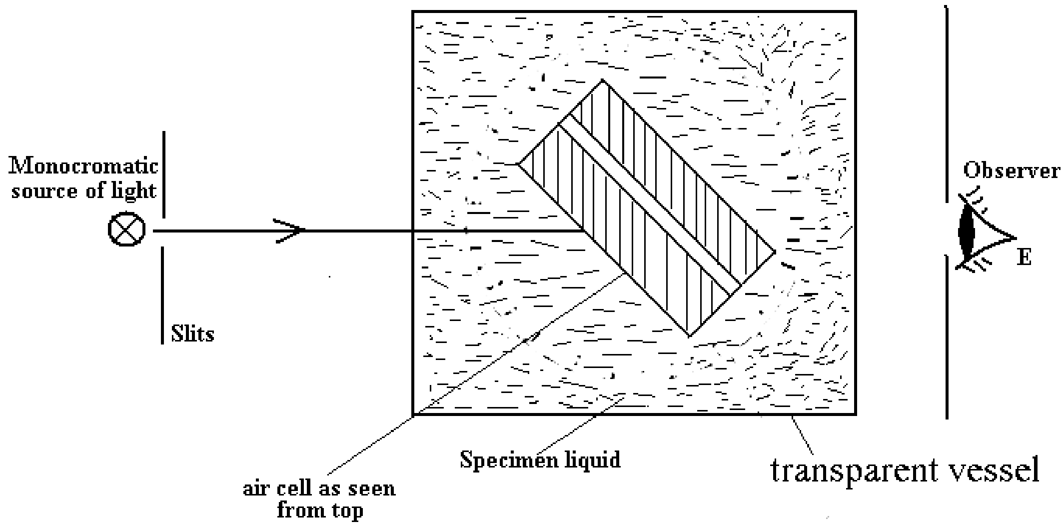
1. (a) Refraction is the bending of light as it moves from one medium to another.

(b)



Two plane-parallel glass plates are cemented together to make an air cell.

The air cell is put in water whose refractive index is to be determined.

Monochromatic light is directed normal to the air cell, and observed from the opposite side at E.

The air cell is rotated about a vertical axis until light is suddenly cut off from,E

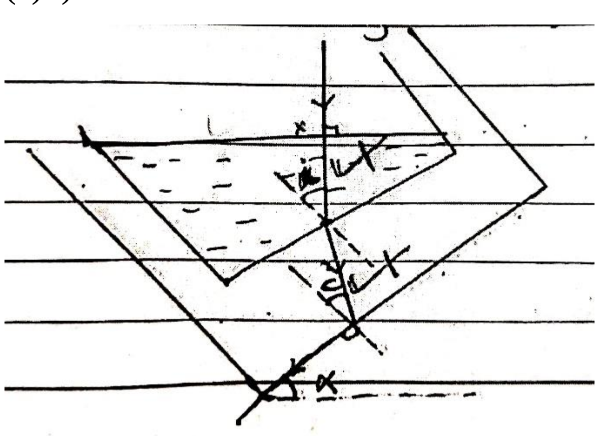
The angle of rotation θ_1 of the air cell is noted

The air cell is rotated back to its original position and then rotated in opposite direction until light is again cut off from, E

The angle of rotation θ_2 of the air cell is noted

The refractive index of water is then obtained from, $n = \frac{1}{\sin(\frac{\theta_1+\theta_2}{2})}$

(c) i)



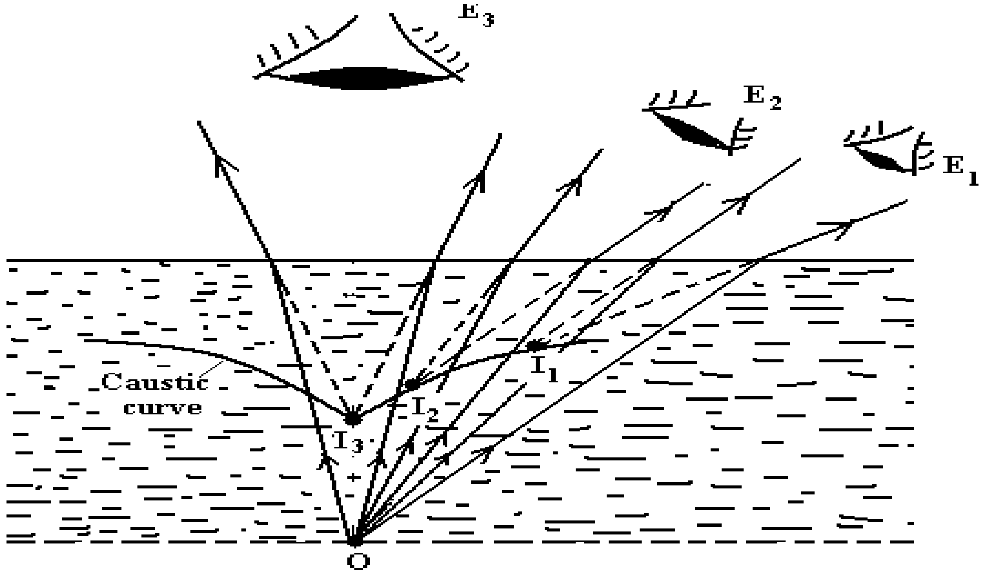
(ii) $1.5\,sinC = 1$

$sin^{-1}\left(\frac{1}{1.5}\right) = 41.8^0$

(iii) The angle of tilting of the container is equal to the angle of incidence, i at the water-glass boundary.

