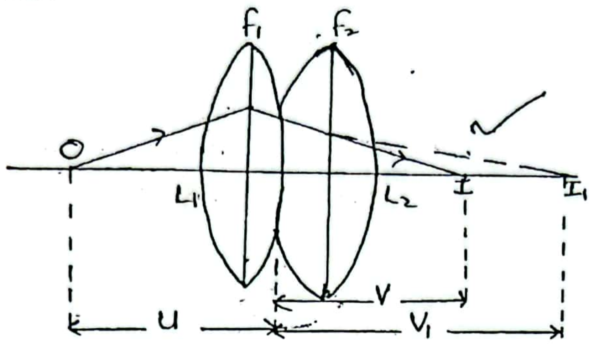
L against $\frac{1}{f}$. f and $\frac{1}{c}$.

WAKISSHA JOINT MOCK EXAMINATIONS
MARKING GUIDE
Uganda Advanced Certificate of Education
PHYSICS P510/2
July/August 2023

1. (a) (i) Focal length is the distance from the optical center to the principle focus of a lens. 01 **(01 mark)**

(ii)



Action of L_1

$\frac{1}{u} + \frac{1}{V_1} = \frac{1}{f_1}$ -- (i)

Action of L_2

$\frac{1}{v} - \frac{1}{V} = \frac{1}{f_2}$ -- (ii)

(i) + (ii)

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

But $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ where f is the combined focal length

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

(04 marks)

(iii) Power $= \frac{1}{focal\ length\ in\ metres}$

$= f_1 = \frac{1}{12.5} = 0.08\text{m or } 8.0\text{cm}$

$f_2 = \frac{1}{-2.5} = -0.4\text{m or} -40\text{ cm}$

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{8} - \frac{1}{40} = \frac{1}{10}$

F = 10cm

But $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} = \frac{1}{10} = \frac{1}{15} + \frac{1}{v}$

$\frac{1}{v} = \frac{1}{10} - \frac{1}{15} = \frac{1}{30} = V = 30cm$

(03 marks)

(b) (i) Refractive index of the medium is the ratio of Sine of angle of incidence to Sine of angle of refraction for light moving from vacuum /air to the medium.

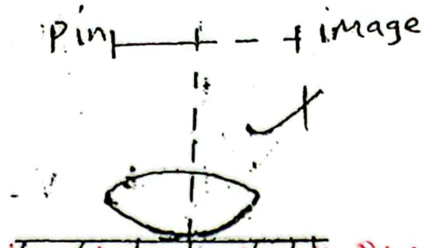
OR

Ratio of velocity of light in vaccum to the velocity of light in the medium.

(01 mark)

(ii)

If diagram is not there, transfer the marks



The convex lens is placed on the plane mirror with its reflecting surface upwards

The convex lens is placed on a retort stand with its tip along the principal axis of the lens. The pin is moved up and down to locate the position where the pin coincides with its image using no parallax method. The distance F_1 of the pin from the lens is measured.

The lens is removed and a small quantity of the specimen liquid is placed on the plane mirror. The convex lens is placed back on top of the liquid and the new position where the pin coincides with its image is located. The distance, f_2 of the pin from the lens is measured. f_2 is the combined focal length of the lens and the liquid. Let the focal length of the liquid lens be f_L.

$\frac{1}{f_l} = \frac{1}{f_2} - \frac{1}{f_1}$ but $\frac{1}{f_l} = (n-1)\frac{1}{r}$

The refractive index of the liquid

$n = \frac{r}{f_2} + 1$ or $n = \frac{-r}{f_2} + 1$ (if r is the radius of curvature of the liquid lens)

(05 marks)

(c) Magnifying power is the ratio of angle subtended by the final image at the eye when using the optical instrument to the angle subtended by the object at the unaided eye. (01 mark)

(d) (i) Action of the objective

$\frac{1}{V_0} = \frac{1}{f_0} - \frac{1}{\mu_0}$

$= \frac{1}{1} - \frac{1}{1.1}$

$V_o = 11.0$ cm

Action of the eye piece

$\frac{1}{u_e} = \frac{1}{f_e} - \frac{1}{V_e} = \frac{1}{5} - \frac{1}{-30}$

$u_e = 4.3\ cm$

Lens separation

$= U_e + V_o$

$= 4.3 + 11.0$

$= 15.3$cm

(02 marks)

(ii) $m = \left(\frac{v_e}{f_e} - 1\right)\left(\frac{v_o}{f_o} - 1\right)\frac{D}{V_e}$

