PRESIDENT'S OFFICE

REGIONAL ADMINISTRATION AND LOCAL GOVERNMENT

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

FORM SIX MOCK EXAMINATION SOUTHERN ZONE
(MTWARA AND LINDI)

131/1 **PHYSICS 1**

(For Both School and Private Candidates)

TIME: 3:00 HOURS **2024**

INSTRUCTIONS

1. This paper consists of section 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 section B carries **thirty (30)** marks.
4. Mathematical tables and non-programable calculators may be used.
5. Write your **Examination Number** on every page of your answer booklet(s).
6. The following information may be useful
   (i) Stefan's constant $\sigma = 5.67 \times 10^{-8}\text{Wm}^{-2}\text{K}^{-4}$
   (ii) Electronic charge $e = 1.6 \times 10^{-19}\text{C}$
   (iii) Thermo conductivity of copper $= 400\text{Wm}^{-1\circ}\text{C}^{-1}$
   (iv) Density of air$=1.23\text{kg/m}^3$
   (v) Acceleration due to gravity $=9.8\text{m/s}^2$
   (vi) Radius of the earth R$= 6.4 \times 10^6\text{m}$
   (vii) Density of water$=1000\text{kg/m}^3$
   (viii) Universal gas constant R$= 8.31$J/mol K
   (ix) Molar gas ratio constant for monoatomic gas $\gamma = \frac{5}{3}$

This paper consist of five printed pages

SECTION A (60 marks)

Answer **all** questions in this section.

1. (a) (i) Find the value of x, y and z, so that the quantity $Q = P^{(x-y)}M^{(y+z)}V^z$ is dimensionless given that P is pressure, M is mass and V is velocity. **(03 marks)**

   (ii) Show that the ratio of dimensions of plank's constant and that of moment of inertia are dimensions of frequency. **(03 marks)**

   (b) (i) Identify two ways of minimizing systematic error in measurements. **(02 marks)**

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

2. (a) (i) If a car is moving with a constant speed in a straight line. Is there any net work done by the external forces on the car? If yes or no give one reason. **(01 marks)**

   (ii) What are head-on and oblique collisions?. **(01 marks)**

   (iii) What will be the maximum weight of the block A resting on the table. If the coefficient of static fraction between block A and the table is 0.25 and the mass of block B is 25N. **(03 marks)**

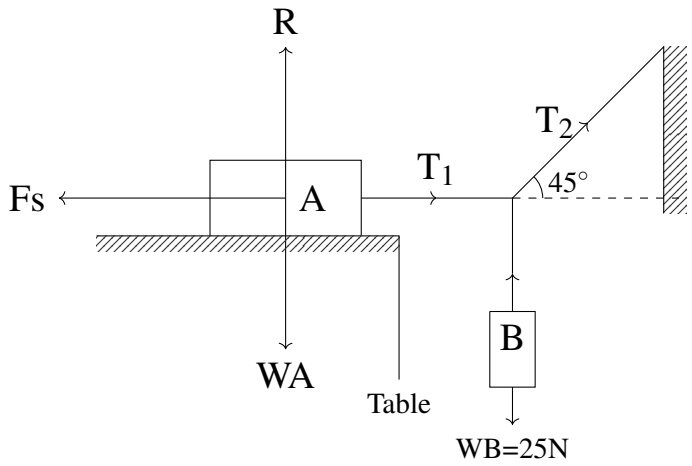

Figure 1:

   (b) (i) What is the difference between orbiltal velocity from parking orbit of a satellite. **(01 marks)**

   (ii) A rocket is launched vertically from the surface of the earth with an initial velocity $v_\circ$. Show that its velocity V at height h is given by $V = \sqrt{V_\circ - \frac{2gh}{(1+\frac{h}{R_e})}}$. **(04 marks)**

3. (a) (i) State the meaning of time of flight and write its equation. **(02 marks)**

(ii) An aeroplane flying in a horizontal direction with a velocity of 720km/h drops a bomb at a height of 1960m. Find the magnitude and direction of resultant velocity with which the bomb strikes the ground. **(03 marks)**