$1.33 sinC = 1$ $\Rightarrow C = 48.8^0$

(d)

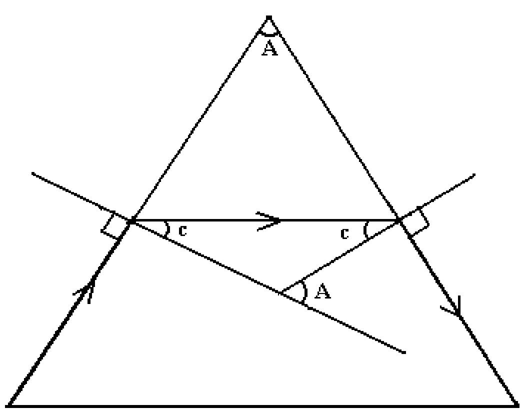


With the point O observed from above at E_3, rays of light are refracted away from the normal at the water-air interface and appears to be at I.

With O observed obliquely from E2, the angle of incidence increased the apparent depth decreased and the water tank appears shallow.

(e) (i) Limiting angle is the refracting angle of a prism for which there is grazing incidence and grazing emerges for light passing through the prism.

(ii)



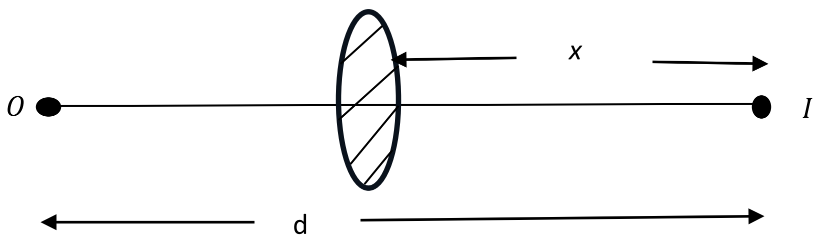
$$c = \sin^{-1}\frac{1}{1.5} = 41.8°$$

$$\text{Limiting angle } A = 2c = 83.6°$$

2. (a) Principal axis is a line through the optical center of the lens and joins the Centre of curvature of the lens surface.

Focal plane is a plane perpendicular to the principal axis and through the focal point of the lens.

(b) (i)



Let the image distance be x, the object distance is (d-x)

$$\frac{1}{f} = \frac{1}{d-x} + \frac{1}{x}$$

$$\frac{1}{f} = \frac{d}{dx-x^2}$$

$$dx - x^2 = fd, \qquad x^2 - dx + fd = 0$$

for real values of x, for real image

$$b^2 > 4ac$$

$$for\ ax^2 + bx + x = 0$$

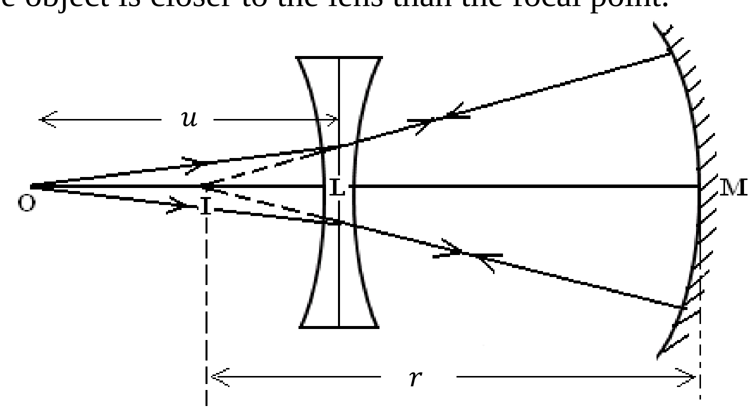
$$d^2 > 4fd$$

$$d > 4f$$

So for non-real values, $d \leq 4f$. No image is formed on the screen.

(ii) When the object is closer to the lens than the focal point.

(c)



An illuminated object is placed in front of a concave lens and a concave mirror is placed behind L

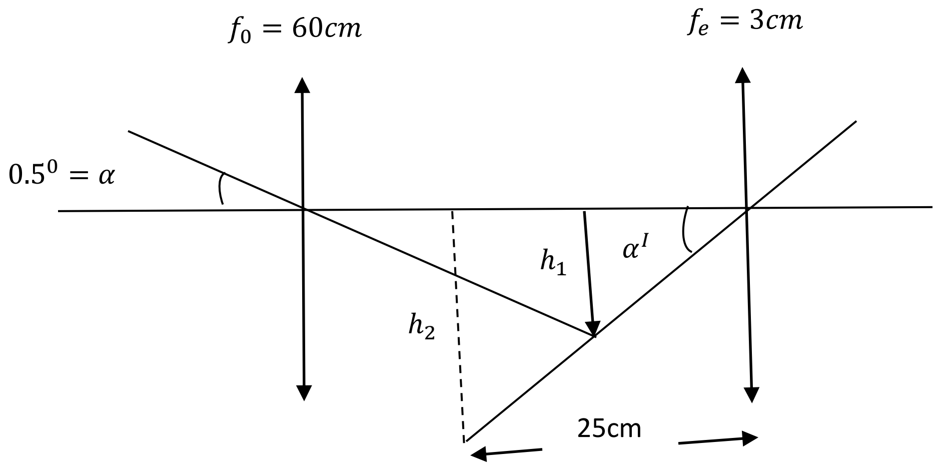
M is adjusted until, the final image coincides with the object, O

The distance LM, and OL are measured.

