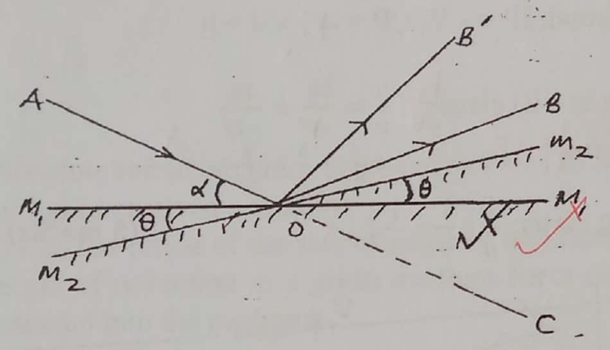
WAKISSHA JOINT MOCK EXAMINATIONS
MARKING GUIDE
Uganda Advanced Certificate of Education
PHYSICS P510/2

1. (a) (i) - The angle of incidence is equal to the angle of reflection.
- The incident ray, the reflected ray and the normal at the points of incidence all lie in the same plane. (02)

(ii)

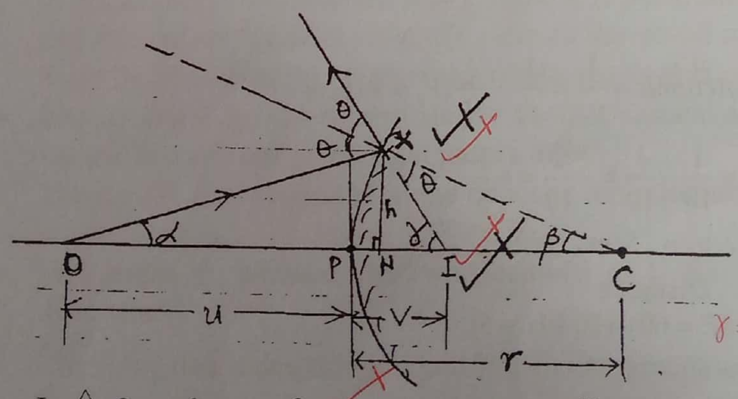


- For an incident ray AO, angle of deviation: < COB = 2α
Where α is the glancing angle.
- On rotating the mirror M_1M_1 to position M_2 M_2 through angle θ with the direction of the incident ray AO constant, the reflected ray is OB^1:
- The new glancing angle = $(\alpha + \theta)$ = new angle of deviation = $2(\alpha + \theta)$
- The new reflected ray BOB^{11} is thus rotated through angle
$BOB^1 = <COB^1 = 2(\alpha + \theta) - 2\alpha = \mathbf{2\theta}$
$\angle COB^1 - \angle COB$ (03)

(b) (i) Principal focus of a convex mirror is the point on the principal axis from which the rays originally parallel and close to the principal axis appear to diverge or come after reflection from the mirror. (01)

(ii) Radius of curvature of a convex mirror is the radius of the sphere of which the mirror forms a part (or it the distance between the Centre of curvature and the pole) (01)

(c)



P – Pole
O – Object
I – Image
C – Centre of curvature

$\gamma = \theta + \beta$

- In $\triangle$ Cox, $\theta = \alpha + \beta$ ______________ (i)
- In $\triangle$ C1x, θ = ~~γ~~ γ + β ______________ (i)

From (i) and (ii); $\alpha + \beta = \gamma - \beta$

From which $\gamma - \alpha = 2\beta$ ______ (iii)

Since angles α, β and γ are very small,

$\tan\alpha \approx \alpha = \frac{XN}{ON} = \frac{XN}{OP}$ Since P is very close to N.

Similarly, $\tan\beta \approx \beta = \frac{XN}{CN} = \frac{XN}{CP} = \frac{XN}{CP}$ and $\tan\gamma \approx \gamma = \frac{XN}{IN} = \frac{XN}{IP}$

Since I is virtual, IP = - V, CP = -r, XN = h

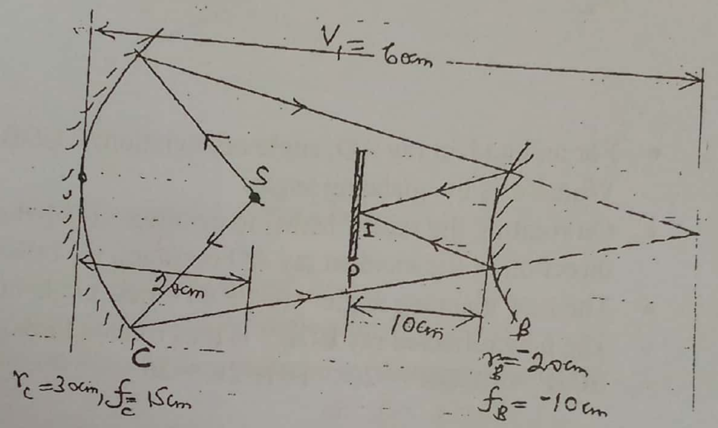
Substituting in (iii) gives $\frac{h}{-V} - \frac{h}{u} = \frac{2h}{-r} = \frac{2h}{-2f}$

$\frac{h}{-V} - \frac{h}{u} =$

$\Rightarrow \frac{1}{-v} - \frac{h}{u} = \frac{h}{-f}$

Rearranging gives: $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ **(5 marks)**

(d)



(i) Action of concave mirror C:

$f_c = 15cm$

$\frac{1}{v} = \frac{1}{f_c} - \frac{1}{u}, u = 20cm.$

$\frac{1}{15} - \frac{1}{20} = \frac{4-3}{60} = \frac{1}{60}$

$\therefore V_1 = 60cm$

$Action B = \frac{1}{u_2} = \frac{1}{f_B} - \frac{1}{V_2}, V_2 = +10cm$

$= \frac{1}{10} - \frac{1}{10} = -\frac{2}{10} = -\frac{1}{5}$

$\therefore u_2 = {}^{-}5cm.$

$\therefore$ Distance

$SP = 60 - (20 + 10 + 5)$

$= 60 - 35$

$= 25cm.$

(05 marks)

(ii) Magnification of

$$S = m_c \times m_B$$
$$= \frac{V_1}{u_1} \times \frac{V_2}{u_2}$$
$$= \frac{60}{20} \times \frac{10}{5}$$
$$= 3 \times 2$$
$$= 6$$

03

(03 marks)

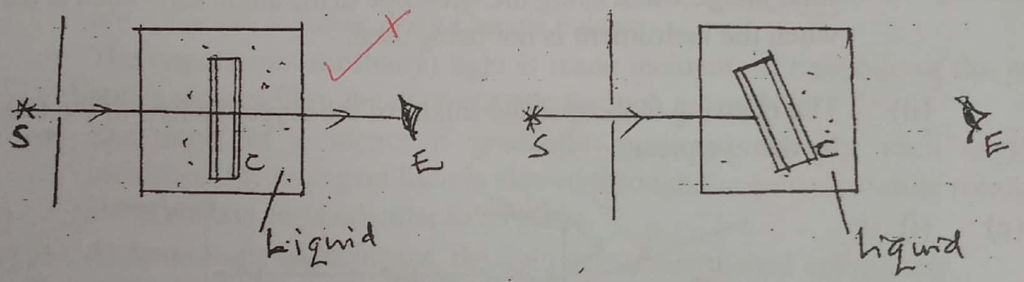
TOTAL MARK = 20

2. (a) (i) Absolute refractive index is the ratio of ~~vol.~~ velocity/speed of light in a vacuum to the ~~vol.~~ velocity/speed of light in a given medium. (01)
(or at The ration of the sine of angle of incidence in a vacuum to the sine of angle of refraction in a given medium for a ray of light travelling from a vacuum into the medium).