$= \left(\frac{-30}{5} - 1\right)\left(\frac{11}{1.0} - 1\right)\left(\frac{25}{-30}\right)$

$= 58.3$

(03 marks)

OR

$M = \frac{h_1}{u_e} . \frac{D}{h} = \left(\frac{h_1}{h}\right)\frac{D}{u_e} = \left(\frac{V_0}{f_0} - 1\right)\frac{D}{\mu_e}$

$= \left(\frac{11}{1.0} - 1\right)\frac{25}{4.3}$

$= 58.1$

TOTAL = 20 Marks

bending

2. (a) (i) Refraction is the change in direction of light as it travels from one medium into another. **(01 mark)**

(ii) Critical angle is the angle of incidence in the dense medium for which the angle of refraction in the less dense medium is 90^0

(b) Two glass slides are cemented together to form an air cell and viewed from the opposite side. The air cell is dipped into water in a parallel sided transparent vessel.

A narrow beam of monochromatic light is directed onto the air cell and viewed from the opposite side. The cell is then turned in one direction until light just disappears. This position is noted. The air cell is then turned in opposite direction until light just disappears again. This position is noted. the angle between the two positions, θ is measured.

The critical angle C $= {}^{\theta}/_{2}$ **(05 marks)**

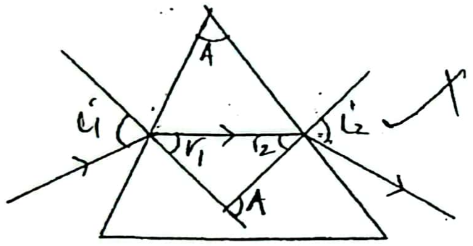
(c) Let t_1 and t_2 be the thicknesses of water and glass respectively. Then total displacement.

$d = t_1\left(1 - \frac{1}{nw}\right) + t_2\left(1 - \frac{1}{ng}\right)$

$0.5 = 0.8\left(1 - \frac{1}{1.33}\right) + t_2\left(1 - \frac{1}{1.5}\right)$

$t_2 = 0.91$ cm **(04 marks)**

(d)



At minimum deviation

$l_1 = l_2 = l$

$r_1 = r_2 = r$

$D = 2l - 2r$

$r = {}^{A}/_{2}$

$D = 2l - A$

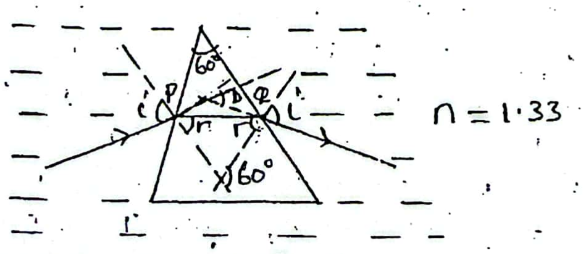
$i = \frac{D+A}{2}$

$n = \frac{\sin l}{\sin r}$

$n = \frac{\sin\left(\frac{D+A}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

(04 marks)

(e) (i)



Using n sin I = constant at P

1.33 sin I = 1.60 sin r

but $2r = 60^0 = r = 30^0$

$1.33 \sin I = 1.60 \sin 30^0$

$I = \sin^{-1}\left(\frac{1.60 \sin 30^0}{1.33}\right)$

$= 37^0$ **(03 marks)**

(ii) $D = 2I - A$

$= (2 \times 37) - 60$

$= 74 - 60$

$= 14^0$ **(02 marks)**

TOTAL = 20 MARKS

3. (a) (i) Amplitude is the maximum displacement of a wave particle from its equilibrium / rest position. **(01 mark)**

- Frequency is the number cycles / oscillations made in one second. **(01 mark)**
- Wave length is the distance between two successive crests or troughs. **(01 mark)**

OR

Distance between two successive wave particles vibrating in phase.