(b) (i) State the most important characteristic of simple harmonic motion. **(02 marks)**

(ii) A pendulum clock shows correct time. If the length increases by 0.1%, find the error in time per day. **(03 marks)**

4. (a) (i) What is the reason for no atmosphere on the moon? **(02 marks)**

(ii) A satellite takes 24 hours to revolve on it's orbit around the earth. Find the height above the earth at which the satellite should be placed. **(03 marks)**

(b) (i) Show that the rotational kinetic energy of a ball rolling over a horizontal plane is $\frac{2}{7}$ of it's total kinetic energy. **($02\frac{1}{2}$ marks)**

(ii) Radius of gyration of a body about an axis at a distance 6cm from it's centre of mass is 10cm. Find it's radius of gyration about a parallel axis through it's centre of mass **($02\frac{1}{2}$ marks)**

5. (a) (i) Why birds often swell their feathers in winter? **(02 marks)**

(ii) A copper bar of length 1m and cross-sectional area $10 \times 10^{-2}m^2$ has its one end maintained at 100°C by means 0.4kW heater. Calculate the temperature of the other end in the steady state. **(03 marks)**

(b) (i) State the two laws of black body radiation. **(02 marks)**

(ii) At what temperature will the filament of a 100W lamp operate if it is supposed to be a perfectly black body of area $1cm^2$? **(03 marks)**

6. (a) (i) Explain why air pressure in a car tyre increases during driving. **(02 marks)**

(ii) What is adiabatic reversible change as used in thermodynamics? Give two examples of adiabatic processes. **(03 marks)**

(b) (i) A cylinder fitted with a piston which can move without friction contains 0.05mol of a monoatomic ideal gas at a temperature of 27°C and a pressure of 1 atm. The temperature of the gas is raised to 77°C, the pressure remaining constant. Calculate the total heat energy supplied. **(03 marks)**

(ii) State two conditions for isothermal process and plot its PV graph. **(02 marks)**

7. (a) What is the difference between barrage and the Tip Speed Ratio (TSR). **(04 marks)**

(b) (i) Explain three (3) importances of mulching as used to improve plant environment. **(03 marks)**

(ii) Calculate the power extractable by a wind turbine of blades' length 52m if the wind is blowing at a speed of 12m/s. Assume the power coefficient to be 0.4. **(03 marks)**

SECTION B (30 MARKS)

Answer **Two (2)** questions in this section

8. (a) (i) Can you verify ohm's law by using a filament? Give reason for your answer. **(02 marks)**

(ii) The thermal speeds of freed electrons are very large. Inspite of these high speeds, why they fail to escape from the surface of a conductor? **(02 marks)**

(b) (i) What does it mean by safe value of fuse wire current? **(02 marks)**

(ii) Three cells are connected in parallel with their like poles connected together with wires of negligible resistance. If the e.m.f.s of he cells are 2V, 1V and 4V respectively and their internal resistances are 4Ω, 3Ω and 2Ω respectively, find the current through each cell. **(04 marks)**

(c) (i) For a very high frequency a.c supply a capacitor behave as a pure conductor. Why? **(02 marks)**

(ii) In an R-L series circuit, a voltage of 100V at 25Hz produces one ampere while the same voltage at 75Hz produces half ampere. Find the value of R and L. **(03 marks)**

9. (a) (i) Why is a semiconductor virtually an insulator at room temperature? **(02 marks)**

