P510/2

Physics

Paper 2

July-August-2023

2 ½ Hours

UGANDA MUSLIM TEACHERS' ASSOCIATION

UMTA JOINT MOCK EXAMINATIONS 2023

UGANDA ADVANCED CERTIFICATE OF EDUCATION

Physics

Paper 2

2 Hours 30 Minutes

INSTRUCTIONS TO CANDIDATES:

*Answer only **five** questions, including at least **one** question from each of the sections A, B, C and D but **not** more than **one** question from either section A or **B**.*

*Any additional question(s) answered will **not** be marked.*

Mathematical tables and squared paper will be provided where need be.

Non-programmable scientific calculators may be used.

Begin each question on a fresh page of the answer sheets / booklet provided.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ m\ s^{-2}$
Speed of light in Vacuum, c	=	$3.0 \times 10^{8}\ m\ s^{-1}$
Speed of sound in air,	=	$340\ ms^{-1}$
Electronic charge, e	=	$1.6 \times 10^{-19}\ C$
Electronic mass, m_e	=	$9.11 \times 10^{-31}\ kg$
Permeability of free space, μ_o	=	$4.0\pi \times 10^{-7}\ H\ m^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ Fm^{-1}$
The Constant, $\frac{1}{4\pi\varepsilon_o}$	=	$9.0 \times 10^{9}\ F^{-1}\ m$
Planck's constant, h	=	$6.6 \times 10^{-34}\ Js$
Avogadro's number, NA	=	$6.02 \times 10^{23}\ mol^{-1}$
One electrons volt (eV)	=	$1.6 X 10^{-19}$
Specific heat capacity of water	=	$4.2 X 10^{3}\ Jkg^{-1}\ k^{-1}$
Resistivity of Nichrome wire at 25°C	=	$1.2 X 10^{-6}\Omega m$

SECTION A:

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

(ii) Derive an expression relating the focal length, f, and radius of curvature r, of a convex mirror. (04 marks)

(b) (i) Define **critical angle** as applied to light. (01 mark)

(ii) Explain how total internal reflection is applied in rear reflectors. (03 marks)

(c) (i) Describe an experiment in which the refractive index of a liquid can be determined using an air cell. (05 marks)

(ii) Monochromatic light is made incident at an angle of 43^0 on a glass prism of refracting angle 65^0 in air. If the emergent light just grazes the other refracting surface of the prism, find the refractive index of the glass material. (05 marks)

2. (a) (i) Define **refractive index** of a material. (01 mark)

(ii) A ray of monochromatic light moving in air is incident on a parallel - sided glass block of width, h as shown in figure1. The glass block is made out of a material of refractive index, n.

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

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

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

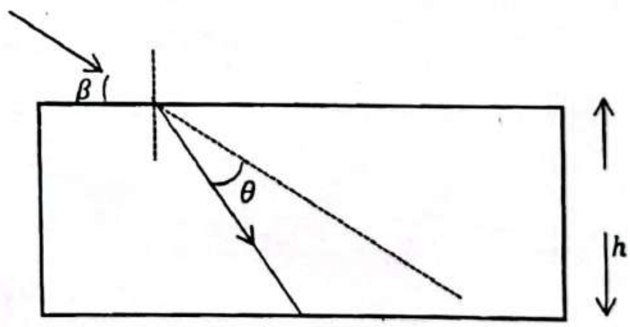


Fig.1

If the ray suffers a deviation, θ, on first face of the block, show that the ray will take time, t, to emerge from the opposite face of the block given by;

$$t = \frac{nh\,cosec(\theta+\beta)}{c}$$

Where c is speed of light in vacuum. (03 marks)

(b) Define the following as applied to lenses and optical instruments;

(i) **focal length** (01 mark)

(ii) **angular magnification** (01 mark)

(c) A thin liquid lens is formed between a bi-convex lens of focal length 10 cm and a plane mirror. The focal length of the combination is found to be 16.0cm; when the lens is turned over the focal length of the combination is 16.5cm. Calculate the refractive index of the liquid if the refractive index of the glass is 1.5.

(05 marks)

(d) (i) With the aid of a labeled diagram, describe how a Galilean telescope works in normal adjustment. (05 marks)

(ii) Explain the limitation of the telescope in (c)(i) above. (02 marks)

(c) State **two** differences between Microscopes and telescopes. (02 marks)

SECTION B

3. (a) What is meant by the following;

(i) **Beats?** (01 mark)

(ii) **Doppler effect?** (01 mark)

(b) A radar speed gun emitting radio waves of frequency f is pointed at an approaching car moving at speed, v.

$V = f\lambda$

$f = \frac{V}{\lambda}$

$f = \frac{V}{\lambda}$

(i) Derive the expression for frequency, f_b of the beats registered by the speed gun. (03 marks)

(ii) Calculate speed of the car if $f = 6.0MHz$ and $f_b = 1.8Hz$. (02 marks)

$f'' =$

$(c - V)$

(c) (i) Define **fundamental note** and a **harmonic** in sound. (02 marks)

(ii) Explain why a note emitted by a string can easily be distinguished from that of a turning fork with which it is in unison. (03 marks)

$\lambda'' = \frac{c - V}{f''}$

$f'' = \frac{c - V}{\lambda''}$

(d) A string of length **1m** and mass **0.5g** is fixed at both ends and kept under tension of 20N. The string is plucked at a point 25cm from one end. Find the frequency of the note emitted by the string. (03 marks)

(e) Describe how the effect of increasing tension in a stretched string on its fundamental frequency may be investigated. (05 marks)

4. (a) (i) State Huygen's principle. (01 mark)

(i) Use Huygen's principle to show that the angle of incident is equal to the angle of reflection of light. (05 marks)

(b) (i) Define the term diffraction as applied to a light wave. (01 marks)

(ii) Describe an experiment in which the wave length of light can be determined using a diffraction grating and a spectrometer. (06 marks)

(c) (i) What is meant by interference of light waves? (01 marks)

(ii) Explain why a series of bright and dark lines are observed in an air wedge when irradiated normally with a monochromatic light. (03 marks)

(d) Two plane glass plates which are in contact at one edge are separated by a piece of metal foil **12.5cm** from that edge. Interference fringes parallel to the line of contact are observed in reflected light of wavelength 5.46×10^{-7}m and are found to be 1.50mm apart. Find the thickness of the foil. (04 marks)

SECTION C

5. (a) (i) Define **magnetic flux density** and **a magnetic moment.** (02 marks)

(ii) Write down the expression for magnetic flux density at the centre of a plane circular coil of **N** turns, radius **R**, and carrying a current **I** in a vacuum. (01 mark)

(b) A short wire forming part of a current balance of length 2.5cm is at the centre of a coil of radius 8.0cm of 40 turns each carrying a current of 10.0A. Calculate the magnetic force experienced by the wire if a current through it is 3.0A. (04 marks)

(c) With the aid of a diagram, describe an experiment to show how the force acting on a conductor carrying current in a magnetic field depends on the magnitude of the current in the conductor. (05 marks)

(d) (i) Explain with the aid of a sketch diagram and relevant equations why a large voltage builds up across opposite faces of a conductor when a current is passed through it. (04 marks)

(ii) State the effect of increasing temperature on voltage developed in d(i). (01 mark)

(e) A slice of a semi-conductor is 2.0mm thick and carries a current of 50mA. A magnetic field flux density 0.49T correctly applied, produces a maximum hall voltage of 420mV between the edges of the slice. Calculate the number of free charge carriers per unit volume. (03 marks)

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

(ii) Describe an experiment to verify Faraday's law of electromagnetic induction. (05 marks)

(b) Figure 2 shows a loop of wire has its shape bent into a semi-circle of radius 20cm. The normal to the plane of the loop is parallel to a uniform magnetic fieldof flux density 0.85T .