(ii) Speed $= \frac{Distance}{time}$

Wave speed $= \frac{Wave\ length}{Periodic\ time}$

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

$= \lambda \times \frac{1}{T}$

But $\frac{1}{T} = f$

$V = f\lambda$

(b) (i) compare $y = 3\cos\left(\pi t - \frac{\pi x}{10}\right)$

with $y = a\cos\left(2\pi ft - \frac{2\pi x}{\lambda}\right)$

$\rightarrow 2\pi ft \Leftrightarrow \pi t$ $\quad 2f = 1 \quad f = \frac{1}{2} = 0.5 H_z$

$\frac{2\pi x}{\lambda} = \frac{\pi x}{10} \rightarrow \frac{2}{\lambda} = \frac{1}{10}$

$\lambda = 2 \times 10 = 20$ m

$V = fx = 0.5 \times 20 = 10ms^{-1}$ **(03 marks)**

(ii) $V_{max} = WA = 2\pi FA$

$= 2 \times 3.14 \times 0.5 \times 3$

$= 9.42ms^{-1}$ **(02 marks)**

(c) (i) Resonance is the vibration of a body at its natural frequency due to impulses received from a nearby source vibrating with the same frequency. **(01 mark)**

(ii) A sounding tuning fork of frequency, f is held near the mouth of the tube filled with water. The level of the water is gradually lowered until a loud sound is heard.

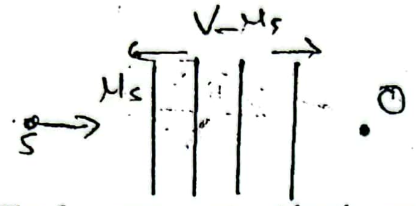
The length, L of the air column in the tube is measured and recorded. The procedure is repeated using tuning forks of different frequencies, f. The results are recorded in a table including values of $\frac{1}{f}$. A graph of L against $\frac{1}{f}$ is plotted.

The intercept, C on the L – axis is noted and is equal to the end correction of the resonance tube.

(04 marks)

(d) (i) Doppler effect is the apparent change in the frequency of a wave due to relative motion between the source and the observer. **(01 mark)**

(ii)



The f – waves sent out by the source occupy a distance V - μ_s.

The apparent wave length $\lambda_a = \frac{v-\mu_s}{f}$

Velocity of waves relative to the observer is V

Apparent frequency $f^1 = \frac{v}{\lambda_a} = \frac{V}{\frac{v-u_s}{f}} = \left(\frac{v}{v-u_s}\right) f$ **(03 marks)**

TOTAL = 20 MARKS

4. (a) (i)
- The two sources must be coherent. i.e. they have a constant phase relationship

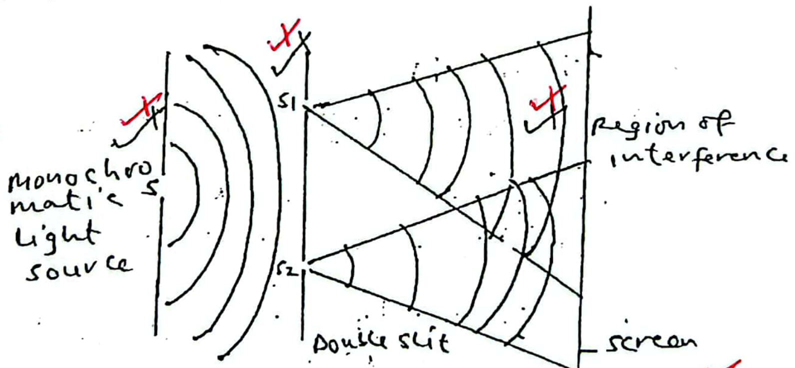
  first two correct

  (OR the sources must have the same frequency and wave length).
- The sources must be close to each other.
- The sources should be narrow.
- The sources should travel in the same region.

(Any two correct) **(02 marks)**

(ii)

- Lloyd's mirror
- Fresnel's bi-prism expt.



S, S_1 and S_2 are narrow slits which are parallel to each other. S diffracts light that falls on it and so illuminates both S_1 and S_2. Diffraction also takes place at S_1 and S_2 and interference occurs in the region when the light from S_1 and S_2 comes (must) from the same wave front as that which emerges from S. Thus S_1 and S_2 are coherent.

(b) Distance of the n^th bright fringe from the central fringe **(04 marks)**

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

For the 9^th bright fringe

$y = 9\frac{\lambda D}{a}$ .... (i)

The distance of the n^{th} dark fringe from the central fringe

$y^1 = \left(n - \frac{1}{2}\right)\frac{\lambda D}{a}$

For the 2^{nd} dark fringe from the central fringe

$y^1 = (2 - \frac{1}{2})\frac{\lambda D}{a}$

$= \frac{3\lambda D}{2a}$ .... (ii)

From (i) and (ii)

$$y_a - y_{\frac{1}{2}}^{1} = \frac{9\lambda D}{a} - \frac{3\lambda D}{2a} = 15\frac{\lambda D}{2a}$$

$$y_a - y_{\frac{1}{2}}^{1} = 8.84x10^{-2}$$

$$= 15\frac{\lambda D}{2a} = 8.84 \ x \ 10^{-2}$$

$$\lambda = \frac{8.84 \ x \ 10^{-2} \ x \ 2 \ x \ 0.5 \ x \ 10^{-3}}{15 \ x \ 1}$$

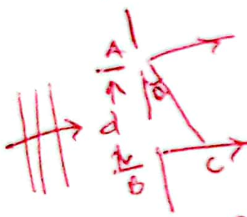
$= 5.59 \times 10^{-6}$m **($3^1/_2$marks)**

Incident light of wavelength λ?

