P510/2
PHYSICS
Paper 2
Nov./Dec.2017
2½ hours

UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

PHYSICS

Paper 2

2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

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

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

Mathematical tables and squared paper will be provided.

Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	$= 9.81\ ms^{-2}$
Electron charge, e	$= 1.6 \times 10^{-19}\ C$
Electron mass	$= 9.11 \times 10^{-31}\ kg$
Plank's constant, h	$= 6.6 \times 10^{-34}\ Js$
Speed of light in a vacuum, c	$= 3.0 \times 10^{8}\ ms^{-1}$
Avogadro's number, N_A	$= 6.02 \times 10^{23}\ mol^{-1}$
Gas constant, R	$= 8.31\ Jmol^{-1}\ K^{-1}$
Charge to mass ratio, e / m	$= 1.8 \times 10^{11}\ Ckg^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	$= 9.0 \times 10^{9}\ F^{-1}m$
Permeability of free space, μ_0	$= 4.0 \times 10^{-7}\ Hm^{-1}$
Permittivity of free space, ε_0	$= 8.85 \times 10^{-12}\ Fm^{-1}$

Turn Over

SECTION A

1. (a) (i) State **two** differences between **real** and **virtual** images. *(02 marks)*

(ii) Explain with the aid of a diagram how a thick plane mirror forms multiple images. *(04 marks)*

(b) A concave mirror forms a real image which is three times the linear size of the object. When the object is displaced through a distance y, the real image formed is four times the linear size of the object. If the distance between the two image positions is 20.0 cm, find the

(i) focal length of the mirror. *(03 marks)*

(ii) distance y. *(03 marks)*

(c) Use a geometrical ray diagram to derive the relation $\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$ for a concave mirror. *(05 marks)*

(d) Explain how a mirage is formed. *(03 marks)*

2. (a) Define the following as applied to a converging lens;

(i) Principal focus. *(01 mark)* ✓

(ii) Centre of curvature. *(01 mark)* ✓

(b) Find the power of a lens of focal length 15 cm. *(02 marks)* ✓

(c) Derive an expression for the focal length of a lens in terms of the radii of curvature of its surfaces and its refractive index. *(05 marks)* ✓

(d) Describe an experiment to determine the focal length of a thin converging lens mounted inside a short cylindrical tube. *(05 marks)* ✓

(e) A compound microscope consists of two thin lenses, an objective of focal length 1.0 cm and the eye-piece of focal length 5.0 cm. The objective forms an image of an object placed in front of it at a point 16.0 cm away. If the final image is formed at the near point of the eye, calculate the

(i) separation of the lenses. *(03 marks)*

(ii) magnifying power of the instrument. *(03 marks)*

SECTION B

3. (a) Define the following as applied to a wave:

(i) Amplitude, *(01 mark)*

(ii) Wavelength. *(01 mark)*

(b) (i) State the conditions necessary for the formation of a standing wave. *(02 marks)*

(ii) A string fixed at both ends is made to vibrate in two different modes. If the frequencies of the n[th] harmonic and the fundamental note are f_n and f_1 respectively, show that

$$f_n = n\,f_1.$$ *(04 marks)*

(c) The mass of a vibrating length of a sonometer wire is 1.20 g. A note of frequency 512 Hz is produced when the wire is sounding its second overtone. If the tension in the wire is 100 N, calculate the vibrating length of the wire. *(04 marks)*

(d) Explain why the quality of a note from an open pipe is preferred to that given by a closed pipe. *(03 marks)*

(e) Describe an experiment to investigate the variation of frequency with length for a vibrating wire. *(05 marks)*

4. (a) Define **optical path**. *(01 mark)*

(b) With reference to Young's double slit experiment,

(i) explain how an interference pattern is formed. *(03 marks)*

(ii) state what happens to the fringes when the source is moved nearer to the slits. *(01 mark)*

(iii) state what happens to the fringes when separation of the slits is changed. *(02 marks)*

(iv) describe the appearance of the fringes when white light is used. *(03 marks)*

(v) calculate the separation of the slits if the distance from the slits to the screen is 800 mm and the 8[th] bright fringe is formed 5 mm away from the centre of the fringe system, given that the wavelength of light is 6.2×10^{-7} m. *(03 marks)*

$= \frac{1}{2L}$

$= \frac{1}{4L}$

f_0 $2f_0$ $3f_0$

$\frac{10^7\ L}{5}$ = Ans

$2f_0$

$n(\frac{1}{4}$

Turn Over

(c) An air wedge is formed by placing two glass slides of length 5.0 cm in contact at one end and a wire at the other end as shown in figure 1.

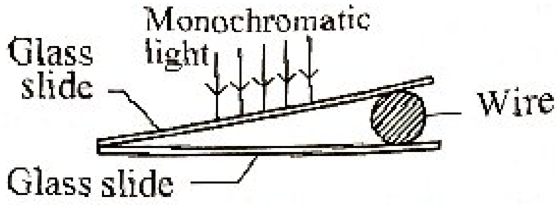

Fig. 1

When the slides are illuminated with light of wavelength 500 nm, 10 dark fringes are observed to occupy a distance of 2.5 mm.

(i) Explain how the fringes are formed. *(03 marks)*

(ii) Determine the diameter of the wire. *(04 marks)*

SECTION C

5. (a) Define **magnetic flux density.** *(01 mark)*

(b) Write an expression for the

(i) magnetic flux density B at a distance r from a long straight wire carrying a current I. *(01 mark)*

(ii) force F on a straight wire of length l carrying current I perpendicular to a uniform magnetic field of flux density B.

F = BIL sinθ *(01 mark)*

(c) A moving-coil galvanometer consists of a rectangular coil of N turns each of area A suspended in a radial magnetic field of flux density B.

(i) Derive an expression for the torque on the coil when a current I passes through it. *(04 marks)*

(ii) If the coil is suspended by a torsion wire for which the couple per unit twist is C, show that the instrument will have a linear scale. *(03 marks)*

(iii) How can the current sensitivity of the instrument be measured? *(02 marks)*

(d) Describe an experiment to determine the magnetic flux density of a uniform magnetic field using a search coil and a ballistic galvanometer. *(05 marks)*

KB = BINA

(c) Figure **2** shows an ampere balance. Wires AB and CD each of length 100 cm, lie in the same vertical plane and are separated by 2.0 mm.

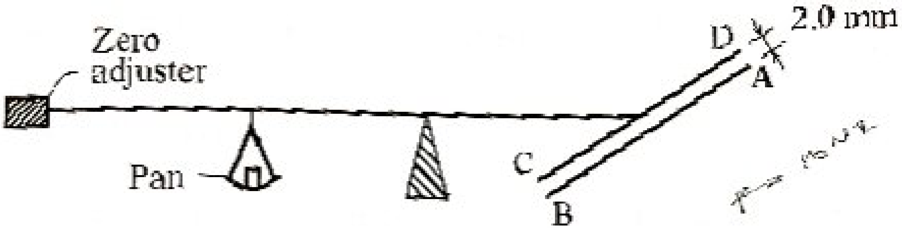

Fig. 2

When a current I is passed in opposite directions through the wires, a mass of 0.3 g is placed in the pan to obtain balance.
Find the value of the current I. *(03 marks)*

6. (a) In figure **3**, **X** and **Y** are smooth conducting rails connected to a source of e.m.f, **E**. **CD** is a metal rod of length l m placed horizontally on **X** and **Y** perpendicular to magnetic field of flux density **B**.