The image distance $IL = (r - LM), r$ is the radius of the curvature of the mirror M

The focal length of the lens is obtained from $\frac{1}{f} = \frac{1}{OL} - \frac{1}{r-LM}$

(d) (i)



For the eye piece, $\frac{1}{f_e} = \frac{1}{u_e} + \frac{1}{V_e}$

$\frac{1}{3} = \frac{1}{U_e} - \frac{1}{25}$, $\qquad U_e = \frac{75}{28}$, $\qquad U_e = 2.679cm$

Angular magnification, $M = \frac{f_0}{u_e} = \frac{60}{2.679} = 22.4$

(ii) $M = \frac{\alpha^I}{\alpha}$, $\quad \alpha^I = (22.4x0.5)$, $\alpha^I = 11.2^0$, $tan\alpha^I = \frac{h_2}{25}$, $h_2 = 4.95cm$

SECTION B

3. (a). In longitudinal wave motion, the wave particles vibrate parallel to the direction of travel of the wave.
   In transverse waves, the wave particles vibrate perpendicular to the direction of travel of the wave.
   (b). (i) f=250Hz, $\qquad$ V=30ms^{-1}
   From the general wave equation, $y = A\sin(wt - \frac{2\pi x}{\lambda})$

$\omega = 2\pi f \quad = 2\pi x 250 \quad = 500\pi$ rad^{-1}

$$\lambda = \frac{v}{f} \quad \boldsymbol{\lambda} = \frac{\mathbf{30}}{\mathbf{250}} = \frac{3}{25}$$

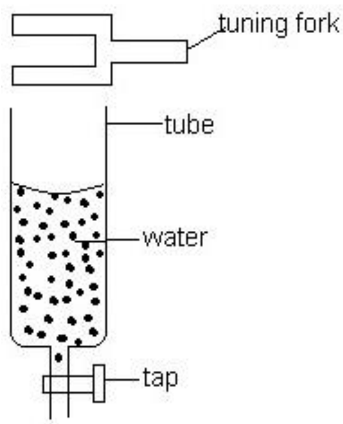
$$y = 0.03\sin(500\pi t - \frac{50\pi x}{3})$$

(ii) Phase difference $\triangle\,\Phi = \frac{50\pi\triangle x}{3}$

$\triangle\,\Phi = \frac{50\pi(10x10^{-2})}{3}$

$\triangle\,\Phi = \frac{5\pi}{3}$ radians

(c)



A tall glass jar is filled with water, and a vibrating tuning fork of frequency **f** held above the tube.

The tap is opened, and water is allowed to flow out until a loud sound is heard

The length **L** of the air column is measured,

The experiment is repeated for different values of f and the corresponding values of **L** determined.

Results are tabulated including values of $\boldsymbol{\frac{1}{f}}$

A graph of **L** against $\boldsymbol{\frac{1}{f}}$ is plotted, and the intercept **C** on the **L** axis is recorded

The end correction $\boldsymbol{e = -C}$

(d) $\boldsymbol{\lambda}$=397nm $\quad \boldsymbol{\lambda}^1$= 478nm

(i) The Galaxy is moving away from the earth

Increase in apparent wavelength shows red shift in the spectrum. Thus the galaxy is moving away.

$$V = \left(\frac{\lambda^1 - \lambda}{\lambda}\right)C$$

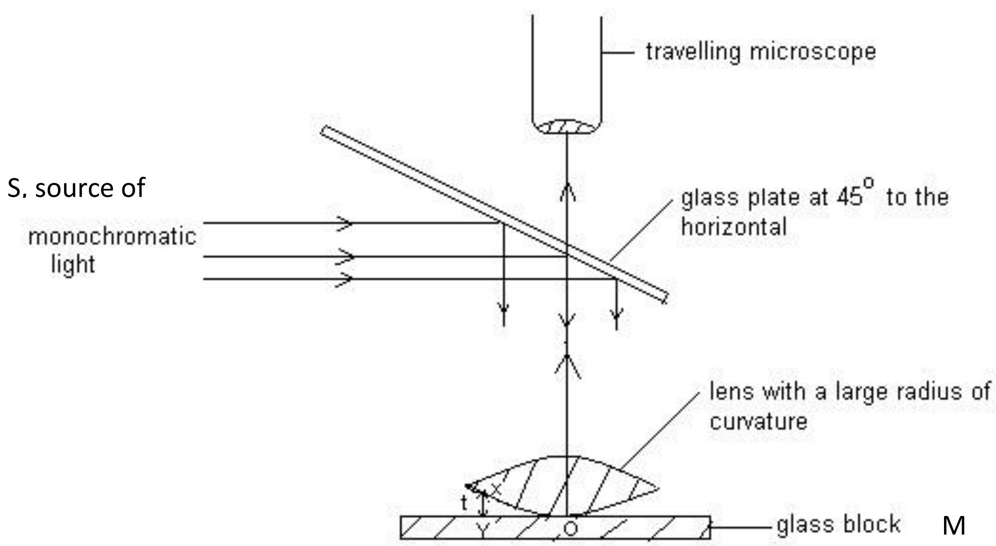
$$V = \left(\frac{478x10^{-9} - 397x10^{-9}}{397x10^{-9}}\right)3.0x10^8$$

$$V = \frac{81}{397}x3.0x10^8$$

$$V = 6.127x10^7 ms^{-1}$$

(e) At night the air near the earth's surface is cold compared to the air progressively above. Since sound travels faster at high temperature, sound is progressively refracted away from the normal. Sound thus bends downward towards the earth. During the day, the air near the earth is hot, compared to air progressively above. Sound is refracted towards the sky

4. (a) interference of the light is the superposition of light from coherent source leading to alternate regions of maximum and minimum intensity
Interfering lights must;
- have same frequency
-have equal or comparable amplitude
- have constant phase relationship
(b) (i)



Monochromatic light from S is reflected by the glass plate on to the convex lens placed on to the glass block labeled M
A travelling microscope is focused on to the lens, alternate bright and dark rings are observed.