(ii) Total internal reflection is a phenomenon which occurs when the angle of incidence in the optically denser medium exceeds the critical angle and all the light is reflected back into the denser medium.

(01 marks)

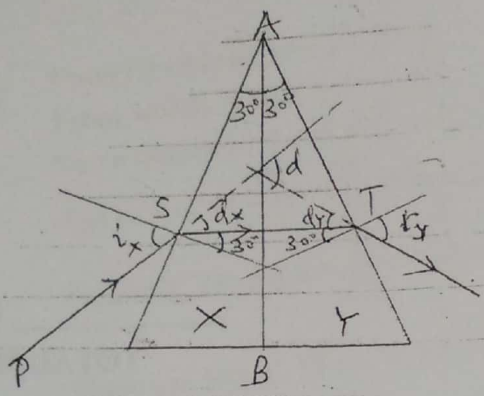
(b)



- The liquid whose ~~refraction~~ refractive index is required is placed in a transparent glass vessel having thin plane – parallel sides.
- The air cell, C, is then lowered into the liquid so that it can rotate about a vertical axis.
- A bright source of monochromatic light S, is positioned on one side of the vessel so that its rays are incident normally on the sides of the vessel and the air cell; and light from S can be seen directly by ~~a person whose eye is at E~~. observer at E
- The air cell C is then rotated slowly about a vertical axis until the light is suddenly cut off from E; and so no light passes through C.
- The air cell is now rotated in the opposite direction until the light is again suddenly cut off from E. observer E
- The angle, θ, between the two positions of C for the ~~extriction~~ extinction of the light is determined.
- The refractive index of the liquid is then obtained from $n = \dfrac{1}{\sin\left(\dfrac{\theta}{2}\right)}$.

(05 marks)

(c)



For refraction at S:

$$n_x = \frac{\sin i_x}{\sin_x}$$

$$\therefore 1.51 = \frac{\sin i_x}{\sin 30^0}$$

From which $i_x = 49.03^0$

$\therefore$ *deviation* at S, $dx = ix - 30^0 = 49.03^0 - 30^0$
$= 19.03^0$.

For refraction at $T: n_r = \dfrac{\sin ry}{\sin 30^0} \Rightarrow 1.65 = \dfrac{\sin ry}{\sin 30^0}$

from which $ry = 55.59^0$

$\therefore$ *deviation at* $T, \; = d_Y = r_y - 30^0 = 55.59^0 - 30^0 \;\; = 25.59^0$

$\therefore$ *Total deviation* $d = d_x + d_y$

$= 19.03^0 + 25.59^0$

$= 44.62^0$

added

(04 marks)

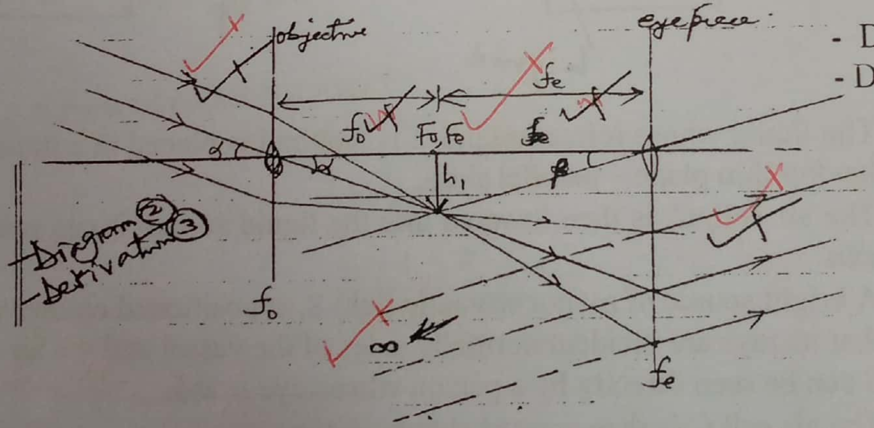
(d) (i) Magnifying power of a telescope is the ratio of the angle subtended at the eye by the final image when using the telescope to the angle subtended at the eye by the object when the instrument is not being used.

(01 marks)

(ii) The eye-ring is the circular image of the objective lens of the telescope formed by the eye piece.

(01 marks)

(e) (i)



- Diagram (2)
- Derivation (3)

- A normal adjustment, the final image is formed at infirmity.
- Since angles α and β are small
- Since angles $\alpha = \dfrac{h_1}{f_0}$ *and* $\beta = \dfrac{h_1}{f_e}$
- Magnifying power, $M = \dfrac{\beta}{\alpha} = \dfrac{h_1}{f_e} / \dfrac{h_1}{f_o}$

$$= \frac{f_o}{fe}$$

(05 marks)

(ii)
- Refracting telescope have chromatic aberration unlike in reflecting telescopes.
- Refracting telescopes have lower resolving power and less bright images unlike reflecting telescopes.

(Any two)

- More expensive in terms of costs to construct since two surfaces of the lenses have to be ground unlike the mirrors in reflecting telescopes.
- May experience spherical aberration for a point object on the axis at infinity unlike a reflecting telescope which uses parabolic mirror.

Any two @(02 marks)

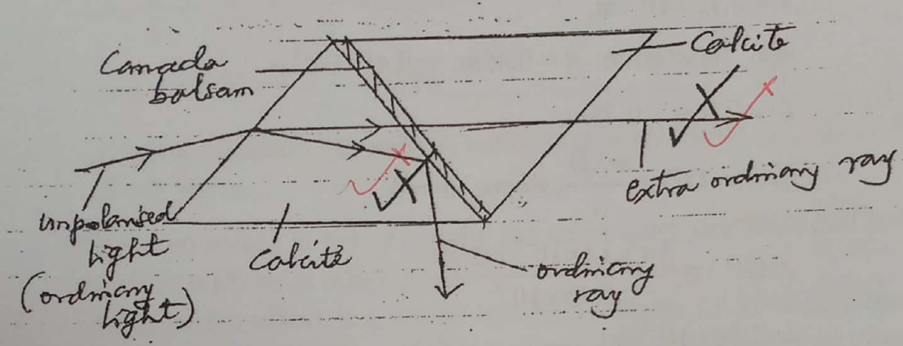
TOTAL MARKS 20

SECTION B

(electromagnetic vector)

3. (a) (i) Plane – polarized light is light whose electric field vector oscillates in one particular plane perpendicular to the direction of propagation of the light. (Or it is light which has only one plane of vibration).

(ii)



- A nicol prism is used – it consists of a calcite crystal cut into two pieces and are ~~corrected~~ cemented together using Canada balsam.
- The unpolarised (ordinary) light is made incident on one side of the prism and is viewed from the opposite side through an analyser. (Polaroid)
- The angle of incidence is gradually increased and for each angle of incidence, the emergent light is viewed through the analyser while rotating it about an axis perpendicular to its plane.
- At some angle of incidence, the light gets extinguished completely.
- At this point, the emergent light is completely plane-polarised.

