TANZANIA HEADS OF ISLAMIC SCHOOL COUNCIL

FORM SIX INTER ISLAMIC MOCK EXAMINATION

PHYSICS - 1

WK

MODERATED

PROPOSED MARKING GUIDE - 2024

1 (a) (i) This is due to fact that there is uncertainity associated with every measurement (Error). When giving the results of a measurement, it is good practice to state the estimated error or Uncertainity —— (02 marks)

(ii) Mean time period of pendulum is given by

$$\bar{T} = \frac{2.63 + 2.56 + 2.42 + 2.71 + 2.80}{5}$$

$$\bar{T} = \frac{13.12}{5} = 2.62 \text{ sec} \longrightarrow \text{(01 mark)}$$

This mean Value is accepted as the true Value of time period

Absolute error in each observation is given by

$2.62 - 2.63 = -0.01s$; $2.62 - 2.56 = 0.06 \text{ sec}$;

$2.62 - 2.42 = 0.20s$; $2.62 - 2.71 = -0.09s$;

$2.62 - 2.80 = -0.18s$ ⟶ (0.5 mark)

∴ Mean absolute error, $\Delta T = \frac{\sum |\Delta T|}{5}$ ⟶ (0.5 mark)

$$= \frac{0.01 + 0.06 + 0.20 + 0.09 + 0.18}{5}$$

$$\Delta T = 0.11 \text{ sec} \longrightarrow \text{(0.5 mark)}$$

$$= \frac{0.11s}{2.62s} \times 100\% = 4.2\%$$ —— (0.5 mark

1 b) i) The diameter of steel rod is somewhere within the range 56.45mm to 56.49mm. The exact value is not Known due to uncertainity when taking the measurements. —— (01 mark)

(ii) By using data given, the data points are represented by errors bars (which include error in Vertical bar and horizontal bar

→ Using error bars, three graphs (Straight lines) are drawn, the best fit line passing through the intersection of the two worst fit lines (maximum slope line and minimum Slope line) —— (0.5 mark)

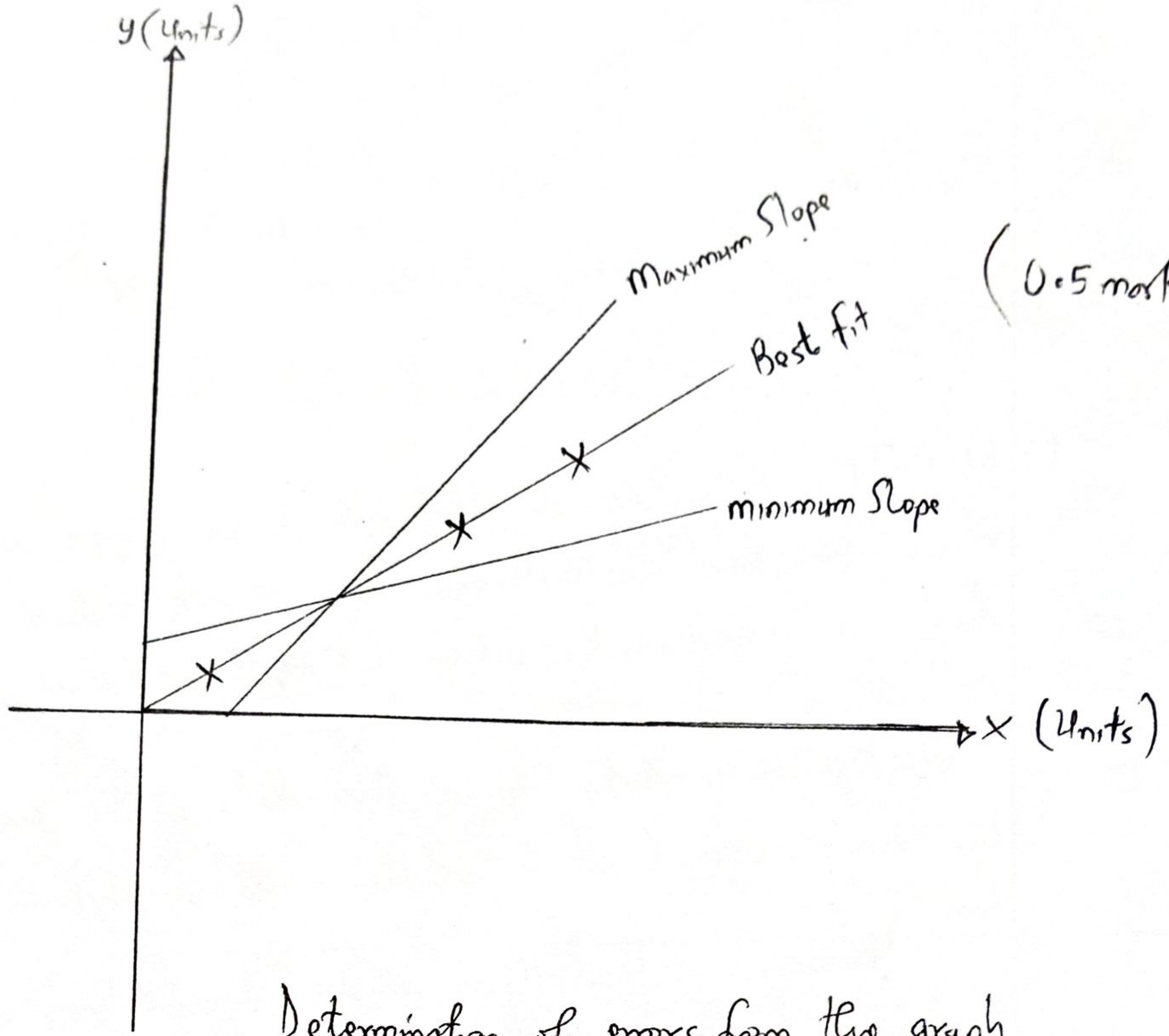
→ From the graph we can find three slopes m for the best fit, m_1 for maximum slope and m_2 for minimum slope —— (0.5 mark)

