P510/2
PHYSICS
Paper 2
Nov./Dec. 2013
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 are provided.

Non-programmable scientific calculators may be used.

Assume where necessary:

Acceleration due to gravity, g	=	$9.81\ ms^{-2}$
Speed of light in a vacuum, c	=	$3.0 \times 10^{8}\ ms^{-1}$
Electron charge, e	=	$1.6 \times 10^{-19}\ C$
Electron mass	=	$9.11 \times 10^{-31}\ kg$
Planck's constant, h	=	$6.6 \times 10^{-34}\ Js$
Permeability of free space, μ_0	=	$4.0\pi \times 10^{-7}\ Hm^{-1}$
Permittivity of free space, ε_0	=	$8.85 \times 10^{-12}\ Fm^{-1}$
The constant $\frac{1}{4\pi\varepsilon_0}$	=	$9.0 \times 10^{9}\ F^{-1}\ m$
One electron volt (eV)	=	$1.6 \times 10^{-19}\ J$
Avogadro's number N_A	=	$6.02 \times 10^{23}\ mol^{-1}$
Resistivity of Nichrome wire at 25°C	=	$1.2 \times 10^{-6}\ \Omega m$
Specific heat capacity of water	=	$4.2 \times 10^{3}\ J\ kg^{-1}\ K^{-1}$

SECTION A

1. (a) Distinguish between a **real image** and a **virtual image**. *(02 marks)*

(b) Derive an expression relating the focal length, f, of a convex mirror to the object distance u and image distance v. *(05 marks)*

(c) A concave mirror forms an image half the size of the object. The object is then moved towards the mirror until the image size is three quarters that of the object. If the image is moved by a distance of 0.6 cm, calculate the

(i) focal length of the mirror. *(03 marks)*
(ii) new position of the object. *(03 marks)*

(d) (i) What is **critical angle**? *(01 mark)*
(ii) Explain how a mirage is formed. *(04 marks)*

(e) State **four** applications of total internal reflection. *(02 marks)*

2. (a) State the **laws of refraction**. *(02 marks)*

(b) (i) The deviation, d, by a small angle prism of refracting angle A and refractive index, n, is given by

$d = A(n - 1)$.

Use this expression to show that the focal length, f, of a thin converging lens of refractive index, n, is given by

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

Where r_1 and r_2 are the radii of curvature of the lens surfaces. *(05 marks)*

(ii) Figure **1** shows a glass convex lens in air with surface A and B having radii of curvature 10 cm and 15 cm respectively.

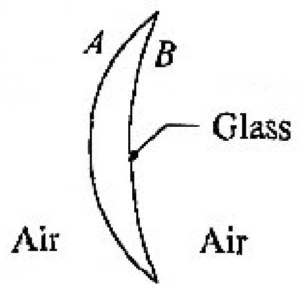

Fig. 1

If the refractive index of the glass material used is 1.50, calculate the power of the lens. *(03 marks)*

(c) (i) With the aid of a ray diagram, describe the structure and action of a Galilean telescope in normal adjustment. *(05 marks)*

(ii) Derive an expression for the angular magnification of the telescope in (c) (i). *(03 marks)*

(d) Explain the disadvantage of a Galilean telescope over the refracting type. *(02 marks)*

SECTION B

amp
frequency
wavelength

3. (a) (i) Distinguish between **free oscillation** and **damped oscillations** *(02 marks)*

(ii) What is meant by **resonance** as applied to sound? *(01 mark)*

(b) Describe an experiment to determine the velocity of sound in air using tuning forks of different frequencies and a resonance tube. *(05 marks)*

(c) A uniform tube 80 cm long is filled with water and a small loudspeaker connected to a signal generator is held over the open end of the tube. With the signal generator set at 600 Hz, the water level in the tube is lowered until resonance is first obtained when the length of air column is 13 cm. If the third resonance is obtained when the air column is 69.8 cm long, calculate the

(i) velocity of sound in air. *(04 marks)*

(ii) fundamental frequency for the tube if it were open at both ends. *(03 marks)*

(d) (i) What is meant by **Doppler effect**? *(01 mark)*

(ii) A motor cyclist and a police car are approaching each other. The motor cyclist is moving at 10 ms^{-1} and the police car at 20 ms^{-1}. If the police siren is sounded at 480 Hz, calculate the frequency of the note heard by the cyclist after the police car passes by. *(03 marks)*

(iii) Give **two** applications of the Doppler effect. *(01 mark)*

4. (a) Explain the formation of fringes by transmission gratings. *(05 marks)*

(b) Describe how the wavelengths of monochromatic light can be measured using a diffraction grating and a spectrometer. *(07 marks)*

(c) Explain why an oil layer on the water surface appears coloured on a rainy day. *(03 marks)*

Turn Over

(d) Explain,

(i) what is meant by plane polarized light. *(02 marks)*

(ii) **one** application of polarized light. *(03 marks)*

SECTION C

5. (a) Define the following:

(i) Magnetic flux density. *(01 mark)*

(ii) Magnetic flux linkage. *(01 mark)*

(b) (i) A rectangular coil of N turns, length l, and width, b, carrying a current, I, is placed with its plane making an angle, θ, to a uniform magnetic field of flux density, B.
Derive the expression for the torque exerted on the coil. *(05 marks)*

(ii) A current of 3.25 A flows through a long solenoid of 400 turns and length 40.0 cm.
Determine the magnitude of the force exerted on a particle of charge 15.0 μC moving at $1.0 \times 10^3 ms^{-1}$ through the centre of the solenoid at an angle of 11.5^0 relative to the axis of the solenoid. *(04 marks)*

(c) Describe with the aid of a diagram, an absolute method of measuring current. *(06 marks)*

(d) Explain why a current carrying conductor placed in a magnetic field experiences a force. *(03 marks)*

6. (a) (i) State Lenz's law of electromagnetic induction. *(01 mark)*

(ii) Describe an experiment to demonstrate Faraday's law of electromagnetic induction. *(06 marks)*

(b) Figure **2** shows a piece of metal swinging between opposite magnetic poles.