(04 marks)

(b) n = 1.50; From tan ip = n = tan ip = 1.50.
= Polarising angle ip = 56.3^0

From n $= \dfrac{\sin ip}{\sin r}, \Rightarrow 1.50 = \dfrac{\sin 56.3^0}{\sin r}$

$\Rightarrow r = 33.7^0$

(03 marks)

(c) Principle of ~~supervision~~ superposition of waves states that whenever two waves are travelling (meet) in the same region, (meet) the total displacement (at) any point is equal to the vector sum of their individual displacements at that point.

(01 marks)

(d) (i) Constructive ~~interface~~ interference – occurs when a crest of one wave (meets crest of) a another wave and a wave of large amplitude result whereas destructive interference occurs when a crest of another wave (meets a trough of another) and no wave is observed.
(Reinforcement)

(02 marks)

(ii) - The sources must be coherent (i.e they must have the same frequency and amplitude and be in phase with each other)

(02 marks)

- The two source must be very close to each other.
  - Distance from the slits must be as far as possible

(iii)
- The oil film on water appears coloured due to interference.
- When light is incident on the oil surface it is partly reflected and partly refracted.
- The refracted light is then internally reflected at the oil – water interface. So the original incident ray is divided into two different rays of different amplitude that are coherent.
- When the two rays are combined ~~but~~ by the lens of the eye, they interfere.
- The colours for which the waves meet in phase are observed in the film while those that meet out of phase are not seen.

(03 marks)

(e)

$\lambda = 5.12\times10^{-7}\,m,$

$slit\ \ seperation\ \ a = 0.45mm = 0.45\times10^{-3}\,m$

$D = 75cm = 0.75m.$

$from\ \ OP = \frac{m\lambda D}{a}, where\ \ m = 3$

$\therefore OP\ \ = \frac{3\times5.12\times10^{-7}\times0.75}{0.45\times10^{-3}}$

$= 2.56\times10^{-3}\,m$

(04 marks)

TOTAL MARKS = 20

4. (a)
- In progressive waves, transfer of energy takes place in the direction of wave motion, while in stationary waves, no energy is transferred from one point to another.
  - Amplitude is the same while stationary amplitude varies
- In progressive waves, the wave form advances with the wave motion whereas in stationary waves, the waveform does not advance in any direction.
- In progressive waves, all particles within one wavelength have different phases while in stationary waves, the phase of all particles ~~with~~ between two adjacent nodes is the same.

In progressive wave Particles in phase are $n\lambda$ and
- In progressive waves, have crests and troughs while stationary waves have compressions and rarefactions vibrating

(03 marks)

(b) (i) Resonance is a phenomenon which occurs when a body is vibrates at its natural freq. due to impulses received from a nearby source oscillating at the same freq. to produce a loud sound.

(ii)
- A long tube (resonance tube) with a tap at the bottom is filled with water with a short length of air column left at the top.
- A vibrating turning fork of frequency f is sounded and placed above the open end of the tube.
- The level of water in the tube is gradually lowered by opening the tap until a loud sound is heard.
- The length l, of the air column in the tube is measured and recorded.
- The procedure is repeated by using turning forks of different frequencies.
- Results are tabulated to include values of $\frac{1}{f}$

- A graph of $\frac{l}{f}$ against l, is plotted and its slope S obtained.
- The velocity V of sound is got from V= 4/s $V = 4S$

(05 marks)

(c) At first position of resonance length of air column, l_1 = 80 - 67 =13 cm = 0.13m.

$\therefore \frac{\lambda}{4} = \lambda_1 + C \Rightarrow \frac{\lambda}{4} = 0.13 + C$ where c - end correction

From which $C = \frac{\lambda}{4} - 0.13$ ______________ (i)

For third position of resonance l_3=80 -10.2
= 69.8cm
= 0.698m.

$\Rightarrow \frac{5\lambda}{4} = l_3 + C \Rightarrow \frac{5\lambda}{4} = 0.698 + C$

third l

from which c = $\frac{5\lambda}{4}$ - 0.698 ______________ (ii)

Solving equation (i) and (ii) simultaneously gives. $V = f\lambda$, $V = 0.568 \times 60$

$\lambda = 0.568$m. $V = 34.08$ m/s

(04 marks)

(d) (i) - When two sound notes of nearby the same freq. and equal amplitude are sounded together, they interfere with each other. a periodic rise and fall in the intensity of sound which is called beats.
- The resultant effect is a sound whose loudness or intensity **increases** and **decreases** periodically and this rise and fall in intensity of sound is beats.

Sources must be of nearly the same amplitude and frequency

(02 marks)

(ii) - Suppose the beat period is T and that one wave train of f_1 makes one cycle more than the other of freq. f_2. (Suppose the wave of frequency f_1 makes one more cycle than the other of frequency f_2 in time T then T will be called beat period.)
- No. of cycles of freq. f_1 made in Time T = f_1T and No. of cycles of freq f_2 made in Time T = f_2 T

f_1T = f_1 T- f_2 T= 1 $\Rightarrow (f_1 - f_2) = \frac{1}{T}$ where $\frac{1}{T}$ which is frequent beat frequency, f

$\Rightarrow$ beat freq $f = f_1 - f_2$.

(03 marks)

(e) - Tuning of a musical (stringed) instrument.
- Measurement of an unknown freq. of a note.

(02 marks)

TOTAL MARKS = 20

SECTION C

5. (a) Unit of magnetic ~~fluid~~ flux density is the tesla and is defined as the magnetic flow density of a field in which a force of IN acts on a 1m length of a conductor which is carrying a current of 1A and is perpendicular to the field.

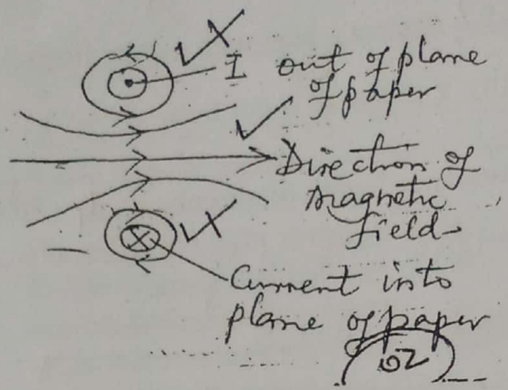
(01mark)

(b) (i) $B = \frac{\mu_o NI}{2R}$

- N_o = permeability of free space.
- N = No of turns in the coil
- I = current flowing in the coil.
- R= radius of the coil.