(c) (i) Diffraction of light is the spreading of light around an obstacle in the geometrical shadow leading to interference. **(01 mark)**

(ii) d $\sin\theta = n\lambda$

θ is the angle of diffraction and n is an integer or order of diffraction. **(03 marks)**



from ΔABC, $\sin\theta = \frac{BC}{AB}$

$\sin\theta = \frac{BC}{d}$

$BC = d\sin\theta$

For occurance of diffraction maxima (constructive interference) the path difference should be an integral multiple of the full wave length

i.e $BC = n\lambda$

$\Rightarrow d\sin\theta = n\lambda$

(d) (i) $d = \frac{1}{N} = \frac{1}{500 \ x \ 1000} = 2.0 \ x \ 10^{-6}m$

From d $\sin\theta$ = nx $\quad \sin\theta = \frac{n\lambda}{d} = \frac{2 \ x \ 5.8 \ x \ 10^{-7}}{2.0 \ x \ 10^{-6}}$

$\theta = 35.5^0$ **(03 marks)**

(ii) n is maximum when $\theta = \cancel{35.5^0}$ 90°

d = n_{max} $\longrightarrow$ $n_{max} = \frac{d}{\lambda} = \frac{2 \ x \ 10^{-6}}{5.8 \ x \ 10^{-7}} = 3.4$ **(02 marks)**

$n_{max} = 3$

TOTAL = 20 MARKS

5. (a) Magnetic moment is the torque experienced by a coil carrying current per tesla of magnetic field acting along parallel the plane of the coil. **(01 mark)**

or It is the product of number of turns area and current in the coil.

(b) (i) m = NIA = $20\pi \ x \ (4 \ x \ 10^{-2})^2 x \ 2 = 0.2 \ Am^2$ **(02 mark)**

(ii) T = mBsinθ = $0.2 \ x \ 5 \ x \ 10^{-2} \ x \ Sin \ 30$

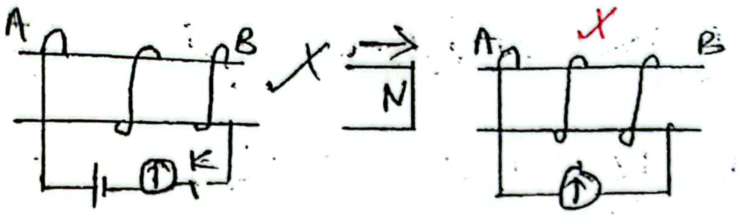
= 5.0×10^{-3}Nm **(03 marks)**

OR

T = mBcos60 = 0.2 x 5 x 10^{-2} cos 60 = 5.0 x 10^{-3}Nm.

(c) (i) The direction of the induced e.m.f is such as to oppose the change causing it. **(01 mark)**

(ii)



Switch K is closed. The direction of the galvanometer for which current flows at end A is noted.
The battery is then disconnected from the circuit containing the coil and the switch is made complete.

A strong magnet is brought towards the coil with North Pole facing end A. The galvanometer deflects in a direction for which the side of the coil facing the magnet is the North Pole.

The magnet is moved away from the coil and the galvanometer deflects in the opposite direction implying that the pole of the coil near the magnet is the South Pole.

In the first case the pole due to the induced current was repelling the approaching magnet while in the second case, the pole was attracting the receding magnet.

The induced current therefore is in such a direction as to oppose the change causing it which is Lenz's law.

(05 marks)

(d) (i) Magnetic flux density is the force acting on a conductor of 1m length carrying current of one ampere in a direction perpendicular to the magnetic field. **(01 mark)**

- Unit is Tesla. **(01 mark)**

(ii) Consider a coil of N turns each linked by a magnetic flux of $\emptyset_1$ that changes to $\emptyset_2$.
The emf induced is given by

$E = -N\frac{d\emptyset}{dt}$ $\qquad\qquad$ $I = \frac{E}{R}$

Where R is the resistance of the coil.