→ Errors will be as follows

$\Delta m_1 = \pm(m_1 - m)$ and $\Delta m_2 = \pm(m_2 - m)$; the mean absolute error is therefore calculated by the given formula below

$$\Delta m = \frac{\Delta m_1 + \Delta m_2}{2}$$ —— (0.5 mark)

1 b) ii) Consider a graph below



(0.5 mark)

Determination of errors from the graph

b) iii) $m = 1.0$

$m_1 = 1.16$ (0.5 mark)

$m_2 = 0.81$

From

$$\Delta m = \frac{|m_1 - m| + |m_2 - m|}{2}$$ (0.5 mark)

$$\Delta m = \frac{|1.16 - 1.0| + |0.81 - 1.0|}{2} = 0.175$$ → (01 mark)

2 a) i) This is true due to fact that both Newton first law of motion and Newton third law of motion are contained in a Newton Second law of motion —— (01 mark)

i.e Newton first law in Second law can be shown as follow

From

$$F = ma \text{ — Newton Second law of motion}$$

i.e

$$a = F/m \text{ , when } F = 0$$

$$\therefore a = \frac{0}{m} = 0\,m/s^2 \quad \text{—— (01 mark)}$$

Acceleration will be zero when body is at rest or moving in uniform motion, and this is Newton's first law of motion

- And also case of Newton third law in Newton Second law

If F_{12} is the action force and F_{21} is the reaction force

From Newton Second law

$$F = \frac{\Delta P}{t}$$

$$\therefore F_{12} = \frac{\Delta P_2}{t}, \text{ then } tF_{12} = \Delta P_2 \text{ and } tF_{21} = \Delta P_1$$

0.5 mark

$$\text{Total momentum} = \Delta P_1 + \Delta P_2 \text{ —— (i)}$$

If momentum is Conserved

$$\text{Total momentum} = tF_{12} + tF_{21} = 0 \text{ —— (ii)}$$

$$\therefore F_{12} = -F_{21} \text{ ——} \rightarrow \text{ 0.5 mark}$$

and this is Newton's third law of motion

2 a) ii) Recall

Thrust of the engine = Rate of change of linear momentum

$\therefore$

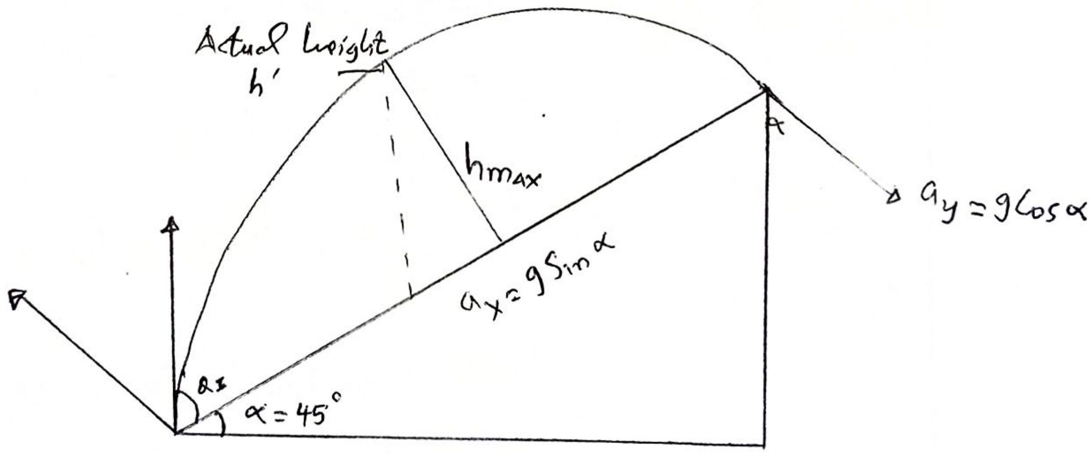
$$\text{Thrust} = \frac{\left[(m_f + m_a)V_o - m_a V_i\right]}{t}$$ —— (01 mark)