(ii) Identify four (4) properties of semiconductors. **(02 marks)**

(b) The figure below is a logic circuit

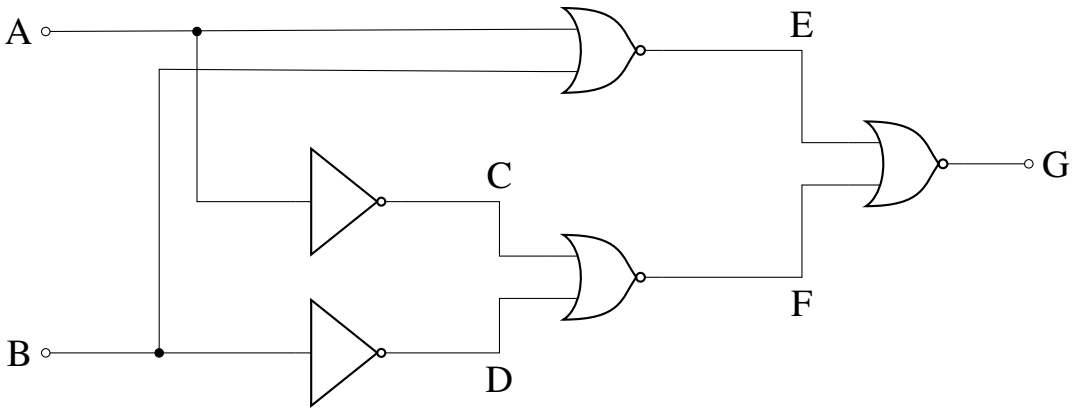

Figure 2:

From the circuit above in figure 2

(i) Draw the truth table for the logic circuit for which A and B are inputs and C, D, E, F and G are output. **(04 marks)**

(ii) What single gate is equivalent to the logic circuit above (b)? **(01 marks)**

(iii) Draw symbol for a logic gate mentioned in (b)(ii) **(01 marks)**

(c) (i) Why is collector of a transistor made wider than emitter and base? **(02 marks)**

(ii) In an NPN transistor, 10^{10} electrons enter the emitter in 10^{-6}s. If 2% electrons are lost in the base, calculate the current amplification factor. **(03 marks)**

10. (a) (i) What do you understand by the term OPAMP? State any three of its properties. **(02 marks)**

(ii) Briefly explain the three elements of communication system. **(03 marks)**

(b) The figure 3 below is an opamp circuit where V_1 and V_2 are independent input voltages. What values of R_2 and R_3 would give an output $V_o = -(4V_1 + 0.5V_2)$? **(04 marks)**

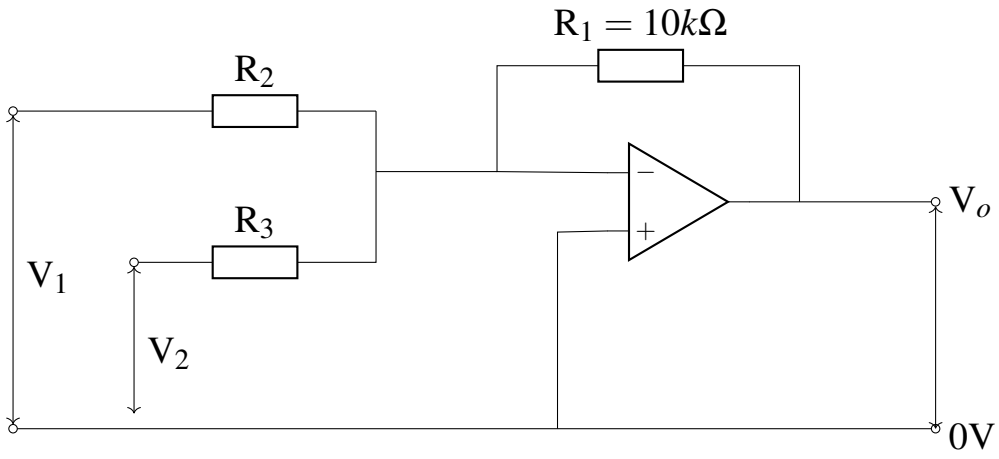

Figure 3:

(c) (i) State three factors for effective transmission of information (signals) **(01$\frac{1}{2}$ marks)**

(ii) Given the signal wave equation as $y = 10\cos(1800\pi t) + 20\cos(2000\pi t) + 10\cos(2200\pi t)$. Find the modulation index (μ) of the given signal wave and also calculate the frequencies of the modulated wave. **(04$\frac{1}{2}$ marks)**

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131/1 PHYSICS 1

MARKING SCHEME

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1. (a) (i) $Q=P^{x-y}M^{y+2}V^{z}$