When light is incident on the lens, some light is reflected from the lower surface of the lens, and the light transmitted is reflected from the upper surface of the glass block.
The reflected wave trains are coherent they overlap and interference takes place.
Alternate bright and dark rings formed.
Due to reflection on the glass block, there is a phase change of 180^0 (extra path difference of $\lambda/_2$)
At the center of the pattern, path difference is $\lambda/_2$, a dark band is formed.
At the positions, where $2t = n\boldsymbol{\lambda}$, $\boldsymbol{n = 0, 1, 2, 3}, \ldots \ldots$ .... **where** t is the thickness of the air film between the lens and glass block, dark rings are formed
At positions where $2t = \left(n - \frac{1}{2}\right)\boldsymbol{\lambda}, n = 1,2,3, \ldots \ldots$ bright rings are formed

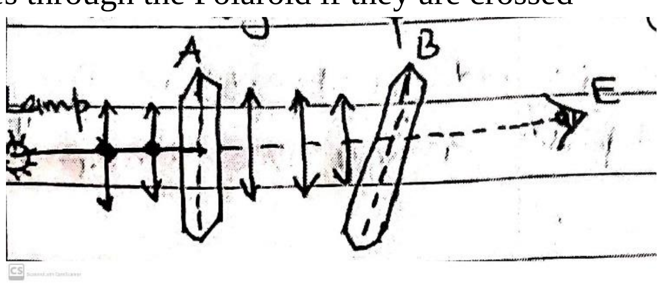
(ii) $y_{10} = 3.44cm$, $D = 2cm$ $\boldsymbol{\lambda} = 5.89x10^{-7}\ m$

$$y_n = \frac{n\lambda d}{a}$$

$$a = \frac{n\lambda d}{y_n} = \frac{10x5.89x10^{-7}x2x10^{-2}}{3.44x10^{-2}}$$

$$a = 3.424x10^{-6}\ m$$

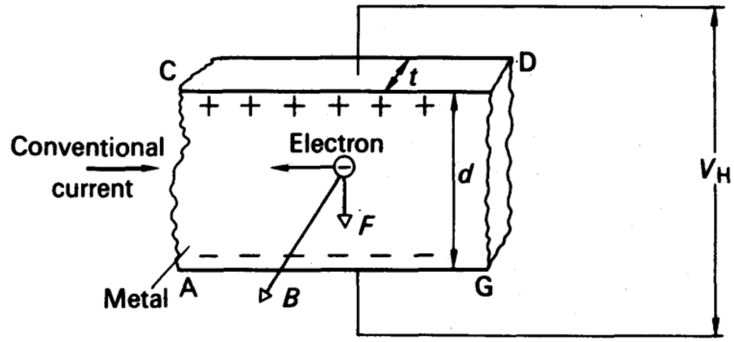
(c) (i) Diffraction is the spreading of light beyond the geometric shadow leading to interference pattern at the edge of the shadow.
Polarization of light is when the vibration of the electric vector of light is restricted in only one plane perpendicular to the direction of travel of light.
(ii) No light passes through the Polaroid if they are crossed



As B is rotated, intensity of light increases and reaches maximum after 90^0 rotation of B. As B is rotated, a component of the electric vector of polarized light passes through it. After 90^0, the orientation of A and B is the same. All the polarized light passes through.
(ii) $\tan i = \frac{1.53}{1.33}$, $i = \tan^{-1}\frac{1.53}{1.33}$, $i = 49^0$
(d)-used in sun glasses to reduce glare
-Stress analysis
-Measurement of concentration of sugar solution

5.(a) Magnetic field is a space in which a magnetic force is experienced .

(b)



(i) When a magnetic field is applied, each electron experiences a magnetic force , perpendicular to magnetic field and current .

One face of the strip becomes negative relative to the opposite face p.d is developed across the strip.

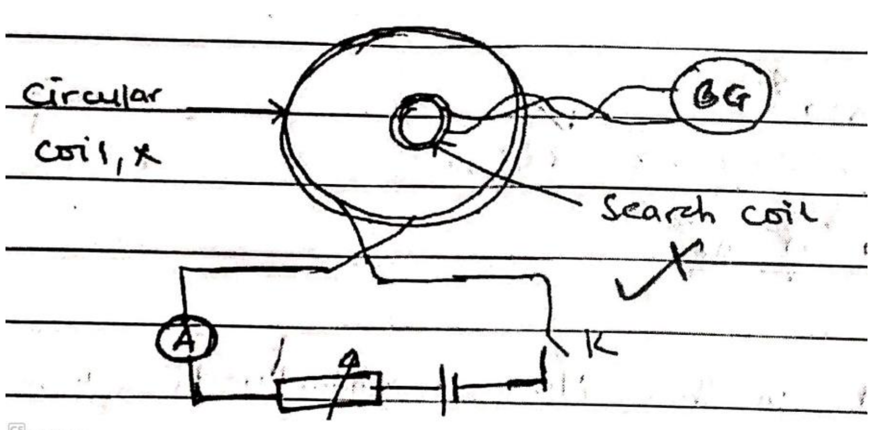
(ii) drift velocity, v = $\frac{I}{neA} = \frac{0.5}{5X10^{22}X10^{6}X1.6X10^{-19}(1.2X10^{-2}X1.5X10^{-5})}$ = $3.47X10^{-4}ms^{-1}$

(iii) p.d is maximum when a magnetic force is equal to electrostatic force on an electron.