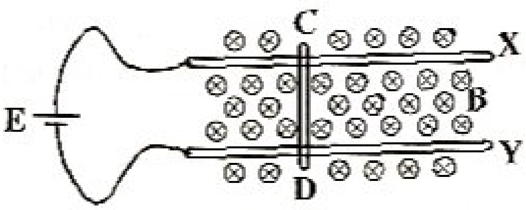

Fig. 3

(i) Copy the diagram and indicate the direction of force F acting on the rod. *(01 mark)*

(ii) Using the principle of conservation of energy, show that $F = BIl$, where I is the current supplied by the source. *(04 marks)*

(b) (i) Describe the features of earth's magnetic field. *(05 marks)*

(ii) Sketch the resultant magnetic flux around a wire carrying current vertically upwards in the earth's magnetic field. *(02 marks)*

(c) A circular coil of 50 turns and radius 0.5 m is placed with its plane perpendicular to earth's magnetic meridian. It is connected to a ballistic galvanometer of sensitivity 5.7×10^3 rad C^{-1} and circuit resistance of 100 Ω. When the coil is rotated through 180^0 about a horizontal axis, the galvanometer deflects through 0.8 rads.

Calculate the

(i) horizontal component of earth's magnetic flux density. *(04 marks)*

(ii) p.d across a solenoid of 2000 turns per metre and resistance 5 Ω that produces the same magnetic flux density as that calculated in (c) (i). *(04 marks)*

7. (a) Define **root mean square** value of an alternating current. *(01 mark)*

(b) (i) Write down the expression for the e.m.f generated by a dynamo and use it to identify the factors which determine the maximum e.m.f. *(04 marks)*

(ii) Explain the structural modifications needed to convert an a.c generator into a d.c generator. *(02 marks)*

(c) An iron-cored coil having a low resistance and high inductance is connected in series with a filament lamp P. The coil and the lamp are then connected across a d.c supply as shown in figure **4**.

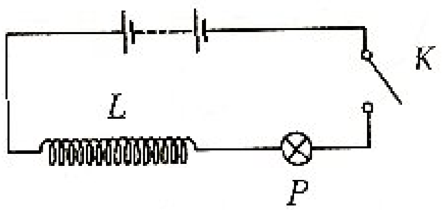

Fig. 4

Explain what is observed when switch K is closed and then opened. *(04 marks)*

(d) An alternating voltage $V = V_0 \cos wt$ is connected across an inductor of inductance L.

(i) Derive the expression for the reactance of the inductor, X_L. *(04 marks)*

(ii) Sketch using the same axes the variation of applied voltage and current through the inductor with time. *(02 marks)*

(e) Describe how a thermocouple ammeter is used to measure an alternating current. *(03 marks)*

SECTION D

8. (a) (i) State the law of conservation of current at a junction in an electric circuit. *(01 mark)*

(ii) Explain why current from a battery is greater when bulbs are connected in parallel than when they are in series across the battery. *(03 marks)*

(b) A conductor of length l and cross sectional area A has n free electrons per unit volume. The average drift velocity of the electrons is v and each electron carries charge e.

Derive an expression for the current which flows. *(03 marks)*

(c) A battery with an e.m.f of 12 V and internal resistance $2\ \Omega$ is connected to a wire of resistance $10\ \Omega$.

(i) Calculate the p.d across the wire. *(02 marks)*

(ii) What will the p.d across the wire become if a $15\ \Omega$ resistor is connected in parallel with it? *(03 marks)*

(d) (i) Define **electrical resistivity** and state its unit. *(02 marks)*

(ii) Describe an experiment to determine the resistivity of the material of a wire using an ammeter, a meter rule and voltmeter. *(06 marks)*

9. (a) (i) Define **temperature coefficient** of resistance and state its unit. *(02 marks)*

(ii) Explain why temperature coefficient of resistance is positive for metals. *(03 marks)*

(b) (i) Derive the condition for balance of a metre bridge. *(05 marks)*

(ii) Explain why the metre bridge is unsuitable for comparison of low resistances. *(02 marks)*

(c) A standard resistor is connected across the right hand gap of a meter bridge and a coil X across the left hand gap of the bridge.

When the coil X is heated to a temperature of $40\ ^0C$, the balance length is 525 mm from the left-hand end of the bridge.

When the temperature of X is raised to $100\ ^0C$, the balance point is 546 mm from the left end.

(i) Calculate the temperature coefficient of resistance of coil X. *(06 marks)*

(ii) Why are standard resistors made of alloys such as constantan and manganin? *(02 marks)*

V = IR

Turn Over

10. (a) Derive an expression for the energy stored in a capacitor of capacitance C, charged to a voltage V. *(04 marks)*

$W = \frac{VQ}{2}$

(b) A parallel plate capacitor with plate area of $2 \times 10^{-2}\ m^2$ and plate separation of 5.0×10^{-3} m is connected to a 500 V supply.

(i) Calculate the energy stored in the capacitor. *(04 marks)*

(ii) If the space between the plates is completely filled with oil and the total charge in the capacitor becomes 4.42×10^{-8} C, find the dielectric constant of the oil. *(03 marks)*

(c) Explain how a lightning conductor may protect a building from damage by lightning. *(05 marks)*

(d) Describe an experiment to show that charge on a hollow conductor resides on the outer surface. *(04 marks)*

$C = \frac{\varepsilon A}{d}$ $\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$

$C = \frac{\varepsilon_r \varepsilon_0 A}{d}$

$\frac{1}{2}\frac{Q^2}{C}$

$C = Q/V$

Q/C

$C = \varepsilon A/d$

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

$E =$

END

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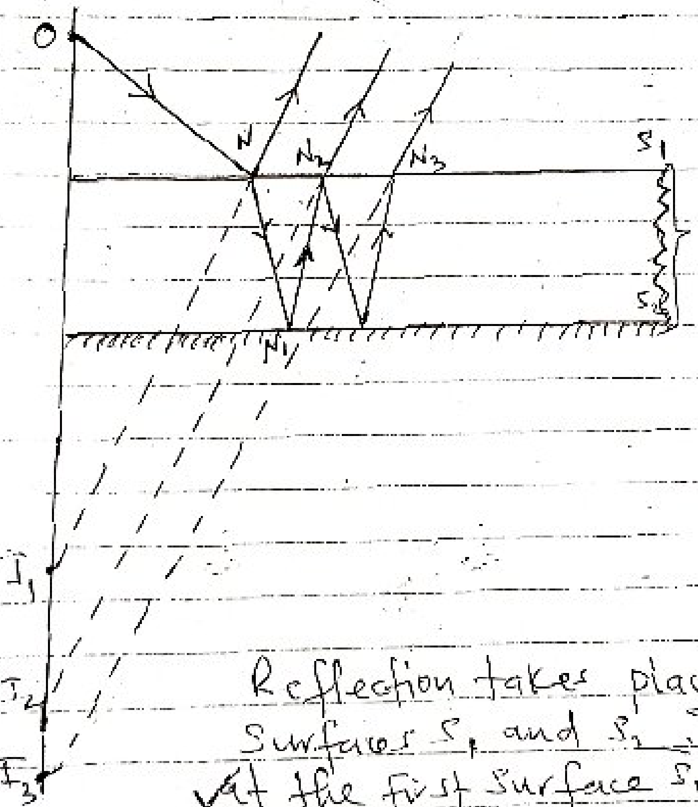
(1)

1a(i)

Real Image	Virtual Image
- Formed by convergence of rays/Actual intersection	- Formed by apparent intersection/convergence of rays
- Can be formed on the screen	- Cannot be formed on the screen

(2)

(ii)



Reflection takes place at the two surfaces S_1 and S_2. The reflection at the first surface S_1 at point N leads to image I_1. The transmitted light is reflected at the silvered surface at point N_1. It undergoes partial reflection and refraction at N_2. The refracted light appears to originate from I_2 and this leads to formation of image I_2. Other successive internal reflections lead to formation of other multiple images.

