TANZANIA HEADS OF ISLAMIC SCHOOLS COUNCIL

FORM SIX INTER ISLAMIC MOCK EXAMINATION

PHYSICS 1

131/1

(For both School and Private candidates)

Time: 3 Hours Monday 4th March, 2024 p.m.

Instructions

1. This paper consists of sections A and B with a total of ten (10) questions.
2. Answer all questions in section A and two (2) questions from section B.
3. Section A carries seventy (70) marks and sectioin B carries thirty (30) marks.
4. Mathematical tables and non-programmable calculators may be used.
5. Cellular phones and any unauthorized materials are not allowed in the Examination Room.
6. Write your Examination Number on every page of your ansewr booklet(s).
7. The following information may be useful:
   (a) Acceleration due to gravity, $g=9.8m/s^2$.
   (b) Ratio of specific heat capacities, $=1.67$
   (c) Thermal conductivity of Copper, $K=380JS^{-1}\,{}^{o}C^{-1}$
   (d) Molar gas constant, $R=8.31JK^{-1}mol^{-1}$
   (e) Density of air, $\delta=1.3kg/m^3$.
   (f) Pie, $\pi=3.14$

SECTION A (70 Marks)

Answer **all** questions from this section

1. (a) (i) " Today accurate measurement is an important part of physics. But no measurement is absolutely precise." Explain the meaning of the above statement. **[02 marks]**

(ii) The period of oscillations of simple pendulum in an experiment are recorded as 2.63s, 2.56s, 2.42s, 2.71s and 2.80s respectively. Find the mean time period and absolute error in each observation and their percentage error. **[03 marks]**

(b) (i) The diameter of steel rod is given as (56.47 ± 0.02) mm. What does this statement mean? **[01 mark]**

(ii) Discuss how errors can be computed form the straight line graphs.

[02 marks]

(iii) Suppose the slope of the best fit line is 1.0 and the slopes of maximum and minimum worst lines are 1.16 and 0.81 respectively. Estimate the value of the slope of graph. **[02 marks]**

2. (a) (i) "Newton's second law of motion is a real law of motion." Discuss.

[03 marks]

(ii) A jet engine on a test bed takes in 40kg of air per second at a velocity of 100m/s, burning 0.8kg of oil per second. After compression and heating, the exhaust gases are ejected at 600m/s relatives to the air craft. Calculate the thrust of the engine. **[02 marks]**

(b) A projectile is thrown with an initial velocity of 20m/s from the base of an inclined plane of 45^o with projection angle of 75^o. Find:

(i) Time of flight **[01 mark]**

(ii) Range on an inclined plane **[02 marks]**

(iii) Maximum height reached on an inclined plane **[02 marks]**

3. (a) Briefly explain the following

(i) Why does a pilot not fall when his aeroplane loops a vertical loop?

[01 mark]

(ii) In rain, generally the scooter slips at the tuming of road. Why?

[01 mark]

(iii) Why are passengers in car rounding a curve thrown outward?**[1 mark]**

3. (b) A body oscillates vertically in SHM with amplitude of 30mm and frequency of 5.0Hz. Calculate the acceleration of the particle

(i) At the extremities of the motion **[03 marks]**

(ii) At the centre of the motion **[02 marks]**

(iii) At the position midway between the centre and extremities.**[02 marks]**

4. (a) (i) State Kepler's laws of planetory motion. **[03 marks]**

(ii) When a body is taken from the centre of the earth to the moon, explain the changes in the weight of the body. **[02 marks]**

(b) (i) Define a term radius of gyration. **[01 mark]**

(ii) A 5kg disc of moment of inertia 0.1kgm^2 about its centre rest on an inclined plane at 30^o to the horizontal. Estimate the angular velocity it has rolled 2m down the slope. **[04 marks]**

5. (a) What type of thermometer would you use to measure each of the following? In each case give the reason of your choice.