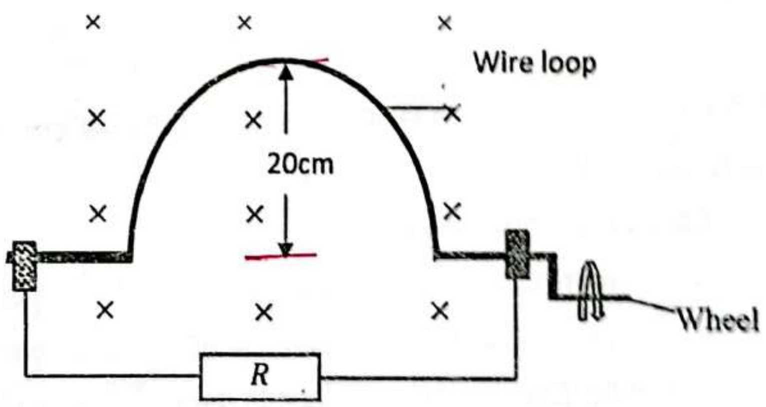


Fig.2

Starting with the position shown in diagram, the loop is rotated through half a revolution,

(i) find the change in magnetic flux linking the loop. (03 marks)

(ii) if the change in **(i)** takes **0.28s**, and $R = 15\Omega$, calculate the current that flows through *R*. (03 marks)

(c) (i) What is meant by **back emf** in a dc motor? (01 mark)

(ii) Show that the *emf* induced in a motor rotating at ω radians per second in a radial magnetic field of flux density B is $E = \omega NBA$, where N is the number of turns and A is the area of the coil. (04 marks)

(d) Explain the structural modifications needed to improve on the efficiency of a motor. (02marks)

7. (a) Distinguish between **self** and **mutual** inductions. (02 marks)

(b) **Figure 2** shows a small disc of copper lying on top of a vertical solenoid of 300 turns of wire per metre and of radius 3.0cm.

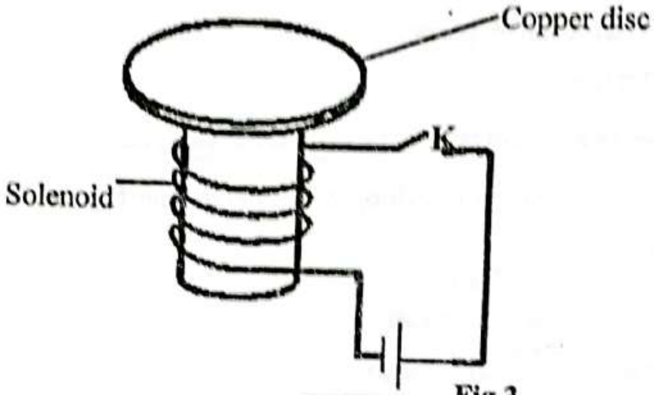


Fig.3

When current in solenoid is suddenly switched on, the disc flies up and very quickly falls back.

(i) Explain the observation made. (03 marks)

(ii) If current in solenoid is increasing at a rate of **50A** per second, and the solenoid is surrounded by a small coil of 120 turns wound tightly round its middle, find the emf generated in the small coil while the current in solenoid is increasing. (04 marks)

(c) (i) Define the term **root mean square** value of alternating current. (01 mark)

(ii) With aid of a diagram, describe how a hot – wire ammeter is used to measure alternating current. (04 marks)

(d) A capacitor of **16.0** F and an inductive coil of **300Ω** resistance are connected in series across a **20V, 50Hz** ac supply to form part of a radio circuit. The current obtained is **40mA**.

(i) Calculate the inductance of the coil. (04 marks)

(ii) find the resonant frequency of the circuit. (02 marks)

SECTION D

8. (a) (i) What is meant by the term **electrostatic induction**? (01 mark)

(ii) With aid of diagrams, describe how a metal sphere can be charged positively at zero potential. (04 marks)

(b) (i) Define electric field intensity and electric potential energy. (02 marks)

(ii) Derive an expression for electric field intensity perpendicular to a charged conductor of surface charge density δ in air. (03 marks)

(c) Charges Q_1, Q_2 and Q_3 of magnitude $-3\mu C$, $+2\mu C$ and $-5\mu C$ respectively are situated vertices of an equilateral triangle of side 10cm in a vacuum as shown in the figure 4.

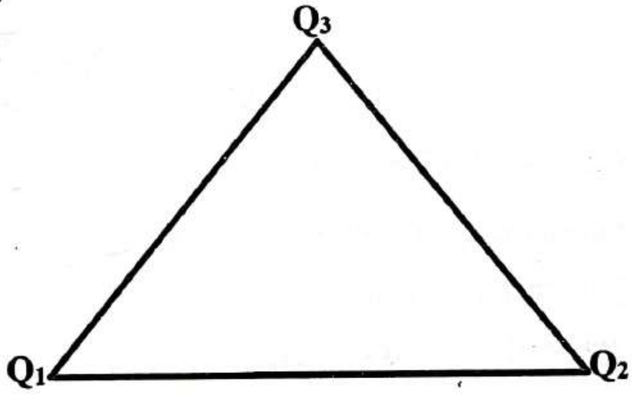


Fig.4

Calculate;

(i) the net force on Q_1 (04 marks)

(ii) the potential energy Q_3 (03 marks)

(d) Explain how electrostatics is applied in oil spray gun. (03 marks)

9. (a) (i) Define **capacitance** and a **farad** as applied to a capacitor. (02 marks)

(ii) Derive the expression for the effective capacitance of three capacitances of capacitances C_1, C_2 and C_3 connected in series. (04 marks)

(b) A capacitor is connected a dc supply of emf, E as shown in figure 5.

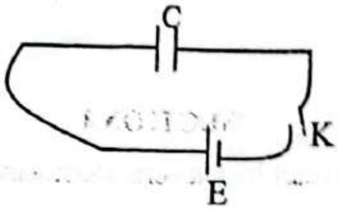


fig.5

(i) On same axes, sketch graphs showing variation of voltage and current from the time switch, K is closed. (02 marks)

(ii) Explain why the capacitor stores energy on charging. (02 marks)

(c) Two isolated metal spheres **A** and **B** of radius 80mm and 50mm respectively are charged using an electrophorus such that **A** carries charge of $+10\mu C$ while **B** carries charge of $+4\mu C$. If the two spheres are later connected using a wire, find the difference in energy before and after connection. (05 marks)

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

(ii) Describe how you would investigate the effect of a dielectric on capacitance of a capacitor. (04 marks)

10. (a) Define the following as applied to a battery

(i) **Electromotive force** (01 mark)

(ii) **Internal resistance.** (01 mark)

(b) Explain why it is easier to start a car engine on a hot day than on a cold day. (03 marks)

(c) (i) Explain the principle of a potentiometer. (03 marks)

(ii) Describe how you would adapt the potentiometer in (i) to determine the emf of a thermocouple. (05 marks)

(d) In figure 6, AB is a uniform slide wire of length 100cm and resistance 15Ω. Y is a driver cell of e.m.f 3.0V and negligible internal resistance.

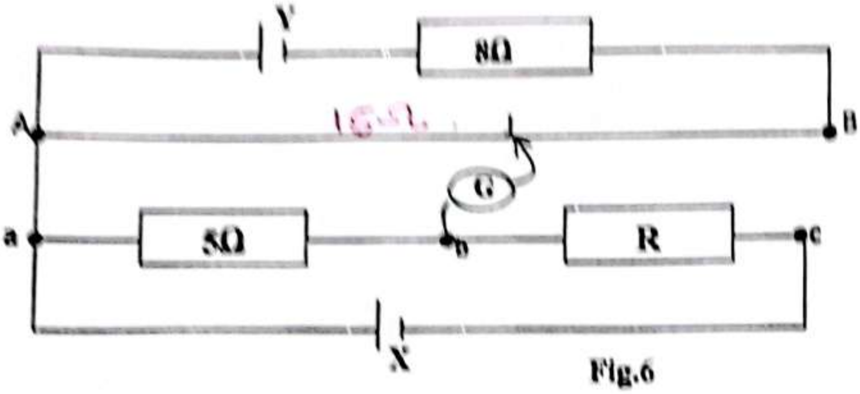


Fig.6

When the galvanometer, G, is connected in turn to points *b* and *c*, the balance lengths are 62.0cm and 75.0cm respectively. Calculate the

(i) current flowing through the resistor, R.. (04 marks)

(ii) e.m.f of cell X given that the cell has negligible internal resistance. (03 marks)

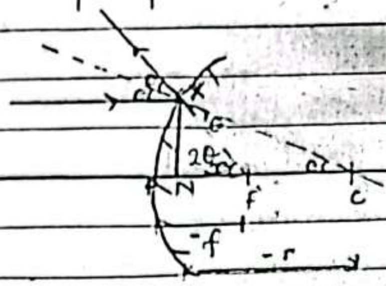
END

1,5,10

PS10/2 PHYSICS GUIDE UMTA - 2023

1. a) The incident ray, reflected ray, the normal at the point of incidence all lie in the same plane. (01)

The angle of incidence equals to the angle of reflection. (01) (02)

ii) 