From the principle of Dimensions analysis

$[L.H.S] = [R.H.S]$

$[Q]= [P]^{x-y}[M]^{y+2}[V]^{z}$

$1 = [ML^{-1}T^{-2}]^{(X-Y)} \times [M]^{y+2}[LT^{-1}]^{z}$

$[M^{\circ}L^{\circ}T^{\circ}] = [M^{x+2}][L^{(-x+y+z)}][T^{(-2x+2y-z)}]$ **(01 mark)**

Equating indices

For M, $0 = x+2 \Longrightarrow x = -2$

For L,

$$\begin{aligned} 0 &= -x+y+z \\ &= -(-2)+y+z \\ -2 &= y+z.....(i)(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

For T,

$$\begin{aligned} 0 &= -2x+2y-z \\ 0 &= -2(-2)+2y-z \\ 0 &= 4+2y-z \\ -4 &= 2y-2.....(ii)(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

Solving simultaneously eqn (i) and (ii)

$$\begin{aligned} y &= -2 \\ z &= 0 \end{aligned}$$

$\therefore (x,y,z) = (-2,-2,0)$ **(01 mark)**

(ii) For E=hf, h=plank's constant

$h= \frac{E}{f}$

$[h]= \frac{[E]}{[f]}$

$[h]= \frac{[ML^{2}T^{-2}]}{[T^{-1}]}$

$[h]= [ML^{2}T^{-1}]$ **(01 mark)**

Also moment of inertia $I=MR^{2}$

$[I]=[ML^{2}]$ **(01 mark)**

$\frac{[h]}{[I]} = \frac{[ML^{2}T^{-1}]}{[ML^{2}]}$

$\therefore \frac{[h]}{[I]} = [T^{-1}]$Dimension of frequency **(01 mark)**

(b) (i) Ways of minimizing systematic error

* By careful design of instrument and calibration. **(01 mark)**
* By using improved methods of measurement. **(01 mark)**

(ii) From the given information

$\Delta M_1 = |1.16 - 1.0| = 0.16$ **($00\frac{1}{2}$ mark)**

$\Delta M_2 |0.81 - 1.0| = 0.19$ **($00\frac{1}{2}$ mark)**

$$\begin{aligned} \Delta M &= \frac{\Delta M_1 + \Delta M_2}{2} \\ &= \frac{0.16 + 0.19}{2} \\ \Delta M &= 0.18(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

$\therefore$The slope of the graph$= M \pm \Delta M = 1.0 \pm 0.18$ **($00\frac{1}{2}$ mark)**

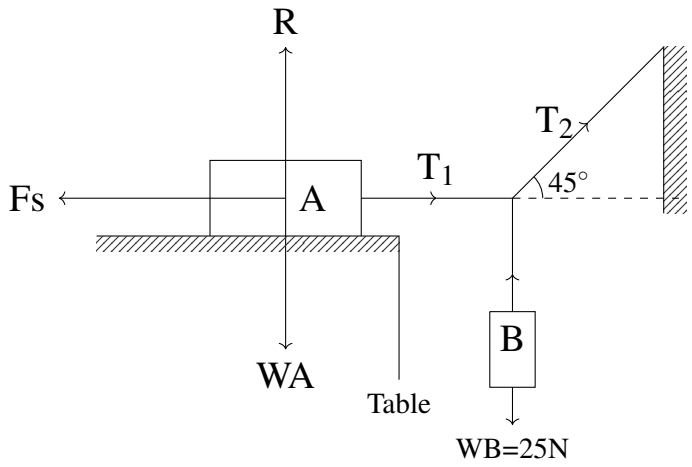
2. (a) (i) No, because net work done is equal to the change in kinetic energy

$w = \Delta KE = \frac{1}{2}m(V_f\text{-}V_i)$ where $V_f\text{-}V_i$

$w = \Delta KE = \frac{1}{2}mx_\circ = 0$ **(01 mark)**

(ii) Head on collision is the collision where by the colliding objects mve along straight line joining their centres. WHILE
Oblique collision is the collision where the colliding objects do not move along the straight joining their centres. **(01 mark)**

