ROWA ELEARNING PLATFORM
MARKING GUIDE S.6 PHYSICS 2 UNEB 2020

Question 1:

(a).

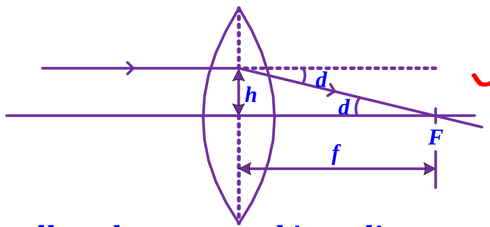
- The incident ray, refracted ray, and the normal at the point of incidence all lie in the same plane.
- For a given pair of optical media, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

02

(a).

(b). (i).

Consider ray parallel and close to the principal axis incident on a lens at a small height h above the axis as shown below.



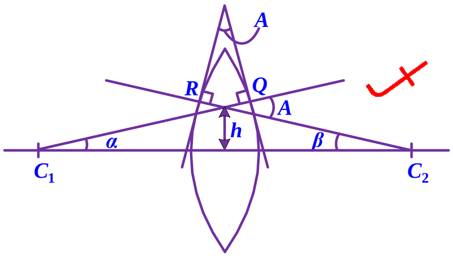
Assuming that d is a small angle expressed in radians,

$$d \approx \tan d = \frac{h}{f}$$

but, $d = A(n-1)$, $\Rightarrow \frac{h}{f} = A(n-1)$, $\therefore \frac{1}{f} = (n-1)\frac{A}{h} \longrightarrow (1)$

(b).

The normals at Q and R pass respectively through the centres of curvature C_1 and C_2 of the lens surfaces as shown below.



$$\alpha \approx \tan\alpha = \frac{h}{r_1} \quad \text{and} \quad \beta \approx \tan\beta = \frac{h}{r_2}$$

$$A = \frac{h}{r_1} + \frac{h}{r_2}, \qquad \Rightarrow \frac{A}{h} = \left[\frac{1}{r_1} + \frac{1}{r_2}\right]$$

Substituting for $\left(\frac{A}{h}\right)$ in equation (1) gives:

$$\frac{1}{f} = (n-1)\left[\frac{1}{r_1} + \frac{1}{r_2}\right]$$

05

From geometry, $A = \alpha + \beta$

Assuming that α and β are small angles expressed in radians

(ii).

$$\frac{1}{f} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{-25} + \frac{1}{20}\right)$$

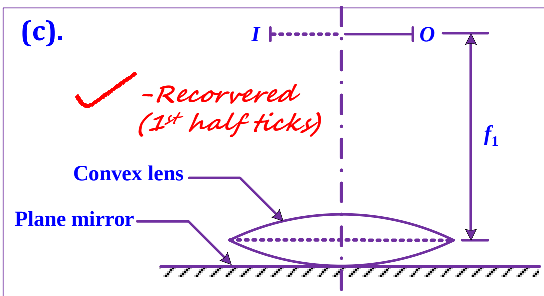
$$\frac{1}{f} = \frac{1}{200}$$

$$f = 200 \text{ cm}$$

02

(b).

(c).



-Recorvered (1st half ticks)

A plane mirror is laid on a table with its reflecting face upwards and a thin biconvex lens of known radius of curvature r is placed on it.

An optical pin O is clamped horizontally in a retort stand above the lens so that its tip lies along the principal axis of the lens.

The pin is then moved up and down vertically while viewing from above and a point is located where the pin coincides with its image I and there's no parallax between them.

The distance, f_1 of the pin from the lens is measured and recorded.

(c).

The lens is then removed from the plane mirror and a small quantity of the test liquid is placed on the plane mirror.

The lens is then placed back on top of the liquid and the new position where the pin coincides with its image is located.

The distance, f, of the pin from the lens measured and recorded.

The focal length, f_2 , of the liquid lens only is obtained from

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

Now the refractive index, n, of the test liquid is calculate from

$$n = \left(1 + \frac{r}{f_2}\right)$$

06

(d). (i).

$$m = \frac{v}{f} - 1$$

$$300 = \frac{v}{3} - 1$$

$$301 = \frac{v}{3}$$

$$v = 903 \text{ cm}$$

03

(ii).

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

$$300 = \frac{903}{u}$$

$$u = \frac{903}{300} = 3.01 \text{ cm}$$

02

(d).

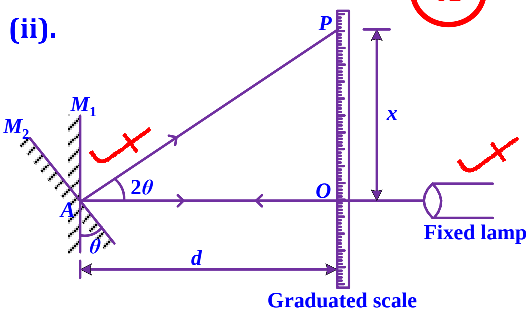
Question 1:

(a). (i).

- The angle of incidence is equal to the angle of reflection.
- The incident ray, reflected ray, and the normal, at the point of incidence; all lie in the same plane.

02

(ii).



A small plane mirror M_1 is rigidly attached to a system which rotates when current flows through it and a beam of light from a fixed lamp shines on the mirror as shown in the diagram.

(a).

If the light is incident normally on the mirror at A, the beam is reflected directly back along the same path and a spot is obtained at O on a graduated scale placed just below the lamp.

When a current, I, is passed in the system, the mirror rotates through an angle θ to position M_2 and the spot of light is deflected through a distance, x, to position P on the scale.