N is very close to P

2θ and θ are small in radians

from ΔNXC, $\theta \approx \tan\theta = \frac{NX}{NC} = \frac{NX}{-r}$ — ①

from ΔNXF, $2\theta \approx \tan 2\theta = \frac{NX}{NF} = \frac{NX}{-f}$ — ②

Equation ① ÷ equation ②

$$\frac{\theta}{2\theta} = \frac{NX}{-r} \div \frac{NX}{-f}$$

$$\frac{1}{2} = \frac{NX}{-r} \times \frac{-f}{NX}$$

$$\frac{1}{2} = \frac{f}{r}$$

$$\therefore r = 2f$$

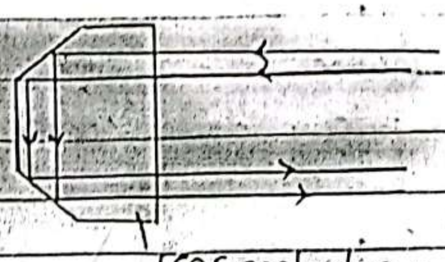
(04)

b(i) Critical angle is angle of incidence for which the angle of refraction is 90°. (01)

(ii)

3, 4, 6, 8

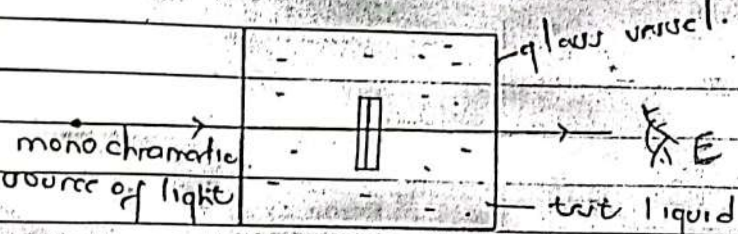
(ii)



- Light hits front surface of the reflector at very small angle of incidence (almost normally).
- Since back of reflector is curved, light hits the back at high angle of incidence greater the critical angle.
- Hence totally internally reflected from back of the reflector and turned in direction it came from.
- The driver sees image of his car head lamp noticing obstacle or other users on road.

03

i)



- A test liquid is poured into a parallel glass vessel
- A beam of monochromatic light is made incident normally on the vessel and viewed from opposite side at E.
- An air cell is placed into the test liquid such that light strikes it normally on one side.
- The air cell is rotated at one direction until the light ray is just cut off.
- Angle of rotation, θ_1 is measured.
- The air cell is then rotated in an opposite direction until light is cut off again.
- Angle of rotation, θ_2 is measured
- The critical angle $c = \theta_1 + \theta_2$

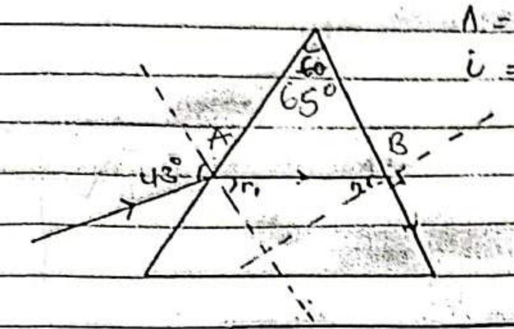
(05)

- The refractive index, n, of the liquid is calculated from, $n = \frac{1}{\sin c}$

(ii)

$A = 60^\circ$

$i = 43^\circ$



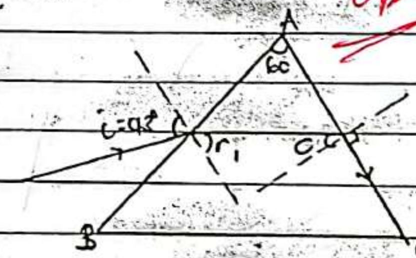
$$n_g = \sqrt{\left(\frac{\sin i + \cos A}{\sin A}\right)^2 + 1}$$

$$n_g = \sqrt{\left(\frac{\sin 43 + \cos 65}{\sin 65}\right)^2 + 1}$$

05

$n_g = 1.58$

OR 02



On face AC, Since = Constant.

$n_g \sin c = n_a \sin 90$

$n_g = \frac{1}{\sin c}$

But also $r_1 + c = 65$

$r = 65 - c$

On face AB, $n_a \sin i = n_g \sin r_1$

$\sin 43 = n_g \sin(65 - c)$

$\sin 43 = \frac{1}{\sin c}(\sin 65 \cos c - \sin c \cos 65)$

$\sin 43 = \frac{\sin 65}{\tan c} - \cos 65$

$C = 37.4$

But $n_g = \frac{1}{\sin 37.4}$

$= 1.58$

05

$r_1 + r_2 = 65^\circ$ --- eqn

$\boxed{r_1 + r_2 = A}$

At point B,

$n_g \sin r_1 = n_a \sin 90$

$n_g \sin r_1 = 1$

$n_g = \frac{1}{\sin C}$

$\boxed{r_1 + C = 65}$

$r_1 = (65^\circ - C)$ --

Also;

At point A,

$n_a \sin 43^\circ = n_g \sin(65^\circ$

$\sin 43^\circ = \frac{\sin(65^\circ - C)}{\sin C}$

$\sin 43^\circ \sin C = \sin 65^\circ \cos C -$
$\cos 65 \sin$

$(\sin 43^\circ + \cos 65^\circ)\sin C = \sin 65^\circ$

$\tan C = \left(\frac{\sin 65^\circ}{\sin 43^\circ + \cos 65}\right.$

$C = \tan^{-1}\left(\frac{\sin 65^\circ}{\sin 43^\circ + \cos 65^\circ}\right)$

$C = 3\cancel{9}.\cancel{17}^\circ$

04

$n_g = \frac{1}{\sin 3\cancel{9}.\cancel{17}^\circ}$

$n_g = \cancel{1.83}$

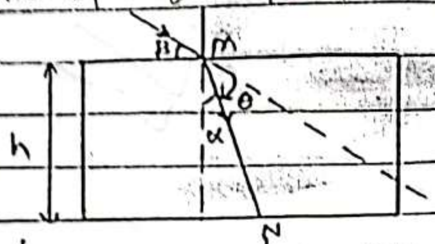
1.58

Qn2

i) Refractive index of material is the ratio of speed of light in vacuum to the speed of light in a given medium.

OR

ii) Refractive index is the ratio of sine of angle of incidence to the sine of angle of refraction at an interface between two media of diff optical densities



Distance covered is MN

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

$$\cos\alpha = \frac{h}{MN}$$

but $\alpha = 90 - (\beta + \theta)$

$$\cos[90 - (\beta + \theta)] = \frac{h}{MN}, \quad \sin(\beta+\theta) = \frac{h}{MN}$$

$$MN = \frac{h}{\sin(\beta+\theta)} = h\operatorname{cosec}(\beta+\theta)$$

03

$$\therefore \text{Time taken} = \frac{h\operatorname{cosec}(\beta+\theta)}{v}$$

but from $n = \frac{c}{v}$

$$v = \frac{c}{n}$$

$$t = h\operatorname{cosec}(\beta+\theta) / \frac{c}{n}$$

$$t = \frac{n\,h\operatorname{cosec}(\beta+\theta)}{c}$$

2)i) Focal length is the distance from optical centre of the lens to the principal focus.

ii) Angular magnification is the ratio of angle subtended by final image at aided eye to the angle subtended by object at naked eye (un aided eye)

Egw-any

c) $F = 16.0\,cm$, $f_1 = 10\,cm$

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

$$\frac{1}{16} = \frac{1}{10} + \frac{1}{f_2}$$

$f_2 = -\frac{80}{3}$

$$f_2 = -\frac{80}{3}\,cm$$

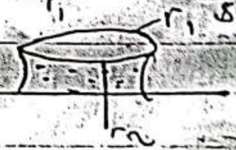
$$\frac{1}{f_2} = (n_L - 1)\left(\frac{1}{-r_1}\right)$$