(iii) Consider



From

$$\begin{aligned} T_1 &= T_2\cos 45^\circ \\ \text{But } F_s &= T_1 \\ F_s &= 0.25 \times W_A \\ 0.25W_A &= T_2\cos 45^\circ \ldots\ldots\ldots\ldots\ldots\ldots (i)\ \textbf{(01 mark)} \\ W_B &= T_2\sin 45^\circ \\ 25N &= T_2\sin 45^\circ \ldots\ldots\ldots\ldots\ldots\ldots (ii)\ \textbf{(01 mark)} \end{aligned}$$

Take eqn (ii)÷(i)

$$\begin{aligned} \frac{25N}{0.25W_A} &= \frac{T_2\sin 45^\circ}{T_2\cos 45^\circ} \\ \frac{25N}{0.25W_A} &= \tan 45^\circ \\ W_A &= \frac{100N}{\tan 45^\circ} \\ W_A &= 100N\ \textbf{(01 mark)} \end{aligned}$$

The maximum weight of block A=100N

(b) (i) The difference between orbital velocity and parking orbit

Orbital velocity	Parking orbit
Is the velocity required to put the satellite into a given circular orbit around the earth	Is the orbit in which a satellite revolving around te earth has the same (equal) to the period of rotation of the earth.

(**01 mark**)

(ii) proof

From the principle of conservation of energy,

Total energy at the surface of the earth equals to total energy at height *h* attained by the rocket laurched with initial velocity $V_\circ$ to velocity V

$$\begin{aligned} \text{Energy at the surface of the earth} &= \text{P.E} + \text{K.E} \\ &= -\frac{GM_eM_r}{R_e} + \frac{1}{2}M_rV_\circ^2 (\textbf{01 mark}) \\ \text{Energy at h} &= \text{P.E}_h + \text{K.E}_h \\ &= -\frac{GM_eM_r}{R_e + h}\frac{1}{2}M_rV^2 \end{aligned}$$

$$
\begin{aligned}
-\frac{GM_eM_r}{R_e}+\frac{1}{2}M_rV_\circ^2 &= -\frac{GM_eM_r}{R_e+h}+\frac{1}{2}M_rV^2\\
-\frac{GM_e}{R_e}+\frac{1}{2}V_\circ^2 &= -\frac{GM_e}{R_e+h}+\frac{1}{2}V^2\\
\frac{GM_e}{R_e+h}-2\frac{GM_e}{R_e}+\frac{1}{2}V_\circ^2 &= V^2\\
V^2 &= V_\circ^2+2GM_e\left(\frac{1}{R_e+h}-\frac{1}{R_e}\right)\\
\text{but } GM_e &= gR_e^2(\textbf{01 mark})\\
&= V_\circ^2+2GM_e\left(\frac{R_e-(R_e+h)}{R_e.R_e+h}\right)\\
&= V_\circ^2+\frac{2gR_e^2}{R_e(R_e+h)(-h)}\\
&= V_\circ^2-\frac{2gR_e}{R_e+h}(\textbf{01 mark})\\
&= V_\circ^2-\frac{2gR_e}{R_e\left(1+\frac{h}{R_e}\right)}\\
&= V_\circ^2-\frac{2gh}{\left(1+\frac{h}{R_e}\right)}\\
V &= \sqrt{V_\circ^2-\frac{2gh}{\left(1+\frac{h}{R_e}\right)}}(\textbf{01 mark})
\end{aligned}
$$

3. (a) (i) * Time of flight (T) is the time elapsing from the launching to the time the projectile returns to the ground again. **(01 mark)**

* Equation $T=\frac{2U_\circ \sin\theta}{g}$, where $U_\circ$ is the initial velocity of a projectile. **(01 mark)**