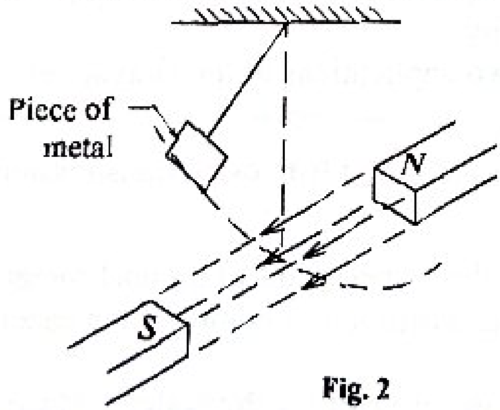

Fig. 2

Explain what will be observed after some period of time. *(04 marks)*

(c) (i) Define the terms **self induction** and **mutual induction**. *(02 marks)*

(ii) Describe an experiment which can be used to demonstrate self-induction. *(03 marks)*

(d) A search coil has 40 turns of wire and cross-sectional area of 5 cm^2. The coil is connected to a ballistic galvanometer and then placed with its plane perpendicular to a uniform magnetic field of flux density B. When the coil is withdrawn from the field, the galvanometer gives a deflection of 240 divisions. When a capacitor of 4 μF is charged to 20 V and then discharged through the circuit, the galvanometer deflection is 180 divisions. Find the value of B, if the total resistance of the circuit is 20 Ω. *(04 marks)*

7. (a) What is meant by the terms **reactance** and **impedance** as applied to alternating currents. *(02 marks)*

(b) (i) A source of sinusoidal current of amplitude I_o and frequency, f, is connected across a pure inductor of inductance, L. Derive an expression for the peak voltage across the inductor. *(04 marks)*

(ii) Sketch, using the same time axis, graphs to show variations of the voltage across the inductor and current through it. *(02 marks)*

(c) An alternating current, $I = 5 \sin 200\pi t$, flows through a pure inductor of inductance 2.0 H. Calculate the

(i) reactance of the inductor. *(03 marks)*

(ii) root mean square value of the voltage across the inductor. *(03 marks)*

(d) (i) Explain how an alternating current can be measured using a rectifier meter. *(04 marks)*

(ii) Explain why a moving coil ammeter is unsuitable for measuring alternating current. *(02 marks)*

SECTION D

8. (a) The voltage versus current graphs for two wires A and B of same material, same radii and at the same temperature are shown in Figure 3.

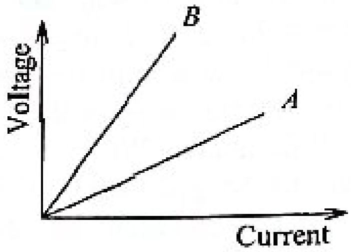

Fig. 3

Account for the difference between the graphs. *(02 marks)*

(b) Three identical cells are connected in series with resistors of 3 Ω and 5 Ω. A current of 1.2 A flows in the circuit. When the two resistors are connected in parallel across the three cells in series, the current in the circuit is 2.2 A. Calculate the

(i) internal resistance of each cell. *(03 marks)*

(ii) e.m.f of each cell. *(01 mark)*

(iii) power dissipated in the 3 Ω resistor for the parallel connection. *(04 marks)*

(c) Two students X and Y performed separate experiments using a potentiometer arranged as shown in Figure 4 and both obtained a balance point.

X increased the value of R.

Y decreased the value of S.

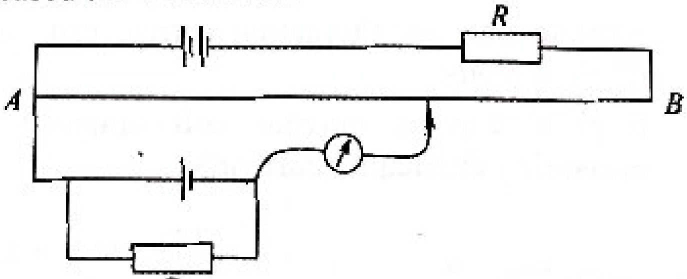

Fig. 4

Explain what happens to the position of the balance point when

(i) X increases the value of R. *(02 marks)*

(ii) Y decreases slightly the value of S from an initially large value. *(02 marks)*

(d) Describe an experiment to determine the e.m.f of a thermocouple. *(06 marks)*

9. (a) Define the following.

(i) Capacitance. *(01 mark)*

(ii) Dielectric. *(01 mark)*

(b) Describe an experiment that can be used to show how capacitance of a capacitor depends on the permittivity of a dielectric. *(04 marks)*

(c) A capacitor of capacitance C, is fully charged from a 200 V battery. It is then discharged through a small coil of wire embedded in thermally insulated block of heat capacity 250 JK^{-1}. If the temperature of the block rises by 0.4 K, calculate C. *(04 marks)*

(d) (i) State **three** properties of an equipotential surface. *(03 marks)*

(ii) What is meant by **charge quantisation**? *(01 mark)*

(e) With the aid of a labelled diagram, describe the structure and action of a Van de Graaff generator. *(06 marks)*

10. (a) (i) State **Coulomb's law of electrostatics.** *(01 mark)*

(ii) Sketch the electric field patterns for a positively charged metallic sphere and for a negative point charge. *(02 marks)*

(b) (i) Define **electric field intensity** and **electric potential** at a point. *(02 marks)*

(ii) What is the relationship between them? *(01 mark)*

(c) Two charges of 1.0×10^{-5} C are placed 10 cm apart as shown in Figure 5

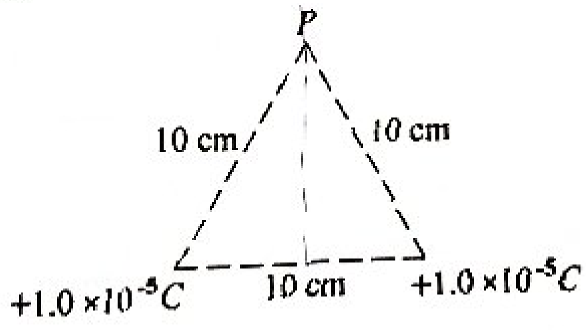

Fig. 5

Calculate the

(i) electric field intensity at P. *(06 marks)*

(ii) electric potential at P. *(03 marks)*

Turn Over

(d) Two conducting spheres A and B supported on insulating stands are placed in contact. A negatively charged rod is then held near sphere A. The spheres are then separated after which the rod is removed. With the aid of suitable diagrams, explain the processes which occur.