(i) The boiling point of water on the mountain. **[01 mark]**

(ii) The temperature just after the ignition in a cylinder of an internal cumbustion engine. **[01 mark]**

(iii) Temperature of the filament of an electric lamp **[01 mark]**

(iv) The normal melting point of Zinc. **[01 mark]**

(b) (i) Form V students in KWETU Ilsmaic Seminary had a practical of shaking bottles vigorously containing hot liquids. Their corks blow off. Explain why so? **[02 marks]**

(ii) One end of Copper rod 2m long and having a radius of 1cm is maintained at 250^{o}C. When the steady state is reached, the rate of heart flow across any section is 2.1J/s. Estimate the temperaure of the other end. **[04 marks]**

6. (a) (i) Physics teachers in Tanzania have researched recently that in practice, completely reversible process is not possible. Explain clearly conditions on how it can be possible. **[02 marks]**

(ii) One mole of an ideal gas which is Kept at a temperature of 320k is compressed isothermally from its initial volume of 8 litres to a final volume of 4 litres. How do you think the total work done in the whole process could be? **[03 marks]**

(b) (i) In an industrial refrigerator, ammonia is vaporized in a cooling unit to produce a low temperature. Why would evaporation of ammonia reduce the temperature in refrigerator? **[02 marks]**

(ii) A vessel contains 2.5 x $10^{-3}m^3$ of an ideal gas at a pressure of $8.5x10^4Nm^{-2}$ and temperature of 35ºC. The gas is compressed isothermaly to a volume of $1x10^{-3}m^3$, it is then allowed to expand adiabatically to the origional volume. Calculate the final temperature of the gas and hence draw the graph of process.

[03 marks]

7. (a) (i) Briefly explain any four disiadvantages of particulate matter in the atmosphere. **[04 marks]**

(ii) Explain why the small ozone layer on the top of the stratosphere is crucial for human survival? **[02 marks]**

(b) A solar cell of surface area $100cm^2$ is illuminated by a monochromatic light of wavelength 760nm and powe density of $1000Wm^{-2}$. The open circuit voltage is 0.67V when the cell temperature is 300K. Estimate the dark cell I_0, assuming a 100% quantum efficiency. **[04 marks]**

SECTION B (30 Marks)

Answer **two (2)** questions from this section

8. (a) (i) Explain the term "resistance matching" as applied to a simple electric circuits.

[01 mark]

(ii) A cell of e.m.f, E and internal resistance, r is used to drive a current I through a load resistance R. Show that for maximum power to be transferred to the load, a load resistor R must be equal to the internal resistance r of a cell.

[04 marks]

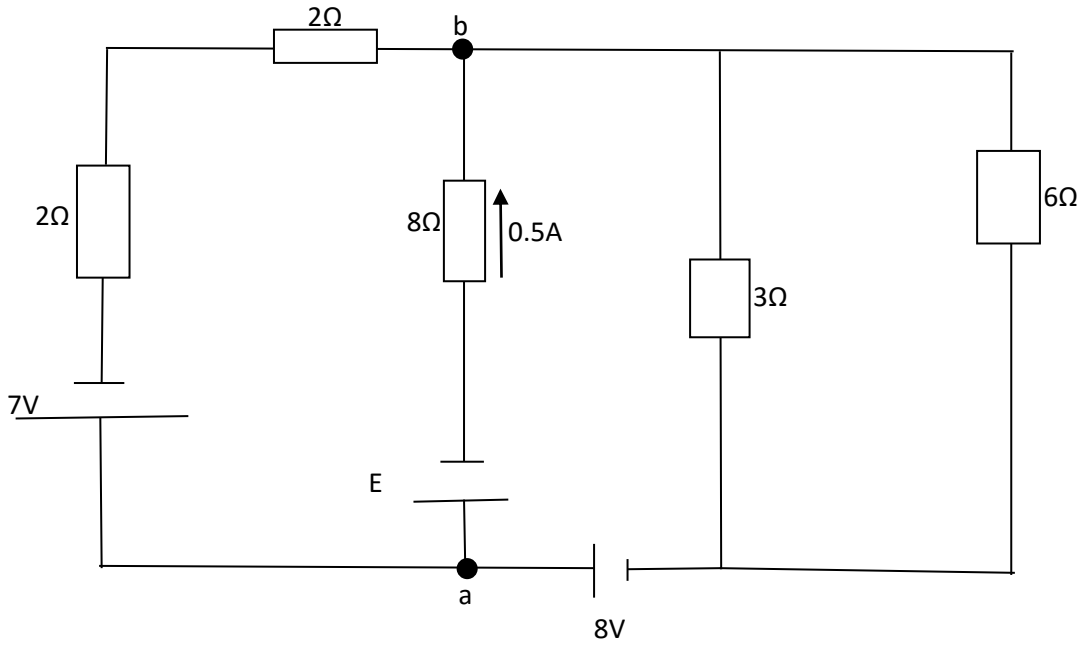
(b) (i) Our homes are supplied with an a.c voltage whose equation should be $E=E_oSmwt$. But we always say that the a.c voltage in our home is 230V. How do you explain this difference? **[02 marks]**