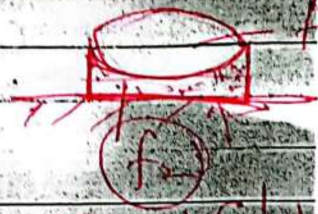
$$\frac{1}{f_2} = (n-1)\left(\frac{1}{-r_1} + \frac{1}{\infty}\right)$$

$$-\frac{3}{80} = (n_L - 1)\left(\frac{1}{-r_1}\right)$$

$$\therefore \frac{1}{r_1} = \frac{3}{80(n_L-1)}$$

$f = 10\,cm$





$$-\frac{3}{80} = (n_L - 1)\left(\frac{1}{-r_1}\right)$$

$$\frac{1}{16.5} = \frac{1}{10} + \frac{1}{f_2'}$$

$$\frac{330}{13} = f_2'$$

$$\frac{1}{f_2'} = (n_L - 1)\left(\frac{1}{-r_2}\right)$$

$$= \frac{13}{330} = (n_L - 1)\left(\frac{1}{r_2}\right)$$

$$\frac{1}{r_2} = \frac{13}{330(n_L-1)}$$

for glass lens

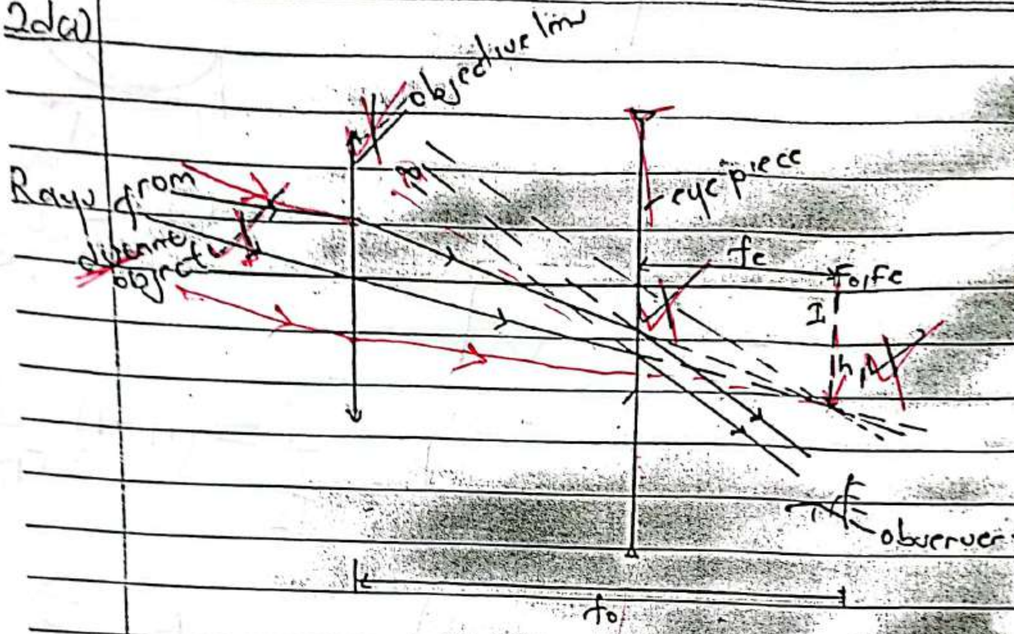
$$\frac{1}{f_1} = (n_g - 1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$\frac{1}{10} = (1.5-1)\left(\frac{3}{80(n_L-1)} + \frac{13}{330(n_L-1)}\right)$$

(05)

$$n_L = 1.384$$

2d(a)



(02)

- The objective refracts rays from distant object to form a real image I at its principal focus, fo
- The eye lens then forms a final image at infinity in normal adjustment.
- Hence principal foci coincide at fo,fe (05)

ii) It has a virtual eye ring and therefore has limited field of view hence forms less bright image.

c)

Microscope	Telescope
- Has high resolving power	- Has low resolving power
- Forms final image at near point in normal adjustment	- forms final image at infinity in normal adjustment
- Has refracting lenses only	- Has reflecting mirrors & refracting lens
- The objective has shorter focal length than eyepiece.	- Objective lens has longer focal length than eye piece

(02) (02) (first 2)

20

Q4'3

2i) Beats refers to the periodic rise and fall in intensity of sound heard when two notes of nearly equal frequency and of same amplitude are sounded together. (1)

ii) Doppler effect refers to the apparent change in frequency of wave motion due to relative motion between the source and the observer. (1)

b) Case ①

The gun is the source, car is the observer.

Let c be speed of light in air, v is speed of car.

Apparent change in wave length, $\lambda' = \lambda$

speed of light relative to observer, $V' = c + v$

Apparent change in frequency, $f' = \frac{V'}{\lambda'} = \left(\frac{c+v}{c}\right)f$

Case ②.

Consider a car to be source of echo and the gun is the observer

Apparent change in wave length,

$$\lambda'' = \frac{c-v}{f'}$$

speed of light relative to observer

$$V'' = c$$

Apparent change in frequency

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

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

$$f_b = f'' - f$$

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

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$$f_b = f\left[\left(\frac{c+v}{c-v}\right)-1\right]$$

$$= f\left[\frac{c+v-c+v}{c-v}\right]$$

$$= f\left[\frac{2v}{c-v}\right]$$

But $v \lll c \therefore c-v \simeq c$

$$\therefore f_b = f\left(\frac{2v}{c}\right)$$

(03)

(ii) $f_b = f\left(\frac{2v}{c}\right)$

$1.8 = 6\times10^{6}\left(\frac{2v}{3\times10^{8}}\right)$

$v = 45\,ms^{-1}$

(02)

c(i) Fundamental note refers to the note of lowest frequency produced a particular instrument.

(01)

Harmonic refers to the note produced by an instrument whose frequency is an integral multiple of fundamental frequency

(01)

(01)

c(ii) - The quality of a note depends on the number of overtones ~~and~~ an instrument produces.

- Plucked string produces overtones while a tunning fork produces no overtones.

- Therefore the two instruments produce notes of different quality making them sound differently

(03)

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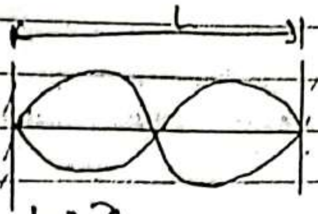
d)



$L = \lambda$

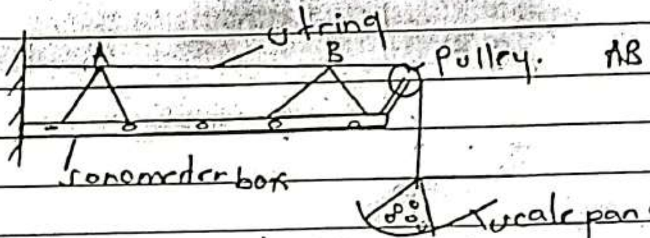
$f = \frac{v}{\lambda} = \frac{v}{L} = \frac{1}{L}\sqrt{\frac{T}{\mu}}$

$= \frac{1}{1}\sqrt{\frac{20}{0.5 \times 10^{-3}}}$

$f = 200Hz$.

(03)

c)



- The string is stretched between two bridges as shown above
- A tuning fork of known frequency is sounded and held near the string plucked in the middle.
- Masses are added on the scale pan in bits until a loud sound is heard.
- The total mass M on the scale pan is noted and frequency f of sound is noted.
- The experiment is repeated with different values of different frequencies and corresponding total masses on the scale pan are noted.
- Results are tabulated including values of f^2
- A graph of f^2 against M is plotted and it is a straight line through the origin.

$\therefore f^2 \alpha M$, but $M \alpha T$, Hence $f \alpha \sqrt{T}$

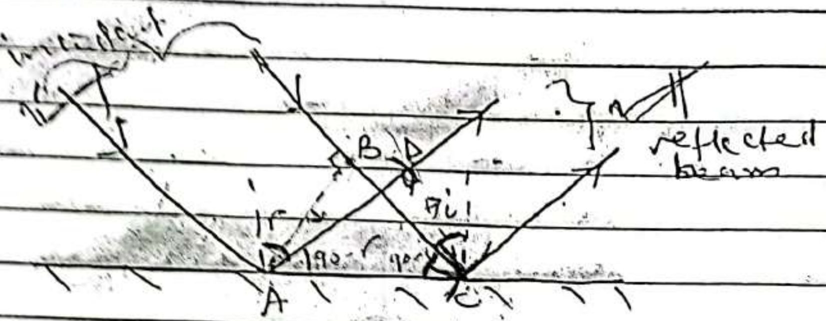
(05)

20

Phy

4 (i) Every point on a wavefront becomes a secondary source of wavelets and the new wavefront is an envelope of all secondary wavelets 01

(ii)



AB - incident wavefront.
CD - reflected wavefront 05

At time, t the Wavelet that had emerged from A has traveled adistance AD = BC

From $\triangle ABC$ and $\triangle ADC$, side AC is common. since BC = AD, and $\angle ABC = \angle ADC = 90°$, then $\triangle ABC$ and $\triangle ADC$ are congruent.

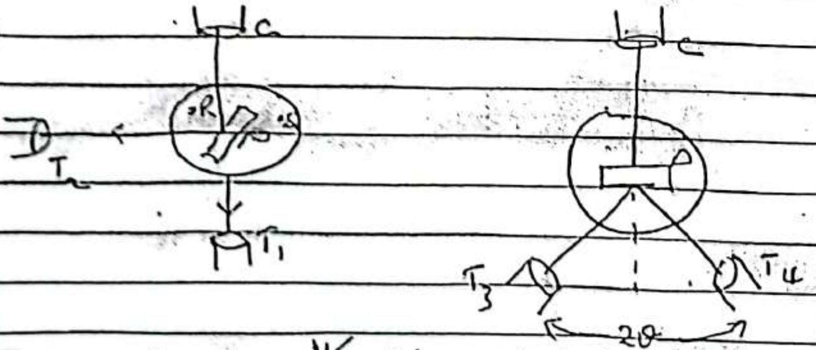
$\therefore B\hat{C}A = D\hat{A}C$

$90 - i = 90 - r$

$\Rightarrow i = r.$ 05

iii) Diffraction is the spreading of waves through slits. 01

(iv)



- The collimator is adjusted to produce parallel light, the telescope T_1 is adjusted to to receive parallel light at its cross wires.