$\therefore$ Thrust = $(0.8 + 40)600 - (40 \times 100)$

$= 20480N$

$\therefore$ Thrust of the engine = 20480N —— (01 mark)

2 b) Consider an illustration below



i) Time of flight

$$T = \frac{2U\sin(\theta - \alpha)}{g\cos\alpha}$$ —— (0.5 mark)

Where $\theta = 75°$, $\alpha = 45°$, $U = 20m/s$

2 b) i) $T = \frac{2 \times (20) \times \sin(75^\circ - 45^\circ)}{9.8 \times \cos 45^\circ}$ —— 0.5 mark

Time of flight = 2.886 sec

ii) Case of range of a projectile

$Range = \frac{u^2}{g\cos^2\alpha}\left(\sin(2\theta - \alpha) - \sin\alpha\right)$ —— (01 mark)

$\therefore Range = \frac{(20)^2}{9.8 \times \cos^2 45^\circ} \times \left[\sin((2\times75^\circ) - 45^\circ) - \sin 45^\circ\right]$

Range = 21.13 m —— (01 mark)

iii) Case of maximum height (h_{max})

From

$h_{max} = V_{oy}t + \frac{1}{2}a_y t^2$ —— (0.5 mark)

but

$V_{oy} = V_o \sin 30^\circ$

then

t = Time of maximum height = $\frac{1}{2}$ × Time of flight

$\therefore t = \frac{1}{2} \times 2.886$ sec (0.5 mark)

Time of maximum height, $t = 1.443$ sec

2 b) iii) Then $a_y = -g\cos\alpha$

$\therefore$

$$h_{max} = (20\sin 30^\circ)t - \frac{1}{2}(g\cos 45^\circ)t^2$$

$$\therefore = 20\sin 30^\circ \times 1.443 - \frac{1}{2}(9.8 \times \cos 45^\circ)(1.443)^2$$

$$h_{max} = 7.2m$$ —— (0.5 mark)

And also

Case of actual maximum height (h'_{max})

$$\cos 45^\circ = \frac{h_{max}}{h'_{max}}$$

$$\therefore h'_{max} = \frac{h_{max}}{\cos 45^\circ} = \frac{7.2m}{\cos 45^\circ}$$

$$h'_{max} = 10.2m$$ (0.5 mark)

$\therefore$ A required actual maximum height $= 10.2m$

3 a) i) It is because at the highest point of the Vertical loop, the weight of the pilot is used up in providing the centripetal force, as the results the pilot does not fall. (01 mark

(ii) On the wet road, the friction between the tyres and the road is reduced. Therefore, necessary centripetal force is not provided. (01 mark)

(iii) Because there is no centripetal force to hold the passenger in the circular motion (01 mark)

b) Given data

Frequency, $f = 5.0Hz$

Amplitude, $a = 30mm / 0.030m$

$\omega = 2\pi f$

$\therefore \omega = 2\pi \times 5 = 10\pi \, rad/s$ —— (01 mark)

i) At the extremities of the motion

$y = 0.030m$

From

$a = -\omega^2 y$

At the top of the motion y is positive, so $y = {}^+0.03m$

$\therefore a = -\left(10\pi \, rad/s\right)^2 \times {}^+0.030m$

$acc^n = {}^-29.61 \, m/s^2$ —— (01 mark)

i.e. Acceleration is negative (downward) while its displacement is positive (upward)

3 b) i) At the bottom of the Oscillation, $y = -0.030m$

From

$$a = -\omega^2 y$$

$\therefore$ Acceleration $= -\left(10\pi \, rad/s\right)^2 \times (-0.030m)$

$= +29.61 m/s^2$ ——— (01 mark)

i.e Acceleration is positive (upward) while displacement is negative (downward)

b) ii) At the Centre of motion

i.e At the Centre, $y = 0$ ——— (01 mark)

From

$$a = -\omega^2 y$$

$\therefore$ $a = -\left(10\pi \, rad/s\right)^2 \times 0m$

$a = 0 m/s^2$ ——— (01 mark)

$\therefore$ At the Centre of motion, acceleration is Zero (0)

iii) At the point midway between the Centre and the extremities

→ At positive half way upward, $y = +0.015m$

From

$$a = -\omega^2 y$$

$a = -\left(10\pi \, rad/s\right)^2 \times (+0.015m)$ ——— (01 mark)

3 b) iii) Acceleration, $a = ^{-}14.8 m/s^2$

<u>And also</u>

At the negative half way upward, $y = ^{-}0.015 m$

From

$$a = -\omega^2 y$$

$$\therefore \quad a = -\left(10\pi \, rad/s\right)^2 \times \left(^{-}0.015\right)$$

$$a = 14.8 m/s^2$$ ——— (01 mark)