(4)

Partial refl & refraction to be at N or N_2 or N_3

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(2)

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{f} = \frac{1}{u_1} + \frac{1}{3u_1}$ or $\frac{1}{f} = \frac{1}{u_2} + \frac{1}{4u_2}$

$3u_1 = 4f$, $4u_2 = 5f$

$v_1 = 4f$, $v_2 = 5f$

$v_2 - v_1 = f = 20$

1b(i) $M_1 = \frac{v_1}{f} - 1$

$M_2 = \frac{v_2}{f} - 1$

$M_2 - M_1 = \frac{v_2 - v_1}{f}$

$4 - 3 = \frac{20}{f}$

$\Rightarrow f = 20\text{ cm}$

OR $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

OR
$M = \frac{v}{f} - 1$
$3 = \frac{v_1}{f} - 1$
$4 = \frac{v_2}{f} - 1$
$\frac{v_2 - v_1}{f} = 5 - 4 = 1$
$\frac{20}{f} = 1$
$f = 20\text{cm}$

(ii) Also $\frac{1}{m} = \frac{u}{f} - 1$

$\Rightarrow \frac{1}{3} = \frac{u_1}{f} - 1$

$\frac{1}{4} = \frac{u_2}{f} - 1$

$\Rightarrow \frac{y}{3} - \frac{1}{4} = \frac{u_1 - u_2}{f} = \frac{y}{20}$

$y = \frac{20}{12}$

$= 1.67\text{cm}$

(3)

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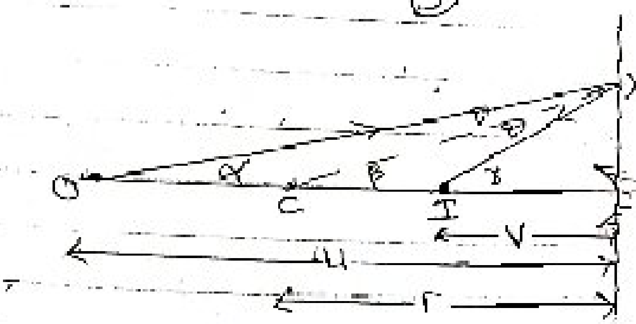
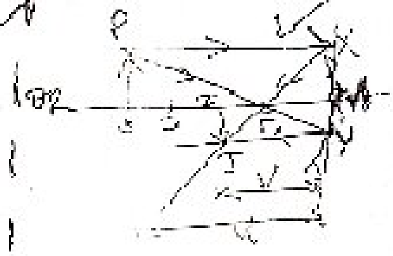
(3)

(C)

Mirror absent deduct ½ for error of omission





Let h be a very small height of the point X above the principal axis as shown above

The angle α, β and γ are very small angles in radians

∴ from △ CXI

$\gamma = \beta + \theta$ ---(i)

from △ OXC

$\alpha + \theta = \beta$ ---(ii)

from (i) and (ii)

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

$\alpha + \gamma = 2\beta$ ---(iii)

$\tan\alpha \simeq \alpha = \frac{h}{u}$ ---(iv)

$\tan\beta \simeq \beta = h/r$ ---(v)

$\tan\gamma \simeq \gamma = \frac{h}{v}$ ---(vi)

from (iv), (v) and (vi)

$\frac{2h}{r} = \frac{h}{u} + \frac{h}{v}$

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

$r = 2f$

(5)

R still using finite object.

$\frac{OP}{IJ} = \frac{MY}{FM}$

$\frac{MX}{OF} = \frac{FM}{OF} = \frac{f}{u-f}$

$\frac{IJ}{IF} = \frac{MX}{FM}$

$\frac{MX}{IJ} = \frac{FM}{IF} = \frac{f}{v-f}$

but $MX = OP$ and $MY = IJ$

$\frac{IJ}{OP} = \frac{f}{u-f}$ and $\frac{OP}{IJ} = \frac{f}{v-f}$

$\frac{f}{u-f} = \frac{v-f}{f}$

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

$uf + vf = uv$

divide through by uvf

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{MY}{OF} = \frac{\quad}{\quad}$

$\frac{XM}{IJ} = \frac{FM}{IF}$

$\frac{f}{u-f} = \frac{v-f}{f}$

$f^2 = (u-f)(v-f)$

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

dividing through by uvf

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

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4

(d) On a hot day, layers of air over the earth's surface are hotter than those high up. Optical density thus decreases towards the earth's surface. Light from the sky is thus continually refracted away from the normal. At some point, total internal reflection occurs. An observer on the earth's receiving the totally internally reflected light gets (sees image of sky as pool of water) the impression of a pool of water on the ground. What appears to be a pool of water is the mirrage.

(3)

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(5)

2 a(i) The principal focus of a converging lens is the point on the principal axis to which rays originally parallel and close to the axis converge after passing through the lens. (1)

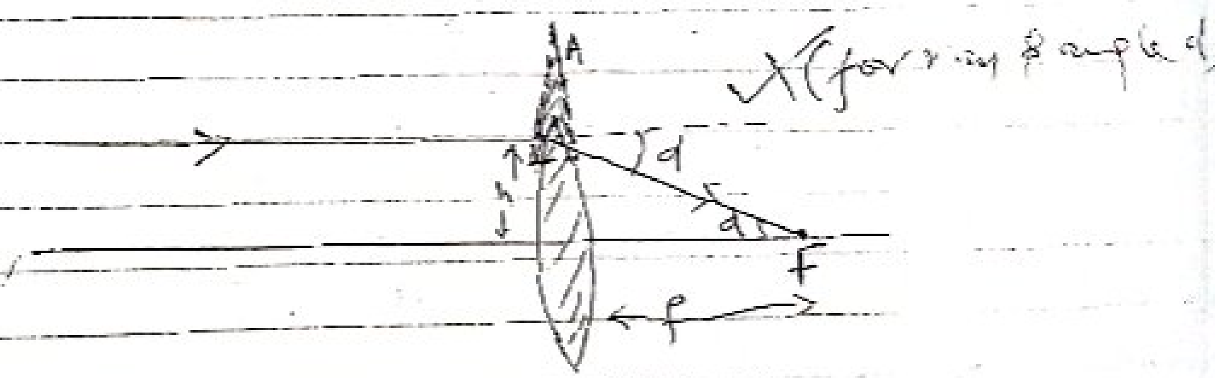
(ii) The centre of curvature of a lens is the centre of the spheres of which one of the spherical surfaces of the lens forms part. (1)

(b) Power $= \frac{1}{f}$

$= \frac{1}{0.15}$

$= 6.67D$

(c) Consider a ray originally parallel and close to the principal axis, incident on the lens a small distance h above the principal axis



Since d is small in radians

$d \simeq \tan d = \frac{h}{f}$ (1)

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(b)

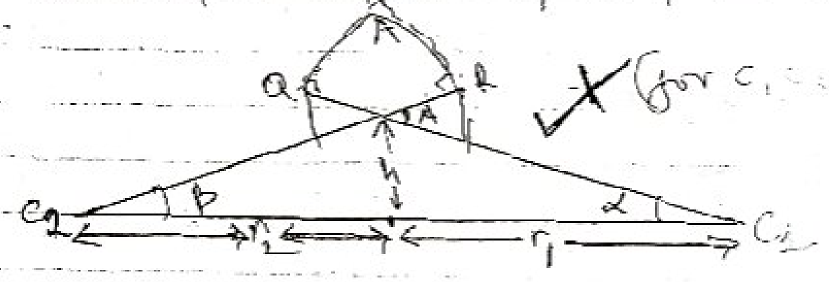
This is the deviation through a prism of small angle A formed by tangents at Q, R to the lens surfaces.