- place grating on table

- The table is levelled so that the plane of P is parallel to the axis of rotation of the telescope.

- The telescope is first placed in position T_1 directly opposite to the illuminated slit of the collimator and rotated exactly through 90° to position T_2.

- The table is now turned until the slit is seen in T_2 by reflection at P and one of the screws Q, R turned until the slit image is in the middle of field of view.

- The plane of P is now parallel to axis of rotation of the telescope. 06

- The table is now turned through 45° so that the plane of grating P is exactly perpendicular to the light from C.

- The telescope is turned to position T_3 to receive first diffraction image.

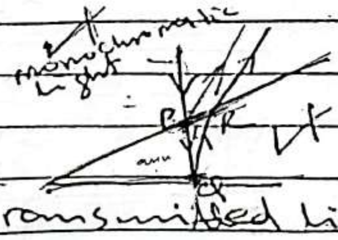
- The readings θ_1 of the first diffraction image are obtained on both sides of the normal.

- ~~Angular difference, 2θ~~

- wavelength, $\lambda = d \sin \theta_1$

where, d is the spacing of the slits.

c (i) Interference is the superposition of two coherent waves resulting into permanent regions of alternate maxima & minimum intensities.

(ii) 

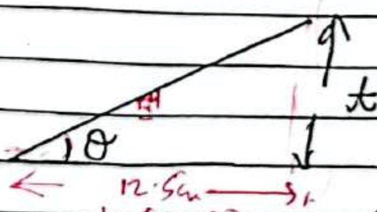
- Some of incident light at P is reflected and part is transmitted into air gap.

- Transmitted light is reflected at Q, along QR.

- P and Q act as coherent sources of waves produced by dividing of amplitude forming alternating alternate bright and dark bands.

07

(d)



$\lambda = 5.46 \times 10^{-7}$ m

$y = 1.5 \times 10^{-3}$ m

$x = 12.5$ cm

$$y = \frac{\lambda}{2t}$$

04

$$1.5 \times 10^{-3} = \frac{5.46 \times 10^{-7} \times 12.5 \times 10^{-2}}{2t}$$

$$t = 2.275 \times 10^{-5} \text{ m}$$

$$\tan\theta = \frac{opp}{Adj}$$

$$\boxed{\theta = \frac{t}{12.5 \times 10^{-2}}}$$

$$\tan\theta = \frac{\lambda}{2y}$$

$$y = \frac{\lambda}{2\theta}$$

$$\boxed{\theta = \frac{\lambda}{2y}}$$

$$\frac{t}{12.5 \times 10^{-2}} = \frac{\lambda}{2y}$$

$$t = \frac{5.46 \times 10^{-7} \times 12.5 \times 10^{-2}}{2(1.5 \times 10^{-3})}$$

$$t = 2.275 \times 10^{-5} \text{ m}$$

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Q N 5

5 a) i) Magnetic flux is the force acting on a conductor of Length 1m carrying current of 1A placed perpendicular to the magnetic field. (01) (01)

Magnetic moment is the product of current, number of turns and area of coil (01)

ii) $B = \frac{\mu_0 I N}{2R}$ (01)

b) $B = \frac{\mu_0 I N}{2R}$

$= \frac{4\pi \times 10^{-7} \times 10 \times 40}{2 \times 8 \times 10^{-2}}$

$= 3.14 \times 10^{-3} T$

$F = BIL$

$= 3.14 \times 10^{-3} \times 3 \times 2.5 \times 10^{-2}$

$F = 2.36 \times 10^{-4} N$

(04)

2.5 cm

3.0 A

r = 8.0 cm

N = 40

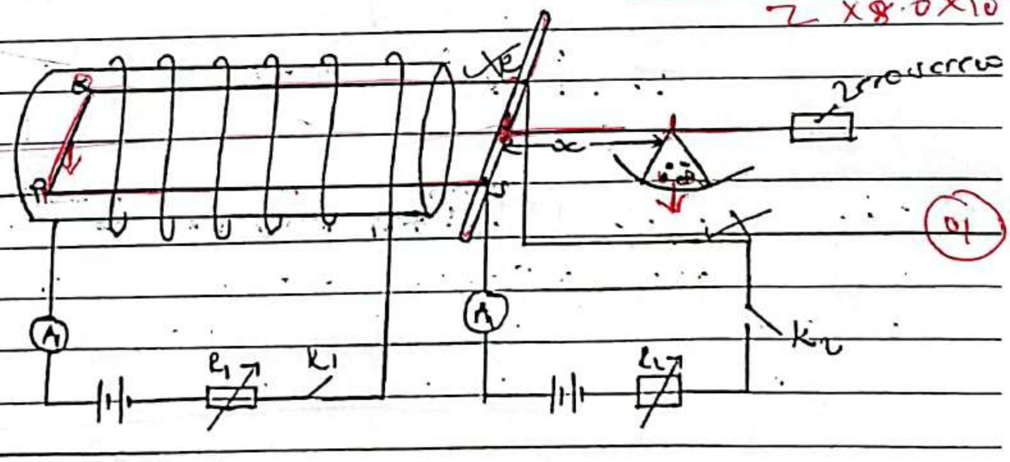
I = 10 A

$F = BIL$

$= \frac{\mu_0 N I_a I_b L}{2R}$

$= \frac{4\pi \times 10^{-7} \times 40 \times 10 \times 3 \times 2.5 \times 10^{-2}}{2 \times 8.0 \times 10^{-2}}$

c)



(01)

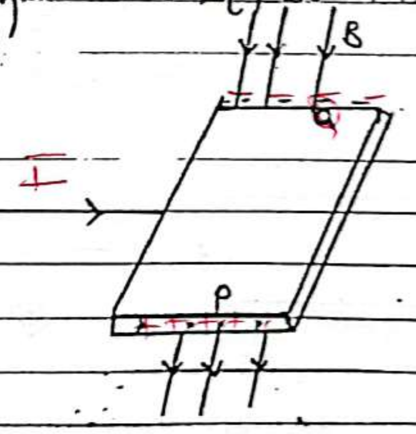
R_1 \$ R_2 – Rheostat

A_1 \$ A_2 – Ammeter

- PQRS is a conducting frame such that RS = ∞ and that conductor PQ is perpendicular to the axis of the solenoid.
- With K_1 and K_2 open, the screw is adjusted until the frame balances horizontally.
- K_1 and K_2 are closed and R_1 & R_2 are adjusted so that A_1 & A_2 registers suitable currents I_1 and I_2 respectively.
- The conductor PQ experiences a downward force.
- Masses are added on the scale pan until the frame balances horizontally again.
- The total mass M on the scale pan is noted.
- Keeping length of PQ and I_1 constant, the experiment is repeated with other values of I_2 and the corresponding total masses needed to restore balance are noted.
- A graph of M against I_2 is plotted and is a straight line through the origin.
- Therefore $M \propto I_2$ but $M \propto F$ ∴ $F \propto I_2$

05

d(i)



Bell

05

- As current flows through the slice, each electron experiences a force BeU according to Fleming's left hand rule.
- Electrons move from face P to Q making P positive and Q negative.
- An electric field is created across the faces opposing motion of electrons.
- Electron drift stops when the magnetic force equals to Electric force.
- Maximum voltage generated is called Hall voltage.

ii) Current increases in the semi-conductor, Therefore number of charge carriers (ne) increase.
- But Hall voltage, $V_H \propto \frac{1}{n}$ hence V_H reduce.