The rotation of the reflected ray is twice the angle of rotation of the mirror.

$$\tan 2\theta = \frac{x}{d}$$

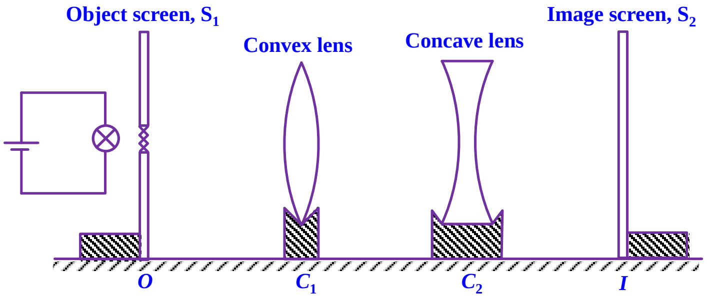
For small angles expressed in radians, $\tan 2\theta \approx 2\theta$

04

$$2\theta = \frac{x}{d}$$

Since $I \propto \theta$, the current flowing through the system can be determined.

(b).



The apparatus is arranged as above.

First, in absence of a concave lens, an illuminated object (wire gauze), O, is placed in front of a convex lens at a distance greater than the focal length.

The position of the screen, S_2 , is then adjusted until a clear/sharp image of the wire gauze is formed on it.

(b).

The new position of the screen , S_2 , is noted and a plane mirror is now made to replace the scree , S_2 , at the same position.

The concave lens whose focal length is required is now placed between the convex lens and the plane mirror.

The position of the concave lens is adjusted until a clear/sharp image of the wire gauze is formed on the object screen just besides the wire gauze.

The distance between the concave lens and the plane mirror is measured and is equal to the focal length of the concave lens.

04

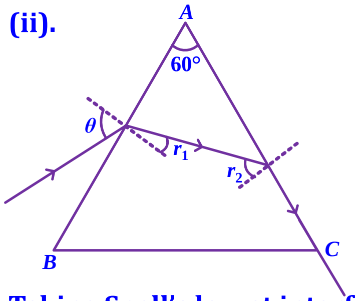
(c). (i).

$$n = \frac{c}{v} = \frac{3.0 \times 10^8}{2.0 \times 10^8} = 1.5$$

02

(c).

(ii).



Taking Snell's law at interface AC,

$$\sin r_2 = \frac{1}{n}$$

$$\sin r_2 = \frac{1}{1.5}$$

$$r_2 = 41.81°$$

but, $r_1 + r_2 = 60$

$$r_1 + 41.81 = 60$$

$$r_1 = 18.19°$$

Taking snell's law at interface AB,

$$\sin\theta = n\sin r_1$$

$$\sin\theta = 1.5\sin 18.19°$$

$$\theta = 27.92°$$

03

(iii).

The ray will emerge through face AC. 02

This is because the angle of incidence on the face AC will be less than the critical angle.

(c).

(d).

The eyepiece is adjusted until the cross wires appear clearly (are in sharp focus).

The telescope is turned to face away from the collimator (or a distant object).

The length of the telescope is adjusted to focus a distant object (or to receive parallel light rays).

The telescope is now turned to face the collimator directly.

The slit of the collimator then illuminated and the length of the collimator adjusted until the image of the slit is formed clearly on the cross wires.

In this way, the spectrometer has been adjusted and read for use. 03

(d).

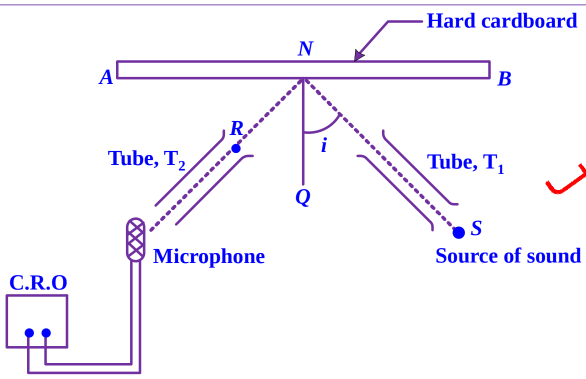
Question 3:

(a).

- Mechanical waves are generated due to mechanical vibration or oscillation of particles in the transmitting medium while electromagnetic waves are generated electronically or due to electron transition.
- Mechanical waves propagate by oscillation of particles of the medium while propagation for electromagnetic waves is due to varying electric and magnetic field. 02
- Mechanical waves require a material medium for propagation while electromagnetic waves can travel in vacuum. Any two
- Mechanical waves propagate at relatively low speed. (or have relatively long wavelength) while electromagnetic waves propagate at relative high speed. (or have relatively short wavelength).

(a).

(b).



A line is drawn on a sheet of paper.

A normal NQ is drawn on the line AB and another line NS is drawn at a measured angle, i.

A hard cardboard is placed along AB and a hollow tube, T_1 , is placed along NS.

(b).

A source of sound is placed at S.

Another tube, T_2 , is placed on the opposite side of NQ facing point N.

A microphone connected to the $Y-$ plates of a cathode ray oscilloscope ($C.R.O$) is placed at the mouth of the tube, T_2 and a vertical trace is observed on the screen.

The position of the tube, T_2 together with the microphone is adjusted by moving them away from NQ until a maximum length of the vertical trace is observed on the screen.

Position, R, is noted.

The tubes are removed and a line RN is drawn.

The angle RNQ is measured and is found to be equal to i. 04

Sound therefore obeys the laws of reflection of light.

(c). (i).

When two notes of equal amplitudes and nearly equal (or slightly different) frequencies are sounded together, they superpose.

When they meet in phase, reinforcement takes places and a loud sound is heard.