But E = IR $\longrightarrow$ $IR = -N\frac{d\emptyset}{dt}$

$\longrightarrow \quad I = \frac{d\emptyset}{dt}$

$\therefore \frac{d\emptyset}{dt} = \frac{-N}{R}\frac{d\emptyset}{dt} \longrightarrow dq = \frac{-Nd\emptyset}{R}$

$(\emptyset_2 - \emptyset_1)$

$Q = \frac{-N}{R}\int_{\emptyset_1}^{\emptyset_2} d\emptyset = \frac{-N}{R}(\emptyset_1 - \emptyset_2)$

$(\emptyset_1 - \emptyset_2)$

$\therefore Q = \frac{N}{R}(\emptyset_2 - \emptyset_1)$

$Q = \frac{\text{total flux}}{\text{resistance}}$

(06 marks)

<u>TOTAL = 20 MARKS</u>

(01 marks)

6. (a) (i) $F = Bqu\sin\beta$

(ii) $F = Bqu\sin\beta$

But drift velocity $U = \frac{I}{neA}$

Total charge flowing per second through the conductor is

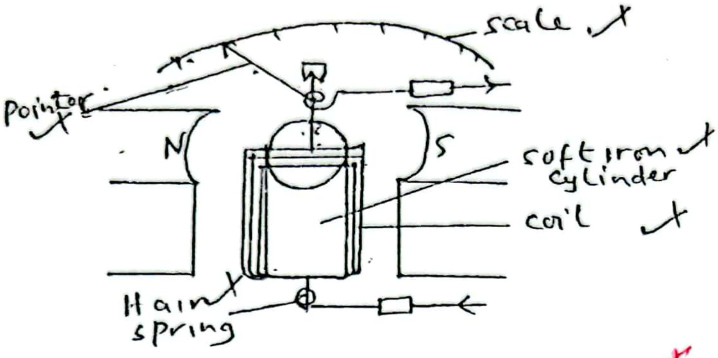
$Q = neAl$

$\therefore F = B \times neAl \times \frac{I}{neA}\sin\beta$

$F = BIl\sin\beta$

(03 marks)

(b) (i)



Current to be measured is passed through the coil.

The coil experiences a magnetic torque

$\tau = BANI$ and rotates

This causes the hair springs to twist this developing an opposing torque

$T = K\theta$ where θ is the angle of turn.

The rotation stops where $K\theta = BANI$.

Thus $\theta = \frac{NBA}{K}.I$ since N, B,A and K are constant, hence $\theta \propto I$

Any five each ½

(05 marks)

(ii) Current sensitivity, $Q/_I = \frac{BAN}{K}$

Current sensitivity is large for: - large magnetic flux density B_1 large area of the coil, A and small tortional constant, K of the hair spring.

(03 marks)

(c) (i) $\emptyset = BA$ but $A = \pi r^2$

$\emptyset = B\pi r^2 = 0.25 \times 3.14 \times (0.05)^2$

$\emptyset = B\pi r^2 = 1.96 \times 10^{-3} Wb$

(03 marks)

(ii) $E = B\pi r^2 f$

$= 0.25 \times 3.14 \times (0.05)^2 \times 15$

$E = 2.9 \times 10^{-2}$

(02 marks)

(d) Any two

- Type of core
- Resistivity of wires used to make primary and secondary coils.
- Coupling between primary and secondary coils
- Design of the core

(02 marks)

TOTAL = 20 MARKS

7. (a) Root mean square value is the value of the steady / direct current which dissipates heat in a given resistor at the same rate as the alternating current.

(01 mark)

(b) (i) Compare $V = 40 \sin 160\pi t$

With $V = V_o \sin 2\pi f t$

$2f = 160$ and $f = \frac{160}{2}$

$F = 80$ Hz

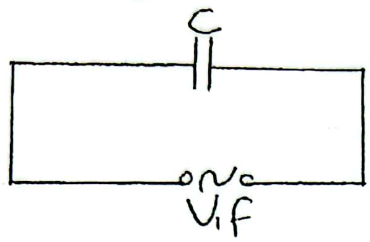
(01 mark)

(ii) $\langle P \rangle = \frac{V_o^2}{2R} = \frac{40 \times 40}{2 \times 200}$

$= 4$ W

(03 marks)

(c)



Let the p.d a cross the capacitor at time t be $V = V_o \sin 2\pi f t$

The instantaneous charge on the capacitor

$Q = CV = CV_o \sin 2\pi f t$

Where C is the capacitance of the capacitor.