(ii) Data

Initial velocity, $U_\circ = 720\text{km/hr} = 200\text{ms}^{-1}$

Height, h= 1960m

Downward vertical velocity

$$\begin{aligned} V_y &= 0+gt \\ t &= \sqrt{\frac{2h}{g}} \\ &= \sqrt{\frac{2\times 1960}{9.8}}\text{s} \\ t &= 20.0\text{sec}(\mathbf{00\frac{1}{2}\ mark}) \\ V_y &= (9.8\times 20)\frac{\text{m}}{\text{s}} \\ V_y &= 196\text{ms}^{-1}(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

Resultant velocity

$$\begin{aligned} V &= \sqrt{U_{\circ x}^2+V_y^2} \\ &= \sqrt{200^2+196^2}(\mathbf{00\frac{1}{2}\ mark}) \\ V &= 280.02\text{ms}^{-1}(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

Direction

$$\begin{aligned} \alpha &= \tan^{-1}\left(\frac{V_y}{V_x}\right) \\ &= \tan^{-1}\left(\frac{196}{200}\right) \\ \alpha &= 44.42^\circ(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

(b) (i) The most important characteristics of S.H.M is that the acceleration is directly proportional to the displacement and is directed opposite to the displacement.

$A=\omega^2 y$ **(02 mark)**

(ii) * Correct number of seconds per day, f$= 24 \times 60 \times 60 = 86400\text{s}^{-1}$ **(00$\frac{1}{2}$ mark)**

* Let error introduced per day be x second
* Incorrect number of second per day f$' = 86400 + x$
* Let L be the original length **(00$\frac{1}{2}$ mark)**
* The new length is L$' =$ L $+ 0.1\%$ of L$= (1 + 0.001)$L
* Frequency, f$= \frac{1}{2\pi}\sqrt{\frac{g}{L}}$ or f $\propto \frac{1}{L}$ **(00$\frac{1}{2}$ mark)**

$$\begin{aligned}
\frac{f'}{f} &= \sqrt{\frac{L}{L'}} \quad (\mathbf{00\frac{1}{2}\ mark}) \\
\frac{86400 + x}{86400} &= \sqrt{\frac{L}{(1+0.001)L}} \\
1 + \frac{x}{86400} &= (1 + 0.001)^{-\frac{1}{2}} \\
1 - \frac{1}{2} \times 0.001 &= 1 - 0.0005 \\
x &= -0.0005 \times 86400 \\
x &= -43.20\text{s} \quad (\mathbf{00\frac{1}{2}\ mark})
\end{aligned}$$

The negative sign indicates that the clock will run slow and lose 43.20s per day **(00$\frac{1}{2}$ mark)**

4. (a) (i) Since the value of acceleration due to gravity in the surface of the moon is small,the escape velocity on moon's surface ($=\sqrt{2gR_m}$)is also small. The molecules of atmospheric gases on the moon;s surface have thermal velocities greater than it's escape velocity. Due to this reason, all the molecules of gases have escaped and there is no atmosphere. (**02 marks**)

(ii) From period of the satellite

$$h = 2\pi\sqrt{\frac{(r_e+h)^3}{GM_e}}(\textbf{01 mark})$$

$$= \sqrt[3]{g\left(\frac{r_eT}{2\pi}\right)} - r_e$$

$$= \sqrt[3]{9.8m/s^2 \times \left(\frac{6.4\times10^6m\times24\times3600sec}{2\pi}\right)^2} - 6.4\times10^6m$$

$$h = 3.6\times10^7m(\textbf{01 mark})$$

Thus, the satellite should be placed at 3.6×10^7m high above the earth's surface so that it revolves with the period of 1 day. (**01 mark**)

(b) (i) Let

M be mass of the ball

R be the radius of the ball

M.I of the ball about symmetry axis of rotation I= $\frac{2}{5}MR^2$

* Rotation K.E of ball K_r

$$K_r = \frac{1}{2}I\varpi^2$$

$$\text{but } \varpi = \frac{V}{R}$$

$$= \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{V}{R}\right)^2$$

$$K_r = \frac{MV^2}{5}(\textbf{01 mark})$$

Total K.E of ball K

$$\begin{aligned} K &= \frac{1}{2}I\varpi^2 + \frac{1}{2}MV^2 \\ \text{but } \frac{1}{2}I\varpi^2 &= \frac{MV^2}{5} \\ K &= \frac{MV^2}{5} + \frac{MV^2}{2} \\ K &= \frac{7MV^2}{10}(\textbf{01 mark}) \\ \frac{K_r}{K} &= \frac{\frac{MV^2}{5}}{\frac{7MV^2}{10}} \\ \frac{K_r}{K} &= \frac{2}{7} \\ K_r &= \frac{2}{7}K(\textbf{00}\frac{\textbf{1}}{\textbf{2}}\ \textbf{mark}) \end{aligned}$$