(02 marks)

(ii)



We give the marks if everything is correct

(02 marks)

(iii) $l = 9.81\text{m}$; $d = 3.5\text{ cm} = 0.035\text{m}$, $R = 0.0175\text{m}$ $I = 1.5\text{A}$, $B = ?$

$$\text{No. of turns, } N = \frac{\text{length of wire}}{\text{circumference of coil}}$$

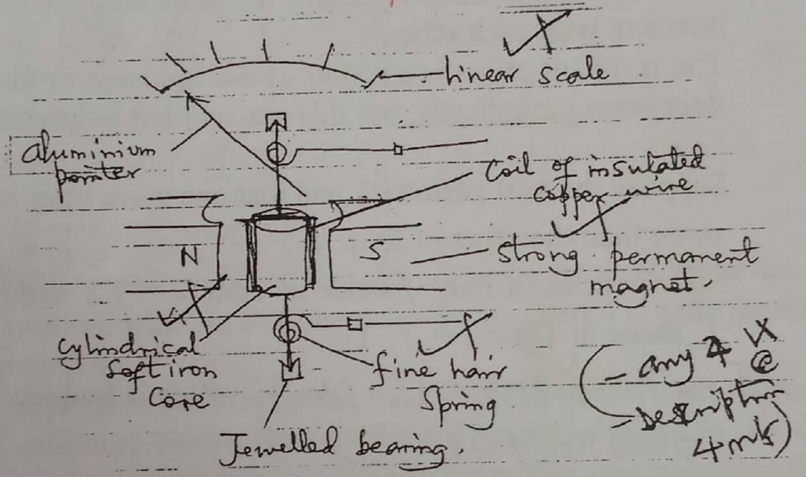
$$= \frac{9.81}{3.14 \times 0.035} = 89.3$$

$$\therefore B = \frac{\mu_0 NI}{2R} = \frac{4 \times 3.14 \times 10^{-7} \times 89.3 \times 15}{2 \times 0.0175}$$

$= \cancel{3.83 \times 10^{-4}\text{T}}$ $4.81 \times 10^{-3}\text{T}$

(03 marks)

(c) (i)



- When a current flows in the coils, the resultant magnetic in the annular space sets up a force on each turn up the coil.
- Two forces, acting on each vertical side of the coil, having the same size act in ~~different~~ opposite directions and will produce a turning effect on the coil.
- The coil will rotate until the deflecting torque is balanced by the control torque due to the hair springs.

  i.e. $NBIA = C\theta$

- Where N = No of turns, B = flux density of the field, I = current in the coil, A = area of the coil, C = torsional constant of the hair springs, θ = angle turned by the coil.
- It can be seen that $I \propto \theta \Rightarrow$ the scale showing current values is linear.

(06 marks)

(d) (ii)
- Large N would increase the resistance of the coil which is undesirable.
- This would increase the weight of the coil, this reducing damping.
- The annular space limits increase of the area.
- A current much greater than that which the meter is intended to measure will burn out its hair springs.

Any two

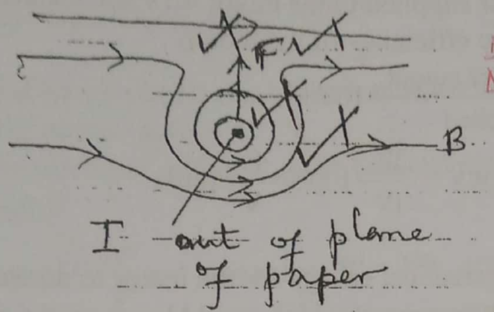
$\frac{\theta}{I} = \frac{BAN}{C}$

$\frac{\theta}{I} = \mu_0 N^2 I$

Any 2 @ (02 marks

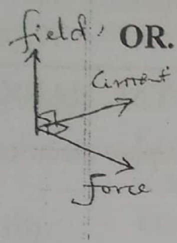
(d) - A current in the conductor produces a magnetic field around the conductor.
- The external magnetic field interacts with the field due to current.
- The resulting magnetic field is stronger on one side of the conductor than the other side, whose direction is in according with Fleming's left hand rule.

(04 marks)



Direction of the current
Direction of the field
of the external field

OR. - Current is constituted by flow of electrons. Each electron experience a mechanical force in the magnetic field.
- The force on the conductor is thus the sum of these individual forces.
- The direction of the resultant force is in accordance with Fleming's left hand rule.



TOTAL : 20 MARKS

6. (a) (i) - The magnitude of the induced emf in a conductor is directly proportional to the rate of change of magnetic flux linking the conductor.
- The direction of the induced induced emf is such that the current which it causes to flow oppose the change which is producing it.

(02 marks)

(ii) - A cell of known polarity is connected to a center-zero galvanometer and the direction of the deflection of the pointer is noted.
- A coil in which the sense of windings is known is then connected to the galv.
- A bar magnet of known poles is then thrust into the coil and the direction of the deflection of the pointer is again noted; hence the direction of flow current through coil is determined.
- The procedure observation is repeated with the bar magnet withdrawn from the coil.
- It is observed that for any movement of the bar magnet, the induced current always flows in the coil in such a direction to induce the magnetic pole in the end of the coil that opposes the motion of the magnet.

(06 marks)

(b) (i) Angle of dip – Is the angle between the direction of the earth's resultant magnetic flux and the horizontal.
Angle in which a freely suspended bar magnet makes with the horizontal

(01 mark)

(ii) Magnetic meridian – is the vertical plane which contains the vertical and horizontal components of the earth's magnetic field.
A verticle plane in which a freely suspended magnet rests.

(01 mark)

(c) $N = 120$ turns, $d = 80cm = 0.80m \Rightarrow r = 0.40m$

$R = 220\,\Omega$, $\theta = 1$ rad; $BH = ?$, $a = 6.0\times10^4$rad

$A = \pi r^2$ Induced charge, $Q = \dfrac{2NABH}{R} = c\theta = \dfrac{1}{a}\theta$ C is the ballistic constant, $C = \dfrac{1}{a}$

$Q = \dfrac{2NAB_H}{R}$ $\therefore B_H = \dfrac{R\theta}{2NAa}$

$$= \frac{220\times1.0}{2\times120\times3.14\times(0.40)^2\times6.0\times10^4}$$

$= 3.04\times10^{-5}$T.

(04 marks

(d) (i) - When the armature of the motor rotates, it cuts the magnetic flux of the field magnet and an emf is induced in it. This emf is called back emf.

- If E and V represent the magnitudes of the back emf and applied p.d respectively and I is the current in the coils, then.
- The electrical power supplied to the motor = IV the mechanical power output of the motor = IE since efficiency of the motor.

$$= \frac{\text{mechanical power output}}{\text{power supplied}} \times 100\%$$

$$\Rightarrow \text{efficiency} = \frac{IE}{IV} \times 100\% = \frac{E}{V} \times 100\%$$

(04 marks)

(ii) - It provides the mechanical energy for the motor to do work.
- It limits the armature current which would burn out the armature coil.

(02 marks)

TOTAL MARKS = 20

7. (a) (i) R.m.s of an a.c. is the value of the steady current which would dissipate electrical(heat) energy at the same rate in a given resistance as the a.c.

(01 mark)

(ii) Peak value of an a.c. is the maximum value of the a.c (or the amplitude of the a.c)

(01 mark)

(b) (i) For a sinusoidal voltage, $V = V_o \sin wt$ $(V = V_o \sin 2\pi ft)$

But $w = 2\pi f$.

