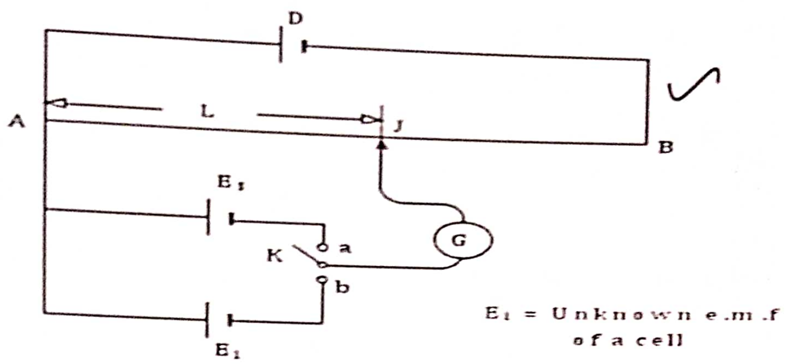
An *unknown e.m.f. or p.d, V*, is ***connected in opposition*** to the driver cell so as to supply current in the opposite direction to that of the driver cell.

The jockey is tapped on the slide wire until the *centre zero galvanometer shows no deflection*, and a balance length L is noted, it means the *unknown p.d. equals the p.d set up along the slide wire.*

Hence, the unknown p.d is proportional to the balance length i.e. $V \propto L$

[04]

(ii) A standard cell (source of e.m.f), **Es** is connected across a uniform resistance slide connected in series with the driver cell as shown in the figure below.



Switch K is thrown to position a , and the sliding contact J is tapped on the slide wire AB until the centre zero galvanometer G, shows no deflection. The balance length L_S is measured and recorded.

At balance $E_S = \frac{pd}{cm} \times L_S$ ....(i)

Switch K is thrown to position b , and the sliding contact J is tapped on the slide wire AB until the centre zero galvanometer G, shows no deflection.

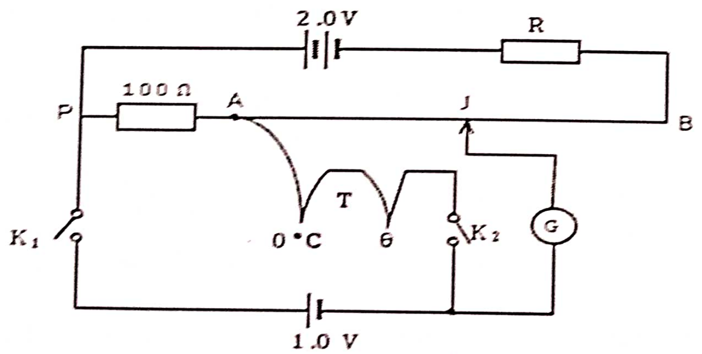
The balance length L_1 is measured and recorded.

At balance $E_1 = \frac{pd}{cm} \times L_1$ ....(ii)

From (i) and (ii) $E_1 = \frac{L_1}{L_S} \times E_S$ ....(iii)

Unknown e.m.f. E_1 is then calculated from equation (iii) above. **[03]**

(d)



(i) Resistance per cm $= \frac{2.00}{100} = 0.02\ \Omega\ cm^{-1}$ and when AJ = 90.0 cm

$R_{AJ} = (0.02 \times 90.0) = 1.8\ \Omega$

With K_1 closed and K_2 open, the p.d across PJ = 1.0 V

$I(100 + 1.8) = 1.0 \quad \Rightarrow I = 9.82 \times 10^{-3} A$

With K_1 open and K_2 closed, AJ = 45.0 cm and the p.d across AJ = e.m.f. of T

$$\Rightarrow E_T = (9.82 \times 10^{-3}) \times (0.02 \times 45.0)$$

$$\therefore E_T = 8.84 \times 10^{-3}\ V$$ **[03]**

(ii) Using $I(100 + R + 2.0) = 2.0$

$$\Rightarrow 9.82 \times 10^{-3}(102 + R) = 2.0$$

$$\therefore R = 101.7\ \Omega$$ **[02]**

= END =