(05 marks)

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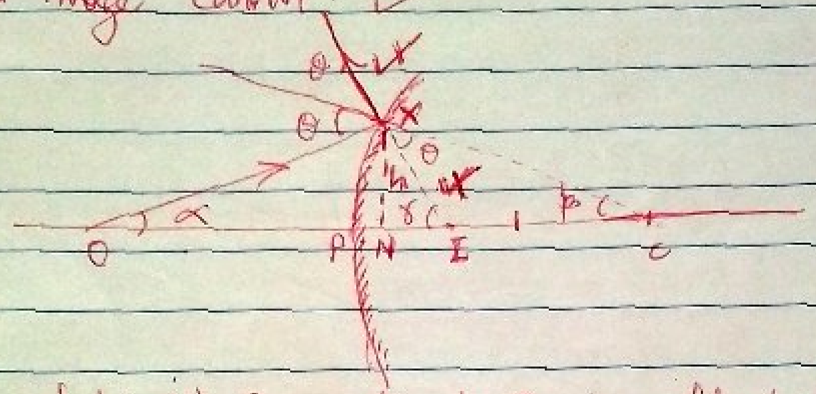
1 (a) - A real image is formed by actual intersection of rays of light while a virtual image is formed by apparent intersection of light rays

- A real image is formed on the screen while a virtual image cannot. 02

(b)



A ray of light from object O is reflected at X and appears to come from I, position of the image.

from Δ OXI, $\alpha + \gamma = 2\theta$ — ①

from Δ OXC, $\alpha + \beta = \theta$ — ②

$\Rightarrow \alpha + \gamma = 2(\alpha + \beta)$

$\Leftrightarrow \gamma - \alpha = 2\beta$ — ③

But for small angles, α, β, γ measured in radians,

$\alpha \simeq \tan \alpha = \frac{h}{ON}$, $\beta \simeq \tan\beta = \frac{h}{NC}$ $\gamma \simeq \tan\gamma = \frac{h}{NI}$

But since N is very close to P, $\overline{ON} \simeq \overline{OP} = u$, $\overline{PC} = r = 2f$, $\overline{NI} \simeq \overline{PI} = V$.

$\therefore \alpha \simeq \frac{h}{u}$, $\beta \simeq -\frac{h}{2f}$, $r = -\frac{h}{u}$

substituting in ③

$$-\frac{h}{V} - \frac{h}{u} = 2\left(\frac{-h}{2f}\right)$$ (5)

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

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(c)(i) using $\frac{v}{f} = m+1$,

Initially $\frac{v}{f} = \frac{1}{2}+1$, $\frac{3}{2}$ — ①

when the object was displaced

$$\frac{v+0.6}{f} = \frac{3}{4}+1 = \frac{7}{4} \text{ — ②}$$ (3)

② − ① $\frac{0.6}{f} = \frac{7}{4} - \frac{3}{2} = \frac{1}{4}$

$\Rightarrow$ $f = 0.6 \times 4 = 2.4\text{ cm}$

(ii) from equation ② above

$v + 0.6 = \frac{7}{4} \times f = \frac{7}{4} \times 2.4 = 4.2\text{ cm}$

$\therefore$ $\frac{4.2}{u'} = \frac{3}{4}$ $\Leftrightarrow$ $u' = \frac{4.2 \times 4}{3} = 5.6\text{ cm}$ (3)

The object is 5.6cm from the mirror

d(i) Critical angle is the angle of incidence in the dense medium for which the angle of refraction in the less dense medium is 90°. (1)

(ii) On a hot day, layers of air near the ground get heated, expand and becomes less dense compared to layers higher up. Light from the sun travelling downwards is therefore continually refracted away from the normal. At some point the angle of incidence exceeds critical angle, and total internal reflection takes place. When this light is received by the eye, the observer sees an image of the sky/cloud on the ground, which appears like a pool of water. (4)

(e) In radio broadcast
- Determination of refractive index of materials
- Telecommunication using optical fibres (2)
- Reflecting prisms in binoculars & periscopes
- Erecting prisms

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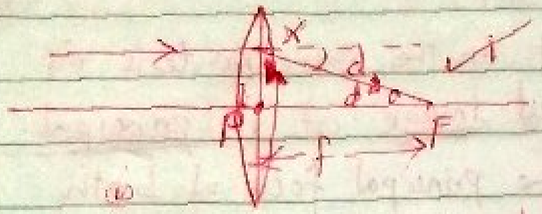
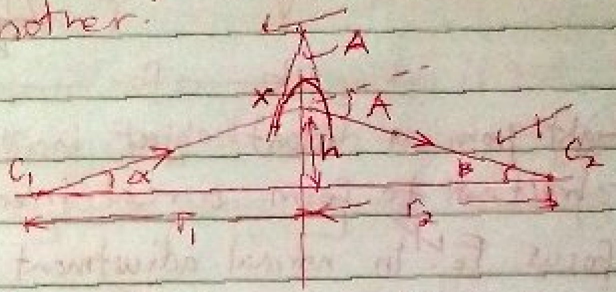
2 (a) - The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane.

- The ratio of sine of angle of incidence to the sine of angle of refraction is a constant for a ray travelling from one medium to another. (2)

(b)

(i)





(ii)

A ray of light parallel and close to the principal axis is refracted to pass through the principal focus F.

Deviation produced, $d \simeq \tan d = \frac{h}{f}$, since d is small and is measured in radians.

But $d = (n-1)A$, $\therefore \frac{h}{f} = (n-1)A$ — (1)

In figure (ii), ~~a ray from C_1 incident at X is refracted to pass through C_2~~ where C_1 and C_2 are the centres of curvatures of the lens surfaces.

From ΔC_1XC_2 $\alpha + \beta = A$

But for small angles α, β measured in radians

$\alpha \simeq \tan\alpha = \frac{h}{r_1}$, $\beta \simeq \tan\beta = \frac{h}{r_2}$ $\Rightarrow \frac{h}{r_1} + \frac{h}{r_2} = A$ (5)

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

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

(ii) $r_1 = 10cm = 0.1m$; $r_2 = -15cm = -0.15m$

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

$= (1.5-1)\left(\frac{1}{0.1} - \frac{1}{0.15}\right) = 0.5\,(10 - 6.67)$

Power $= 1.67D$

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

$= (1.5-1)\left(\frac{1}{10} - \frac{1}{15}\right)$

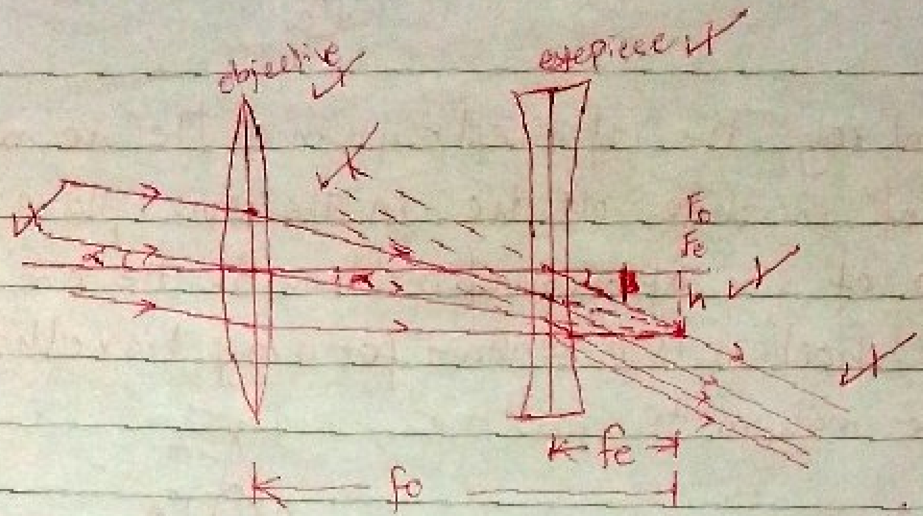
$\Rightarrow f = 60cm = 0.6m$

$\therefore$ Power $= \frac{1}{f}$

$= 1.67D$ (3)