01

01

e) $t = 2\times10^{-3}$, $I = 50\times10^{-3}$
$B = 0.49T$, $V_H = 420\times10^{-3}$

$$V_H = \frac{BI}{net}$$

$$ne = \frac{BI}{V_H t}$$

$$= \frac{0.49\times50\times10^{-3}}{420\times10^{-3}\times2\times10^{-3}}$$

03

$$n = \frac{29.167}{1.6\times10^{-19}}$$

03

$$n = 1.82\times10^{20}$$

20

$$V_H = \frac{BI}{net}$$

$$V_H = \frac{0.49\times50\times10^{-3}}{n(1.6\times10^{-19})\cdot(2.0\times10^{-3})}$$

$$420\times10^{-3} = \frac{0.49\times50\times10^{-3}}{n(1.6\times10^{-19})(2.0\times10^{-3})}$$

$$n = 1.82\times10^{20}$$

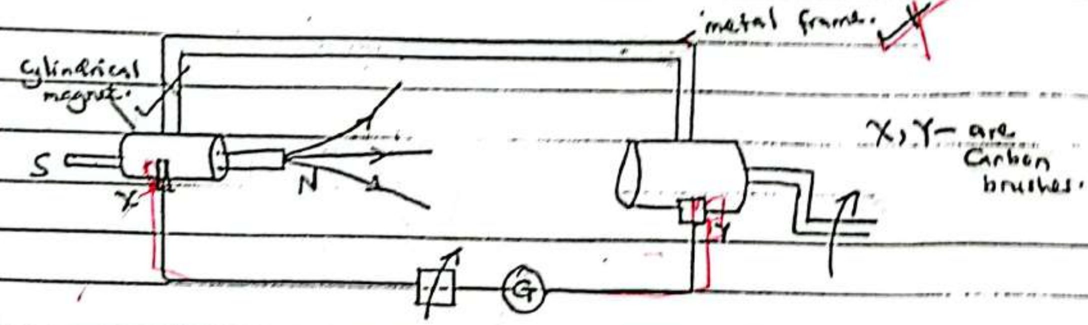
QN 6

6 (a) (i) Faraday's law states that the magnitude of induced emf in the conductor is directly proportional to the rate of change of magnetic flux linking the conductor.

02

Lenz's law states that the induced emf in a conductor acts to oppose the change causing it.

(ii)



- The frame is rotated at a constant speed until the galvanometer shows a steady deflection θ.
- The number of revolutions n made in time t is noted and the frequency of rotation is obtained from, $f = \frac{n}{t}$.
- The experiment is repeated with other values of f and corresponding values of deflection θ noted.
- A graph of f against θ is plotted and it is a straight line through the origin.

∴ $f \propto \theta$ but $\theta \propto I \propto$ ~~inducted~~ induced emf and

$$f \propto \frac{d\Phi}{dt}$$

$$\Rightarrow E \propto \frac{d\Phi}{dt}$$

05

$f \propto \theta$ but $\theta \propto I \propto E$

$$f \propto \frac{d\phi}{dt}$$

$$E \propto \frac{d\phi}{dt}$$

b).

$r = 20 \times 10^{-2}\,m$

$B = 0.25\,T$.

$\Delta\phi = \phi_f - \phi_i$

$\Delta\phi = BA - -BA$

$\Delta\phi = 2BA$

03

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$= 2 \times 0.85 \times \frac{1}{2} \pi (2.0 \times 10^{-2})^2$

$= 0.1068 \text{ wb.}$ (02)

$1.0686 \times 10^{-3} \text{ Wb}$

(ii).

$t = 0.28s.$

$R = 15\Omega.$

$E = \frac{d\phi}{dt}$

$= \frac{0.1068}{0.28} = 0.3815 \text{ V.}$ (03).

$\frac{1.0686 \times 10^{-3}}{0.28}$

$E = 3.82 \times 10^{-3} V$

from Ohm's Law.

$E = IR.$

$I = \frac{0.3815}{15}$

$= 2.54 \times 10^{-2} \text{ A.}$

$E = IR$

$\frac{3.82 \times 10^{-3}}{15} = \frac{15 I}{15}$

$I = 2.54 \times 10^{-4} A$

(C). C (i).

Back emf is the e.m.f induced in the coil of the motor whenever the magnetic flux linking it changes. (01) (02)

(ii).

Let ϕ be the magnetic flux linking the motor.

$\phi = NBA \cos\theta$ but $\theta = wt.$

$\phi = NBA \cos wt.$

$\frac{d\phi}{dt} = NBA w(-\sin wt).$

(04)

but $E = \frac{-d\phi}{dt}.$

$E = NBA w \sin wt.$

since it is a radial field, $wt = 90°$

$E = NBA w$

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d)

- Soft Iron core should be used inorder to reduce hysteresis loss due to friction between dipoles.
- By increasing the number of turns of the coil to increase the speed of the motor
- By lubricating the movable parts of the motor. to reduce friction
- By using a stronger poles of the magnet. to increase the back emf

02

20

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QN 7

7a).

Self induction is a process by which emf is generated in a coil due to changing current in the same coil ~~while~~. Mutual induction is a process of generating emf in a coil due to changing current in the neighbouring coil.

02 02

7b) (i).

- When switch K is closed, increasing current in the coil produces changing magnetic flux linking the copper disc.
- This induces eddy currents in the coil.
- Eddy currents flow to produce magnetic field which opposes that of the solenoid, hence coil is repelled and jumps.
- In a short time, current in coil attains a steady value and the magnetic flux linking the coil is not changing.
- Hence no eddy currents are induced due to its weight.

03

(ii)

$n = 300$ turns/m.

$r = 3.0 \times 10^{-2}$ m.

$\frac{dI}{dt} = 50$ A/s.

$N = 120$ turns.

$E = \frac{d\phi}{dt}$.

But $\phi = NBA$.

$= N(\mu_0 n I)A$.

$E = N\mu_0 n A \frac{dI}{dt}$.

$E = 120 \times 4\pi \times 10^{-7} \times 300 \times \pi (3 \times 10^{-2})^2 \times 50$

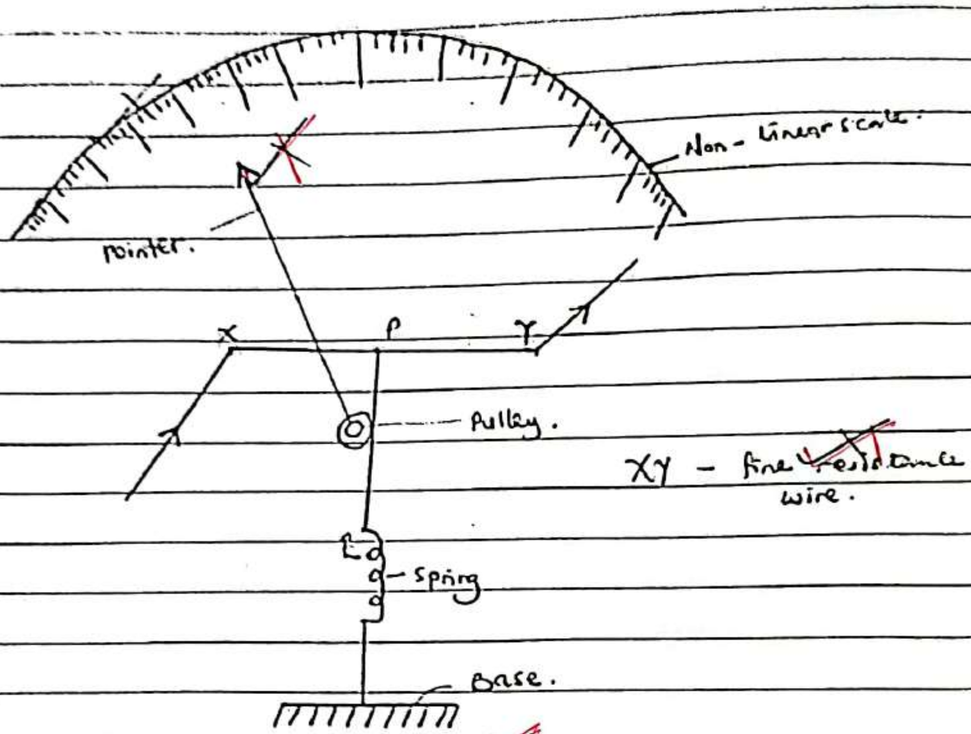
$E = 6.4 \times 10^{-3}$ V.

04 04

c(i) Root mean square value is the steady current that dissipates heat in a given resistor at the same rate as the alternating current.

01 01

c (ii)



- Alternating current is passed through fine resistance wire, XY which it heats, expands and sags.

04

- The sag is taken by wire PQ held taught by a spring which makes the pulley attached on it to turn.
- The pointer attached on the pulley deflects on the non-linear scale.
- The rate at which heat is generated is proportional to the deflection θ of the pointer.
- The deflection is proportional to the mean square value of current.

$$\theta \propto \langle I^2 \rangle$$

7d (i)

$C = 1.6 \times 10^{-5}$ F

$R = 300\,\Omega$.

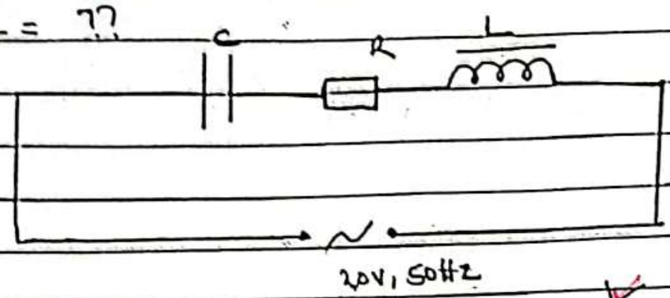
$V = 20V$

$Z^2 = (X_L - X_C)^2 + R^2$.