When they meet completely out of phase, cancellations takes places and a soft sound or no sound is heard.

A sound that rises and falls in intensity periodically is heard, which is called beats.

03

(c).

(ii).

The test note is sounded together with a standard note, say a tuning fork.

The number of loud sounds occurring per second, f_b are counted and recorded together with the frequency, f_1 of the tuning fork.

Now beat frequency $f_b = f_1 - f_2$ or $f_b = f_2 - f_1$.

To tell which is the correct formula to use, one prong of the tuning fork is loaded with plasticine and the procedure repeated and the beats per second counted, $f_b{}'$.

If $f_b{}' > f_b$, then $f_b = f_2 - f_1$ implying that the test frequency $f_2 = f_1 + f_b$.

If $f_b{}' < f_b$, then $f_b = f_1 - f_2$, implying that $f_2 = f_1 - f_b$.

04

(c).

(d). (i).

$$u_s = 108 \text{ km h}^{-1} = \frac{108 \times 1000}{3600} = 30 \text{ m s}^{-1}$$

$$f' = \left(\frac{v}{v - u_s}\right) f$$

$$= \left(\frac{340}{340 - 30}\right) \times 256$$

$$= 280.77 \text{ Hz}$$

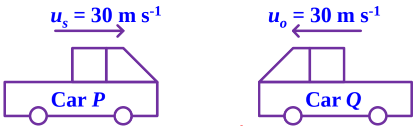
03

(d).

(ii).

The question only says that the cars are in opposite directions but does not is specify whether the cars P and Q are moving towards each other or away from each other. So, any of the two is okay.

Case 1: When the cars P and Q are moving towards each other

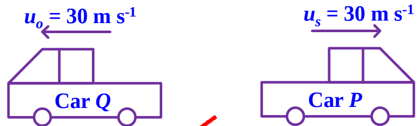


$$f' = \left(\frac{v + u_o}{v - u_s}\right) f = \left(\frac{340 + 30}{340 - 30}\right) \times 256$$

$$= 305.55 \text{ Hz}$$

Alternatively:

Case 2: When the cars P and Q are moving away from each other



$$f' = \left(\frac{v - u_o}{v + u_s}\right) f = \left(\frac{340 - 30}{340 + 30}\right) \times 256$$

$$= 214.49 \text{ Hz}$$

03

(d).

(e).

- **Determination of the direction of motion of the stars.**
- **Estimation of the speed of stars.**
- **Estimation of speed of cars using guns.**
- **Determination of plasma temperature.**
- **Used in radar speed traps to determine the speed of a moving vehicle.**

01 *Any two*

(e).

Question 4:

(a). (i).

Ordinary light is one whose electric vector varies or vibrates in every plane perpendicular to the direction of the light ray. 01

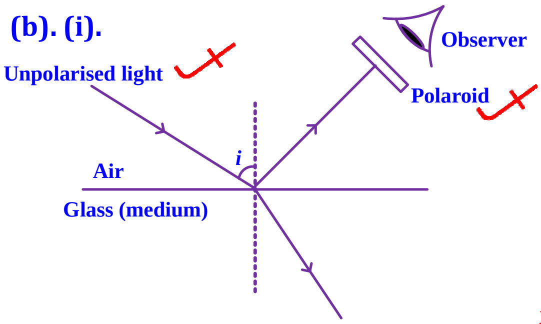
(ii).

Plane polarized light is one whose electric vector varies or vibrates in only one plane perpendicular to the direction of the light ray.

Or: This is one in which the variation of its electric vector takes place in only one plane (and also the magnetic vector). 01 *Any one*

(a).

(b). (i).



A narrow beam of unpolarized light is directed onto the medium and the reflected light is viewed through a polaroid.

Starting with a small angle of incidence, the polaroid is rotated about an axis through its plane.

The angle of incidence is gradually increased whereby at each angle of incidence, the reflected light gets cut off from the observer; as the polaroid is rotated.

At this point, the reflected light is completely plane polarized. 04

(b).

(ii).

Note: The question has an error since a polaroid does not refract.

If a word "polaroid" was replaced by another word say "transparent glass plate", the solution would be as follows:

$$\tan i = n$$

$$\tan i = 2.417$$

$$i = 67.52°$$

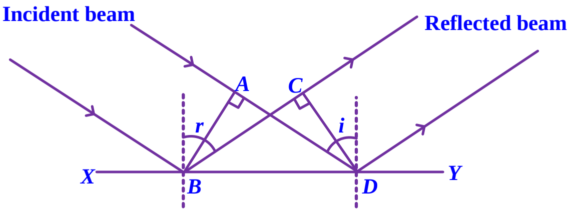
(c). (i).

Huygen's principle states that every point on a wavefront may be regarded as a source of secondary spherical wavelets which move with the speed of the wave and the new wavefront is the envelope which touches the surfaces of the wavelets. 01

(b). (c).

(ii).

Consider a parallel beam of monochromatic light incident on a plane reflecting surface XY, such that its direction of travel makes an angle, i with the normal to the surface as shown.



For i and r

For incident and reflected beam

If two particles A and B on the same wavefront travel to points C and D respectively in time t, then

$$\overline{AD} = \overline{BC}, \quad \text{and,} \quad \angle BAD = \angle BCD = 90°$$

(c).