(ii) A ratio circuit has a capacitor of 2μF with a frequency 1 KHz and the root mean square current flowing of 4mA. Estimate the potential difference across the capacitor and the current flowing when root mean square voltage of 10V, 50Hz is connected to the capacitor. **[03 marks]**

(c) (i) What is significance of Kirchoff's laws? **[02 marks]**

(ii) In the circuit below, determine the value of E such that a current of 0.5A exist in 8Ω resistor with sense from a to b. What is potential difference Va-Vb?

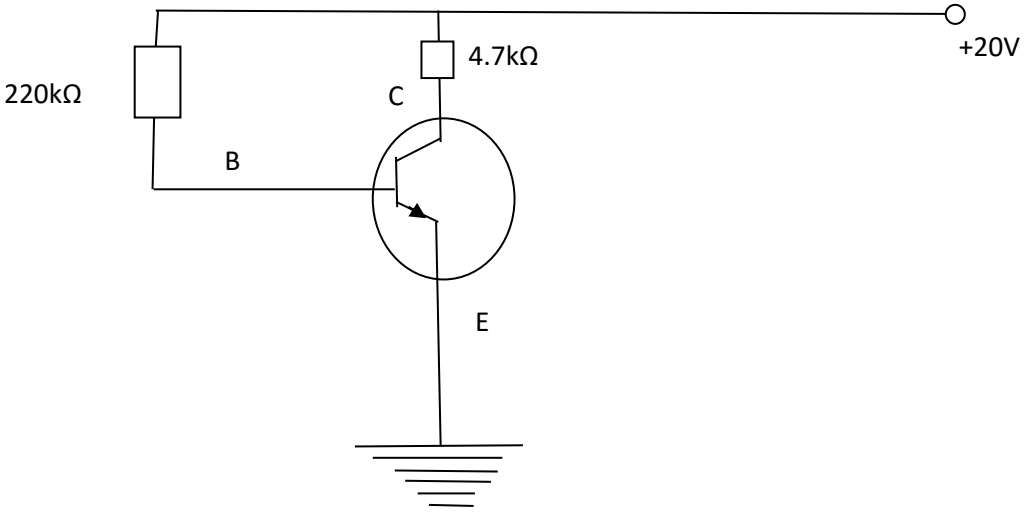
[03 marks]



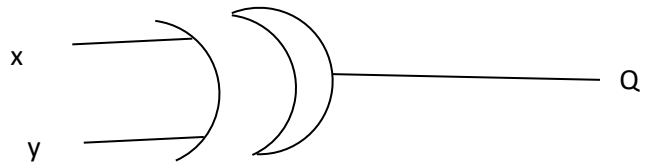
9. (a) (i) Explain why electrical conductivity of intrinsic semiconductor increases with increase in temperature while that of pure conductor decreases with increase in temperature? **[02 marks]**

(ii) An intrinsic germanium has a resistivity of 0.47Ωm at a room temperature. Estimate the intrinsic corner concentration if the mobilities of electrons and holes are $0.39 m^2$/volt-sec and $0.19 m^2$/volt-sec respectively. **[03 marks]**

(b) In the circuit below, the value of β is 100. Find I_B, V_{CE}, V_{BE} and V_{BC} when I_C=2mA. Is that transistor in active, cut-off or saturation state? **[05 marks]**



9. (c) Study the logic circuit shown in the figure below



(i) What is the name of the logic gate above? **[0.5 mark]**

(ii) Write down its Boolean algebra **[0.5 mark]**

(iii) Draw the truth table for the circuit above **[1.5 marks]**

(iv) Sketch the waveform for inputs and outputs signal **[1.5 marks]**

10. (a) With the good diagram explain how differentiator (OP-AMP) can produce an output voltage that is proportional to the rate of change of inputs voltage. **[05 marks]**