$f = 50Hz$.

$I = 40 \times 10^{-3} A$.

$X_L = ??$



$Z = \frac{V}{I} = \frac{20}{40 \times 10^{3}} = 500 \Omega$

$X_C = \frac{1}{2\pi f c} = \frac{1}{2\pi \times 50 \times 16.0 \times 10^{-6}}$

$X_C = 2.0 \times 10^{-2} \Omega$

$Z = \sqrt{(X_L - X_C)^2 + R^2}$

$500 = \sqrt{(X_L - 2.0 \times 10^{2})^2 + 300^2}$

$X_L = 600 \Omega$

04

$X_L = 2\pi f L$.

$L = \frac{600}{2\pi \times 50} = 1.91 H$

(ii). $f_0 = \frac{1}{2\pi f \sqrt{LC}} = \frac{1}{2\pi \times 50 \sqrt{1.91 \times 1.6 \times 10^{-5}}}$ 0.2

$f_0 = 0.5758 Hz$

20

$\frac{1}{2\pi f C} = 2\pi f L$ $\qquad f^2 = \frac{1}{4\pi^2 C L}$.

$\frac{1}{4\pi^2 C L} = \frac{\cancel{4\pi^2} f^2 \cancel{CL}}{\cancel{4\pi^2 CL}}$ $\qquad f = \frac{1}{2\pi \sqrt{CL}}$

$f = \frac{1}{2\pi \sqrt{1.6 \times 10^{-5} \times 1.91}}$

$f = 28.87 Hz$

d ii) Current increases in the semi-conductor, Therefore number of charge carriers (ne) increases.

- But Hall voltage, $V_H \propto \frac{1}{ne}$, hence V_H reduces.

01

c) $t = 2\times10^{-3}$, $I = 50\times10^{-3}$

$B = 0.49T$, $V_H = 420\times10^{-3}$

$$V_H = \frac{BI}{net}$$

$$ne = \frac{BI}{V_H t}$$

$$= \frac{0.49\times50\times10^{-3}}{420\times10^{-3}\times2\times10^{-3}}$$

$$n = \frac{29.167}{1.6\times10^{-19}}$$

$$n = 1.82\times10^{20}$$

03

20

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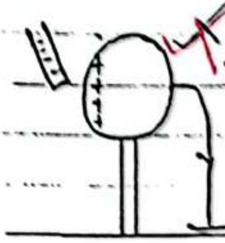
QN 8

Electrostatic induction refers to the process by which a neutral conductor body acquires charge when placed near a charged body. 01

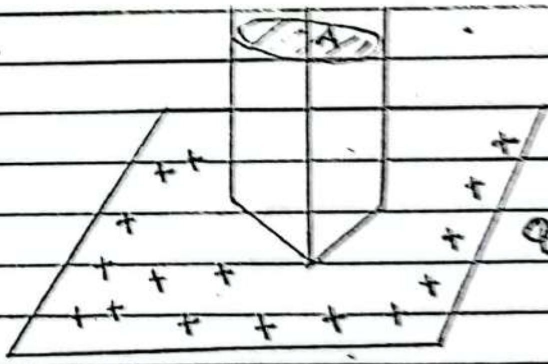
- A negatively charged rod is placed near the neutral sphere.
- The rod induces positive charges and repells negative charges to the further end of the sphere.



- With the rod still in its position, the sphere is earthed and electrons flow to the earth. 04
- The sphere remains with a net positive charge at a zero potential.

Electric field intensity refer to the force acting on a positive charge of one Coulomb placed at a point in an electric field. 01

Electric potential energy is the workdone to move any charge from infinity to a point in an electric field. 01



$Q = A\delta$

$Q = A\delta$

$\phi = EA$

Consider a charged plane conductor of charge density, δ

flux normal to the conductor, $\Phi = EA$ ——— (i)

Also, $\Phi = \frac{Q}{\varepsilon}$ ——— (ii).

$\Phi = \frac{Q}{\varepsilon}$

Equation (i) = equation (ii).

$\frac{Q}{\varepsilon} = EA$

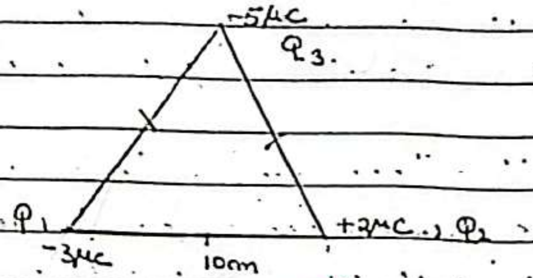
But $Q = \delta A$

$$E A = \frac{\delta A}{\varepsilon}$$

03

$$\therefore E = \frac{\delta}{\varepsilon}$$

(e) i)



$$F = \frac{K Q_1 Q_2}{r^2}$$

Force due to Q_2 on Q_1, F_{Q_2}.

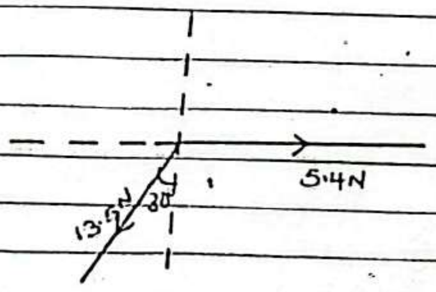
$$F_{Q_2} = \frac{9\times10^9 \times 3\times10^{-6} \times 2\times10^{-6}}{(10\times10^{-2})^2}$$

$$= 5.4N.$$

Force due to Q_3, F_{Q_3}

$$F_{Q_3} = \frac{9\times10^9 \times 3\times10^{-6} \times 5\times10^{-6}}{(10\times10^{-2})^2}$$

$$= 13.5N.$$



Resolving vertically.

$-13.5 \cos 30°$

$= -11.613N.$

Horizontally

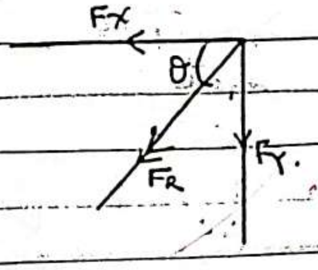
$5.4 - 13.5 \sin 30°$

$= -1.35N.$

Resultant Force, F_R.

$$F_R = \sqrt{(11.613)^2 + (1.35)^2}$$

$$= 11.69N.$$



04

$$\tan\theta = \frac{F_Y}{F_X}$$

$$\tan\theta = \frac{11.613}{1.35}$$

04

$$\theta = \tan^{-1}\left(\frac{11.613}{1.35}\right)$$

$$\theta = 83.4^0$$

(ii).

$$V = \frac{KQ}{r}.$$

$$V = 9\times10^9\left(\frac{-3\times10^{-6}}{10\times10^{-2}} + \frac{2\times10^{-6}}{10\times10^{-2}}\right).$$

$$V = -9.0\times10^4 V.$$

03 marks.

Potential energy, $W = VQ.$

$= -9.0\times10^4 \times -5\times10^{-6}$

$= 0.45J$

03

5/9

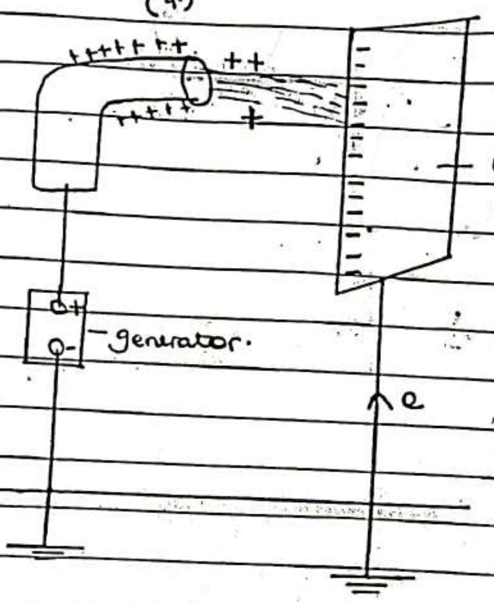
Electric flux is the product of the magnitude of electric field intensity and the projection of the surface area normal to the field.

$\phi = EA$

Unit Vm.

1.5

(d)



03

- The oil drop gets Charged positively ~~it~~ they move out of the nozzle hence they are repelled towards the body to be sprayed.
- As they move towards the body, they Induce ~~include~~ negative Charge on it hence attracted.
- This makes oil drops sticks to the body Causing uniform Coating.