$d = (n-1)A$

$\Rightarrow \frac{h}{f} = A(n-1)$

$\frac{1}{f} = \frac{A}{h}(n-1)$

The normals at Q, R pass respective the centres of curvature C_1, C_2 of the



(for c_1, c_2, r_1, r_2)

from geometry

$A = \alpha + \beta$

α, β are small angles measured in radians

$\alpha \simeq \tan\alpha = \frac{h}{r_1}$. $\beta \simeq \tan\beta = \frac{h}{r_2}$

$\Rightarrow A = \frac{h}{r_1} + \frac{h}{r_2}$ and $\frac{A}{h} = \frac{1}{r_1} + \frac{1}{r_2}$ ---(iii)

from (ii) and (iii)

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

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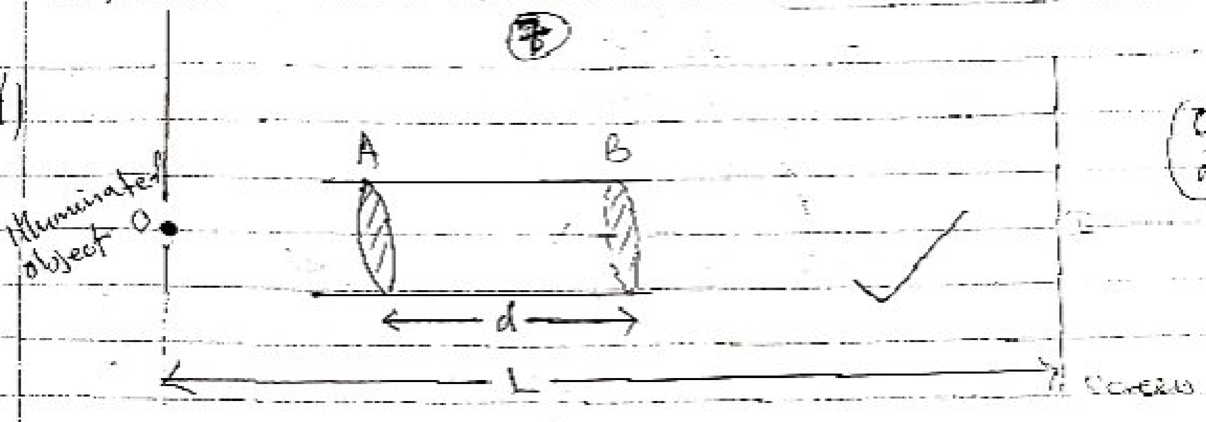
(7)

(d)



O, tube, and screen

An illuminated object O is placed infront of the ~~tube and position of one end of tube is marked~~ ~~Convex lens in position A~~. The position of a clear image of O is located on the screen ~~at~~ the distance L between the object and the screen is measured. Keeping the object O and the screen fixed, the tube is displaced to obtain another clear image on screen. ~~The position of one end of tube is marked~~ ~~displaced to position B to obtain another clear image on the screen~~. The distance d between the two lens positions A and B is measured. The focal length f of the lens is calculated from $f = \frac{L^2 - d^2}{4L}$

(5

if the lens is moved instead of tube

- arrangement looking for first image
- fix L
- measure L
- adjust lens for 2nd image (position of lens changed)

02

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e(i) Consider the eye-piece lens.

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

$$\frac{1}{u} - \frac{1}{25} = \frac{1}{5} \Rightarrow u = 4.17$$

$$= v_o + u_e$$

Separation of lenses $= 16.0 + 4.17$

$= 20.17$ cm

(3)

(ii) Magnifying power $M = \left(\frac{v_e}{f_e} + 1\right)\left(\frac{v}{f_o} - 1\right)$

$$= \left(\frac{25}{5} + 1\right)\left(\frac{16}{1} - 1\right)$$

$$= -6 \times 15$$

$$= -90$$

(3)

OR $M = -\left(\frac{D}{f_e} + 1\right)\left(\frac{v_o}{f_o} - 1\right)$

$$= -\left(\frac{25}{5} + 1\right)\left(\frac{16}{1} - 1\right)$$

$= -90$ (Accept without -ve)

20

SECTION B

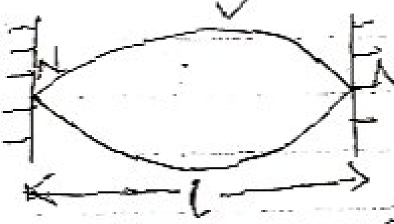
3a(i) Amplitude is the maximum displacement of a wave particle from its equilibrium position. 1

(ii) Wavelength is the distance between two successive crests or troughs. 1

b(i) - The two waves must be travelling in opposite directions.

- The waves must have the same speed, frequency and approximately equal amplitude.

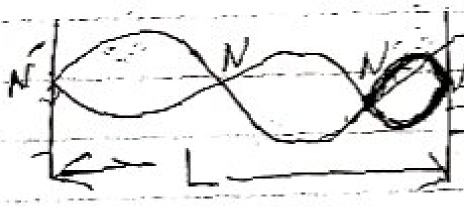
(ii)



$\frac{\lambda_1}{2} = L \Rightarrow \lambda_1 = 2L$

$V = f_1\lambda_1$

$\Rightarrow f_1 = \frac{V}{\lambda_1} = \frac{V}{2L}$



(Accept any other mode)

$\frac{3}{2}\lambda_3 = L$ 4

$\Rightarrow \lambda_3 = \frac{2L}{3}$.

$f_3 = \frac{V}{\lambda_3} = \frac{3V}{2L} = 3\left(\frac{V}{2L}\right) = 3f_1$

If the vibration produced n loops, then the frequency $f_n = nf_1$

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(c) $f_n = \frac{n}{2l}\sqrt{\frac{T}{\mu}}$ ✓ General Modes

$f_3 = \frac{3}{2l}\sqrt{\frac{T}{\mu}}$

but $\mu = \frac{1.2\times10^{-3}}{L}$ ✓

$512 = \frac{3}{2l}\sqrt{\frac{100l}{1.2\times10^{-3}}}$ ✓

$l = 0.715M$ ✓

OR : when plucked in the middle.

$f_n = \frac{n}{2l}\sqrt{\frac{T}{\mu}}$ ✓ but $\mu = \frac{1.2\times10^{-3}}{l}$ ✓

$f_5 = \frac{5}{2L}\sqrt{\frac{100L}{1.2\times10^{-3}}}$

$512 = \frac{5}{2L}\sqrt{\frac{100L}{1.2\times10^{-3}}}$ ✓ 4

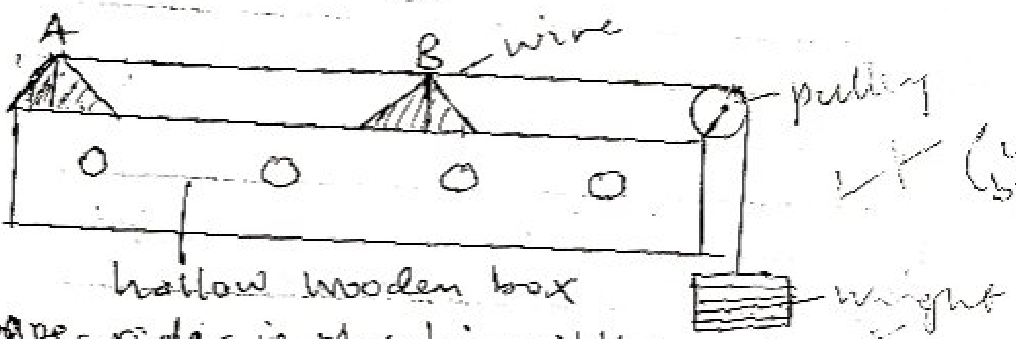
$L = 1.987M$ ✓

(d) Closed pipes give only odd harmonics while open pipes give both odd and even harmonics. ✓ 3
A note with many overtones is of a better quality than the same note with fewer overtones. Thus a note played on an open pipe is of better quality than the same note played on closed pipe. [Alt: open pipes produce more overtones than closed

Error of omission is indicated as error of commission (If student fails to indicate clearly where L is measured penalise & continue marking)

(11)

(e)



L ✓ (wire b/w bridges)

(A paper rider is placed in middle of wire)

The String is plucked in the middle and a Sounding tuning fork placed near it ✓ Bridge B is moved towards A until a loud Sound is heard ✓. The distance between the bridges L is measured ✓. The frequency ✓ of the tuning fork f is Noted.

The procedure is repeated with tuning forks of different frequencies and the results tabulated including values of $\frac{1}{L}$ ✓.

The graph of f against $\frac{1}{L}$ is plotted and a straight line through the origin is obtained.

$\therefore f \propto \frac{1}{L}$

✓ rider, the fork is placed on fixed bridge A

– rider flies off for loud sound

Accept $\frac{1}{f}$ for $\frac{1}{L}$

5

7

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(12)

4(a) Optical path is the product of the refractive index of the medium and the geometrical path length.

or

Optical path is the length ~~of the medium~~ in vacuum that contains the same number of waves as a given length in the medium.