In ΔABD and ΔBCD, $\overline{BD}$ is common to both. Thus, the two triangles are congruent. Therefore,

$$\angle CBD = \angle BCA$$

$$(90 - r) = (90 - i)$$

$$i = r$$

04

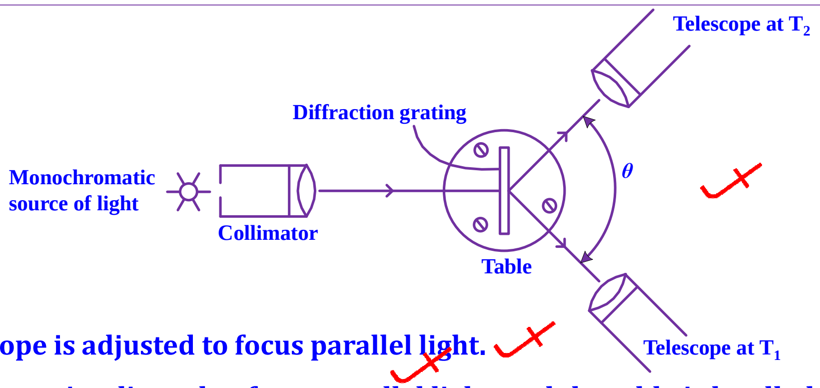
Thus, angle of incidence, i is equal to angle of reflection, r.

(d). (i).

A diffraction grating is a sheet of glass (transparent plate) or polished metal with large number of close parallel equidistant lines ruled/drawn on it using a diamond pencil. 01

(d).

(ii).



The telescope is adjusted to focus parallel light.

The collimator is adjusted to focus parallel light, and the table is levelled.

The telescope is turned to receive light directly from the collimator.

The grating is placed on the table so that its plane is perpendicular to the incident light from the collimator.

(d).

The zero-order image is now received at the telescope.

This position, T, on the scale is noted.

Keeping the turned table fixed, the telescope is rotated to one side until the first order image is obtained.

The new position, T_1, of the telescope is noted.

The telescope is restored to position T, and again rotated in the opposite direction until the first order image is again obtained.

The new position, T_2, of the telescope is noted.

The angle, θ, between T_1 and T_2 is measured and recorded. 06

The wavelength λ is now calculated from $\lambda = d \sin\left(\frac{\theta}{2}\right)$ where d is the spacing of the grating/lines.

Question 5:

(a). (i).

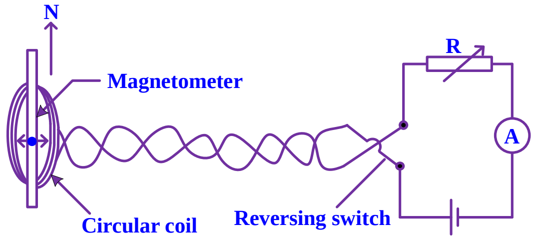
Magnetic meridian is the vertical plane in which a freely pivoted (suspended) magnet sets itself. 01

(ii).

Angle of dip is the angle between the resultant earth's field intensity and the horizontal. 01

(a).

(b).



A circular coil is set with its plane in the magnetic meridian of the earth.

A deflection magnetometer is mounted on a vertical axis at the centre of the circular coil, with its pointer initially at the zero marks.

The coil is then connected through a reversing switch to a battery, rheostat and an ammeter as shown.

The rheostat is adjusted so that the ammeter reads a suitable value of current, I.

(b).

The deflections θ_1 and θ_2 at both ends of the pointer are read and recorded.

The current in the coil is reversed, and the new deflections θ_3 and θ_4 are read and recorded.

The average deflection, θ, is calculated from

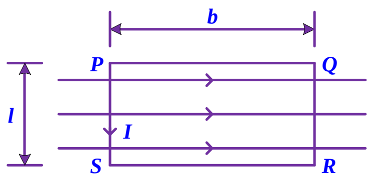
$$\theta = \frac{\theta_1 + \theta_2 + \theta_3 + \theta_4}{4}$$

If B_H is the horizontal component of the earth's magnetic flux density and B_C is the magnetic flux density of the coil due to the current, then:

$$\frac{B_C}{B_H} = \tan\theta$$

05

(c). (i).



When current flows in the coil, the force on PQ and RS is zero.

By, applying Flemings left hand rule on sides PS and QR,

The force on side $PS = NBIl$ (outwards).

The force on side $QR = NBIl$ (inwards).

These two forces constitute a couple which rotates the coil until it is stopped by the hair springs.

(c).

If θ is the angle of rotation, then

Torque on the coil = Force × Perpendicular distance between them

$$= NBIl \times b\cos\theta$$

$$= NBIA\cos\theta$$

where $A = l \times b$ is the area of the coil $PQRS$.

In equilibrium, the torque set by the hair springs, $\tau = K\theta$.

Therefore,

$$NBIA\cos\theta = K\theta$$

04

(ii).

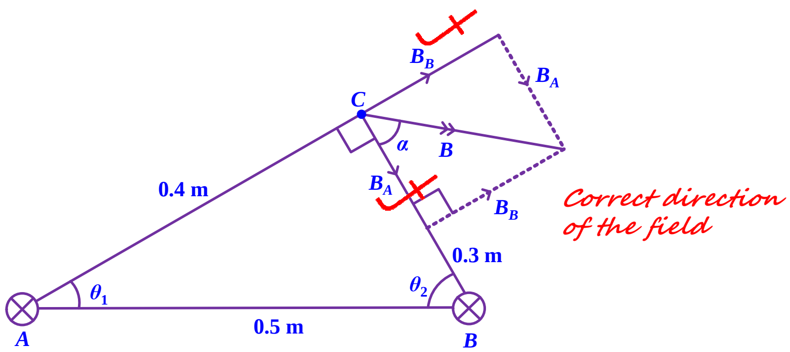
To turn the above into a moving coil galvanometer, the following should be done:

- The magnetic field should be made radial.
- The coil should be supported by jewelled bearings.
- The coil should be wound on a light conducting frame.
- The frame on which the coil is wound should turn about a soft iron cylinder.
- A pointer which can move along a linear scale should be attached to the coil.