The instantaneous current flowing through the capacitor.

$I = \frac{dQ}{dt}$

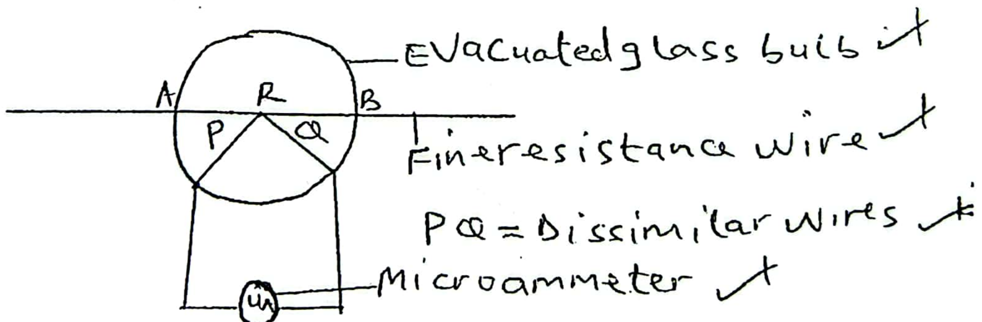
$= \frac{d\,(CV_O \sin 2\pi f t)}{dt}$

$I = 2\pi f C V_0 \sin(2\pi f t + {}^{\pi}/_{2})$

Hence current leads voltage by ${}^{\pi}/_{2}$ radians $= 90^0$

(04 marks)

(d)



Current to be measured is passed through the wire AB and heats the junction R of the thermo couple.

The thermo electric effect generated at R causes a direct current to flow through the micrometer calibrated to measure the r.m.s value of the current.

(04 marks)

(e) Resonance is when the impedance in L – C – R circuit is minimum and the current flowing in the circuit is maximum.

(01 mark)

- When $V_c = V_L$ in a LCR circuit.
- When X_C and X_L cancel in an L-C-R circuit.

(f) (i) Resonant frequency

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{0.8 \times 0.8 \times 10^{-6}}}$$

$$= 198.94 \text{ Hz}$$

(03 marks)

(ii) Voltage a cross the capacitor

$V_c = IX_c$ $X_c = \frac{1}{\omega L}$

$= I \times \frac{1}{2\pi f c}$

$Z = \sqrt{(X_l - X_c)^2 + R^2} = 20\Omega$

But $I = \frac{V}{Z} = \frac{V}{R} = \frac{0.02}{20} = 0.001$ A

$V_C = \frac{0.001}{2\pi \times 198.94 \times 0.8 \times 10^{-6}}$

p.d $= 1.0$ V

(03 marks)

TOTAL = 20 MARKS

8. (a) (i)
- Electric Potential is the work done to move 1 C of positive charge from infinity to that point in an electrostatic field. against electrostatic forces
- Electric field intensity at a point is the force acting on 1 C of positive charge in an electric field.

(02 marks)

(ii) Force on 1 c of charge

$F = \frac{Q}{4\pi\epsilon X^2}$

Work done to move the charge through ΔX aginst the field $\Delta W = -F\Delta X$

Total work done to bring the charge from infinity to a point, a distance r from the charge Q,

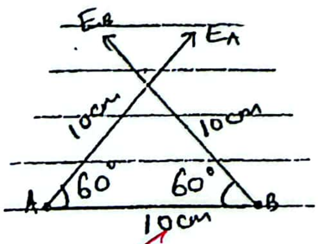
$W = \int_{\infty}^{r} -F dx = \int_{\infty}^{r} \frac{-Q}{4\pi\epsilon X^2} dx$

$W = \frac{-Q}{4\pi\epsilon}\left[\frac{-1}{x}\right]_{\infty}^{r}$

$W = \frac{Q}{4\pi\epsilon R}$

(03 marks)

(b) (i)



$E = \frac{KQ}{r^2} \longrightarrow E_A = \frac{9 \times 10^9 \times 1 \times 10^{-5}}{(0.1)^2} = 9 \times 10^6\ NC^{-1}$

$E_B = \frac{9 \times 10^9 \times 1 \times 10^{-5}}{(0.1)^2} = 9 \times 10^6\ NC^{-1}$

Horizontal component $E_H = E_A\cos 60 - E_B\cos 60 = 0$

Vertical component $E_V = 2 \times 9 \times {}^6 \sin 60^0 = 15.59 \times 6NC$

$\therefore E_R = 15.59 \times 10^6 NC^{-1}$ (Vertically upwards)