(ii) M.I of the body about the given axis is I= MK^2(here K= 10cm)
M.I of the body through a parallel axis through centre of mass is I_{cm}=Mk^2
According to theorem of parallel axis

$$\begin{aligned} I &= I_{cm} + Mh^2(\textbf{01 mark}) \\ MK^2 &= Mk^2 + Mh^2 \\ K^2 &= k^2 + h^2(\textbf{00}\frac{\textbf{1}}{\textbf{2}}\ \textbf{mark}) \\ k^2 &= K^2 - h^2 \\ k &= \sqrt{10^2 - 6^2} \\ k &= 8\text{cm}(\textbf{01 mark}) \end{aligned}$$

5. (a) (i) This enables them to form an envelope of air around their bodies. Since air is a bad conductor of heat, heat can not flow from their bodies to the surroundings. Consequently, the birds do not feel cold. **(02 marks)**

(ii) $Q = \frac{kA(\theta_1 - \theta_2)t}{x}$

Power of heater, $P = \frac{Q}{t} = \frac{kA(\theta_1 - \theta_2)}{x}$ **(01 mark)**

$$\begin{aligned} p &= 0.4kw \\ p &= 0.4 \times 1000w \\ k &= 400wm^{-1}{}^{\circ}C^{-1} \\ A &= 100 \times 10^{-2}m^2 \\ 0.4 \times 1000 &= \frac{400 \times 10 \times 10^{-2}(100 - \theta_2)}{1} \textbf{(01 mark)} \\ \theta_2 &= 90^{\circ}C \textbf{(01 mark)} \end{aligned}$$

(b) (i) **Laws of black body radiations**

1^{st}, Wien's displacement law state that,

"The product of the wavelength(λm) at which maximum energy is emitted and te absolute temperature (T) of the black body is always constant". **(01 mark)**

2^{nd} Stefan'slaw state that

"The rate at which a body radiates energy (that is energy radiated per second) is directly proportional to the fourth power of the absolute temperature of the body". **(01 mark)**

(ii) According to Stefan's law

$$\begin{aligned} P &= \varepsilon\delta T^4 A \\ T^4 &= \frac{P}{\varepsilon\delta A} \textbf{(01 mark)} \end{aligned}$$

$$\begin{aligned} P &= 100\omega \\ \varepsilon &= 1(\text{black body}) \\ \delta &= 5.67 \times 10^{-8}wm^{-2}k^{-4} \\ A &= 10^{-4}m \\ T^4 &= \frac{100}{1 \times 5.67 \times 10^{-8} \times 10^{-4}} \textbf{(01 mark)} \\ T^4 &= \left(\frac{100}{5.67}\right) \times 10^{12} \\ T &= \left(\frac{100}{5.67}\right)^{\frac{1}{4}} \times 10^3 \\ T &= 2049k \textbf{(01 mark)} \end{aligned}$$

6. (a) (i) Because of frictional force acts between the tyres of the car and road. During driving, the work is done against the frictional force which is converted into heat, the temperature and pressure of the air in the tyres increases. **(02 marks)**

(ii) An adiabatic reversible change is the change which goes to and through the same intermediate stages without exchange of heat between inner and outer of the system.