(4)

c(i)



Light from a distant object incident on the objective lens is refracted to form a real inverted image at its principal focus F_o. In normal adjustment the principal foci of both lenses coincide at F_oF_e. The eye piece therefore forms the final image of the object at infinity. (3)

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

$M = \beta/\alpha$ in the diagram above (3)

But for small angles α, β measured in radians

$\alpha \simeq \tan\alpha = \frac{h}{f_o}$ & $\beta \simeq \tan\beta = \frac{h}{f_e}$ (3)

$$M = \frac{h}{f_e} \div \frac{h}{f_o} = \frac{f_o}{f_e}$$

(d) The Galilean telescope has a virtual (and inaccessible) eyering, which leads to limited field of view. Since the eye can not receive all the light entering the instrument, the image appears less bright. (2) (2)

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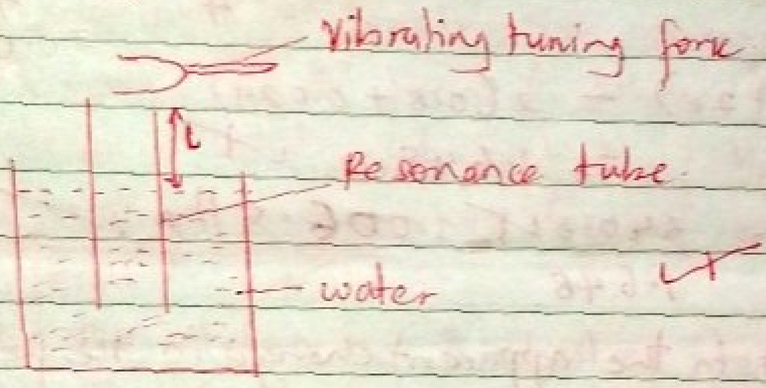
3 a (i) Free oscillations are oscillations in which the total energy of the oscillating system is constant (and the amplitude of oscillation is constant) while a damped oscillation is where the energy of the system decreases with time (and the amplitude decreases). (2)

(ii) Resonance is said to occur when a system is set to vibrate at its natural frequency due to impulses received from a nearby system vibrating at the same frequency. (1)

(b)



A resonance tube is placed to stand in a tall jar full of water, starting with a short length of air column, a vibrating tuning fork is held over the mouth of the resonance tube. The tube is then raised until a point where a loud sound is heard. The length, l, of the air column in the tube is measured and recorded together with the frequency, f, of the tuning fork. The experiment is repeated with other tuning forks, and the results are recorded in a table including values of $\frac{1}{f}$. A graph of l against $\frac{1}{f}$ is plotted and the slope S, is calculated. The velocity v of the sound is now calculated from (5)

$$v = 4S$$

c (i) $l_1 = 13cm$, $l_3 = 69.8cm$

now $l_1 + e = \frac{\lambda}{4}$ — ①

and $l_3 + e = \frac{5\lambda}{4}$ — ②

② − ① $l_3 - l_1 = \lambda \Leftrightarrow \lambda = 69.8 - 13 = 56.8cm$

$\Leftrightarrow \lambda = 0.568m$ (4)

Now $V = f\lambda = 600 \times 0.568 = 340.8ms^{-1}$

(ii) If the tube were open both ends, then

$\frac{\lambda_0}{2} = l + 2e \Rightarrow e = \frac{\lambda_0}{4} - l = \frac{0.568 - 0.13}{4}$

$= 0.012m$

$\therefore \lambda_0 = 2(l + 2e) = 2(0.8 + 0.024)$

$= 1.648m$

$f_0 = \frac{V}{\lambda_0} = \frac{340.8}{1.648} = \underline{206.8Hz}$

d (i) Doppler effect in the apparent change in the frequency of a wave, when there is relative motion between the source and the observer.

(ii) $\xleftarrow{u_s}$)))) $\xrightarrow{V}$ $\xrightarrow{u_o}$

apparent wavelength of reaching observer $\lambda' = \frac{V + u_s}{f}$

apparent velocity of sound received $V' = V - u_o$

$\therefore$ apparent frequency $f' = \frac{V'}{\lambda'} = \frac{V - u_o}{V + u_s} f = \frac{340 - 10}{340 + 20} \times 480$ (3)

$= \underline{440Hz}$

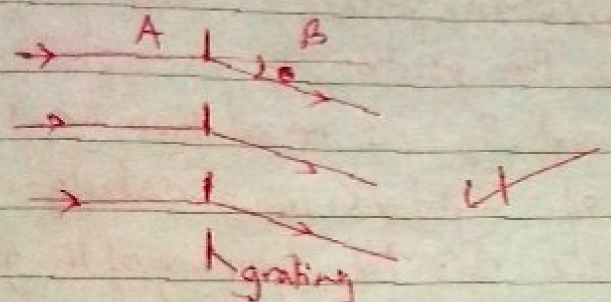
(iii) - Determining direction of motion of stars

- Estimating speed of stars

- Estimating speed of cars using speed guns (1)

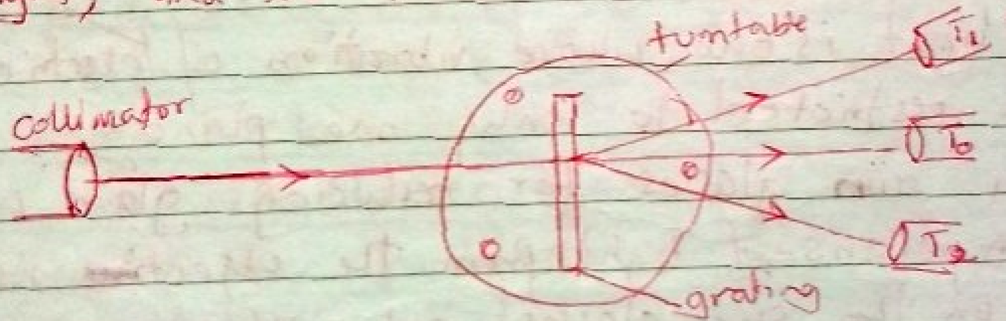
- Determining plasma temperature.