(05 marks)

(ii) $V = \frac{KQ}{r} \longrightarrow V_A = \frac{9 \times 10^9 \times 1 \times 10^{-5}}{0.1}$

$= 9 \times 10^5$ V

$V_B = \frac{9 \times 10^9 \times 1 \times 10^{-5}}{0.1} = 9 \times 10^5 V$

$V_R = V_A + V_B$

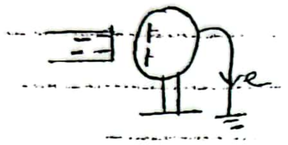
$= 9 \times 10^5 + 9 \times 10^5 = 18 \times 10^5 = 1.8 \times 10^6$V

(03 marks)

(c)
- Two dissimilar dielectrics are rubbed together.
- They are lowered one at a time into a metal can resting on the cap of a neutral gold leaf electroscope in each case the leaf is seen to diverge showing that the materials are charged.
- The two materials are put together and lowered into the cane placed on the cap of a neutral gold leaf electroscope.
- - No divergence is observed implying that the resultant charge is zero. Hence when two bodies are rubbed together, they acquire equal but opposite charges.

(04 marks)

(d)



A negatively charged rod is brought close to a conducting sphere which is earthed. Electrons are driven from the sphere to the earth: leaving the sphere positively charged

But it is at zero potential since it is earthed.

(03 marks)

<u>TOTAL = 20 MARKS</u>

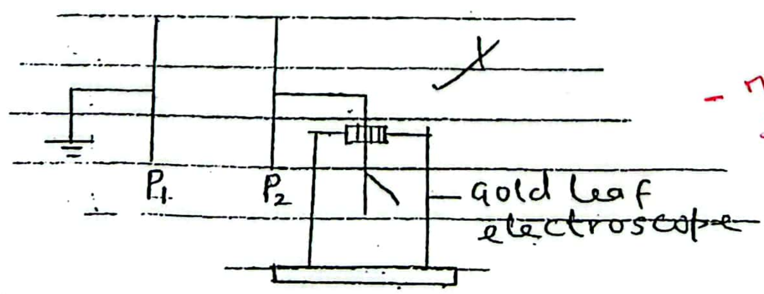
9. (a) (i) Capacitance of the capacitor is the ratio of the magnitude of charge on the either plates of the capacitor to the potential difference a cross the capacitor plates. **(01 mark)**

(ii) Dielectric strength is the maximum electric field intensity a dielectric / insulator can with stand without conducting.

OR

Maximum Potential gradient / electrical field intensity a dielectric can with stand without its insulation breaking down.

(b)



- neutral gold leaf electroscope

Close

Two metal plates P_1 and P_2 are set close to each other but no touching as shown above plate P_2 is given a charge Q and the divergence of the leaf is noted. A sheet of a dielectric material is placed between P_1 and P_2.

The divergence of leaf of the electroscope is observed to decrease implying that the p.d between the plates has decreased. This means that capacitance has increased since $C = {}^{Q}/_{V}$ and Q is constant. Hence a dielectric material between the plates of the capacitor increases its capacitance, i.e. $C \propto \in$ where $\in$ is the permittivity of the material between the capacitor plates.

(04 marks)

(c) $Q = CV$

$= \frac{\epsilon_0 AV}{d}$

$= \frac{8.85 \times 10^{-12} \times 5 \times 10^{-4} \times 6}{2 \times 10^{-3}}$

$= 1.33 \times 10^{-11} C$ **(03 marks)**

(d) (i) Initial charge

$Q = C_1V_1 = 60 \times {}^{-6} \times 120$

$= 72 \times 10{=}{-4}$

Final charge $= (C_1 + C_2)\, V$

$= (60 + 40) \times 10^{-6}\, V$

But initial charge = Final charge

$100 \times 10^{-6}\, V \quad = 72 \times 10^{-4}$

$V \quad = \frac{72 \times 10^{-4}}{100 \times 10^{-6}}$

$= 72\ V$ **(03 marks)**

(ii) Initial energy stored

$= \frac{1}{2} C_1 V_1^2$

$= \frac{1}{2} x\ 60\ x\ 10^{-6}\ x\ (120)^2$

$= 0.432\ J$

Final energy stored

$= \frac{1}{2} \times 100 \times 10^{-6} \times (72)^2$

$= 0.259\ J$

Energy difference

$= 0.432 - 0.259$

$= 0.173\ J$

The energy difference is due to energy lost as heat in the connecting wires.