(b) Explain advantage of FM over AM. Give four points. **[04 marks]**

(c) A sinusoidal carrier voltage of frequency 2MHz and amplitude 70V is amplitude modulated with sinusoidal voltage of frequency 4 KHz producing modulation factor of 55%. Estimate the band width and the amplitude of upper and lower side band. **[06 marks]**

Wabillah Tawfiq

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PHYSICS – 1

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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

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

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

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

Absolute error in each observation is given by

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

$2.62 - 2.42 = \underline{0.20}$ s; $2.62 - 2.71 = \underline{-0.09}$ s;

$2.62 - 2.80 = \underline{-0.18}$ s $\longrightarrow (0.5 \text{ mark})$

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

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

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

$$= \frac{0.115}{2.625} \times 100\% = 4.2\% \longrightarrow (0.5 \text{ mark})$$

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 uncertainty 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) —— (0.5mark)

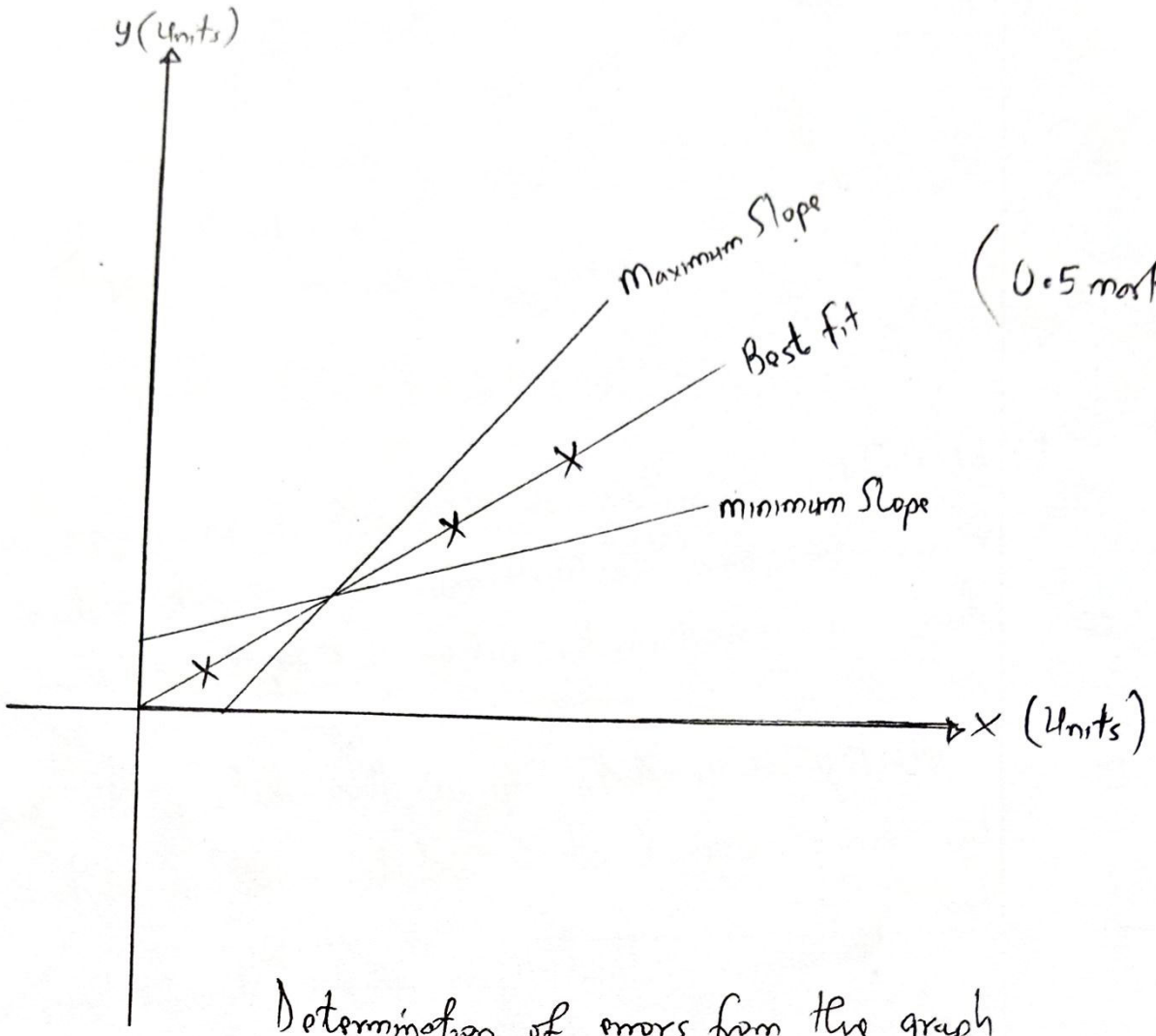
→ From the graph we can find three slopes m for the best fit, m_1 for maximum slope and m_2 for minimum slope — (0.5mark)