4 (a)



Consider a transmission grating illuminated normally by monochromatic light. Light is diffracted through the clear spaces of the grating into region B, where they superpose. Where the resultant path difference of of waves through pair of consecutive slits is an integral multiple of full wave length, constructive superposition occurs and a bright band is formed. Where the resultant path difference is an odd multiple of half a wave length, destructive superposition occurs and a dark band is formed.

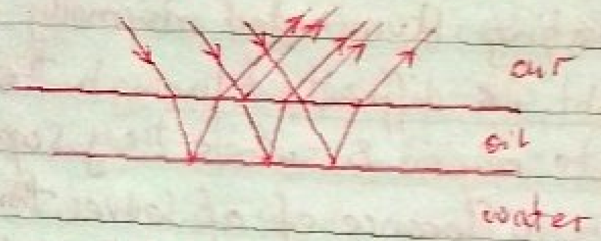
(b) First, the telescope is adjusted to focus parallel light. The collimator is adjusted to produce parallel light, and the turntable is levelled.



The telescope is now turned to receive light directly from the collimator and the position T_0 on the angular scale is noted. The grating is now placed perpendicular to incident light. The telescope is now turned in one direction to receive the first bright image again. The position T_1 is noted. The telescope is restored back to position T_0

and then rotated in opposite direction until the first bright image is again received. The position T_2 is noted. The angle θ between T_1 and T_2 is read from the scale and noted. Wavelength of light is now calculated (7)
from $d \sin \frac{\theta}{2} = \lambda$ where d is the spacing of the grating

(c)



When white light is incident on the oil film, it is partly reflected and partly refracted. Due to refraction, dispersion takes place. The dispersed light is reflected at the interface between oil and water. The light reflected from both surfaces meet again in air and superpose. The colour for which constructive superposition takes (3)
place at a given position is the one viewed there. Hence coloured fringes are seen.

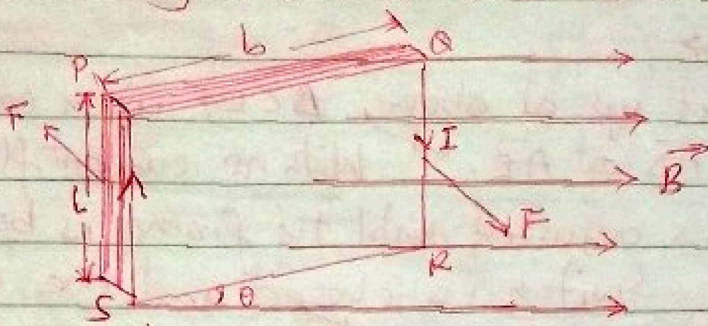
d(i) ~~Polarisation~~
Polarised light is one whose vibration of electric vector is restricted to only one plane (2)

(ii) Used in sun glasses for reducing glare
When unpolarised light from the object is incident on the sun glasses, only vibrations in the prefered plane are transmitted; the others (3)
are absorbed. The intensity of the light received is thus reduced.

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

(ii) Magnetic flux linkage is the product of the magnetic flux density and the area it links perpendicularly (2)

b (i)



When current flows through the coil, the conductor experiences magnetic force

Force on side PQ = NBIbsinθ (downwards)

Force on side RS = NBIbsinθ (upwards). The two forces cancel out due to rigidity of the coil.

side PS experiences force NBIl perpendicularly into the page, while RQ experiences force NBIl perpendicularly out of the page. The two forces constitute a couple whose moment of torque (5)

$T = F \times b\cos\theta$

$= NBIlb\cos\theta$

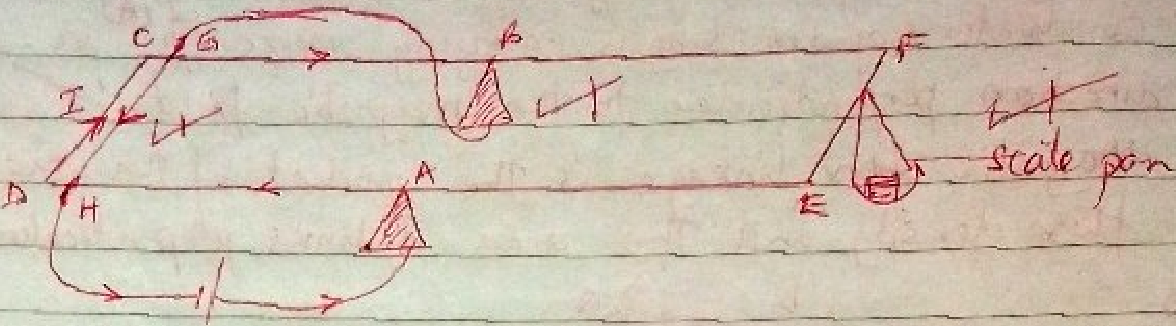
(ii) Magnetic flux density $B = \mu_0 n I = \frac{4\pi \times 10^{-7} \times 400 \times 3.25}{0.4} = 4.08 \times 10^{-3}$ T

Now force $F = BqV\sin\theta$

$= 4.08 \times 10^{-3} \times 1.5 \times 10^{-6} \times 1.0 \times 10^{3} \times \sin 11.5$

$= 1.22 \times 10^{-5}$ N (4)

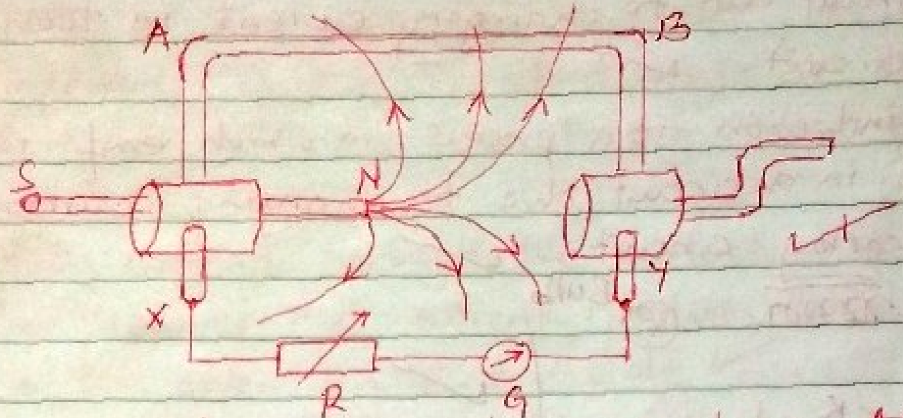
(10)