(05 marks)

(e) On a pointed charged conductor there is high charge density at the sharp point. The electric field intensity there is therefore very high. This causes air molecules around the sharp point to get ionized, creating positive and negative ions. The charge similar to that on the conductor is repelled while the opposite is attracted to the sharp point and neutralizes some of the charge on the conductor.

(03 marks)

TOTAL = 20 MARKS

10. (a) (i) E.m.f of a battery is the energy supplied by the battery to transfer 1 C of the charge around a complete circuit which includes the battery.

work done

(01 mark)

OR

It is the potential difference a cross the terminals of a battery when it is not delivering current. || open circuit

(ii) Internal resistance is the opposition to the flow of current due to the chemical composition of the battery.

(01 mark)

(b) $P = I^2R$ But $I = \frac{E}{R+r}$

$\therefore P = \frac{E^2R}{(R+r)^2}$

$$\frac{dP}{dR} = \frac{E^2\,(r+R)^2 - E^2\,R\,[2(R+r)]}{(R+r)^4}$$

For maximum power

$$\frac{dP}{dR} = 0$$

$$\therefore \frac{E^2\,(r+R)^2 - 2E^2R(R+r)}{(R+r)^4} = 0$$

$\longrightarrow$ R = r

$\therefore Pmax = \frac{E^2}{4r}$ **(04 marks)**

(c) (i) Temperature co-efficient of resistance is the fractional change in resistance at 0^0C to every degree Celsius rise in temperature.
Unit is K^{-1}

(02 marks)

(ii) The resistance of the metal increases with temperature. When the temperature increases the atoms of the metal vibrate with increased amplitude. Thus reducing the mean free path for the conduction electrons charge flow per second (current) is reduced. This implies that the resistance has increased. Hence the fractional change in resistance is positive.

(03 marks)

(iii) From $R = \frac{V}{I}$ $\longrightarrow$ $R = \frac{240}{4} = 60\Omega$

But $R\theta = Ro\,(1 + \propto \theta)$

$52 = Ro\,(1 + 20 \times 2.0 \times 10^{-4})$

$52 = 1.004\ Ro$

$Ro = \frac{52}{1.004} = 51.79\Omega$

$60 = 51.79\,(1 + 2 \times 10^{-4}\theta)$

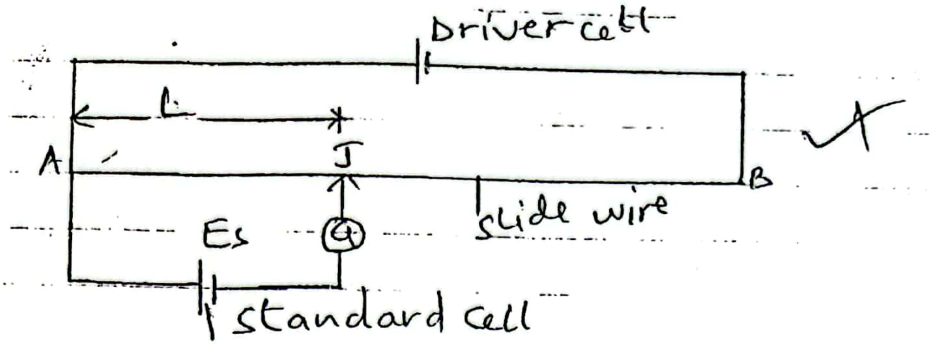
$\frac{60}{51.79} - 1 = 2 \times 10^{-4}\theta$

$0.1585 = 2 \times 10^{-4}\theta$

$\theta = \frac{0.1585}{2 \times 10^{-4}} = 792.5^0C$

(05 marks)

(d)



A cell of known e.m.f E_s is connected in the circuit as shown above.
The sliding contact / Jockey is tapped at different points along the slide wire until a point is found where the galvanometer shows no deflection. The balance length, L is measured. At balance p.d a cross AJ = E.m.f E_s
$E_s = KL$ where K is the p.d per unit length (calibration constant)

(02 marks)

The constant, K is then obtained from the expression $K = \frac{E_s}{l}$ **(01 mark)**

(e) $r = R\left(\frac{L_1}{L_2} - 1\right)$

$= 20\left(\frac{85}{80} - 1\right)$

$= 1.25\Omega$

(03 marks)

<u>TOTAL = 20 MARKS</u>

END