E= BV , $\frac{VH}{d} = BV$, VH = 0.5 X $3.47X10^{-4}$X $1.2X10^{-2}$ = $2.082X10^{-6}$V.

$V_H = \frac{BI}{net} = \frac{0.5x.05}{5x10^{22}x10^{6}x1.6x10^{-19}\,x1.5x10^{-5}}$ = $2.08x10^{-6}$v.

(c)



Switch k, is closed and the ammeter reading, I, is noted.

A search coil connected to a ballistic galvanometer is placed at the center of a circular coil x, such that the magnetic field of the coil enters it normally.
The search coil is quickly turned through 90 ° and the deflection θ noted on the ballistic galvanometer.
The experiment is repeated for different values of I and the corresponding values of θ noted.
A graph of θ against I is plotted and a straight line through the origin is obtained.

(d)

i) $B=\mu_o nI$

$=4\pi x10^{-7}x2000x4$

$=1.0053x10^{-2}T$

ii) $\tau = BIAN\cos\theta, I = \frac{\tau}{BAN\cos\theta}$

$I = \frac{3.0x10^{-8}}{1.0053x10^{-2}x5x10^{-2}x2x10^{-2}x50\cos 60} = 1.194x10^{-4}A$

(e) The bar magnet rests in the north –south direction, and dips southwards .north pole of the magnet points northwards. In the southern hemisphere, the magnetic field of the earth dips southwards .a freely suspended magnet rests along the magnetic field of the earth.

6. (a) The magnitude of induced emf is directly proportional to the rate of change magnetic flux linkage

The direction of the induced current is in a such a way as to oppose the change causing it.

(b) (i)

$$B = 1.2x10^{-2}J$$

$$A = 0.3m^2$$

$$initial\ flux, \emptyset_o = BAN = 1.2x10^{-2}x0.3x150$$

$$\emptyset_o = 0.54Wb$$

(ii)

$$Final\ flux, \emptyset_t = BANcos70°$$

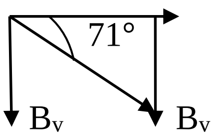
$$= 0.54cos70°$$

$$0.1847Wb$$

$$Emd\ induced = \emptyset_o = \frac{0.54 - 0.1847}{2}$$

$$\varepsilon = 0.17765V$$

(c) (i) As the coil of the motor rotates it cuts the magnetic field and an emf is induced in it. The induced emf opposes the applied voltage of the motor. This induced emf is called back emf.

(ii) 

B_H= 1.6x10^{-5}T   l=40m   v= $\frac{100x1000}{60x60}$=27.8ms^{-1}

$B_V = 1.6X10^{-5}x \tan 71.6°$

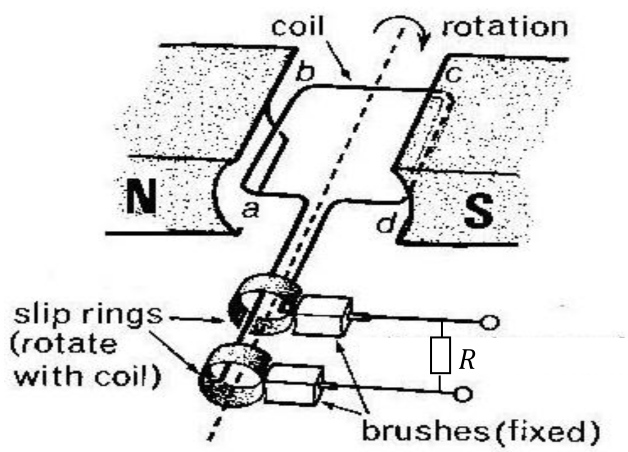
$B_v = 4.81x10^{-5}T$

Induced emf ,$\varepsilon = BlV$

$\varepsilon = 4.81x10^{-5}x40x27.8$

$\varepsilon = 5.349x10^{-2}v$

(d)



When the coil is rotated about the axis, the coil cuts the magnetic field, and an emf is induced in the coil. The induced current flows through the load R.

When the coil reaches vertical position, no emf is induced. Beyond the vertical position, the emf induced in the coil and the direction of the flow of current reverses

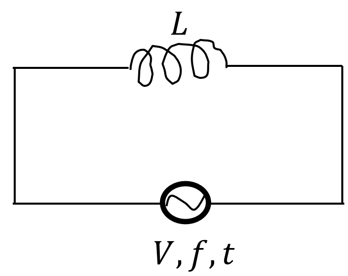
Each carbon brush remains in contact with its split ring, an alternating current then flows through the load R

The emf induced produced is given by $E = BAN\omega sin\omega t$.