$\therefore$ Acceleration, $a = ^{+}14.8 m/s^2$

4 a) i) Kepler's first law state that
"The path of each planet about the Sun is an ellipse with the Sun at one focus"

OR (01 mark)

"Each planet moves around the Sun in an elliptical path with the at one focus"

→ Kepler's Second law state that
"Each planet moves in such way that if an imaginary line is drawn from the planet to the sun sweeps out an equal area in equal period of time" (01 mark)

→ Kepler's third law state that
"The square of period of any planet is directly proportional to the cube of the planets average distance from the sun"
(01 mark)

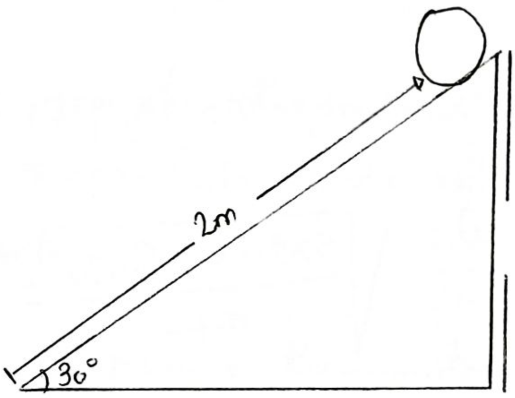
$$T^2 \propto R^3$$

4 a) (ii) The weight of the body at the centre of earth will be Zero ($g=0$). As the body is moved from the centre to the earth Surface, its weight will increase due to increase in the value of g. At the surface of the earth the weight of body will be maximum. As the body moved above the surface of the earth, its weight will decreases due to decrease in the value of g. At one place where the acceleration due to gravity of the earth and of the moon are equal and opposite, the weight will become zero (0). Beyond this up to moon, the gravitational force of the moon increase hence, the weight of body will go on increasing (02 mark)

4 b) i) Radius of gyration

Is the distance from the axis of rotation to a point where moment of Inertia of body, I remains unchanged if the mass of the body is assumed to be Concentrated at that point. 01 mark

b) ii) Consider a diagram below



— (01 mark)

From the principle of Conservation of energy

$$P.E = K.E \quad \text{—— (0.5 mark)}$$

but

$$K.E = \frac{1}{2}mv^2 + \frac{1}{2}\omega^2 I$$

$$P.E = mgh, \text{ Recall } h = L\sin\alpha$$

$$\therefore P.E = mgL\sin\alpha \quad \text{—— (0.5 mark)}$$

$$mgL\sin\alpha = \frac{1}{2}m(\omega r)^2 + \frac{1}{2}\omega^2 I$$

$$mgL\sin\alpha = \frac{1}{2}\omega^2(mr^2 + I)$$

$$2mgL\sin\alpha = \omega^2(mr^2 + I) \quad \text{—— (0.5 mark)}$$

but

$$mr^2 = I$$

4 b) ii)

$$2mgL\sin\theta = \omega^2(2I)$$

$$\omega = \sqrt{\frac{2mgL\sin\theta}{2I}}$$

$$\omega = \sqrt{\frac{mgL\sin\theta}{I}} \quad \text{(0.5 mark)}$$

Given data

$I = 0.1\,Kgm^2$, $m = 5Kg$, $L = 2m$, $\theta = 30^\circ$

$$\therefore \omega = \sqrt{\frac{5 \times 9.8 \times 2 \times \sin 30^\circ}{0.1}} = 22.1\,rad/s$$

$\therefore$ required angular Velocity is $22.1\,rad/sec$ (01 mark)

5

5 a)(i) Platinum resistance thermometer —— 01 mark

It is very accuracy than all other thermometer except gas thermometer

(ii) ThermoCouple thermometer —— 01 mark

It respond quikly to varying temperature and it is suitable to measure temperature of a point

(iii) Optical pyrometer thermometer —— 01 mark

It is respond to visible radiation emmited by the filament.

(iv) Platinum resistance thermometer —— 01 mark

It is accuracy and respond quickly

b) i) On shaking a hot liquids, its temperature increases and some of liquid molecules is Converted into a vapours. The vapour pressure inside the bottle may become high enough to blow off the Corks —— 02 ma

ii) Area, $A = \pi r^2 = 3.14 \times (0.01m)^2 = 3.14 \times 10^{-4} m^2$

From

$$\frac{Q}{t} = \frac{KA(\theta_1 - \theta_2)}{X}$$ —— (01 mark)

$\therefore$ Let $\frac{Q}{t} = P$

5 b) ii) :-

$$P = \frac{KA(\theta_1 - \theta_2)}{x}$$

$$\theta_1 - \theta_2 = \frac{Px}{KA}$$ ——— (01 mark)

$$\theta_1 - \frac{Px}{KA} = \theta_2$$

Given data

$\theta_1 = 250^\circ c$

$P = 2.1 J/s$

$x = 2m$ ——— (01 mark)