02 *Any four*

(c).

(d). (i).



$$\sin\theta_1 = \frac{0.3}{0.5}, \quad \Rightarrow \theta_1 = 36.87°$$

$$\theta_2 = 90 - \theta_1 = 90 - 36.87 = 53.13°$$

(d).

Using, $B = \frac{\mu_0 I}{2\pi r}$

$$B_A = \frac{4\pi \times 10^{-7} \times 2}{2\pi \times 0.4} = 1.0 \times 10^{-6}\ \mathrm{T}$$

$$B_B = \frac{4\pi \times 10^{-7} \times 2}{2\pi \times 0.3} = 1.3333 \times 10^{-6}\ \mathrm{T}$$

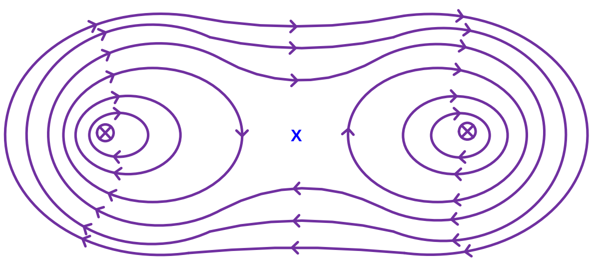
$$B = \sqrt{(1.0 \times 10^{-6})^2 + (1.3333 \times 10^{-6})^2} = 1.6666 \times 10^{-6}\ \mathrm{T}$$

$$\tan\alpha = \frac{1.3333 \times 10^{-6}}{1.0 \times 10^{-6}}, \quad \Rightarrow \alpha = 53.13^\circ$$

06

The resultant magnetic flux density at C is 1.6666×10^{-6} T in the direction 53.13° with side CB.

(ii).



-Pattern

-Direction

01

X is the neutral point

(d).

Question 6:

(a). (i).

Self-induction is the generation of e.m.f in the coil due to changing current in the same coil.

01

(ii).

Magnetic flux, Φ, linking a coil is given by:

$$\Phi = AB$$

but, $B \propto I$, $\Rightarrow \Phi \propto I$, $\therefore \Phi = LI$

If the current in the coil changes, then the flux linkage also changes. Therefore,

$$\frac{d}{dt}\Phi = \frac{d}{dt}LI$$

$$\frac{d\Phi}{dt} = L\frac{dI}{dt}$$

Induced e.m.f, $E = -\frac{d\Phi}{dt}$

$$\Rightarrow E = -L\frac{dI}{dt}$$

03

(a).

(b). (i).

When a straight wire of resistance, R, is connected across a voltage source, V, back e.m.f in the wire is negligible implying that the current which flows through the coil is $I_1 = \frac{V}{R}$.

When a coil of resistance, R, is connected across the same voltage source, V, back e.m.f, E_b, is induced in it and this reduces the current flowing through the coil to a value $I_2 = \frac{V-E_b}{R}$.

Since $I_2 < I_1$, it implies that the current in A is less than that in the straight wire.

03

(b).

(ii).

When the distance between A and B is reduced, the magnetic flux linking coil B due to the changing current in A increases.

The induced e.m.f and hence induced current in the circuit increases.

Accordingly, the reading in A_2 increases.

The induced current in B produces a changing flux in B.

This flux opposes the flux produced by the applied voltage in A and so reduces the total flux linking coil A.

Back e.m.f induced in coil A reduces and the resultant voltage in the circuit increases.

Current through A increases hence increase in the reading of A_1.

03

(b).

(c). (i).

For a motor, the field is radial,

$$\text{Torque} = BANI$$

$$0.30 = B \times 20 \times 10^{-4} \times 50 \times 2.5$$

$$B = 1.2\ \text{T}$$

03

(ii).

For a motor, the field is radial,

$$E_b = NAB\omega = NAB \times 2\pi f$$

$$= 50 \times 20 \times 10^{-4} \times 1.2 \times 2\pi \times \frac{2400}{60}$$

$$= 30.1593\ \text{V}$$

03

(c).

(d). (i).

As the coil of the motor rotates in the magnetic field, the core onto which the coil is wound rotates in the magnetic field of the motor.

The changing flux linking the core induces e.m.f in the core.

This e.m.f causes current to circulate in the core in such a direction to oppose the rotation of the core.

These are eddy currents. 03

(ii).

The effect of eddy currents are minimized by laminating the core of the motor.

03

(d).

Question 7:

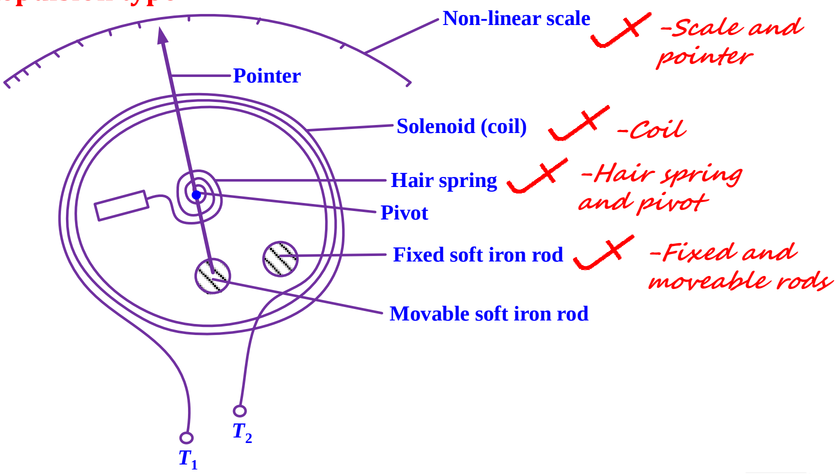
(a).