$\Rightarrow V = V_o \sin 2\pi ft$

The charge, Q on the capacitor at time t is given by $Q = CV = CV_o \sin 2\pi ft$

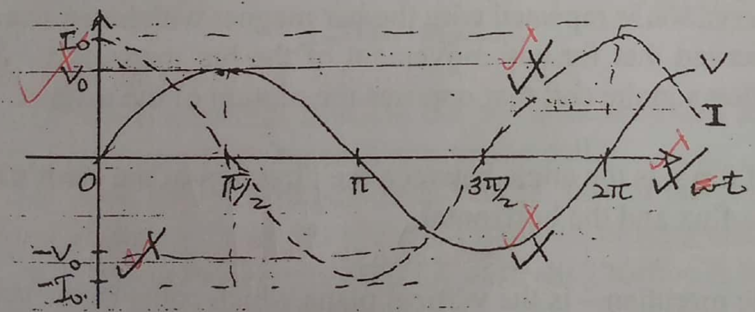
The current I flowing in the circuit.

$$I = \frac{dQ}{dt} = \frac{d}{dt}(CV_o \overset{\sin}{\cancel{smi}} 2\pi ft)$$

$$\therefore I = 2\pi f CV_o \cos 2\pi ft \qquad I = \omega CV_o \cos \omega t$$

(03 marks)

(ii)



(iii) $C = 1.0\,\mu f = 1.0 \times 10^{-6}F$, $f = 1.1kH\cancel{z} = 1.1 \times 10^3 H\cancel{z}$ $I = 5mA = 5.0 \times 10^{-3}A$, $V = ?$

$$X_c = \frac{1}{2\pi fc} = \frac{1}{2 \times 3.14 \times 1.1 \times 10^3 \times 1.0 \times 10^{-6}}$$

$$= 144.76\Omega$$

But $V = IX_C$

$= 5.0 \times 10^{-3} \times 144.76 = 0.724V$

(03 marks)

(c) On closing K, current starts to flow from the capacitor
- This sets up a magnetic field in the coil L to build up and in accordance with len's law, a back emf is indiced in L.
- The back emf will oppose the current flow this consequently makes the discharge process of C slow.

- When the discharge of C is complete, the energy that was initially in the source (ie.c) is stored in the magnetic field of the coil, L.
- The emf induced in the coil makes it to act as a generator thereby returning the energy stored in its magnetic field to the source.
- The capacitor is thus recharged to its original state.
- The process keeps on repeating.

(05 marks)

(d) (i) - Electrical power can be transmitted more economically at high p.ds. or voltages with minimum loss of energy.

- Suppose electrical power P is to be delivered at a p.d. V by supply lines of total resistance R
- The current $I = \frac{P}{V}$ and power loss $P^1 = I^2R. \Rightarrow P^1 = \left(\frac{P}{V}\right)^2.R \Rightarrow$ the greater the V, the smaller the power loss P^1.

(02 marks)

(ii)

- Energy loss due to resistance of the windings (ohmic loss) can be minimized by using thick copper wires having low resistance.
- Energy loss due to eddy currents can be minimized by laminating the core.
- Energy loss due to magnetic flux leakage can be minimized by winding the secondary on the primary. Any 3
- Hysteress loss can be minimized by using a magnetically soft material for the core.

(02 marks)

TOTAL : 20 MARKS

SECTION D

8. (a) (i) E.m.f of a cell is the potential difference between the terminals of a cell when it doesnot supply current is in an open circuit.
Or it is the energy needed to convey 1C of charge round a closed circuit in which the cell is connected.

value in complete circuit

(01 mark)

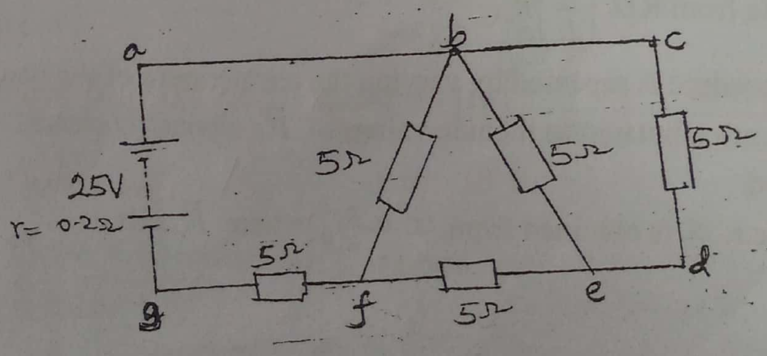
(ii) For a charge Q that flows in an electrical circuit in a time t:, $I = Q/t \Rightarrow Q = It$.
Work done to transfer charge Q is given by $W = QV$ where V is the pd between two points in the circuit .
But work done is stored as electrical energy E

Thus $E = QV \Rightarrow E = It.V$

But $V = IR \Rightarrow E = It.IR$

$\therefore E = I^2 R t$

(b)



i)

Resistors

- Resistance Cd and be are in parallel; their effective resistance $R_1 = \frac{5\times5}{5+5} = 2.5\Omega$
- The parallel combination of resistance R_1 is in series with fe $\Rightarrow$ Their effective resistance $R_2 = 2.5+5$
  $= 7.5\Omega$

Now R_2 is in parallel with bf and so their effective resistance $R_3 = \frac{5\times7.5}{5+7.5} = 3\Omega$

$\Rightarrow$ Effective resistance $R = 5+3 = 8\Omega$

$\therefore$ Power dissipated in the battery $= I^2R = \left(\frac{E}{R+r}\right)^2 \times R$

$\therefore P = \left(\frac{25}{8+0.2}\right)^2 \times 8 = \cancel{74.4W}$ 0.2

$P = 1.859W$

(05 marks)

(c) (i) Temp. Coefficient of resistance of a conductor is the fractional change in resistance at 0^0C for every degree celsivs rise in temperature.
S.I unit is K^{-1}.

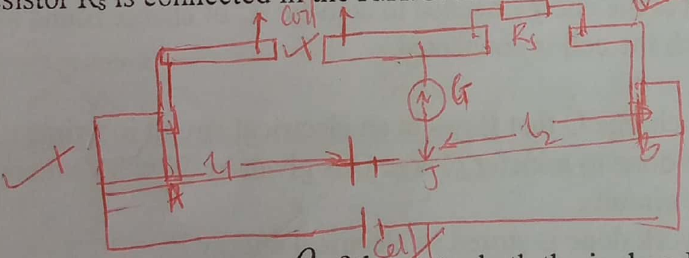
(02 marks)

(ii)
- Negative temperature coefficient of resistance means that the resistance of the semi-conductor decreases with increase in temperature.
- Increase in temperature leads to greater vibration of the atoms about their fixed points; this eventually leads to setting free more elections making the semi-conductor a better conductor.

Semi conductors have few electrons available for conduction at room temp and when temp increases more electrons are set free for conduction thus current increases as temperature increases

(02 marks)

(d) (i)
- The metal wire is made into a coil and is immersed in a water bath.
- The coil is then connected in the L.H.G. of the inter bridge and a standard resistor R_s is connected in the R.H.G. as shown below.



Any two parts labelled (each ½)

- At a given temperature θ of the water bath the jockey J is moved along the resistance wire AB until the galvanometer G shows no deflection.
- The balance length l_1 and l_2 are recorded and resistance of the coil $R\theta$ is calculate from $R\theta = \left(\frac{l_1}{l_2}\right)R_s$
- The procedure is repeated by varying the temperature of the bath by warming it.
- Results are tabulated to include values of R_θ against θ plotted and its slope S is obtained. Against R_θ and θ
- Then t.c.r. $\propto$ is obtained from $\propto = S/R$ where R_θ is the intercept on the axis.

(05 marks)

(ii) Precautions.

- R_s must be chosen such that the balance points are near the middle of resistance wire AB.
- R_s and R_θ should be interchanged when l_1 and l_2 have been determined and the average value of the balance lengths obtained.
- The slide wire AB should the jockey J scrapped by sliding the jockey J as this makes the wire non-uniform.