$K = 380$

$A = 3.14 \times 10^{-4}$

$$\therefore \theta_2 = 250^\circ c - \left(\frac{2.1 \times 2}{380 \times 3.14 \times 10^{-4}}\right) = 214.8^\circ c$$ ——— (01 mark)

$\therefore$ A required temperature of other end is $214.8^\circ c$

6 a) i) - The process should take place at extremely slow rate (01 mark)

- The system should be free from friction and any other form of energy loss (01 mark)

(ii) From

$$\text{Work done, } W.d = nRT \ln\left(\frac{V_2}{V_1}\right) \text{ ——— (01 mark)}$$

Given data

$n = 1$, $R = 8.31$, $V_1 = 8L$ and $V_2 = 4L$

$$W.d = 1 \times 8.31 \times 320 \times \ln\left(\frac{4L}{8L}\right) \text{ ——— (01 mark)}$$

$$W.d = -1843J$$

∴ The total work done in the whole process is

$W.d = -1843J$ (01 mark)

6. b) i) As the ammonia vaporizes, it absorbs its latent heat of vaporization from the surrounding refrigerator in so doing it cools the refrigerator (02 marks)

b (ii) Initial data/states

$V_0 = 2.5 \times 10^{-3} m^3$, $P_0 = 8.5 \times 10^4 Nm^{-2}$, $T_0 = 308K$

~~End~~ Isothermal Condition $(T_1 = T_0)$

$$P_0 V_0 = P_1 V_1 \text{ ——— (0.5 mark)}$$

$$P_1 = \frac{P_0 V_0}{V_1}, \quad V_1 = 1 \times 10^{-3} m^3$$

6 b) ii) $P_1 = \frac{8.5\times10^{4} \times 2.5\times10^{-3}}{1.0\times10^{-3}}$ ———— (0.5 mark)

$P_1 = 2.125\times10^{5}\ Nm^{-2}$

Case of adiabatic expansion

$V_2 = V_0$, $\gamma = 1.67$

$P_2 = ?$

$T_2 = ?$

From

$P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$ ———— (0.5 mark)

$\therefore P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma}$

$\therefore P_2 = 2.125\times10^{5} \times \left(\frac{1.0\times10^{-3}}{2.5\times10^{-3}}\right)^{1.67}$

$\therefore P_2 = 4.6\times10^{5}\ Nm^{-2}$ ———— (0.5 mark)

From

$\frac{V_1^{1-\gamma}}{T_1} = \frac{V_2^{1-\gamma}}{T_2}$

$T_2 = T_1 \left(\frac{V_2}{V_1}\right)^{1-\gamma} = 308 \times \left(\frac{2.5\times10^{-3}}{1.0\times10^{-3}}\right)^{1-1.67}$

$T_2 = 166.7K$ ———— (01 mark)

7 a) i) - Cause global warming (any four points = 01 mark)
- Can block the atmosphere
- Once deposited on leaves they block stomata and hence no photosynthesis for plants
- Can lead to development of heart and lung disease
- Changing the timing and location and traditional rainfall patterns

ii) Ozone layer is crucial for human survive because it protects human and other living things from harmful radiations from the sun and stars which can reach the earth surface and harm human and other living organism (02 marks)

7 b) Current generated by Solar Cell is given by

$$I = I_o\left(e^{\frac{qV}{KT}} - 1\right) - I_L$$

for open circuit voltage $(I = 0)$

$$\therefore \quad 0 = I_o\left[e^{\frac{qV}{KT}} - 1\right] - I_L \quad \text{———} \quad (0.5\text{ mark})$$

$$\therefore \quad I_L = I_o\left(e^{\frac{qV}{KT}} - 1\right)$$

$$\frac{I_L}{I_o} = e^{\frac{qV}{KT}} - 1, \quad \frac{I_L}{I_o} + 1 = e^{\frac{qV}{KT}}$$

for 100% quantum efficiency, $\frac{I_L}{I_o} \ggg 1$

$$\therefore \quad \frac{I_L}{I_o} = e^{qV/KT} \quad \text{———} \quad (0.5\text{mark})$$

7 b) $\frac{I_L}{I_0} = e^{\frac{qV_{ac}}{KT}}$

$$\frac{qV_{ac}}{KT}\ln e = \ln\left(\frac{I_L}{I_0}\right)$$

$$\therefore V_{ac} = \frac{KT}{q}\ln\left(\frac{I_L}{I_0}\right)$$ — (0.5 mark)

Given data

$V = 0.67V$

$q = 1.6\times10^{-19}C$

$T = 300K$

$K = K_B = 1.38\times10^{-23}$

$$\frac{I_L}{I_0} = e^{\left(\frac{1.6\times10^{-19}\times 0.67}{1.38\times10^{-23}\times 300}\right)}$$ — (0.5 mark)

$$\frac{I_L}{I_0} = 1.75\times10^{11}$$

but

$$I_L = q\Phi$$

Then

$$I_0 = \frac{I_L}{1.75\times10^{11}} = \frac{q\Phi}{1.75\times10^{11}}$$ — (0.5 mark)

but

P = Power intercepted by the Cell

$$P = 1000\,Wm^{-2}\times 100\times10^{-4}m^2 = 10W$$

7 b) Case of frequency

i.e

$$f = c/\lambda = \frac{3.0\times10^{8} m/s}{760\times10^{-9} m} = 3.95\times10^{14} Hz$$ — (0.5mark)