The apparatus is set up as above, DCEF is a conducting frame such that $\overline{AD} = \overline{AE}$. With no current flowing, the zero screw is adjusted until the frame is balancing horizontally. The switch is closed and the arms CD is repelled downwards. Masses are added to the scale pan until horizontal balance is restored. The value of mass m on the pan is noted and the length CD = l is measured together with the separation d between arms CD and GH. Now since $\overline{AE} = \overline{AD}$ the value of the current is now calculated from $I = \sqrt{\frac{2\pi m g d}{\mu_0 l}}$ or $\sqrt{\frac{m g d}{2l \times 10^{-7}}}$ (6)

(d) When a current carrying conductor is placed perpendicular to a magnetic field, the field due to the current interacts with the applied magnetic field. The resultant field pattern is stronger on one side of the conductor compared to the other, hence exerting a greater force from the side of the stronger field. (3)

6 a (i) Emf induced in a conductor is always in such a direction as to oppose the change causing it. (1)



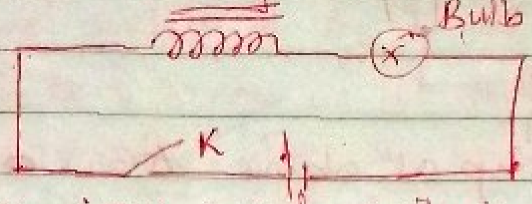
The apparatus was set up as above. AB is a metal frame which is free to rotate round the magnet. X,Y are metal contacts connecting the galvanometer G to the metal frame AB. The frame is rotated at a constant speed so that G shows steady deflection, θ. The time for n revolutions is taken and the frequency f calculated. The experiment is repeated and the frequencies f are recorded in a table with the corresponding steady deflections, θ. A graph of θ against f is plotted and is a straight line through the origin. This shows that $\theta \propto f$. But $\theta \propto I \propto$ emf, E and also $\frac{d\phi}{dt} \propto f$. Hence $E \propto \frac{d\phi}{dt}$ where $\frac{d\phi}{dt}$ is the rate of change of magnetic flux linkage.

b) The amplitude of oscillation reduces gradually until the oscillation stops. This is because as the metal oscillates, it cuts the magnetic field between the poles. Eddy currents are induced in the metal, whose magnetic field opposes the oscillation. Thus causing the oscillation to stop. (4)

c (i) - Self induction in a process in which emf is induced in a circuit due to changing current in the same circuit.

- mutual induction is a process in which emf is induced in a circuit due to changing current in a nearby circuit (2)

(ii)



An iron cored coil is connected in series with a bulb and switch ~~has~~ as above. When K is closed, the bulb lights dimly then its brightness increases to maximum current flowing initially was small due to large back emf as the emf reduces it current increases.

(d) $N = 40$, $A = 5\times10^{-4} m^2$, $R = 20\Omega$, $\theta_1 = 240$

$c = 4\times10^{-6} F$, $V = 20V$, $\theta_2 = 180$

Now $\frac{NAB}{R} = K\theta_1 \Rightarrow K = \frac{NBA}{R\theta_1}$

but $Q = CV = K\theta_2 \Rightarrow K = \frac{CV}{\theta_2}$

$\therefore \frac{NBA}{R\theta_1} = \frac{CV}{\theta_2} \Rightarrow B = \frac{CVR\theta_1}{NA\theta_2}$ (04)

$B = \frac{4\times10^{-6}\times20\times20\times240}{40\times5\times10^{-4}\times180}$

$= 0.107 T$

7 a (i) - Reactance is the non resistive opposition to flow of a.c in a circuit containing either an inductor or capacitor

- Impedance is the resultant opposition to flow of a.c. in a circuit containing reactive and resistive components. (2)

b (i) Let current through the inductor be $I = I_0 \sin 2\pi f t$

The flow of this current, induces back emf E in the coil given by $E = -L\frac{dI}{dt} = -LI_0 \frac{d}{dt}(\sin 2\pi f t)$

$\Rightarrow E = -2\pi f L I_0 \cos 2\pi f t$ (4)

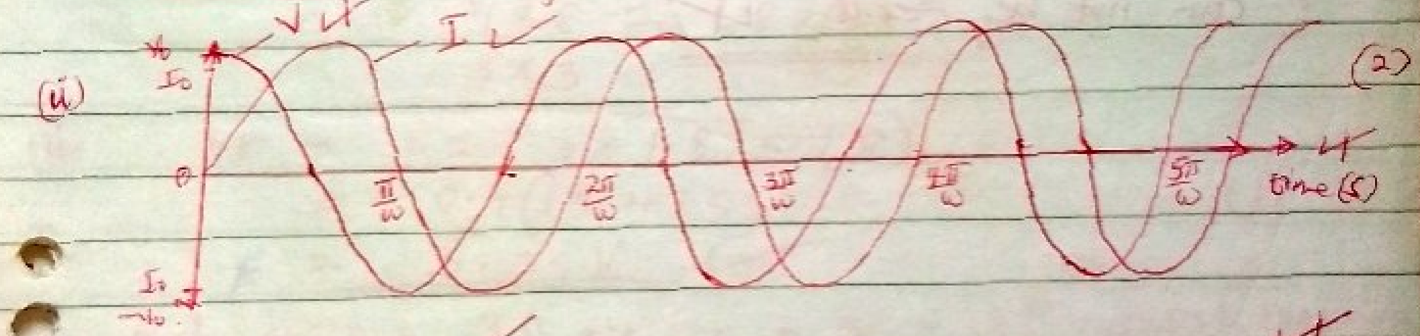
for finite current through a pure inductor

$V = -E$

$V = 2\pi f L I_0 \cos 2\pi f t = V_0 \cos 2\pi f t$

where $V_0 = 2\pi f L I_0$ is the amplitude

(ii) (2)



c (i) $X_L = 2\pi f L$, from $I = 5 \sin 200\pi t$, $f = 100\,Hz$ (3)

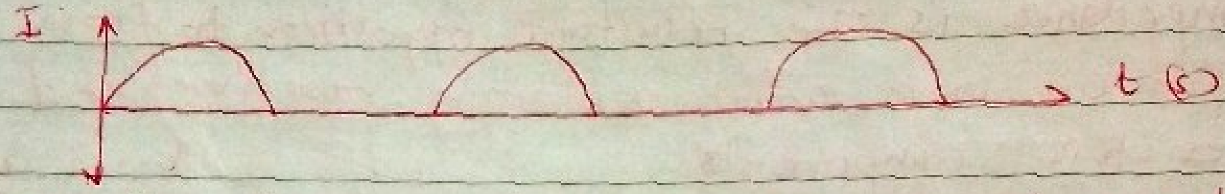
$\therefore X_L = 2\pi \times 100 \times 2 = 1.256 \times 10^3 \,\Omega$

d (i) $V_0 = X_L I_0$

$= 1.256 \times 10^3 \times 5 = 6.28 \times 10^3$ (3)

$\therefore V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{6.28 \times 10^3}{\sqrt{2}} = 4.44 \times 10^3\, V$

d (ii) When alternating current is supplied to a rectifier meter, current flows in only one direction and the meter deflects in one direction current flows in the half cycle for the positive bias of the diode, and in the next half cycle current flows is zero. The characteristic is as below



(4)

when the frequency is high, the ammeter reads a steady r.m.s value of the current.