1

b(i) When two coherent waves travel in a medium they meet and superpose. where they meet in phase constructive interference takes place and the intensity is increased (or max). Where they meet out of phase cancellation takes place and the intensity reduces (minimum).
Pattern of alternate regions ~~of~~ maximum and minimum intensities are formed which is interference pattern.

3

(ii) The intensity of the fringes increases

1

(iii) When the seperation of the slits is reduced fringe seperation increases and vice versa.
or If the ~~fringe~~ slit seperation changes (1mark) the fringe width also changes

2.

(iv) When white light is used coloured fringes are observed,
With central fringe is white followed by

1½

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blue and red fringes farther off. Outwards the colours overlap leading to white illumination. $1\frac{1}{2}$

(v) $y = \frac{n D \lambda}{a}$

$a = \frac{n D \lambda}{y}$

$= \frac{8 \times 800 \times 10^{-3} \times 6.2 \times 10^{-7}}{5 \times 10^{-3}}$

$a = 7.94 \times 10^{-4} m$

$y = \frac{\lambda D}{d}$

$y = \frac{5 \times 10^{-3}}{8}$

$\frac{5 \times 10^{-3}}{8} = \frac{6.2 \times 10^{-7} \times 800}{d}$

$d = 7.94 \times 10^{-4} m$

c(i) Light is partly reflected and partly transmitted at the bottom surface of the top slide. The transmitted light is reflected by the bottom slide. The two waves meet and superpose, where the geometrical path difference (2t) is an integral multiple of a full wavelength, a dark fringe (band) is formed. Where the geometrical path difference (2t) is an odd multiple of half wavelength, a bright band is formed. This is because the wave reflected at the surface of the bottom slide suffer a phase change of π (180°) equivalent to extra path length of $\frac{\lambda}{2}$. 3

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$$\Delta x = \frac{\lambda s}{2t}$$

$\Delta x = \frac{2.5}{10} = 0.25mm$

$$t = \frac{\lambda s}{2\Delta x}$$

$$t = \frac{500 \times 10^{-9} \times 5 \times 10^{-2}}{2 \times 0.25 \times 10^{-3}}$$

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

4

20

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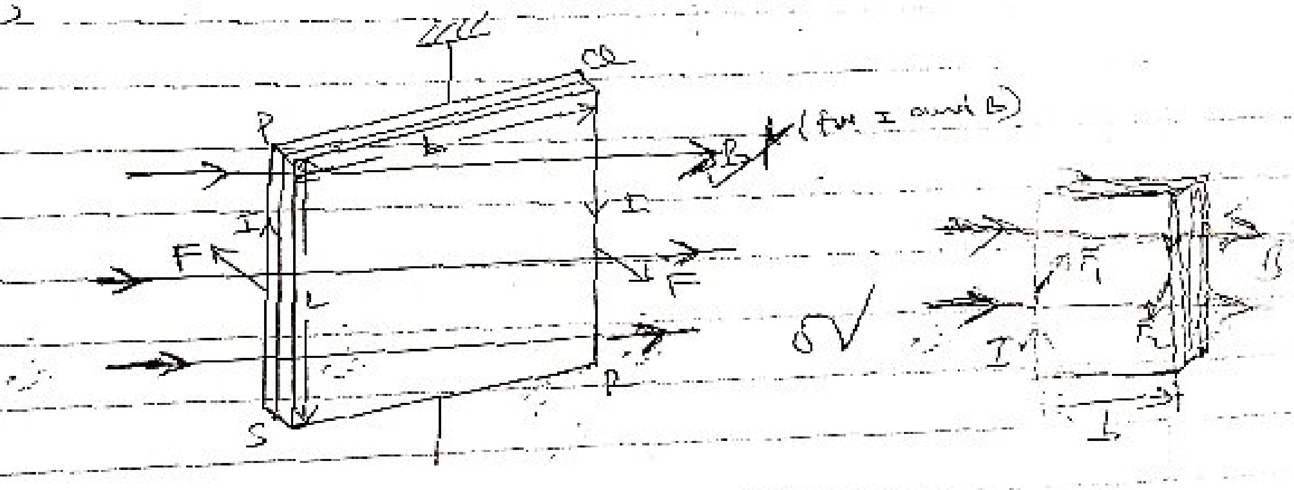
(15)

5\. (a) Magnetic flux density is the force acting on a conductor of length 1m and carrying a current of 1A placed perpendicular to the magnetic field (1)

(b) (i) $B = \frac{\mu_0 I}{2\pi r}$ (1)

(ii) $F = BIL$ (1)

(c)(i)



There are no forces on the sides PQ and SR since they are parallel to the field.
Applying Fleming's left hand rule.
The force initially on PS, $F = NBIL$ (into the plane)
The force initially on QR, $F = NBIL$ (out of the plane)
These forces constitute a couple whose moment is given by:

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Torque, $\tau = F \times b$

$= NBIL \times b$

But $L \times b = A$

$\therefore$ Torque $\tau = NBIA$

(4)

(ii) Torque on the coil $\tau = NBIA$,

Torque due to the torsion wire $\tau = c\theta$,

At balance, $c\theta = NBIA$

$\Rightarrow \theta = \frac{NBA}{c} I$

but N, B, c and A are constant

$\Rightarrow \theta \propto I$, the scale is linear.

(3)

(iii) The instrument is connected in series with an ammeter to a voltage source. The current I is measured, and the deflection θ of the instrument is recorded. current sensitivity is then calculated from

$S_I = \frac{\theta}{I}$

(2)

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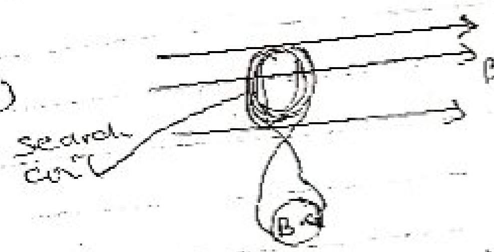
(17)

(d)



A search coil of known cross sectional Area A and number of turns N is connected in series with a ballistic galvanometer.
The search coil is then placed in a uniform magnetic field such that the plane of the coil is perpendicular to the magnetic field. The coil is then pulled completely out of the field while maintaining its orientation in the field. The first deflection of the ballistic galvanometer is noted, θ_1.

A capacitor of known capacitance C is then charged to a p.d V and then discharged through the ballistic galvanometer. The first deflection of the B.G θ_2 is noted.

The magnetic flux density of the uniform magnetic field is obtained from

$$B = \frac{CVR}{AN} \times \frac{\theta_1}{\theta_2}$$

where R is resistance of the whole circuit.

(5)

(Deny ½ if R is not defined)

~~(e)~~ ~~$NO\,I^2$~~

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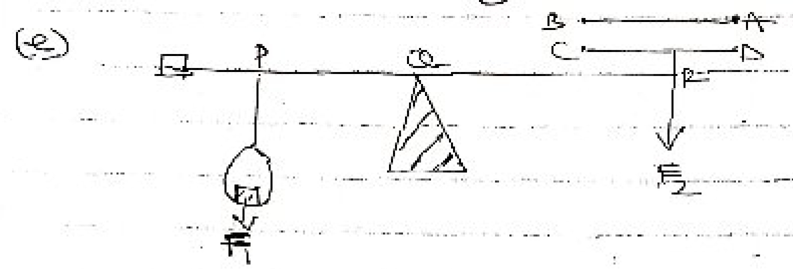
(18)

(e)



Assumptions b'se geometry was not clear

- $\overline{PQ} = \overline{QR}$ and AB is fixed.
- AB is above $\overline{CD}$

i.e equilibrium.

$$F_1 \times PQ = F_2 \times QR \Rightarrow$$

$$F_1 = F_2$$

$$mg = \frac{\mu_0 I^2 L}{2\pi a}$$

$$I = \sqrt{\frac{2\pi mga}{4\pi \times 10^{-7} \times L}}$$

$$= \sqrt{\frac{mga}{2L \times 10^{-7}}}$$

$$= \sqrt{\frac{0.3\times10^{-3} \times 9.81 \times 2\times10^{-3}}{2\times 1\times10^{-7}}}$$

$$= 5.4A$$

(3)

Alternatively, if CD is above AB

Force at P is downward and Force at R is upward. Hence equilibrium will not be attained. OR

Both forces produce a turning effect in the same direction. equilibrium will not be attained.