Photon flux, $\Phi = \frac{P}{hf}$

$$\therefore \Phi = \frac{10W}{6.62\times10^{-34}\times 3.95\times10^{14}}$$

$$\Phi = 3.82\times10^{19} \text{ photons } s^{-1} m^{-2}$$ — (0.5mark)

Recall

$$I_o = \frac{q\Phi}{1.75\times10^{11}}$$

$$\therefore I_o = \frac{1.6\times10^{-19}\times 3.82\times10^{19}}{1.75\times10^{11}}$$

$$I_o = 3.49\times10^{-11} A$$ — (0.5mark)

$\therefore$ A required dark current is 3.49×10^{-11} A

8 a) i) Resistance matching

"Is the phenomena where by the internal resistance of a battery are matched/equal with the external resistance in a simple circuit in order to produce maximum power output (01 mark)

ii) From $P = IV$, $V = IR$

$$\therefore P = I^2R \text{ ——— (i)}$$

but

$$I = \frac{E}{r+R} \text{ ——— (ii)} \text{ ——— } (0.5\text{mark})$$

$\therefore$ Substitute eqn (ii) into eqn (i)

$$\therefore P = \left(\frac{E}{r+R}\right)^2 R = \frac{E^2R}{(r+R)^2} \text{ ——— } (0.5\text{mark})$$

Differentiate the above equation

Let $u = (r+R)^2$, $\frac{du}{dR} = 2(r+R)$

then $v = E^2R$, $\frac{dv}{dR} = E^2$

From

$$\frac{dp}{dR} = \frac{u\,dv - v\,du}{u^2} \text{ ——— } (01\text{ mark})$$

$$\therefore \frac{dp}{dR} = \frac{(r+R)^2 \cdot E^2 - E^2R\left(2[r+R]\right)}{(r+R)^4}$$

$$\frac{dp}{dR} = \frac{(r+R)\left[(r+R)E^2 - 2RE^2\right]}{(r+R)(r+R)^3}$$

8 a) ii) $\frac{dp}{dR} = \frac{(r+R)E^2 - 2RE^2}{(r+R)^3} = \frac{E^2[r+R-2R]}{(r+R)^3}$ (01 mark

$\frac{dp}{dR} = \frac{E^2(r-R)}{(r+R)^3}$, For maximum power $\frac{dp}{dR} = 0$

$\therefore 0 = \frac{E^2(r-R)}{(r+R)^3}$

$0 = E^2(r-R)$ (01 mark)

$0 = r - R$

$\therefore r = R$ Hence shown

b) i) The domestic a.c supply is 230V, 50Hz. It is the r.m.s or effective value, It means that alternating voltage available has the heating effect as 230V d.c under similar condition.

Equation of alternating Voltage is (02 marks)

$E = E_0 \sin \omega t$

$\therefore E = 230\sqrt{2} \sin 314t$ Volts

Where

$\omega = 314$,

$E_0 = \sqrt{2}\, E_v$

8 b) ii) From

$$X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

Given data (01 mark)

$f = 1000Hz$

$C = 2 \times 10^{-6} F$.

$\therefore X_c = \frac{1}{2\pi \times 1000 \times 2 \times 10^{-6}}$

$X_c = 79.58 \Omega$

but

$V_c = I \cdot X_c$

$\therefore V_c = 4 \times 10^{-3} \times 79.58$

$V_c = 0.32V$ (01 mak)

$\therefore$ A p.d across a capacitor is $0.32V$

Then $X_c \propto \frac{1}{f}$, Since Capacitance is Constant

$\therefore \frac{X_{c_1}}{X_{c_2}} = \frac{f_2}{f_1}$, $X_{c_2} = \frac{f_1 \cdot X_{c_1}}{f_2} = \frac{1000 \times 79.58}{50}$

$\therefore X_{c_2} = 1591.6 \Omega$

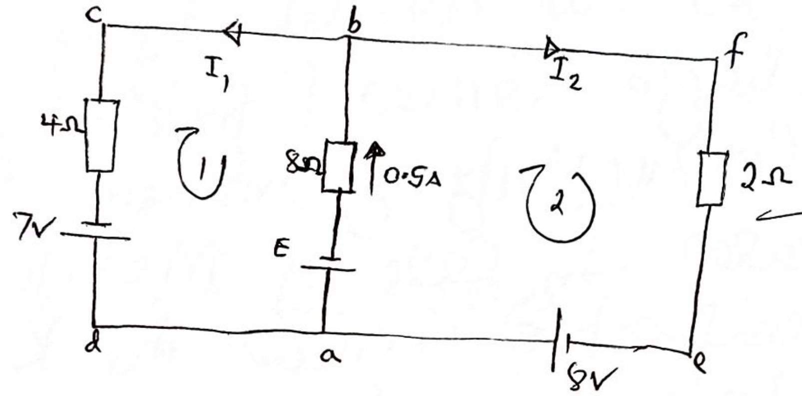
but $I_{rms} = \frac{V_{rms}}{X_{c_2}} = \frac{10V}{1591.6\Omega} = 6.28 \times 10^{-3} A$ (01 mark)