→ 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

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

1 b) ii) Consider a graph below



(0.5 mark)

Determination of errors from the graph

b) iii) $m = 1.0$

$m_1 = 1.16$

$m_2 = 0.81$

(0.5 mark)

From

$$\Delta m = \frac{|m_1 - m| + |m_2 - m|}{2}$$

(0.5 mark)

$$\Delta m = \frac{|1.16 - 1.0| + |0.81 - 1.0|}{2} = 0.175 \longrightarrow (01 \text{ mar}$$

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

$F = ma$ — Newton Second law of motion

i.e

$a = F/m$, when $F = 0$

$\therefore a = 0/m = 0\ m/s^2$ ——— (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

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

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

0.5 mark

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

If momentum is Conserved

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

$\therefore F_{12} = -F_{21}$ ——— 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

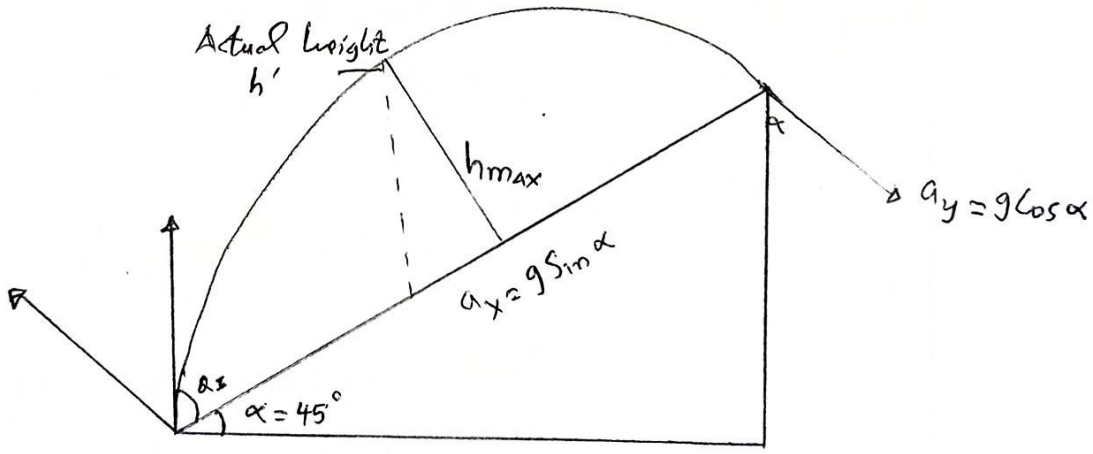
$$\therefore \text{Thrust} = \frac{[(m_f + m_a)V_o - m_a V_i]}{t} \quad \text{——— (01 mark)}$$

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

$$= 20480N$$

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

2 b) Consider an illustration below



i) Time of flight

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

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

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

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

$$\therefore Range = \frac{(20)^2}{9.8 \times \cos^2 45^\circ} \times \left[\sin((2\times 75^\circ) - 45^\circ) - \sin 45^\circ\right]$$

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

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

Time of maximum height, $t = 1.443$ sec

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

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

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

$$h_{max} = 7.2m \quad \text{——} \quad (0.5mark)$$

And also

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

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

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

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

$\therefore$ 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, $f = 5.0\,Hz$

Amplitude, $a = 30mm / 0.030m$

$\omega = 2\pi f$

$\omega = 2\pi \times 5 = 10\pi\ rad/s$ ——— (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 $y = +0.03m$