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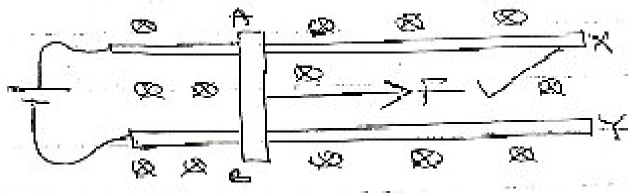
(19)

6. (a) (i)

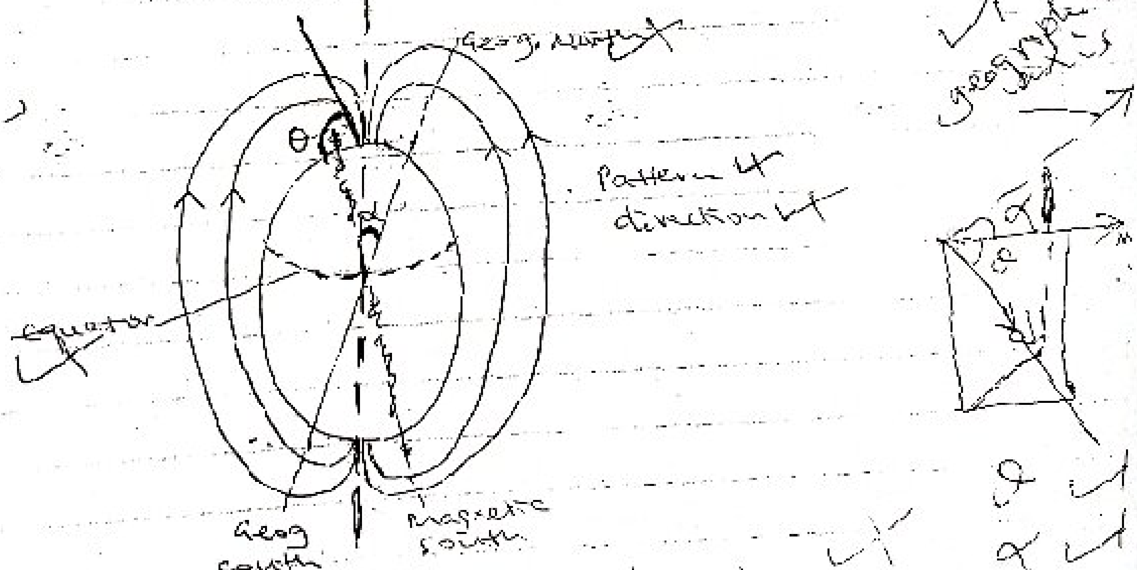


(1)

(ii) Induced emf $E = BLV$
where V is the velocity of the rod
Let I be the current in the rod
electrical power generated $P_{gen} = EI$
mechanical power spent $= FV$
∴ From the principle of conservation of energy,
$FV = EI$ since $V = E$
$= BLVI$
$\Rightarrow$ Force $F = BIL$

(4)

(b) (i)



α - angle of declination
θ = angle of dip.

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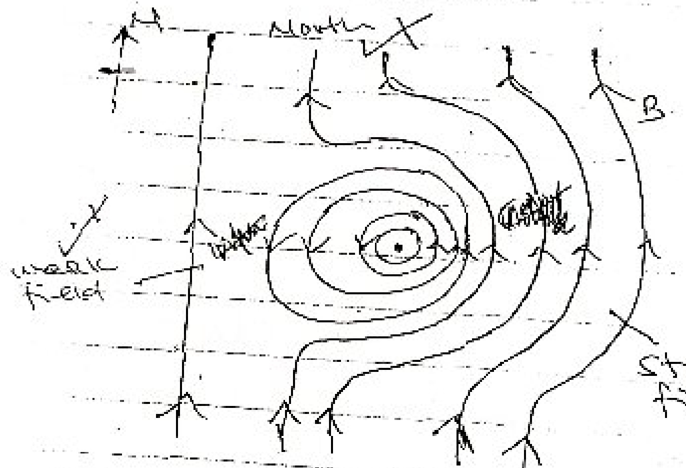
Geographic meridian is the vertical plane containing the geographic axis.
Magnetic meridian is the vertical plane containing the magnetic axis.
Angle of dip varies from 0° at the magnetic equator to 90° at the poles.

(ii)



(02)

(c)(i) $Q = \frac{2BAN}{R} = \theta/\alpha$

$B = \frac{R\theta}{2\alpha NA}$

$= \frac{100 \times 0.8}{2 \times 5.7 \times 10^3 \times 50 \times \pi \times 0.5^2}$

$= 1.79 \times 10^{-4}\ T$

OR

$K\theta = \frac{BAN}{R}$

$\therefore B = \frac{K\theta R}{2AN}$

where $K = \frac{1}{5.7 \times 10^3}$

$\therefore B = \frac{0.8 \times 100}{5.7 \times 10^3 \times 2 \times 50 \times 5 \times 0.5}$

$= 1.79 \times 10^{-4}$

(4)

(ii) $B = \mu_0 n I$ but $I = \frac{V}{R}$

$B = \mu_0 n \cdot \frac{V}{R}$

$\Rightarrow V = \frac{BR}{\mu_0 n} = \frac{1.79 \times 10^{-4} \times 5}{4\pi \times 10^{-7} \times 2000}$

$= 0.36V$

if constant of No paper:
$= \frac{1.79 \times 10^{-4} \times 5}{4 \times 10^{-7} \times 2000}$

$V = 1.18V$

(4)

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Qn 7

(a) The root mean square value of an a.c. is the value of a steady current which dissipates heat in a given resistor at the same rate as the alternating current. ✓ (1)

(b)(i) Induced Emf $E = 2\pi f NAB \sin 2\pi f t$
Maximum Emf $E_0 = 2\pi f NAB$
Maximum induced Emf thus increases with increase in:
- frequency or angular velocity
- Number of turns of the coil
- Area of the coil
- magnetic flux density

(ii) The slip rings are replaced by commutators and the brushes are arranged so that the change over of contacts occur over each half of the cycle. (2)

(c) When K is closed bulb P lights dimly and increases to full brightness. This is because when K is closed and current begins to flow, back E.M.F is induced in the coil which opposes the flow of current in the circuit. Gradually back Emf reduces to zero and brightness increases.

When K is opened, sparks ~~are~~ occur across the contacts, the bulb goes off. This is due to Emf induced

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~~between~~ ~~switch~~ contacts, ~~then the bulb goes off~~ (or bulb goes off immediately)

Alt [Since ~~there~~ is no current

(d)(i) $V = V_0 \cos \omega t$.