Root mean square value of an alternating current is the value of steady (direct) current that dissipates heat in a given resistance (or in a resistor) at the same rate as the alternating current. 01

(a).

(b).

Approach 1: Repulsion type



(b).

Current to be measured is passed through the coil (solenoid) via terminals T_1 and T_2, creating a magnetic field at the centre of the coil.

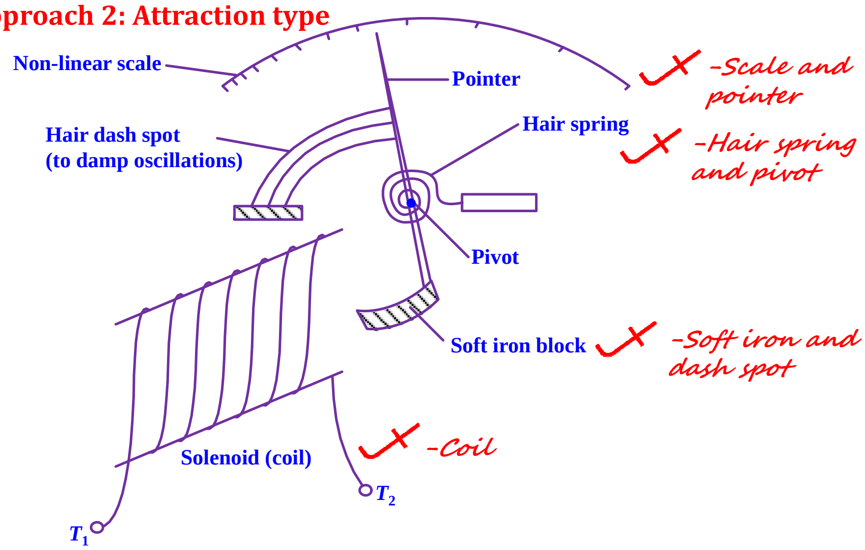
Whatever the direction of current, the two soft iron rods get magnetized in the same sense (same polarity) and so they repel one another.

The moveable iron rod is pushed away; and as it moves, the pointer rotates over the scale until it's stopped by the restoring torque (couple) of the hair spring.

Now the deflection torque is proportional to the force of repulsion which is proportional to the square of the current. Hence the deflection, $\theta \propto \langle I^2 \rangle$.

05

Approach 2: Attraction type



Current to be measured is passed through the coil (solenoid) via terminals T_1 and T_2 , creating a magnetic field inside the coil.

Whatever the direction of current, the coil magnetizes and attracts the soft iron block.

As the block turns, the pointer rotates over the scale until it is stopped by the restoring torque (couple) of the hair spring the hair dash pot.

Now the deflection torque is proportional to the force of attraction which is proportional to the square of the current. Hence the deflection, $\theta \propto \langle I^2 \rangle$.

05

(c). (i).

$$I_{\text{rms}} = 2\pi f C V_{\text{rms}} = 2 \times 3.14 \times 50 \times 8 \times 10^{-6} \times 200 = 0.5024\ \text{A}$$

$$I_0 = I_{\text{rms}}\sqrt{2} = 0.5024 \times \sqrt{2} = 0.7105\ \text{A}$$

04

(ii).

If the frequency of the alternating current is increase, the number of times the capacitor charges and discharges in a unit time increases.

The quantity of charge flowing in the circuit in a unit time increases. So current increases.

Alternatively: From $X_C = \frac{1}{2\pi f C}$, capacitive reactance, $X_C \propto \frac{1}{f}$. This implies that as frequency, f, increases, X_C reduces.

02

From $I = \frac{V}{X_C}$, current, $I \propto \frac{1}{X_C}$. This implies that as X_C reduces, I increases.

(c).

(d).

When alternating current flows in the coil, back e.m.f, E_b is induces in it.

$$\text{but,} \qquad E_b = -L\frac{dI}{dt}$$

$$\text{and for a pure inductor,} \qquad V = -E_b, \qquad \Rightarrow V = L\frac{dI}{dt}$$

When current, $I = 0$, the rate of change of current, $\frac{dI}{dt}$, is maximum implying that V is maximum.

When current, I, increases to a maximum, the rate of change of current, $\frac{dI}{dt} = 0$, implying that $V = 0$.

Hence V and I are out of phase by a phase difference of 90°.

04

(d).

(e).

$$V = V_o \sin \omega t$$

$$\text{Instantaneous power,} \qquad P = \frac{V^2}{R} = \frac{(V_o \sin \omega t)^2}{R} = \frac{{V_o}^2 \sin^2 \omega t}{R}$$

$$\text{Average power,} \qquad \langle P \rangle = \frac{\langle {V_o}^2 \sin^2 \omega t \rangle}{R} = \frac{{V_o}^2}{R}\langle \sin^2 \omega t \rangle$$

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

$$\therefore \langle P \rangle = \frac{{V_o}^2}{2R}$$

02

(e).

(f).

$$\text{Energy due to a.c} = 3 \times \text{Energy due to d.c}$$

$$\frac{1}{2}{I_o}^2Rt = 3 \times {I_{\text{d.c}}}^2Rt$$

$${I_o}^2 = 6{I_{\text{d.c}}}^2$$

$$I_o = I_{\text{d.c}}\sqrt{6} = 2 \times \sqrt{6} = 4.8990\text{ A}$$

02

Question 8:

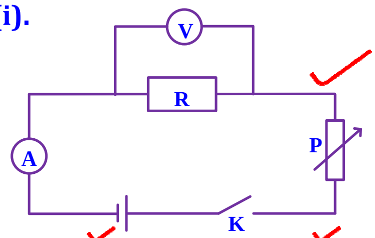
(a).