$\therefore a = -(10\pi\ rad/s)^2 \times +0.030m$

$acc^n = -29.61\ m/s^2$ ——— (01 mark)

1.0 Acceleration is negative (downward) while its displacement is positive (Upward)

3 b) i) At the bottom of the Oscillation, $y = -0.030m$ 7

From

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

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

$$= +29.61 m/s^2 \quad \text{——— (01 mark)}$$

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

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

$$a = -\left(10\pi \text{ rad/s}\right)^2 \times 0m$$

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

∴ At the Centre of motion, acceleration is Zero (0)

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

→ At positive halfway upward, $y = +0.015m$

From

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

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

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

And also

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

From

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

$$\therefore a = -(10\pi\ rad/s)^2 \times (-0.015)$$

$$a = 14.8 m/s^2 \quad \text{——— (01 mark)}$$

$\therefore$ 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"

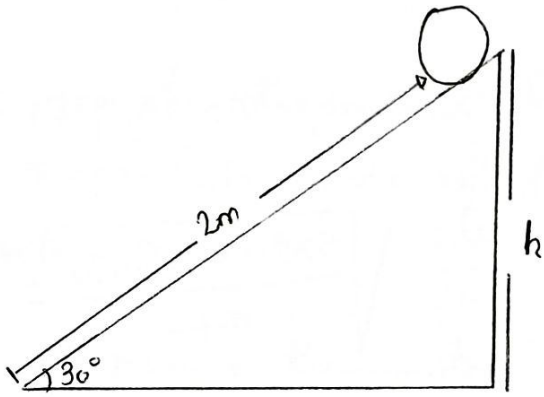
$$T^2 \propto R^3$$ (01 mark)

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

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

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

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

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

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

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

but

$$mr^2 = I$$

4 b) ii)

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

5

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

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

Given data

$I = 0.1\,kgm^2$, $m = 5kg$, $L = 2m$, $\theta = 30^\circ$

$$\therefore \omega = \sqrt{\frac{5\times9.8\times2\times\sin30^\circ}{0.1}} = 22.1\,rad/s$$

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

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

$$\frac{Q}{t} = \frac{KA(\theta_1 - \theta_2)}{x} \quad \text{(01 mark)}$$

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

5 b) ii) :-

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

$$\theta_1 - \theta_2 = \frac{PX}{KA} \quad \text{——— (01 mark)}$$

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

Given data

$\theta_1 = 250^\circ C$

$P = 2.1 J/s$

$X = 2m$ ——— (01 mark)

$K = 380$

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

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

∴ A required temperature of other end is $214.8^\circ C$

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

Given data

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

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

$W.d = -1843\,J$

∴ The total work done in the whole process is $W.d = -1843\,J$ (01 mark)

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

b (ii) Initial data/states

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

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

$P_0V_0 = P_1V_1$ —— (0.5 mark)

$P_1 = \frac{P_0V_0}{V_1}$, $V_1 = 1 \times 10^{-3}\,m^3$

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

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

Case of adiabatic expansion

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

$P_2 = ?$

$T_2 = ?$

From

$P_1V_1^{\gamma} = P_2V_2^{\gamma}$ ——— (0.5mark)

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

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

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

From

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

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

$T_2 = 166.71K$ ——— (01mark)

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 ($I = 0$)

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

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

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

For 100% quantum efficiency, $\frac{I_L}{I_o} >>>> 1$

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

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

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

$$V_{ac} = \frac{KT}{q} \ln\left(\frac{I_L}{I_o}\right) \quad \text{—— (0.5 mark)}$$

Given data

$V = 0.67V$

$q = 1.6 \times 10^{-19} C$

$T = 300K$

$K = K_B = 1.38 \times 10^{-23}$

$$\frac{I_L}{I_o} = e^{\left(\frac{1.6 \times 10^{-19} \times 0.67}{1.38 \times 10^{-23} \times 300}\right)} \quad \text{(0.5 mark)}$$

$$\frac{I_L}{I_o} = 1.75 \times 10^{11}$$

but

$I_L = q\Phi$

Then (0.5 mark)

$$I_o = \frac{I_L}{1.75 \times 10^{11}} = \frac{q\Phi}{1.75 \times 10^{11}}$$

but

P = Power intercepted by the Cell

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

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, $\Phi = P/hf$

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

$$\Phi = 3.82\times10^{19}\ photons\ s^{-1}m^{-2}$$

——— (0.5mark)