(02 marks)

TOTAL: 20 MARKS

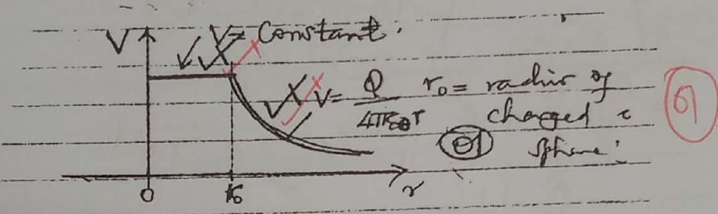
EK

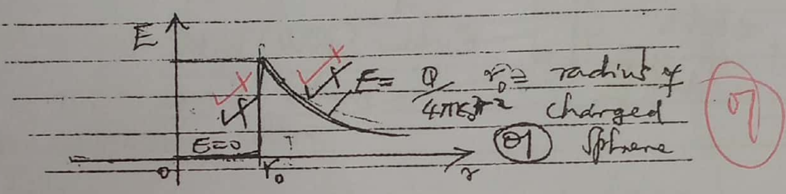
9. (a) (i)

- Electric field intensity – Is the electric force exerted on a Positive charge of 1c at a point.
- Electric potential – Is the work done to transfer a positive charge of 1c from infinity to a given point.

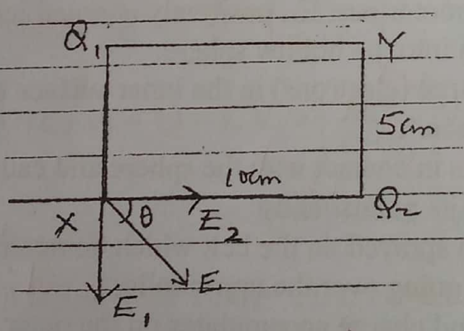
Not unit Positive

(ii)





(b)



(i) Electric potential at X $= \frac{Q_1}{4\pi\varepsilon r_1} + \frac{Q_2}{4\pi\varepsilon r_2}$

$$= \frac{1}{4\pi\varepsilon}\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right)$$

$$= 9.0\times10^{9}\left(\frac{+4.0\times10^{-6}}{0.05} - \frac{10\times10^{-6}}{0.10}\right)$$

$$= -1.80\times10^{5}\,\text{V}$$

(ii) Electri field intensity at X is given by

$E = \sqrt{E_1^2 + E_2^2}$

$$\text{But } E_1 = \frac{Q_1}{4\varepsilon_0 r_1^2} = \frac{9.0\times10^9\times4.0\times10^{-6}}{(0.05)^2}$$

$$= 1.44\times10^7\ \text{Nc}^{-1}$$

$$E_2^1 = \frac{Q_1}{4\varepsilon_0 r_1^2} = \frac{9.0\times10^9\times10\times10^{-6}}{(0.10)^2}$$

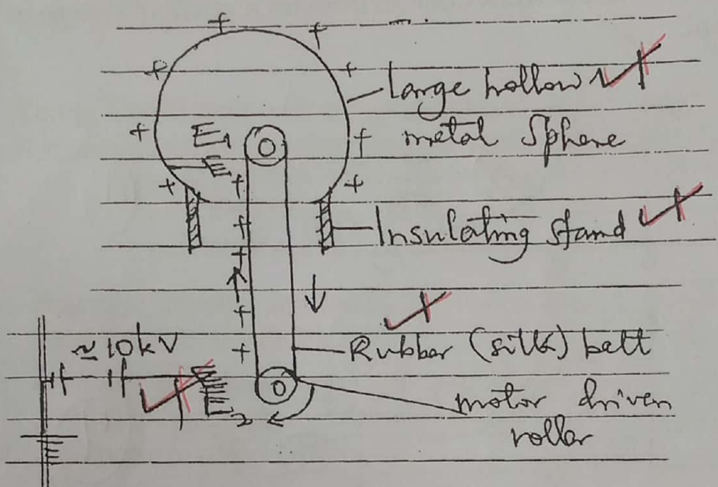
$$= 9.0\times10^5\text{Nc}^{-1}$$

$$\therefore E=\sqrt{(1.44\times10^7)^2+(9.0\times10^5)^2}=1.44\times10^7\ Nc^{-1}$$

(04 marks)

In the direction $\theta=86.4^{\circ}$ to the horizontal

(d)



- E_2 is at a high positive potential with respect to the earth, and so corona discharge occurs in its vicinity.
- As the belt is driven by a motor past E_1, positively charged ions are sprayed (repelled) onto the belt and are carried up into the hollow sphere.
- This induces negative charge (electrons) in the inner surface of the sphere and positive on the outer surface.
- The second electrode E_1 is in contact with the sphere and causes corona discharge due to the high density at its points/ ends.
- Negative charges are then sprayed on the belt which do neutralize the positive charge on the belt before going over the upper roller.
- The process is repeated and charge accumulates on the outer surface of the sphere.

(06 marks)

(e)

- All points on an equipotential surface are at the same potential $\Rightarrow$ p.d between points is zero.
- Therefore, along any direction lying in an equipotential surface, there is no potential gradient. electric field on

  there is no PD
- $\Rightarrow$ Electric field limes must be at right angles to an equipotential surface.

(02 marks)

TOTAL MARKS = 20

10. (a) The farad is the capacitance of a capacitor such that 1C of charge is stored when the p.d applied across its plates is IV (01 mark)

order

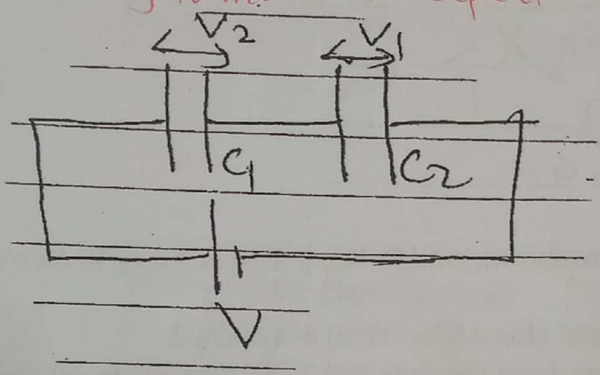
(b) (i) Energy changes from chemical energy in the battery to electrical energy in the connection wires and then electrical potential energy in the capacitor and then later to heat in the connecting wires. (02 marks)

(ii)

- When a dielectric is in a charged capacitor, its molecules are polarized due to the electric field because of the charges on the plates.
- Therefore, at the surface of the dielectric, charges of opposite sign to the charges on the plates are induced.
- An electric field of intensity E' due to the charges on the surfaces of the dielectric is set up and it is in the opposite direction to E_o the electric field intensity due to charge on the plates.
- The resultant field intensity $E_0^{\prime} - E^{\prime}$ is less than the initial E_o.
- This reduces the p.d between the plates, leading to increase in capacitance

(04 marks)

(c)



Effective capacitance

$$C = \frac{C_1C_2}{C_1 + C_2}$$

Total charge $Q = CV = \left(\frac{C_1C_2}{C_1+C_2}\right)V$

But $Q = C_1 V_1 = Q = CV = \left(\frac{C_1C_2}{C_1+C_2}\right)V$

$$\Rightarrow V_1 = \left(\frac{C_2}{C_1+C_2}\right)V$$

$C_1 = 4\,\mu F = 4\times10^{-6}F$, $C_2 = 2.0\,\mu F = 2.0\times10^{-6}$

(04 marks)