Potential difference is the work done to transfer/move a positive charge of one coulomb (1 C) from one point to another in an electrical circuit.

01

(f).

(b). (i).



The apparatus is set up as shown above.

Switch K is closed and the rheostat *P* adjusted so that the ammeter and voltmeter read suitable values of *I* and *V* respectively.

The ammeter and voltmeter readings are recorded.

The procedure is repeated for different values of the current, *I*, by adjusting the rheostat, *P*, and the corresponding p.d, *V*, is read from the voltmeter.

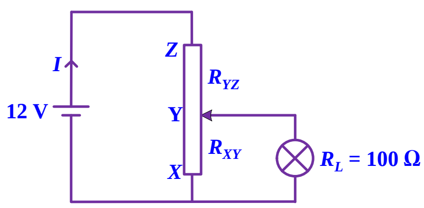
The results are tabulated and a graph *I* against *V* is plotted.

A straight line graph through the origin is obtained, implying that $I \propto V$ and hence this verifies Ohm's law.

04

(b).

(ii).



$$R_{XY} = \frac{1}{3}R_{XZ} = \frac{1}{3} \times 600 = 200\ \Omega$$

$$R_{YZ} = R_{XZ} - R_{XY} = 600 - 200 = 400\ \Omega$$

Combining resistors R_L and R_{XY} in parallel

$$R_1 = \frac{R_L \times R_{XY}}{R_L + R_{XY}} = \frac{100 \times 200}{100 + 200} = \frac{200}{3} = 66.67\ \Omega$$

p.d across XY

$$V_{XY} = \left(\frac{R_1}{R_1 + R_{YZ}}\right)V = \left(\frac{66.67}{66.67 + 400}\right) \times 12 = 1.7144\text{ V}$$

04

$$\text{Energy consumed by the bulb} = \frac{{V_{XY}}^2}{R_L} \times t = \frac{1.7144^2}{100} \times 10 = 0.2939\text{ J}$$

(b).

(c).

When current flows through a conductor, conduction electrons gain kinetic energy and drift through the metal.

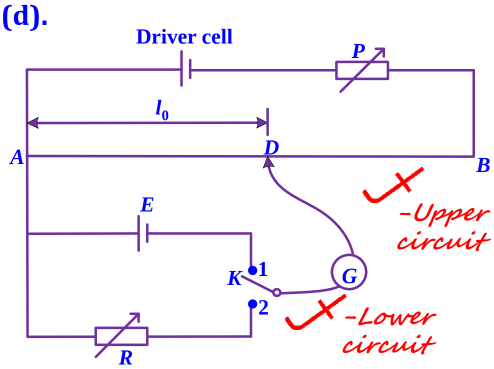
As they move, they collide with the atoms of the metal in their lattice positions, losing some of their kinetic energy to the atoms.

The atoms thus vibrate about their mean positions with a large amplitude which manifest as increase in temperature (or increase in internal energy of the atoms).

04

(c).

(d).



The set up is as shown.

With switch K at position 1, the jockey is tapped at different positions along the wire AB until a point is found where the galvanometer G shows no deflection.

The balance length, l_0 , is noted.

Switch K is then connected to position 2 and the rheostat R adjusted to a suitable value.

The new balance point is located and the new balance length, l , is noted.

(d).

The procedure is repeated for different values of R and the results are tabulated including values of $\frac{1}{l}$ and $\frac{1}{R}$.

A graph of $\frac{1}{l}$ against $\frac{1}{R}$ is plotted and its slope, S, is determined.

The internal resistance,r, is then calculated from: $r = Sl_0$.

07

Question 9:

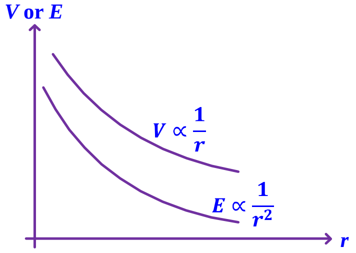
(a). (i).

Electric field intensity is the force experienced by (or acting on) a positive charge of 1 C placed at a point in the electric field. 01

(ii).

Electric potential is the work done to move/transfer a positive charge of 1 C from infinity to a point against the electrostatic field. 01

(b).



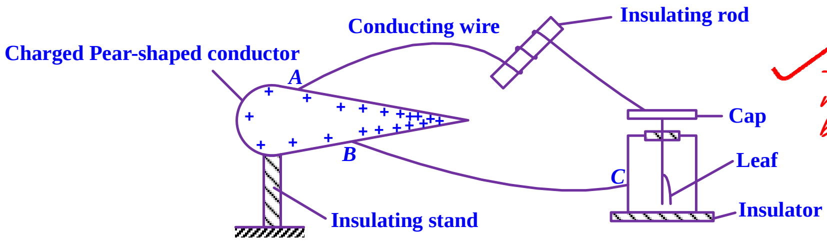
-Axes (accept if axes are interchanged)

-V drawn above E

-E (if sphere is used, penelise ½ on E) 02

(a). (b).

(c).



-Earthing must not be done

A wire wound on an insulating rod is connected to the cap of a neutral gold leaf electroscope.

The free end, *A*, of the wire is connected to the surface of the charged conductor.

Another wire is connected to point *B* on the conductor and to point *C* on the electroscope. The leaf collapses.

(c).

The leaf remains collapsed as the free end *A* of the wire is tapped at different points on the conductor.