$\therefore$ The Current flowing is $6.28mA$

8 c) i) Significance of Kirchhoff's law

- KLC implies the Conservation of charge at junction (01 mark)
- KLV implies the Conservation of energy in a loop (01 mark)

(ii) Consider a circuit below



(0.5 mark)

Let E be V_{a-b}

Apply KLC

$$I_1 + I_2 = 0.5A \quad \text{(i)}$$ (0.5 mark)

Apply KLV

- loop abcde

$$-E - 0.5\times 8 + -4I_1 + 7 = 0$$

$$E = 3 - 4I_1 \quad \text{(ii)}$$ (0.5 mark)

- Loop abfea

$$-E - 0.5\times 8 - 2I_2 + 8 = 0$$

$$E = 4 - 2(0.5 - I_1)$$

$$E = 3 + 2I_1 \quad \text{(iii)}$$ (0.5 mark)

Compare eqn (ii) and (iii)

$$3 - 4I_1 = 3 + 2I_1$$

$$I_1 = 0, \quad E = 3 + 2(0) = 3V$$ (01 mark)

9 (a)(i) A Semiconductor is formed by Covalent bonds. When the temperature of the Semi conductor increases, some Covalent bonds are broken, resulting in the production of free electrons and equal number of holes. Due to the availability of large number of charge Carriers [free electrons and hole] the Conductivity of intrinsic Semiconductor Increases. In Case of Metals, the increase in temperature increases the KE of free electrons, resulting in greater number of Collisions between free electrons and Metal Ions Hence resistance of the metal Increases and its conductivity decreases.
(02 Marks)

(ii) let n_i be the Intrinsic Carrier Concentration

Electrical Conductivity, $\sigma = 1/\rho = \frac{1}{0.47}$

Now $\sigma = n_i(\mu_e + \mu_h)$ — 01 Mark

$$n_i = \frac{\sigma}{e(\mu_e + \mu_h]}$$

$\sigma = 1/0.47 \; S/m$ — 01 Mark

$\mu_e = 0.39 \; M^2/\text{Volt}\cdot\text{Sec}$

a) ii) ($\mu_h = 0.19\, m^2/Vs$ and $e = 1.6\times10^{-19} C$)

$$\therefore n_i = \frac{1}{0.47\times 1.6\times10^{-19}\times(0.39+0.19)}$$

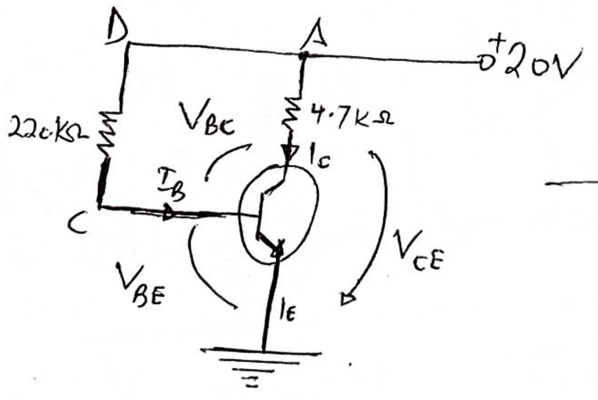
$$n_i = 2.3\times10^{19}/m^3$$ ——— (01 mark)

9 b)

$$\beta = I_C/I_B$$

$$\therefore I_B = I_C/\beta = \frac{2mA}{100} = 0.02mA$$ ——— (0.5 mark)

Consider a circuit below



——— (1.5 marks)

i.e

$$V_{CC} = V_{CE} + I_C R_L$$

$$V_{CE} = V_{CC} - I_C R_L = 20 - (2.0mA \times 4.7\times10^3)$$

$$V_{CE} = 10.6V$$ ——— (01 mark)

Then

$$V_{CC} = V_{BE} + I_B R_B$$

$$V_{BE} = V_{CC} - I_B R_B$$

$$V_{BE} = 20 - (0.02mA \times 220\times10^3)$$

$$V_{BE} = 15.6V$$ ——— (01 mark)

9 c) i) The name is Exclusive OR-gate (0.5 mark)