Recall,

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

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

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

∴ 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 $P = IV$, $V = IR$

$\therefore P = I^2R$ —— ①

but

$I = \frac{E}{r+R}$ —— ② —— (0.5mark)

$\therefore$ Substitute eqn ② into eqn ①

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

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

$\frac{dP}{dR} = \frac{u\,dv - V\,du}{u^2}$ —— (01 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 (01mark)

$f = 1000Hz$

$C = 2\times10^{-6}F$.

$$\therefore X_c = \frac{1}{2\pi \times 1000 \times 2\times10^{-6}}$$

$$X_c = 79.58\Omega$$

but

$$V_c = I \cdot X_c$$

$$\therefore V_c = 4\times10^{-3} \times 79.58$$

$$V_c = 0.32V$$ (01mark)

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

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

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

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

but

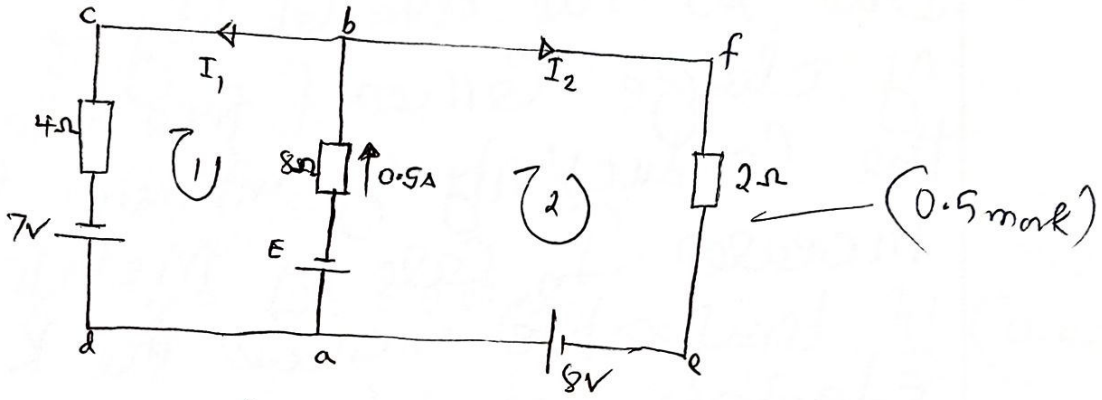
$$I_{rms} = \frac{V_{rms}}{X_{c_2}} = \frac{10V}{1591.6\Omega} = 6.28\times10^{-3}A$$ (01mark)

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

8 (c) i) Significance of Kirchhoff's law

- KLC implies the Conservation of charge of 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

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

Apply KLV

- loop abcde

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

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

- loop abfea

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

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

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

Compare eqn (ii) and (iii)

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

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

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 holes] 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

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

$\sigma = \frac{1}{0.47}$ S/m — 01 mark

$\mu_e = 0.39$ M²/ Volt · Sec

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

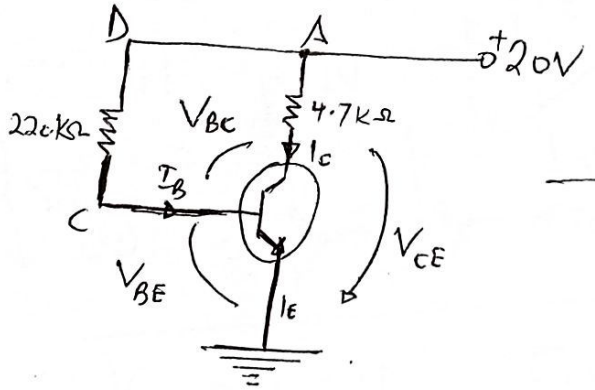
$$\therefore n_i = \frac{1}{0.47\times1.6\times10^{-19}\times(0.39+0.19)}$$

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

9 b) $\beta = I_C/I_B$

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

Consider a circuit below



——— (1.5marks)

1.0 $V_{CC} = V_{CE} + I_C R_L$

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

$$V_{CE} = 10.6V$$ ——— (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 (0.5mark)