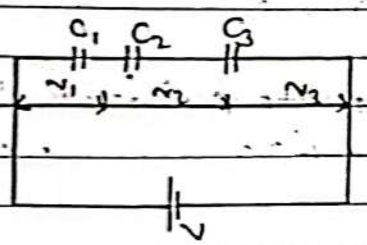
20

QN 9.

9(a)(i) Capacitance is the ratio of magnitude of charge on either plates of capacitor to the potential difference across them. 01

Farad is the capacitance of a capacitor when a charge of one coulomb is stored in the plates when the p.d across the plates is 1 volt. 01

9(a)(ii)



Charge on the plates is the same.

$Q_1 = Q_2 = Q_3 = Q$

$V = V_1 + V_2 + V_3$

$V = \frac{Q}{C}$

$V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$

$V = Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$ 04

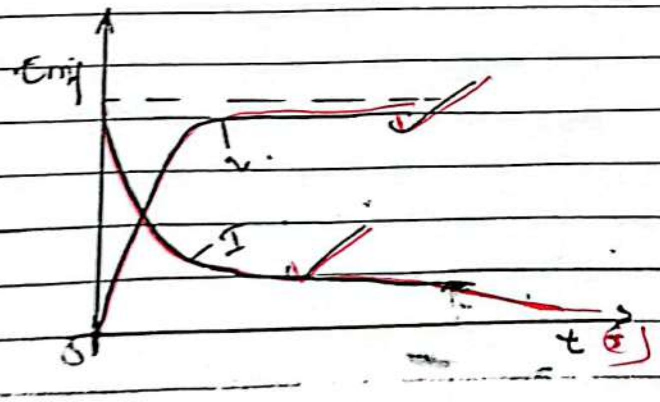
$\frac{V}{Q} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

But $\frac{V}{Q} = \frac{1}{C_T}$

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

where C_T is the effective capacitance.

9(b)



02

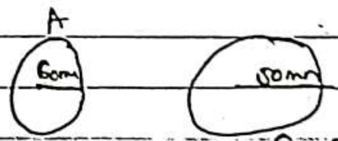
9(b)(i) - Existing charges on the plate oppose flow of electrons respectively.

- The battery does work to overcome this electrostatic force of repulsion.

- This workdone is stored as electrostatic potential energy.

OR - During charging, charge deposited on plates create an electric field between plates.

- ~~It is as a result of the work done by the battery~~ is the energy of ... work done by the battery to move electrons across the plates against the electric field across the plates.



$Q_A = 10\mu C$ $Q_B = 4\mu C$

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

$E = \frac{Q^2}{2C}$

$C = 4\pi\varepsilon_0 r$

Capacitance of A, C_A

$C_A = 4\pi\varepsilon_0 \times 80\times10^{-3}$

$C_A = 8.89\times10^{-12}F$

Capacitance of B, C_B

$C_B = 4\pi\varepsilon_0 \times 50\times10^{-3}$

$C_B = 5.56\times10^{-12}F$

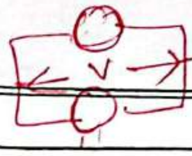
Before connecting

Energy at A

$E = \frac{Q^2}{2C_A}$

$E_A = \frac{(10\times10^{-6})^2}{2\times8.89\times10^{-12}}$

$E_A = 5.624J$



Energy at B.

$$E_B = \frac{(4\times10^{-6})^2}{2\times 5.56\times10^{-12}}$$

$$E_B = 1.439J$$

Total energy Before.

$$E_T = E_A + E_B$$

$$E_i = 5.624 + 1.439$$

$$E_i = 7.063J$$

05

After connection:

$$Q_A + Q_B = (C_A+C_B)V$$

$$V = \frac{Q_A+Q_B}{C_A+C_B}$$

05

$$V = \frac{10\times10^{-6}+4\times10^{-6}}{8.89\times10^{-12}+5.56\times10^{-12}}$$

$$V = 9.69\times10^{5}V$$

$$E_f = \frac{1}{2}CV^2$$

$$= \frac{1}{2}\times(8.89\times10^{-12}+5.56\times10^{-12})(9.69\times10^{5})^2$$

$$E_f = 6.784J$$

$$\Delta E = E_i - E_f$$

$$= 7.063 - 6.784$$

$$\therefore \Delta E = 0.279J$$

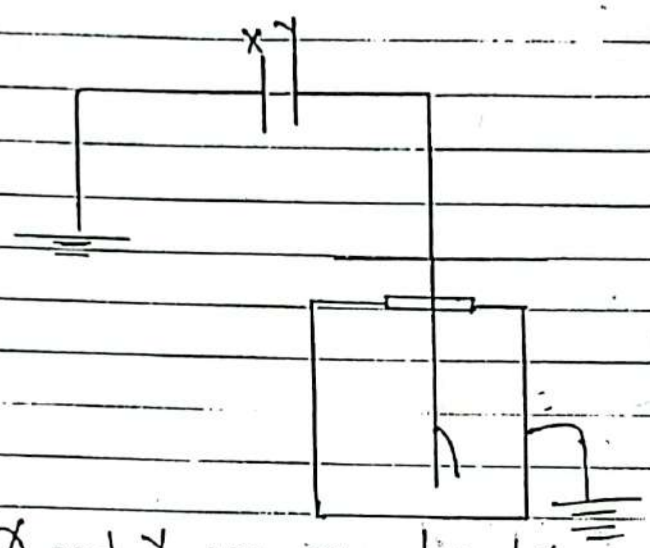
01

9.d(i) A dielectric refers to an insulator which conducts at a high voltage.

9

CamScanner

d(ii)



- X and Y are capacitor plates with plate X earthed and Y charged using an electrophorus and then connected to the cap of neutral gold leaf electroscope.
- The divergence of the leaf is noted and is proportional to the potential difference across the plates.
- Keeping other factors constant, a dielectric is inserted between the plates of the capacitor.
- The divergence of the leaf reduces hence p.d across the plates reduces.
- From $Q = CV$, $C \propto \frac{1}{V}$ hence capacitance increases.
$\therefore C \propto \varepsilon$

(04)

20

10)

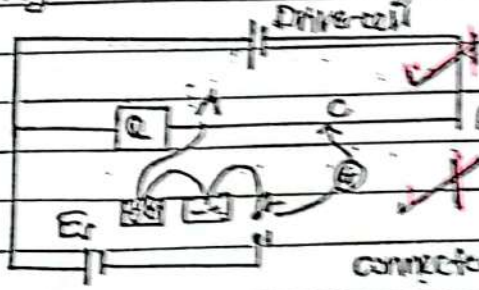
i) Electromotive force is the Workdone to transfer a 1C of charge round a complete circuit in which a cell is connected. OR pd across a battery on an open circuit.

ii) Internal Resistance is the opposition to flow of current in the cell due to the chemical composition inside it.

b) Chemical reactions occur ~~faster~~ at high temperatures to supply the Needed current to start the Engine. Internal resistance reduces in a warmer battery allowing more current to freely flow

c) i) The Driver cell maintains a steady current through the slide wire.
The Wire is uniform and the resistance per cm of the wire is constant hence pd per cm is constant.
Knowing the pd per cm, any pd can be measured by balancing it across known length of slide wire

ii)



AB — Slide Wire
Q — High Resistance
T — thermometer

connected in series with slide wire

- Apparatus is arranged as shown above with High resistance Q.
- With galvanometer connected to portion 1, jockey is tapped along slide wire AB until galvanometer shows zero deflection.
- The balance length L_1 is Noted
- With galvanometer connected to portion 2, jockey is tapped along slide wire AB until it shows zero deflection
- The balance length L_2 is Noted
- Emf E of thermocouple is obtained from

$$E = \left(\frac{kl_2}{kl_1+Q}\right)E_s$$ where k is the pd per cm

10d)

$AB = 100cm$, $R_W = 15\Omega$

$V = 3.0V$

Effective Resistance in Drive-circuit $= 15 + 8$

$= 23\Omega$

Current flowing, $I = \frac{3}{23} A$ $= 0.130A$

p.d per cm, $K = \frac{V}{L}$, $V = \frac{3}{23} \times 15 = 45/23$

1.957 V

$K = \frac{45/23}{100}$

$K = \frac{9}{460} Vcm^{-1}$

0.01957 Vcm

p.d across the 5Ω = P.d across slide wire (balance length)

$(5 \times I) = KL$

$5I = \frac{9}{460} \times 62.0$

$I = 0.243A$

.04

04

$(5+R) \times 0.243 = 75.0 \times \frac{9}{460}$

$R = 1.039\Omega$

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

$E = 0.243(1.039 + 5 + 0)$

$E = 1.407V$

03

03