(ii) When an a.c is passed through a moving coil ammeter, the direction of the couple changes each time the current reverses. With high frequency, the pointer only vibrates about the zero position hence the value of the current can not be read. (2)

8 a Current flowing through a homogeneous conductor is ~~perpendicular~~ proportional to the p.d across it. The slope of the graph is equal to the resistance of the conductor. This implies that the resistance of B is greater than that of A. Since resistance is proportional to length of the conductor, wire B is longer than A (2)

b (i) For the resistors in series, $R_{eff} = 3+5 = 8\Omega$

$\therefore 3E = 1.2(3r+8)$ ①

When in parallel, $R_{eff} = \frac{3\times5}{3+5} = \frac{15}{8}\Omega$

$\therefore 3E = 2.2\left(3r + \frac{15}{8}\right)$ (3)

$\therefore 1.2(3r+8) = 2.2\left(3r+\frac{15}{8}\right)$

$3.6r + 9.6 = 6.6r + \frac{33}{8} \Rightarrow 3r = 9.6 - \frac{33}{8}$

$r = \frac{43.8}{8\times3} = 1.825\Omega$

(ii) $3E = 1.2(3\times1.825+8)$ (1)

$= 0.4(13.475)$

$E = 5.39V$

(iii) p.d across 3Ω resistor $= 3E - 3Ir = 3\times5.39 - 3\times2.2\times1.825$

$= 4.125V$ (4)

Power $= \frac{V^2}{R} = \frac{(4.125)^2}{3} = 5.67W$

c (i) Increasing R reduces the current in the driver circuit. Therefore the p.d per cm reduces. Therefore the balance length increases. (2)

(ii) Decreasing the value of S slightly does not change the ~~p.d~~ current in the test circuit appreciably and hence the p.d across S remains nearly constant. The position of null deflection is almost unaffected. (2)

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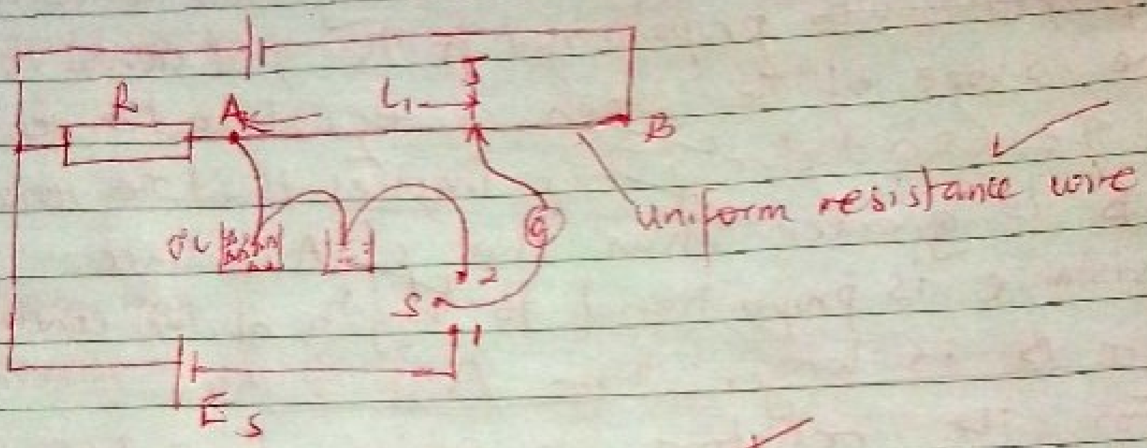
(16)

d)



With switch S in position 1, J is moved along AB until when the galvanometer G shows no deflection. The balance length l_1 is noted. S is now connected to position 2 and J is moved along AB until G shows no deflection. The balance length l_2 is noted. Now Emf E_T of the thermocouple is $E_T = IKl_2$ — (i)

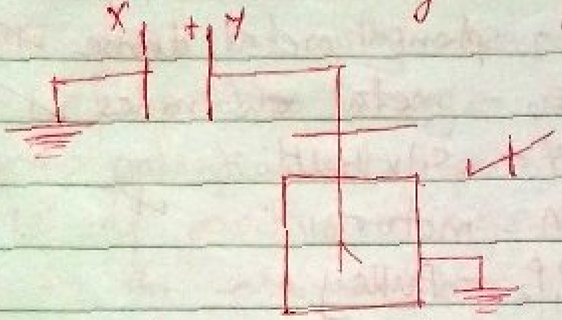
while $E_s = I(Kl_1 + R)$ — (ii)

$$\therefore E_T = \frac{E_s Kl_2}{R + Kl_1}$$

where K is the resistance per cm of the uniform resistance wire

9 a (i) Capacitance is the magnitude of charge required to raise the potential of a given conductor by 1V.
OR The ratio of magnitude of charge on either plates of a capacitor to the potential difference between the plates.
(ii) A dielectric material is a material which doesn't allow charge to flow through it (2)

(b)



The apparatus are set up as above. X, Y are capacitor plates. Y is charged and the divergence of the leaf of the electroscope is noted.
A dielectric material is now placed between the plates, and the divergence of the leaf is seen to reduce. This implies that the p.d between the plates has reduced. Now capacitance $C = \frac{Q}{V}$, where V is the p.d btn the plates and Q is the charge stored on the capacitor.
If V has reduced, then C has increased, hence $C \propto \varepsilon$, since permitivity of the material is greater than that of air (4)

(c) V = 200V, Heat capacity c = 250 J K^{-1}, θ = 0.4 K
Energy stored $= \frac{1}{2}CV^2$ = Heat dissipated in the coil $= c\theta$

$\Leftrightarrow \frac{1}{2} C \times 200^2 = 250 \times 0.4$ (4)

$C = \frac{250 \times 0.4 \times 2}{200^2} = 5.0 \times 10^{-3}$ F

(d)

(18)