(d) Before disconnecting, effective capacitance

$$C = \frac{C_1C_2}{C_1 + C_2} = \frac{4.0\times10^{-6}\times2.0\times10^{-6}}{4.0\times10^{-6}+2.0\times10^{-6}}$$

$= 1.33\times10^{-6}$ F

∴ Charge on each capacitor

$Q = CV = 1.33\times10^{-6}\times120$

$= 1.60\times10^{-4}C$

On ~~goming~~ joining like terminal together total

Total initial charge $= 1.33\times10^{-6} + 1.33\times10^{-6}$

$= 2.66\times10^{-6}$ C

Total final charge, $Q = CV = (C_1+C_2)V$

$1.60\times10^{-4} + 1.60\times10^{-4}$

3.2×10^{-4} C

CamScanner

$3.2\times10^{-4} = ($

$$\Rightarrow 2.66\times10^{-6} = (4.0\times10^{-6} + 2.0\times10^{-6})V$$

From which V= 44.33V ~~53.33V~~

$\therefore$ Charge on $C_1 = C_1V = 4.0\times10^{-6} \times 44.33$ 53.33V

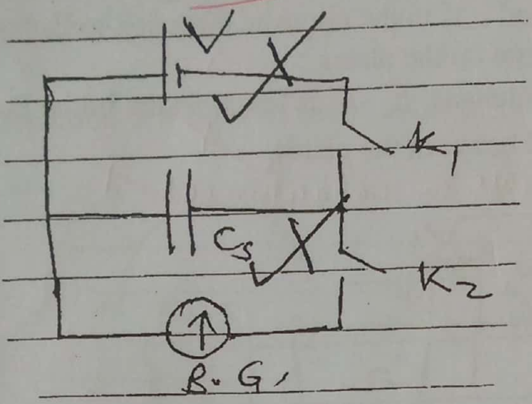
$= 1.77\times10^{-4}C$

Charge on $C_2 = C_2V = 2.0\times10^{-6} \times 44.33$

$= 8.87\times10^{-5}C$ ~~53.33V~~ 1.067×10^{-4}

(05 marks)

(e)



- The circuit is set up as shown, with C_s being a capacitor of known capacitance standard capacitor.
- Switch K_1 is closed and after a short time, it is opened.
- Switch K_2 is then closed and the first deflection θ_s of the balliste galvanometer is noted.
- The standard capacitor is then replaced by the capacitor whose capacitance C is to be measured.
- The procedure is repeated and the corresponding deflection θ is noted.
- The capacitance C of the capacitor is then obtained from;

$$C = \frac{\theta}{\theta_s}\times C_s$$

(04 marks)

TOTAL MARKS = 20

END

SECTION A

1. (a) (i) State the **laws of reflection** of light. (2 marks)

(ii) A ray of light is incident on a plane mirror. The mirror is then turned through an angle θ while keeping the direction of the incident ray fixed. Show that the reflected ray is turned through angle 2θ. (3 marks)

(b) Define the following terms as applied to convex mirrors:

(i) **principal focus.** (1 mark)

(ii) **radius of curvature.** (1 mark)

(c) An object is placed at a distance **u** from a convex mirror of focal length **f**. The mirror forms an image of the object at a distance **v** from its pole. Using a geometrical ray diagram, derive an expression of the mirror formula for the convex mirror. (5 marks)

(d) The diagram in Fig. 1 below shows a small source of light S placed in between a large concave mirror C which is placed coaxially and in front of a small convex mirror B with their reflecting surfaces facing each other. A screen P, large enough to block light from S from falling directly on B but small enough to allow light from C to reach B, is placed at a distance of 10 cm in front of B.

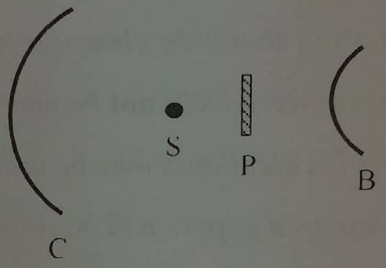


Fig. 1

If S is 20 cm from C and the radii of curvature of C and B respectively are 30 cm and 20 cm and the final image of S is formed on P on the side facing B, find the:

(i) distance between S and P. (5 marks)

(ii) magnification of the final image of S. (3 marks)

2. (a) What is meant by the following as applied to refraction?

(i) **absolute refractive index.** (1 mark)

(ii) **total internal ~~refraction~~.** reflection (1 mark)

(b) Describe an experiment to determine the refractive index of a liquid using an air cell. (5 marks)

(c) The figure 2 below shows two triangular glass prisms X and Y, each of refracting angle 30^0 and refractive index 1.51 and 1.65 respectively, cemented together to form a compound prism with a common interface along AB.

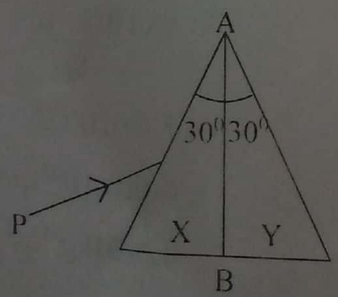


Fig. 2

If a ray of light from P, incident on one surface of X is refracted to pass normally across AB, calculate the angle of deviation of the light. (4 marks)

(d) What is meant by the following as applied to a telescope?
   (i) **magnifying power.** (1 mark)
   (ii) **eye-ring.** (1 mark)

(e) (i) With the aid of a diagram, derive an expression for the magnifying power of an astronomical telescope in normal adjustment. (5 marks)
   (ii) State any **two** disadvantages refracting telescopes have as opposed to the reflecting type. (2 marks)

SECTION B

3. (a) (i) What is meant by **plane – polarised light**? (1 mark)
   (ii) Describe how plane – polarised light can be produced by double refraction. (4 marks)

(b) A parallel beam of unpolarised light incident on a transparent glass of refractive index 1.50 is reflected as plane polarised light. Calculate the angle of refraction in glass. (3 marks)

(c) State the **principle of superposition** of waves. (1 mark)

(d) (i) Distinguish between **constructive** and **destructive** interference. (2 marks)
   (ii) State the conditions for interference of two waves to occur. (2 marks)
   (iii) Explain why an oil film on a water surface appears to be coloured. (3 marks)

(e) Figure 3 below shows two slits S_1 and S_2 and a screen S in Young's double – slit experiment. Light of wavelength 5.12×10^{-7} m is used.