7. (a) Peak value of alternating voltage is the maximum value of the voltage.

Root mean square value is the value of direct voltage that dissipates heat in a given resistor at the same rate as the alternating voltage.

(b) (i)



$$Back\ emf\ in\ the\ coil: \varepsilon = -L\frac{dI}{dt}$$

$$For\ current\ to\ flow, \varepsilon = -V$$

$$V = L\frac{dI}{dt}$$

$$I = \frac{V_o}{L}\int sin\omega t dt$$

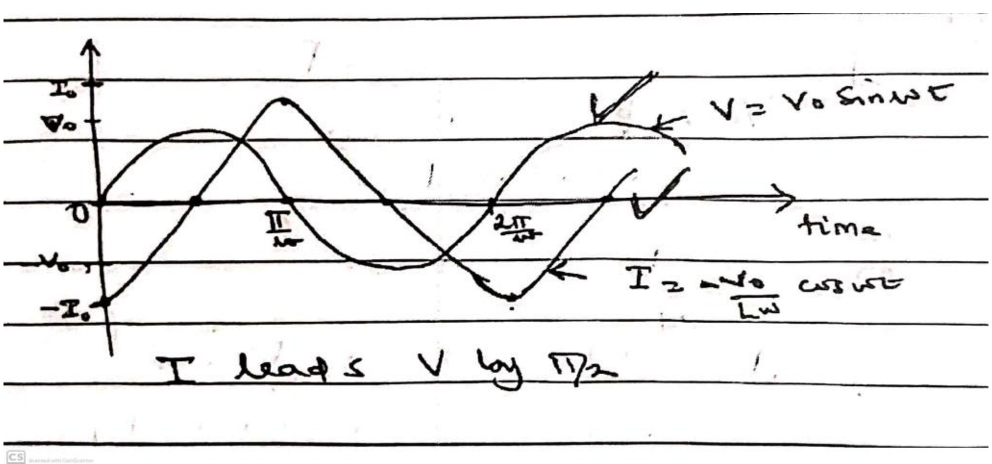
$$I = -\frac{V_o}{L\omega}cos\omega t$$

$$Peak\ value\ I_o = \frac{V_o}{\omega L}$$

$$Reactance\ X_L = \frac{V_o}{I_o} = L\omega \quad But\ \omega = 2\pi f$$

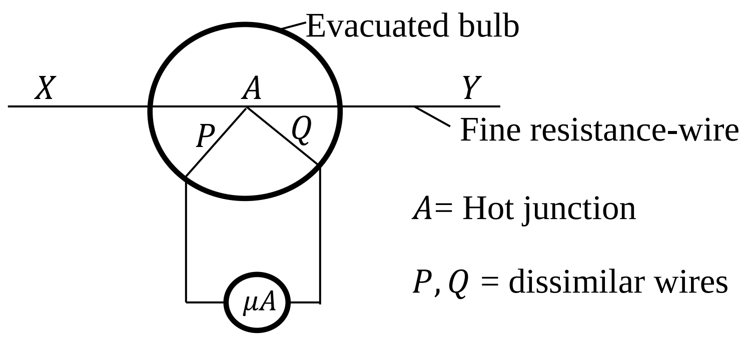
$$X_L = 2\pi f L$$

(ii)



(iii) When current is maximum, it is momentarily constant. Since back emf $\varepsilon = -L\frac{dI}{dt}$, back emf is zero when the current is zero, its the rate of flow is maximum, back emf is maximum since back emf $\varepsilon = -V$ applied voltage is zero when the current is maximum and voltage is maximum when current is zero.

(c)



One junction is connected to the center of the resistance wire, the other junction is at room temperature.

Current to be measured is passed through the resistance wire, the wire gets hot and A becomes the hot junction

Thermal emf is created, a direct current then flows and and is received by the moving coil meter.

The hot junction is enclosed in an evacuated bulb to protect it from droughts.

(d) (i)

$$V^2 = {V_R}^2 + {V_C}^2$$

$$V_C = \sqrt{15^2 - 10^2} = 11.8V$$

(ii)

$$I = \frac{V}{R}$$

$$I = \frac{10}{500} = 0.02A$$

$$V_C = IX_C$$

$$11.18 = 0.02x\frac{1}{2\pi fC}$$

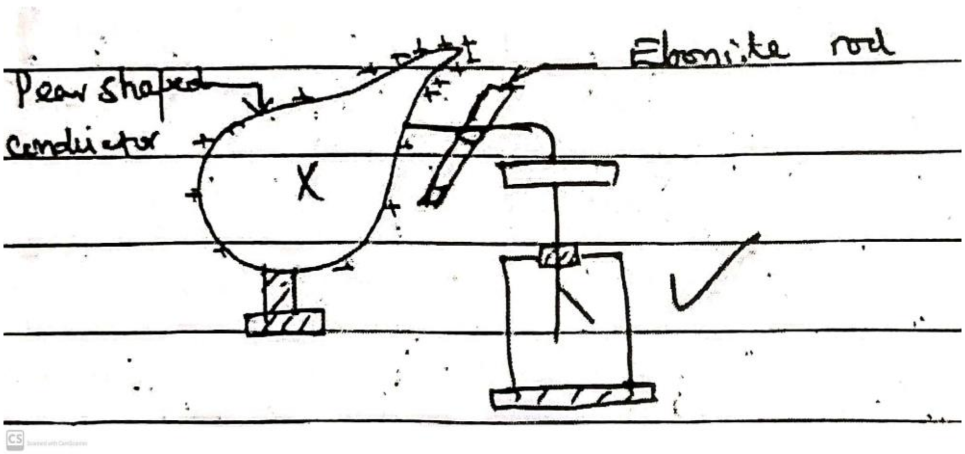
$$C = \frac{0.02}{11.18x2\pi x50} = 5.69x10^{-6}F$$

8. (a) Electric field intensity is the force experienced by one coulomb of charge at a point in an electric field.