This implies that implies that the p.d between any two points on the conductor is zero thus the potential is constant at all points on its surfaces. 04

(d). (i).

Electric potential at A, $V_A = \frac{5}{10} \times 100 = 50\text{ V}$

Electric potential at B, $V_B = \frac{5}{10} \times 100 = 50\text{ V}$

Work done in moving the charge from A to B,

$$W_{AB} = QV_{AB} = 2 \times 10^{-6} \times (50 - 50) = 0\text{ J}$$

02

Reason: There is no change in electric potential from A to B.

(d).

(ii).

Electric potential at C, $V_C = \frac{5 + 10\cos 60°}{10} \times 100 = 100\ \text{V}$

Work done in moving the charge from B to C,

$$W_{BC} = QV_{BC} = 2 \times 10^{-6} \times (100 - 50) = 1 \times 10^{-4}\ \text{J}$$

04

(e). (i).

The alpha particle loses kinetic energy as it approaches the nitrogen nucleons and this is transferred to electrostatic potential energy in the field.

At some point, all the kinetic energy of the alpha particle is lost and it is repelled back by nitrogen nucleons.

02

(d). (e).

(ii).

$$\begin{pmatrix}\text{initial kinetic energy of} \\ \text{the alpha particle in joules}\end{pmatrix} = \begin{pmatrix}\text{potential energy of the} \\ \text{nucleus} - \text{alpha particle system} \\ \text{at distance of closest approach}\end{pmatrix}$$

$$\frac{1}{2}mV^2 = \frac{kQ_1Q_2}{r}$$

$$\frac{1}{2} \times 6.8 \times 10^{-27} \times V^2 = \frac{9 \times 10^9 \times 3.2 \times 10^{-19} \times 11.2 \times 10^{-19}}{9.4 \times 10^{-15}}$$

$$V = \sqrt{\frac{2 \times 9 \times 10^9 \times 3.2 \times 10^{-19} \times 11.2 \times 10^{-19}}{9.4 \times 10^{-15} \times 6.8 \times 10^{-27}}} = 1.0046 \times 10^7\ \text{m s}^{-1}$$

04

(e).

Question 10:

(a). (i).

Capacitance of a capacitor is magnitude of charge required to cause a change of one volt in the p.d across the plates of the capacitor.

Or: Capacitance of a capacitor is the ratio of the magnitude of charge on either plates of the capacitor to the potential difference across its plates.

01

Any one

(ii).

$$V = \frac{kQ}{r}$$

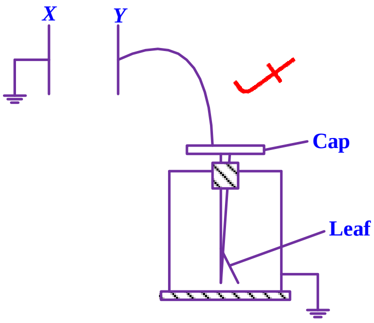
$$9 \times 10^3 = \frac{9 \times 10^9 \times Q}{7.5 \times 10^{-2}}$$

$$Q = \frac{9 \times 10^3 \times 7.5 \times 10^{-2}}{9 \times 10^9} = 7.5 \times 10^{-8}\ \text{C}$$

03

(a).

(b).



Two metal plates X and Y are set close to each other, but not touching as shown above.

Plate Y is given a charge Q and the divergence of the leaf the electroscope noted.

Plate X is slowly moved away from plate Y and the divergence of the leaf is seen to increase.

This means that p.d, V between the plates has increased.

From $C = \frac{Q}{V}$, the capacitance C has reduced.

Therefore, $C \propto \frac{1}{d}$, where d is the separation of the plates.

04

(b).

(c).

$$Q = EA\varepsilon_o = \frac{VA\varepsilon_o}{d} = \frac{6 \times 5 \times 10^{-4} \times 8.85 \times 10^{-12}}{2 \times 10^{-3}} = 1.3275 \times 10^{-11}\ \mathrm{C}$$

03

(d).

When a conductor is placed between the plates of a capacitor, negative charges are conducted to positively charged plate; neutralizing the charge on it. Hence the capacitor becomes discharged.

03

(c). (d).

(e). (i).

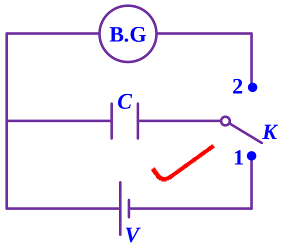
Relative permittivity of an insulating material is the ratio of permittivity of the material to permittivity of free space.

Or: Relative permittivity of an insulating material is the ratio of capacitance a capacitor when the space between its plates is filled with a material to capacitance of the same capacitor when the space between its plates is a vacuum.

01 Any one

(e).

(ii).



A capacitor, C, with air between its plates, is connected in the circuit as shown.

Switch K is connected to position 1 and after a short time, it is connected to position 2.

The first deflection θ_1 of the ballistic galvanometer (B.G) is noted.

The test insulator is then plated between the plates of the capacitor and the procedure repeated.

The first deflection θ_d of the ballistic galvanometer (B.G) is noted.

The relative permittivity of the test insulator, ε_r , is obtained from

$$\varepsilon_r = \frac{\theta_d}{\theta_1}$$

05

(e).

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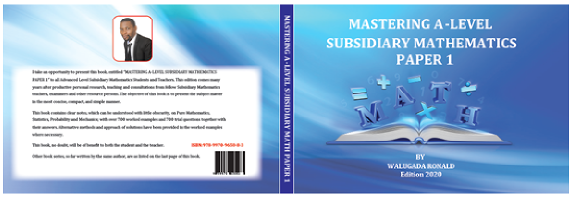

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