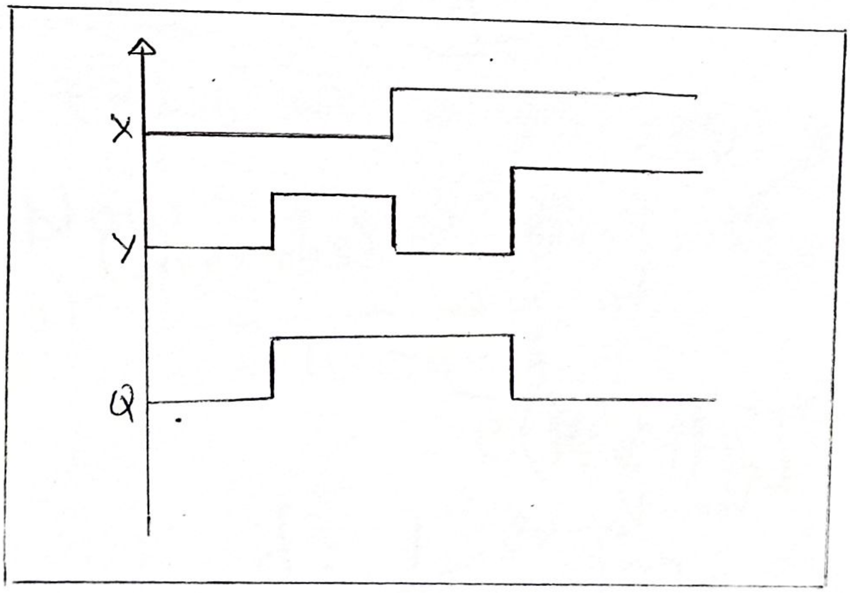
ii) Boolean algebra of $Q = X \oplus y$ (0.5 mark)

iii) Case of its truth table

X	y	Q
0	0	0
0	1	1
1	0	1
1	1	0

(1.5 marks)

iv) Waveform of output Q

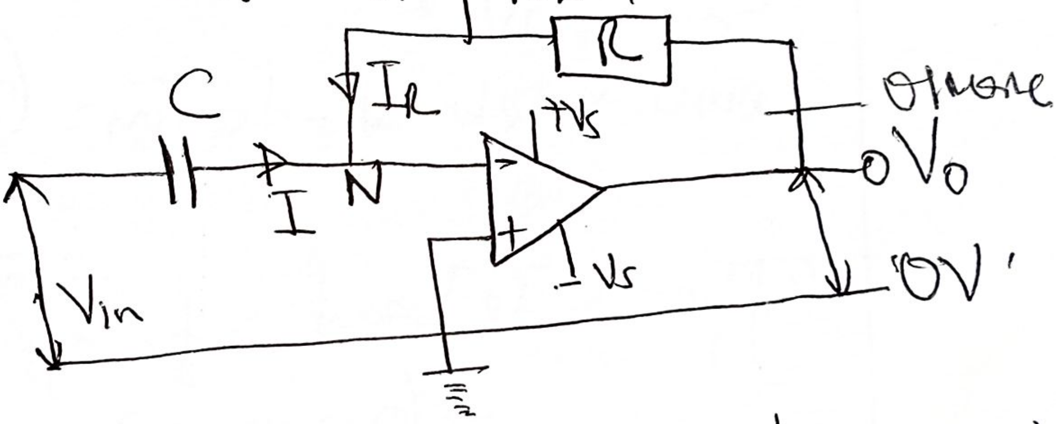


(1.5 marks)

10 (a) Operational amplifier as a differentiator is used to perform a mathematical operation of differentiation.

01 mark

Circuit diagram:



From Kirchhoff's current law of Node

— 01 mark

$I = I_R$

$$I_R = \frac{V_N - V_o}{R} \quad \text{and} \quad I = \frac{dQ}{dt}.$$

but $Q = CV$. 01 mark

$$\frac{V_N - V_o}{R} = C\frac{d}{dt}(V_{in} - V_N)$$

Since $V_N = 0$ [earth potential

It follows that

$$V_o = -RC\frac{dV_{in}}{dt}$$ — 01mark

A differentiator produces an output voltage that is proportional to the rate of change of the input.

10 (c) $f_c = 2MHz$, $f_m = 4KHz$, $M = 0.55$

$E_c = 70V$

01mark

Lower side band $= f_c - f_m = (2000 - 4)$ KHz

$= 1996$ KHz

$= 1.996$ MHz

upper side band $= f_c + f_s$. — 01mark

$= (2000 + 4)$ KHz $= 2004$ KHz

$= 2.004$ MHz.

Bandwidth $= 2004 - 1996$ — 01mark

$= 8$ KHz.

Amplitude $= \frac{ME_c}{2} = \frac{0.55 \times 70}{2}$ — 01mark

$= \underline{19.25\ V}$ — 01mark.

10 b) Advantage of FM over AM — @ 1mark = 04 marks total

- It has a very high signal-to-noise ratio
- Its efficiency of transmission is very high
- It has large number of side bands, which makes its useful in stereo sound Communication
- It gives high fidelity reception, means that there is very little distortion during transmission and a true copy of information is received