Electric potential is the work done in moving one coulomb of electric charge from infinity to a point in an electric field.

(b) (i) At the pointed end of the pin, there is high charge density and high electric field intensity. Air around the pin gets ionized, negative ions get attracted to the pin and neutralize some of the positive charges there. The electroscope is gradually discharged. The gold leaf falls gradually.

(ii)



A wire is connected on the cap of neutral gold leaf electroscope

The free end of the wire is put on the surface of charge pear shaped conductor, divergence on the gold leaf electroscope is noted.

The free end of the wire is moved, ion on the surface of conductor x, divergence on the electroscope remains the same, potential on the surface of X is constant.

(iii) Electric flux through an area A

$$\emptyset = ExA$$

$$Electric\ flux, \emptyset = \frac{\propto}{\varepsilon} \dots\dots (i)$$

$$But\ total\ charge \propto = \sigma . A$$

$$EA = \frac{\sigma . A}{\varepsilon}$$

$$E = \frac{\sigma}{\varepsilon}$$

(c) (i) $Potential\ energy = V_X x \propto$

$$= -100x2x10^{-9}$$

$$= -2x10^{-7}J$$

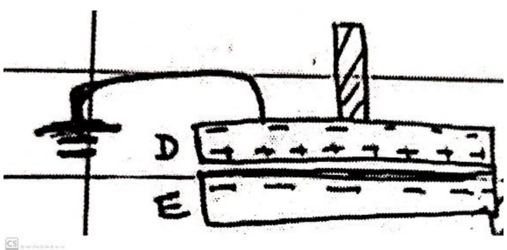
$$p.d;\ V_{xy} = -100 - 200 = -300J$$

$workdone = V_{xy}.\propto$

$$= 300x2x10^{-9}$$

$$= 6x10^{-7}J$$

(d)



E-ebonite base, D-metal disc

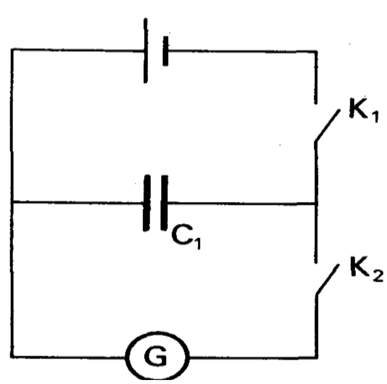
-A metal disc D is placed on a negatively charged ebonite base E; positive charge is induced on the lower surface D and Negative charge is induced on the upper surface.

-The metal disc is then earthed; the disc can then be moved and carries with it the positive charge.

9. (a) Dielectric strength is the maximum potential gradient beyond which the insulation of dielectric breaks down and starts to conduct.

S.I unit of dielectric strength is V/m or N/C

(b)



A parallel plate capacitor is connected in the circuit as shown above.

Switch k1 is closed for a short time and then opened, switch K2 is closed and the first flow direction, θ_0 is noted on the Ballistic galvanometer

A dielectric material is inserted between the plates of the capacitor and the experiment repeated

The first throw deflection θ is noted from the Ballistic galvanometer

Dielectric constant $\varepsilon_r = \frac{\theta}{\theta_0}$

(c) $C = \frac{\varepsilon_O A}{d} = \frac{8.85x10^{-12}x25x25^{-4}}{1x10^{-3}}$

$$C = 2.2125x10^{-11}F$$

$$Q = CV = 2.2125x10^{-11}x100$$

$$Q = 2.2125x10^{-9}C$$

$$C' = \frac{\varepsilon_O A}{d'} = \frac{8.85x10^{-12}x25x10^{-4}}{2x10^{-3}}$$

$$C' = 1.10625x10^{-11}F$$

$$By\ conservation\ of\ charge:$$

$$V' = \frac{\alpha}{C'} = \frac{2.215x10^{-9}}{1.10625x10^{-11}} = 199.1V$$

$$Initial\ energy, E_1 = \frac{1}{2}C_1{V_1}^2 = \frac{1}{2}x2.215x10^{-11}x100^2$$

$$E_1 = 1.10625x10^{-7}J$$

$$Final\ energy, E_2 = \frac{1}{2}x1.10625x10^{-11}x(199.1^2)$$

$$E_2 = 2.1926x10^{-7}J$$

$$\Delta E = 1.0864x10^{-7}J$$

(ii) As plates are moved apart, work is done to overcome the force of attraction between the plates. This work is converted into electrostatic energy thus increase in energy stored by the capacitor.

(d) (i) when capacitors are connected in series, charge on either of the capacitors is equal and same as the total charge. p.d across each capacitor is less than the total p.d across the combination since $C = \frac{Q}{V}$, capacitance of the combination is thus less than capacitance of either capacitor.

(ii)When a dielectric is plates between plates of a charged capacitor, the molecules of the dielectric get polarized.

Negative charges in the dielectric appear near the positive plate, positive charge appear near the negative plate.