induced emf $E = -L\frac{dI}{dt}$

Since the inductor is a coil of zero resistance (for finite current) $V = -E$

$\Rightarrow V_0 \cos \omega t = L\frac{dI}{dt}$

$\Rightarrow dI = \frac{V_0}{L} \cos \omega t \, dt$

$\int dI = \frac{V_0}{L}\int \cos \omega t \, dt$

$I = \frac{V_0}{\omega L} \sin \omega t$

But $I_0 = \frac{V_0}{\omega L}$

$I = I_0 \sin \omega t$

$X_L = \frac{V_0}{I_0} = \frac{V_0}{V_0/\omega L}$

$\therefore X_L = \omega L$

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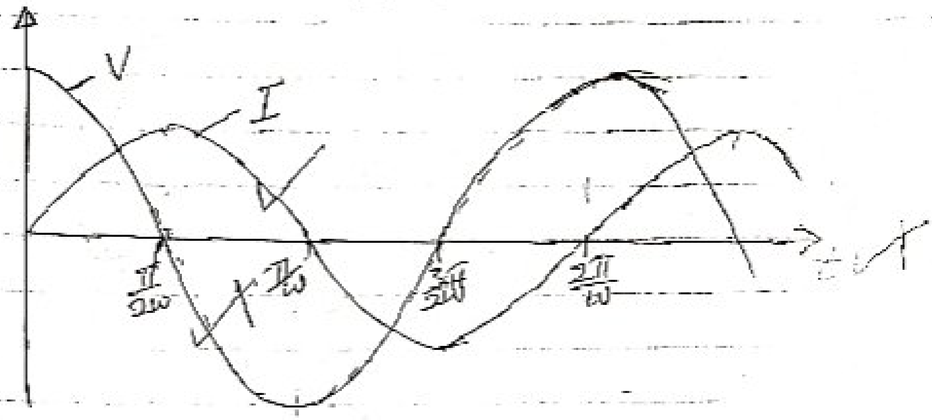
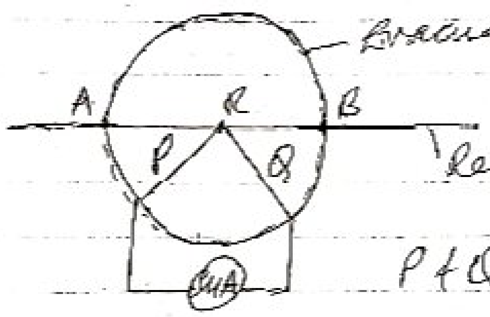
(d)(ii)



(2)

(e)



P & Q dissimilar wires

Current to be measured is passed through the wire AB and heats the junction R of the thermocouple.
The thermoelectric effect generated at R causes a direct current to flow through the microammeter calibrated to measure the r.m.s value of the current.

(3)

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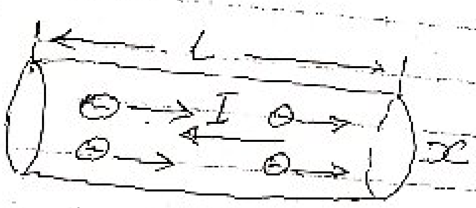
(a)(i) Law of conservation of current at a junction — Qn 8.

States that the total current flowing into the junction is equal to the total current flowing out of the junction. (1

(ii) The effective resistance across the battery is smaller when the bulbs are in parallel than when they are in series. Current is the ratio of p.d to resistance. Hence current will be larger for parallel connections. ✓

b)



Number of free electrons in the length of the wire $= nAl$ ✓

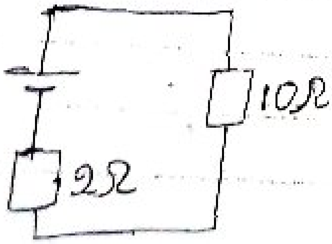
Total charge $Q = nAle$ ✓

Time taken for all electrons to emerge from x, $t = \frac{l}{v}$ ✓ (3

But $I = \frac{Q}{t} = \frac{nAle}{l/v}$ ✓

$= nAve$ ✓

(c)(i)



Total resistance in series
$R = 10+2 = 12\Omega$ ✓

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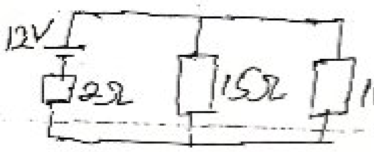
(25)

But $I = \frac{V}{R} = \frac{12}{12} = 1A$ ✓ (2)

P.d across 10Ω resistor $V = IR = 1 \times 10 = 10V$ ✓

(ii) 

Total resistance for parallel
$= \frac{15 \times 10}{15+10} = 6Ω$ ✓

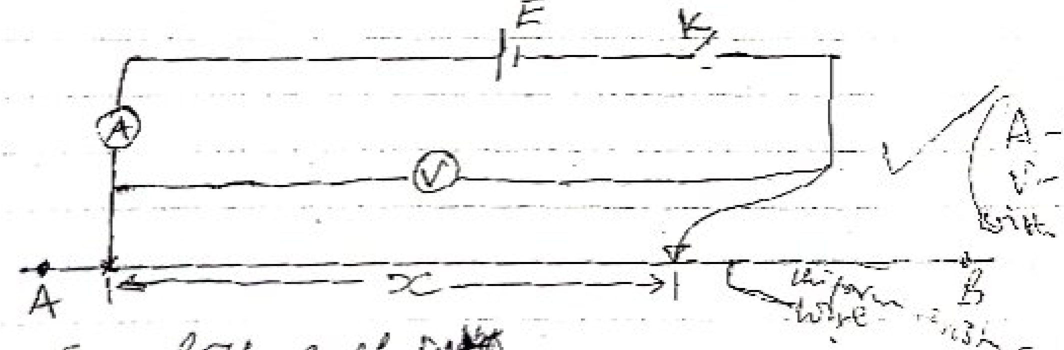
Total resistance in the circuit
$= 6 + 2 = 8Ω$ ✓

$I = \frac{V}{R} = \frac{12}{8} = 1.5A$ ✓ (3)

P.d across parallel $V = IR = 1.5 \times 6$ ✓
$= 9V$

Hence P.d across 10Ω $= 9V$ ✓

(d)(i) Electrical resistivity of a material is the resistance between opposite faces of a 1m cube of the material. (2)
Unit Ohm-meter (Ωm). ✓

(ii) 

A - series
V - parallel with wire

E - dry cell
K - switch
V - Voltmeter
A - Ammeter

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(26)

A uniform resistance wire AB is connected to the circuit as shown above. A length x of the wire is measured using a metre rule, switch K is closed and the corresponding voltmeter reading V and ammeter reading I are recorded. The procedure is repeated with different lengths x of the wire and corresponding values of V and I are recorded. The results are tabulated in a suitable table including values of $R = \frac{V}{I}$. The diameter d of the wire is measured using a micrometer screw guage.

A graph of R against x is plotted and slope S obtained. The resistivity of the wire ρ is calculated from $\rho = S\left(\frac{\pi d^2}{4}\right)$

x
I
V
Repeat
$R = V/I$
d
graph
slope
ρ

20

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(27)

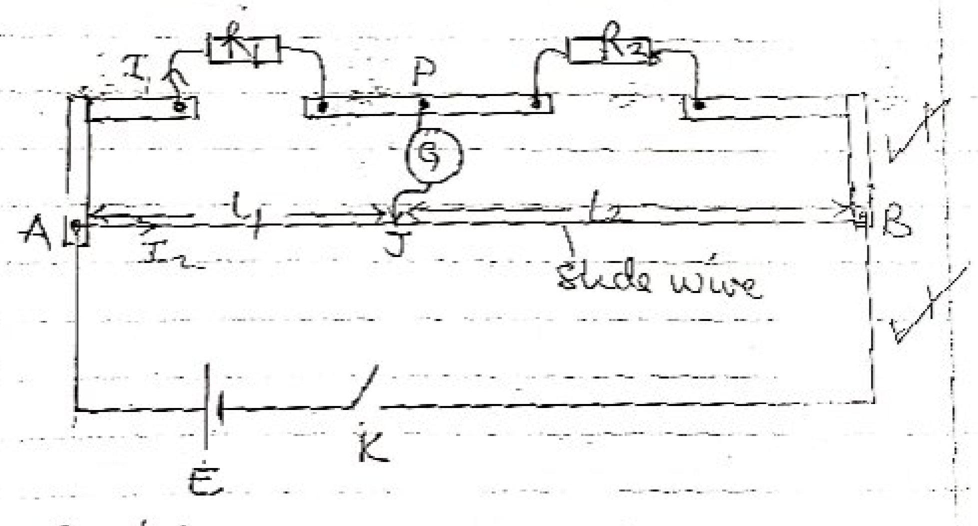
Q9 a(i) The temperature coefficient of resistance is the fractional change in resistance at 0°c for every degree celsius rise in temperature (2)