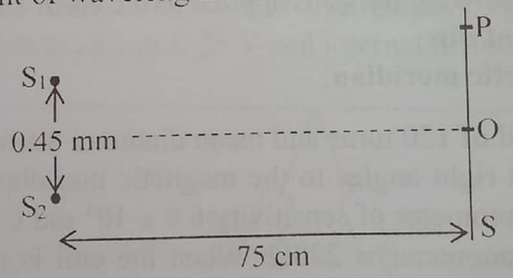


Fig. 3

If P is the position of the third bright fringe from the central fringe O, calculate the distance OP. (4 marks)

4. (a) Distinguish between **progressive** and **stationary** waves. (3 marks)

(b) (i) What is meant by **resonance** as applied to sound? (1 mark)
   (ii) Describe the resonance tube method experiment to determine the speed of sound in air using tuning forks of different frequencies. (5 marks)

(c) A uniform glass tube 80 cm long is fully filled with water. When a tuning fork of frequency 60 Hz is sounded and placed above the tube as the water level is lowered, resonance is first obtained when the length of the water in the tube is 67 cm. If the third resonance is obtained when the liquid column is 10.2 cm, calculate the velocity of sound produced by the tuning fork. (4 marks)

Turn Over

(d) (i) Explain briefly how beats are formed. (2 marks)
(ii) Derive an expression for the beat frequency. (3 marks)

(e) State **two** applications of beats. (2 marks)

SECTION C

5. (a) Define the **unit of magnetic flux density**. (1 mark)

(b) (i) Write down an expression for the magnetic flux density at the centre of a flat circular coil, defining the symbols used. (2 marks)

(ii) Draw a sketch diagram to show the directions of the magnetic field, current and ~~torque~~ due to the current flowing in a flat circular coil. (2 marks)

(iii) A wire of length 9.81 m is wound into a flat circular coil of diameter 3.5 cm. If a current of 1.5 A passes through the coil, find the magnetic flux density at the centre of the coil. (3 marks)

(c) (i) Describe the structure and mode of operation of the moving coil galvanometer. (6 marks)

(ii) State any **two** limitations to increasing current sensitivity of a moving coil galvanometer. (2 marks)

(d) Explain with the aid of a diagram why a conductor carrying current experiences a mechanical force when placed in a magnetic force. (4 marks)

6. (a) (i) State the **laws of electromagnetic induction**. (2 marks)
(ii) Describe an experiment to verify Lenz's law. (6 marks)

(b) Define the following terms as applied to the earth's magnetic field:
(i) **angle of dip**. (1 mark)
(ii) **magnetic meridian**. (1 mark)

(c) A circular coil of 120 turns and mean diameter 80cm is placed in such a way that its plane is at right angles to the magnetic meridian. The coil is connected to a ballistic galvanometer of sensitivity 6.0×10^4 rad C^{-1}. The total resistance of the coil and galvanometer is 220Ω. When the coil is rotated through 180^0 about a vertical axis, the ballistic galvanometer deflects through 1.0 radians. Calculate the horizontal component of the earth's magnetic flux density. (4 marks)

(d) (i) Explain the term **back e.m.f.** as applied to a motor, and derive its relation to the efficiency of the motor. (4 marks)

(ii) State the significance of back e.m.f. in the d.c. motor. (2 marks)

7. (a) Define the following terms as applied to alternating current:
(i) **root – mean** square **value**. (1 mark)
(ii) **peak value**. (1 mark)

(b) (i) A source of sinusoidal voltage of amplitude V_o and frequency f is connected across a capacitor of capacitance C. Derive an expression for the instantaneous current which flows. (3 marks)

(ii) With reference to the circuit in (b) (i) above, sketch using the same axes, graphs to show variation of voltage V and current I with time. (2 marks)

(iii) A capacitor of capacitance 1.0 μF is used in a radio circuit where the frequency is 1.1 kHz and the current flowing is 5 mA. Calculate the voltage across the capacitor. (3 marks)

(c) The figure 4 below shows a charged capacitor C, an inductor L and a switch K, all connected in series.

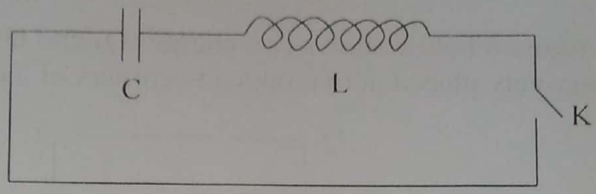


Fig. 4

Explain what happens when switch K is closed. (5 marks)

(d) (i) Explain the advantage of alternating current over direct current in power transmission. (2 marks)

(ii) Explain briefly how energy losses in an a.c. transformer can be minimised. (3 marks)

SECTION D

8. (a) (i) What is meant by **e.m.f.** of a cell? (1 mark)

(ii) Derive the expression for the electrical energy dissipated in a resistor of resistance R ohms, carrying current I amperes for t seconds. (3 marks)

(b) The figure 5 below shows a network of five resistors, each of resistance 5 Ω connected to a battery of e.m.f. 25 V and internal resistance 0.2 Ω.

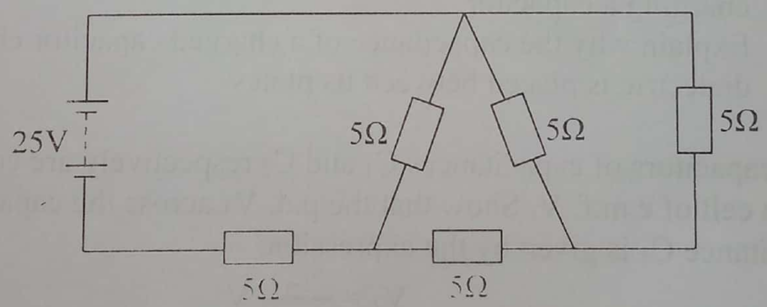


Fig. 5

Calculate the power dissipated in the battery. (5 marks)

(c) (i) Define **temperature coefficient of resistance** and state its S.I unit. (2 marks)

(ii) Explain why semiconductors have negative temperature coefficient of resistance. (2 marks)

(d) (i) Describe an experiment to determine temperature coefficient of resistance of a metal wire using a metre bridge. (5 marks)

(ii) State any **two** precautions that must be taken when carrying out the experiment in (d) (i) above. (2 marks)

Turn Over

9. (a) (i) Define the terms **electric field intensity** and **electric potential** at point. (2 marks)

(ii) Sketch graphs showing variation of electric potential and electric field intensity with distance from the centre of a charged conducting sphere. (2 marks)

(b) The figure 6 below shows two charges Q_1 and Q_2 of $+4.0\ \mu C$ and $-10\ \mu C$ respectively placed at two opposite corners of a rectangle of sides 10 cm and 5 cm.

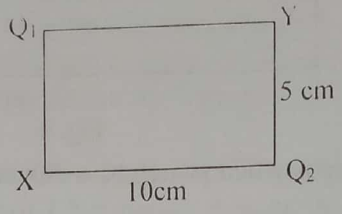


Fig. 6

Calculate the:

(i) electric potential at X. (4 marks)

(ii) electric field intensity at X. (4 marks)

(c) With the aid of a labelled diagram, describe the structure and mode of action of the Van de Graaf generator. (6 marks)

(d) Explain why the electric field intensity close to the surface of a charged conductor is always at right angles to the surface of the conductor. (2 marks)

10. (a) Define the **farad**. 1 mark)

(b) (i) Describe briefly the energy transformations that take place when charging a capacitor. (2 marks)

(ii) Explain why the capacitance of a charged capacitor changes when a dielectric is placed between its plates. (4 marks)

(c) Two capacitors of capacitances C_1 and C_2 respectively are connected in series with a cell of e.m.f. V. Show that the p.d. V_1 across the capacitance of capacitance C_1 is given by the expression:

$$V_1 = \frac{C_2}{C_1 + C_2} V$$ (4 marks)

(d) Two capacitors of capacitance $4\ \mu F$ and $2\ \mu F$ respectively are joined in series with a battery of e.m.f. 120 V. The connections are then broken and the like terminals of the capacitors are joined together. Find the final charge of each capacitor. (5 marks)

(e) Describe how the unknown capacitance of a capacitor can be determined by using a ballistic galvanometer. (4 marks)

END