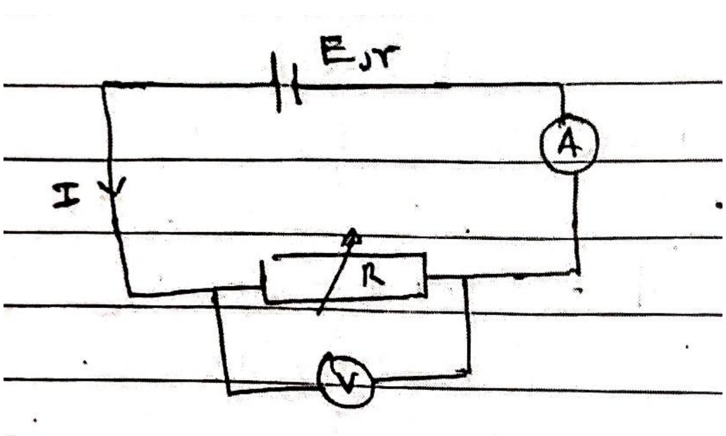
Potential on the positive plate decreases and that on the negative plate increases.

P.d, V between the plates reduced since $C = \frac{Q}{V}$, capacitance increases.

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

Terminal p.d of a cell is the p.d across the terminals of the cell in a closed circuit.

(b)

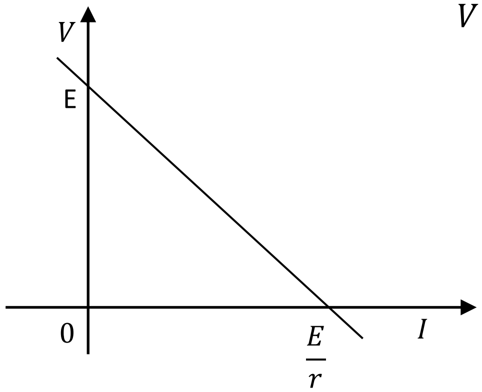


$$E = I(R + r)$$

$$E = V + Ir$$

$$V = E - Ir$$

(i)



-The intercept on V-axis is the emf of the cell

-Slope s of the graph is determined

- $r = -s$

(ii) $r = 2\Omega$

$$R_T = 10 + \left(\frac{2x100}{2 + 100}\right)$$

$$= 11.96\Omega$$

$$emf = I(R + r)$$

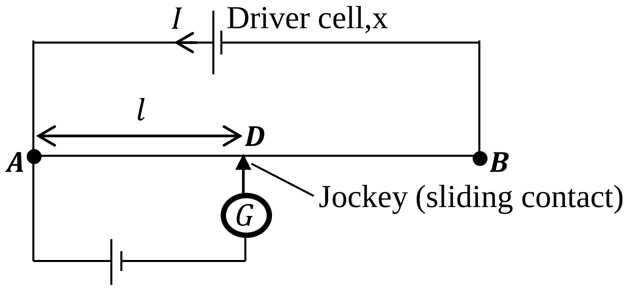
$$Ammeter, I = \left(\frac{2}{11.96 + 2}\right)$$

$$= \frac{2}{13.96} = 0.143A$$

$$Voltmeter: V = IR;$$

$$V = 0.143\left(\frac{2x100}{2 + 100}\right) = 0.28V$$

(c)

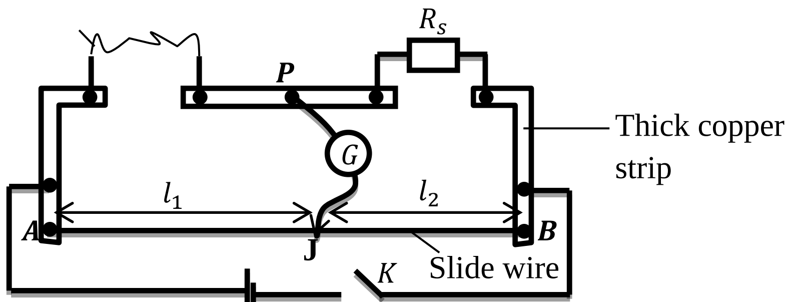


-A driver cell, x maintains a steady current through a uniform resistance wire AB

-Since AB is uniform, its resistance is constant, thus p.d/cm is a constant

-The p.d between two points l distance apart is proportional to the length $l, V_{AB} = kl$

(d)



$$At\ 17°\text{C}: R_{17} = 7.3\Omega$$

$$l_1 = 42.6cm$$

$$\frac{R_{57}}{R_{17}} = \left(\frac{1 + 57\alpha}{1 + 17\alpha}\right)$$

$$R_{57} = \left(\frac{1 + 57x3.8x10^{-3}}{1 + 17x3.8x10^{-3}}\right)7.3$$

$$R_{57} = \frac{1.2166}{1.0646}x7.3 = 8.34\Omega$$

For the meter bridge; $At\ 17°\text{C}$; $\frac{R_S}{7.3} = \frac{57.4}{42.6}$

$$R_s = 9.84\Omega$$

$At\ 57°\text{C}$; $\frac{8.34}{9.84} = (\frac{l_1}{100-l_1})$

$$l_1 = 0.84.76(100 - l_1); \qquad \therefore l_1 = 45.88\ cm$$

(ii) The balance point is taken near the middle to increase sensitivity of the meter bridge.

For small balance length, resistance of copper strips becomes significant.

END