Unit is K^{-1}

(ii) The resistance of a metal increases with temperature. When the temperature increases the atoms of the ~~metal~~ vibrate with increased (or higher) amplitude thus reducing the mean free path for conduction electrons. Charge flow per second (or current) is reduced. This implies that resistance has increased. (3)

Hence, the fractional change in resistance is positive.

b(i)



K - Switch

E - Cell of Emf E

G - Galvanometer

R_1 & R_2 are resistors

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Q9 b(i) The above circuit

At balance, with the position of pointer at J the potential at P is equal to potential at J. It implies current through G is zero. Hence current through R_1 is the current through R_2 and current through AJ is the same as the current through JB

$\therefore$ P.d across R_1 = P.d across AJ

$$I_1 R_1 = I_2 R_{AJ}$$

Accept
$R_{AJ} = \frac{\rho l_1}{A}$
$R_{JB} = \frac{\rho l_2}{A}$

Let r be the resistance per unit length of the wire AB

then $I_1 R_1 = I_2 r l_1$ ——— (1)

P.d across R_2 = P.d across JB

$$I_1 R_2 = I_2 R_{JB}$$

Then $I_1 R_2 = I_2 r l_2$ ——— (2)

(1) divided by (2) we get

$$\boxed{\frac{R_1}{R_2} = \frac{l_1}{l_2}}$$

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(29)

Q9b(ii) when the resistance are very low, the resistance of the connecting wire or the resistance of end errors becomes comparable to the test resistance. Errors in the measured value becomes significant. (2)

c(i) At 40°, $\frac{X_{40}}{R_S} = \frac{52.5}{47.5} = 1.105$ — ①

100° $\frac{X_{100}}{R_S} = \frac{54.6}{45.4} = 1.203$ — ②

Hence $\frac{X_{100}}{X_{40}} = \frac{1.203}{1.105} = 1.089$

Using $R_\theta = R_o(1+\alpha\theta)$

$\Rightarrow X_{100} = X_o(1+100\alpha)$ — ③

Also $X_{40} = X_o(1+40\alpha)$ ④

$\therefore \frac{X_{100}}{X_{40}} = \frac{(1+100\alpha)}{(1+40\alpha)} = 1.089$ (6)

$\Rightarrow 1+100\alpha = 1.089(1+40\alpha)$

$1+100\alpha = 1.089 + 43.56\alpha$

$100\alpha - 43.56\alpha = 1.089 - 1$

$\therefore 56.44\alpha = 0.089$

$\therefore \alpha = \frac{0.089}{56.44} = 1.57\times10^{-3}K^{-1}$

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Q9c(ii) The temperature coefficient of resistance for Constantan and manganin is very small

This means that there is a negligible change in the resistance to moderate change in temperature (2

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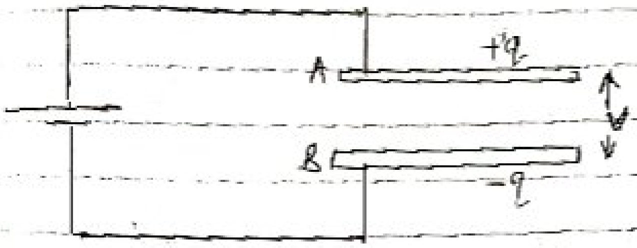
Q1(i)(a)



When a small amount of charge δq is transferred from B to A

Total charge $= q + \delta q$

Total p.d $= V + \delta V$

Work done $\delta w = (V+\delta V)\delta q$

$\therefore \delta w \doteq V\delta q$ but $q = CV$

$\delta w = \frac{q}{c}\delta q$ (4)

Work done $W = \int_0^Q \frac{q}{c}dq = \frac{1}{2}\frac{Q^2}{c}$

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

In case a candidate uses

$\delta q = \delta(CV) = C\delta V$, $\delta w = VC\delta V$

$\therefore$ Work done $= \int_0^V CVdV = \frac{1}{2}CV^2$

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Q 10(b) charge $Q = CV$ but $C = \frac{\varepsilon_0 A}{d}$

$\Rightarrow Q = \frac{\varepsilon_0 AV}{d} = \frac{8.85\times10^{-12}\times2\times10^{-2}\times500}{5\times10^{-3}}$

$= 3.54\times10^{-11}\times500$

$= 1.77\times10^{-8}C$

(4

Energy stored $= \frac{1}{2}QV$

$= \frac{1}{2}\times1.77\times10^{-8}\times500$

$= 4.4\times10^{-6} J$

(ii) Capacitance $C' = \varepsilon_r C$ where ε_r = dielectric constant

From $Q = CV \Rightarrow Q = \varepsilon_r V\frac{\varepsilon_0 A}{d}$

$\therefore \varepsilon_r = \frac{Qd}{\varepsilon_0 AV}$

$= \frac{4.42\times10^{-8}\times5\times10^{-3}}{8.85\times10^{-12}\times2\times10^{-2}\times500}$

$\varepsilon_r = 0.249\times10^{1}$

≈ 2.5

(3

$C_0 = \frac{8.85\times10^{-12}\times2\times10^{-2}}{5\times10^{-3}} = 3.54\times10^{-11}$

$C_m = \frac{4.42\times10^{-8}}{500} = 8.84\times10^{-11}$

$\varepsilon_r = \frac{C_m}{C_0} = \frac{8.84\times10^{-11}}{3.54\times10^{-11}} = 2.5$

OR

$Q = CV$

$4.42\times10^{-8} = \varepsilon_r\times3.54\times10^{-11}\times500$

$\varepsilon_r = \frac{4.42\times10^{-8}}{3.54\times10^{-11}\times500} = 2.5$

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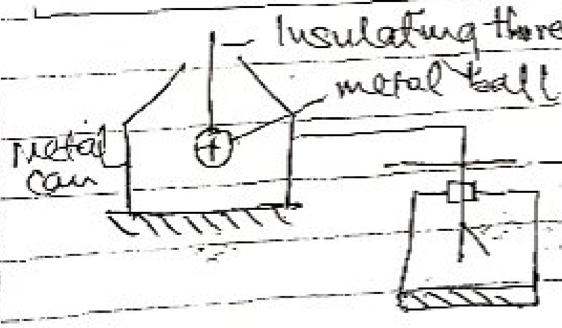
Q1)(c) When a negatively charged cloud passes over a building with lightning conductor. It induces opposite charge on the spike of the conductor. A high charge density on spikes, a high electric field intensity thus develops around the spikes which ionises air around. Ions of similar charge to that on the spikes are repelled to the cloud and they neutralises some of the charge there. While ions of opposite charge are attracted to the spikes and neutralised (or safely conducted to the ground). This way the building is protected.



(d) A metal can is connected to a neutral Gold leaf electroscope. A charged metal ball is lowered into a metal can and the leaf of the electroscope is seen to diverge. When the ball is withdrawn the leaf collapsed showing that the can is not charged. The ball is brought back and the leaf diverge by the same amount as before. When the ball touches the inner wall of the can and then withdrawn the leaf remain diverged showing that the can is in this margin

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Q(d) When the ball is now tested for charge It is found to be neutral. This implies that there is no charge inside the can. Hence charge on a hollow conductor reside only on the outer surface

OR

A hollow metal can is connected to a neutral Gold leaf electroscope. The test conductor is charged from inside. A proof plane is now pressed inside the test conductor then lowered into the metal can. No divergence is observe implying no charge inside.
A proof plane is pressed on the outer wall of the conductor and then tested for charge. The leaf diverge showing presence of charge.
The experiment is repeated by charging the outside of the conductor and it is found to have charge only on the outer wall. Hence charge on a hollow conductor reside only outside.

- A charged conductor is placed on an insulating stand. A proof plane is pressed on the inner side of the conductor and then lowered into a metal can connected to a neutral gold leaf electroscope.
- No divergence is observed implying there is no charge.
- A proof plane is now pressed on the outer wall and then lowered into the metal can. The leaf of the electroscope is seen to diverge. It is shown that there is charge. Hence charge resides outside the hollow conductor.

(4)