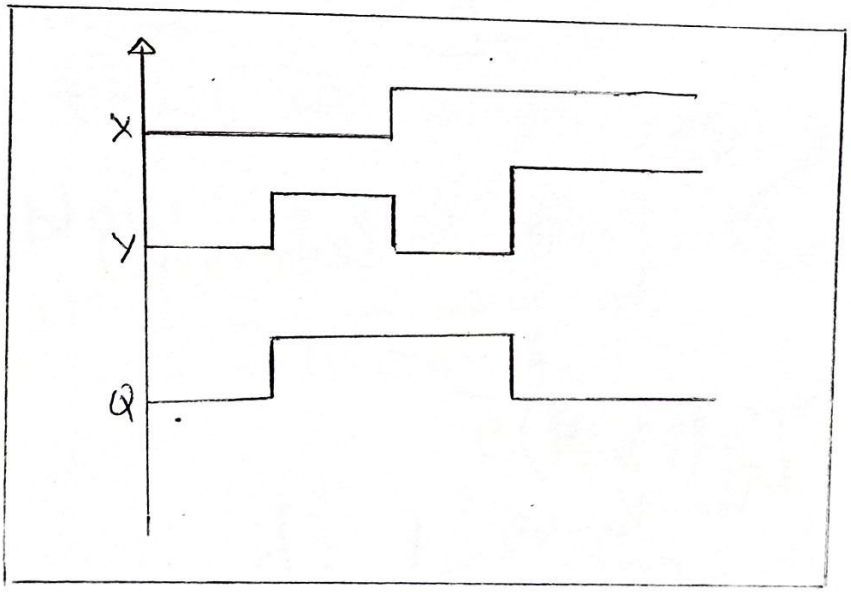
ii) Boolean algebra of $Q = X \oplus y$ (0.5mark)

iii) Case of its truth table

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

(1.5marks)

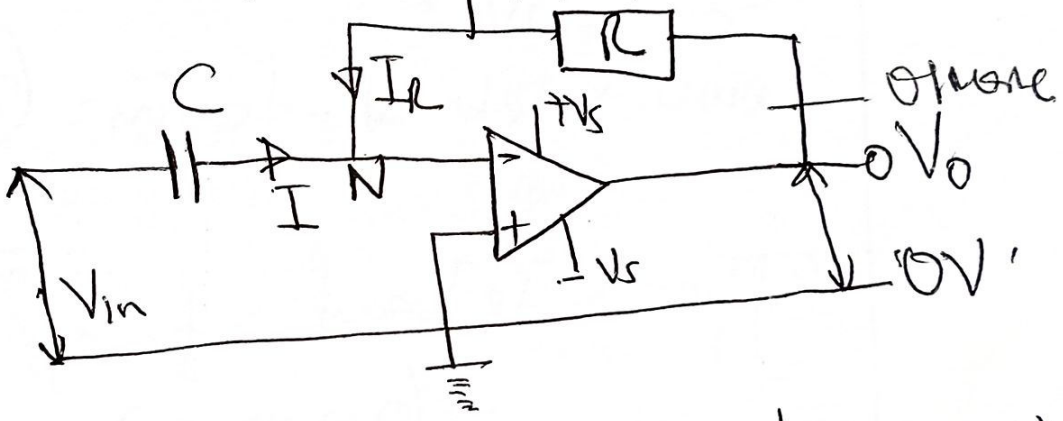
iv) Waveform of output Q



(1.5marks)

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

$$I = I_R$$

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

but $\varphi = CV$. 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

$$V_0 = -RC\frac{dV_{in}}{dt}$$ — 01 mark

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

10 (c) $f_c = 2\text{MHz}$, $f_m = 4\text{KHz}$, $M = 0.55$

$E_c = 70\text{V}$. — 01 mark

Lower side band $= f_c - f_m = (2000 - 4)\text{KHz}$

$= 1996\text{KHz}$

$= 1.996\text{MHz}$

Upper side band $= f_c + f_m$. — 01 mark

$= (2000 + 4)\text{KHz} = 2004\text{KHz}$

$= 2.004\text{MHz}$.

Bandwidth $= 2004 - 1996$ — 01 mark

$= 8\text{KHz}$.

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

$= \underline{19.25\text{ V}}$ — 01 mark.

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