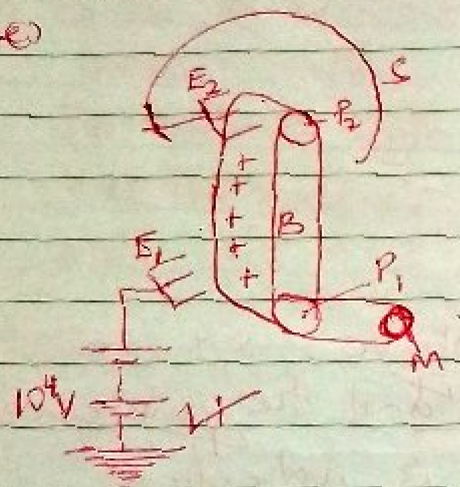
d (i) - All the points on the surface are at the same potential

- Work done to transfer charge from one point to another on the surface is zero (3)

- Electric field intensity is perpendicular to the surface

(ii) Charge quantisation is the product ne where e is the electronic charge and n is an integer (1)

e)



S - spherical metal dome

$E_1 E_2$ - metal electrodes

B - Silk belt

M - motor

$P_1 P_2$ - Pulley

The electrode E_1 is maintained at high electric field intensity around the spikes which ionise air around it. Negative ions are attracted and neutralised, while positive ions are repelled onto the belt. The belt which is driven by the motor carries the positive charge into the metal dome. On reaching E_2 the positive charge induces negative charge on the spikes and repels positive charge on the outer surface of the metal dome. The high electric field intensity around E_2 ionises air around it, and negative charge is repelled on to the belt discharging positive charge on it before it goes over P_2. The process continues until S is about 10^6 V positive relative to earth. (6)

* charge quantisation is the existance of charge in descrete values.

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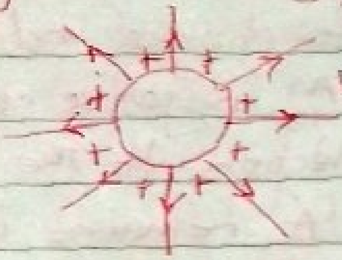
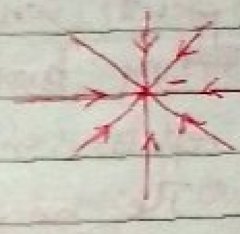
10 a (i) The force between two point charges is directly proportional to the product of the magnitude of the charges and inversely proportional to the square of their separation (1)

(ii)





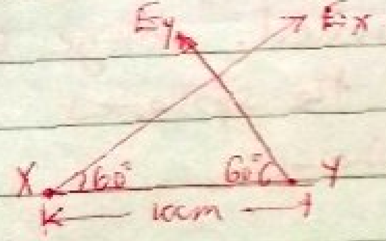
(2)

b (i) - Electric field intensity at a point is the force acting on 1C of positive charge in an electric field.

- Electric potential at a point is the work done to bring 1C of positive charge from infinity to that point in an electrostatic field. (2)

(ii) Electric field intensity is equal to the negative gradient of the electric potential (1)

(c)



$\vec{E_x} = \frac{KQ}{r^2}$

$\vec{E_x} = \frac{9\times10^9 \times 10^{-5}}{0.1^2} = 9\times10^6 NC^{-1}$

$\vec{E_y} = \frac{9\times10^9 \times 10^{-5}}{0.1^2} = 9\times10^6 NC^{-1}$

The horizontal components $\vec{E_H} = E_x \cos 60 - E_y \cos 60 = 0$ (6)

Vertically $\vec{E_V} = 2\times 9\times10^6 \sin 60 = 15.59\times10^6 NC^{-1}$

$\therefore \vec{E_p} = 15.59\times10^6 NC^{-1}$ (Vertically upwards)

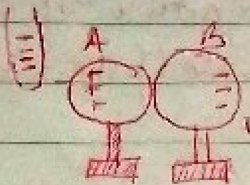
(d) $V = \frac{KQ}{r}$

$V_x = \frac{9\times10^9 \times 10^{-5}}{0.1} = 9\times10^5 V$

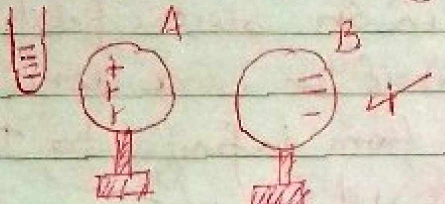
$V_y = \frac{9\times10^9 \times 10^{-5}}{0.1} = 9\times10^5 V$

d

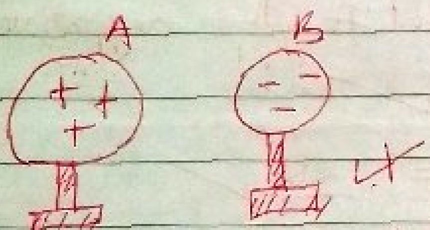
$V = 18\times10^{5}V = 1.8\times10^{6}V$ (3)

(d) 

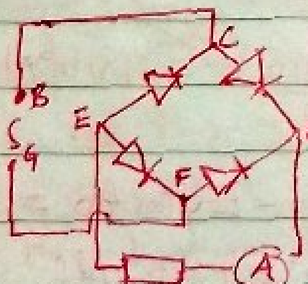
When the spheres are placed in contact and the charged rod is brought near A, negative charge on the rod repels some free electrons to the extreme side of B. The near side of A remains with excess positive charge.



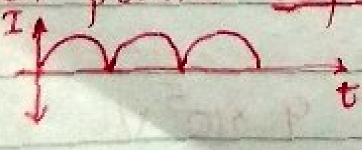
When the spheres are separated, B moves away with excess negative charge while A remains with excess positive charge.



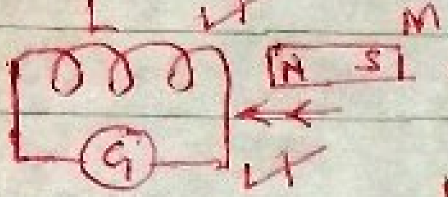
When the charged rod is now removed, charge on each of the spheres distribute uniformly on the spheres. (5)

7d(ii) 

In the half cycle when B is positive current flows in the direction BCDREFG. In the next half cycle when G is positive, currents flows in the direction GFDRECB. In both cases therefore, current flows through A in the same direction and so ammeter pointer deflects in the same direction. The current x-stics is



The ammeter reads a steady (or rms) value of current

6 a (ii) 

The apparatus is set up as above with the magnet M stationary relative to the coil L, the galvanometer G shows no deflection. The magnet is now moved towards L with fairly low speed and the deflection θ_1 of G is noted. M is pulled back and the pointer of G allowed to settle. M is now moved towards L at a faster speed and the deflection θ_2 is noted. θ_2 is greater than θ_1. ~~But the spe~~

But the speed of motion $\propto \frac{d\phi}{dt}$ and

the deflection $\propto I \propto$ emf, E induced in the coil.

Hence $E \propto \frac{d\phi}{dt}$, where $\frac{d\phi}{dt}$ is the rate of change of magnetic flux.