Examples of an adiabatic process are:-

* Expansion and compression of gases in the cylinders of an automobile engine
* Air escaping from a burst car tyre
* Air escaping from the cycle tube on the removing value. **(03 marks)**

(b) (i) Data

Number of moles n=0.05mol

Initial temperature of gas $T_{\circ} = 27^{\circ}C$=300k

Final temperature of a gas $T_1 = 77^{\circ}C = 350k$

Molar gas ratio constant for monoatomic gas $\gamma = \frac{5}{3}$

$R = 8.31J/molK$

Required heat energy (Q)=?

From the first law of thermodynamics

$Q = \Delta U + \Delta w$

Where ΔU for mono atomic $= \frac{3}{2}nR\Delta T$ **(01 mark)**

$$\begin{aligned} \Delta U &= \frac{3}{2}nR\Delta T \\ &= \frac{3}{2}0.05 \times 8.31 \times (350 - 300) \\ \Delta U &= 31.163J \textbf{(01 mark)} \end{aligned}$$

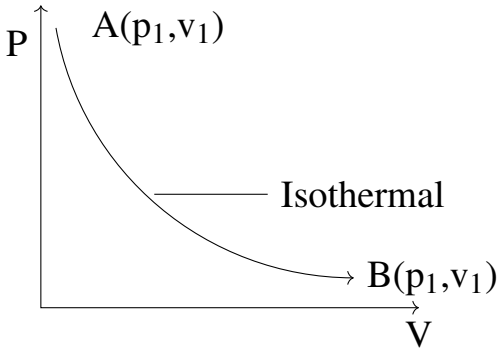
$$\begin{aligned} \Delta w &= p\Delta V \\ &= R\Delta T \\ &= 0.05 \times 8.31(350 - 300) \\ \Delta w &= 20.775J \end{aligned}$$

$$\begin{aligned} Q &= 31.163J + 20.775J \\ &= 51.94J \textbf{(01 mark)} \end{aligned}$$

$\therefore$The total energy supplied is 51.94J

(ii) Two conditions for Isothermal process are

* The gas must be held in a thin walled, highly conducting vessel, surround by a constant temperature bath. **(00$\frac{1}{2}$ mark)**
* The expansion or compression of a gas must take place slowly. **(00$\frac{1}{2}$ mark)**



(01 mark)

7. (a) **Barrage** the tidal power generation method that work similar to hydro power and have sluices that control the tidal flow to drive turbines and generate electricity. **(02 marks)**

Tip speed ration is the ratio of the speed of the tips of the wind turbine blades(rotor) to the wind speed TSR$=\frac{wr}{V}$ **(02 marks)**

(b) (i) **The importance of mulching**

* It reduces evaporation and soil erosion
* It controls weeds. Since weeds need light to grow mulching block the access to sunlight
* It regulates soil temperature. Since it provides lower coefficient of thermal conductivity hence reduces the temperature variation.
* It increase nutrients. **(Any 3 points @1= 03 marks)**

(ii) Area=circular area whose radius is equal to length of blade

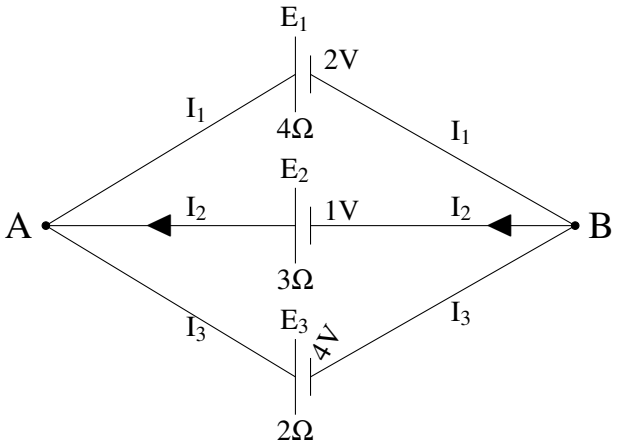
$$\begin{aligned} A &= \pi r^2 \\ A &= \pi L^2 (\mathbf{00\frac{1}{2}\ mark}) \\ P_{ext} &= \frac{1}{2}\rho A V^3 C_p (\mathbf{00\frac{1}{2}\ mark}) \\ P_{ext} &= \frac{1}{2}(1.23 kgm^{-3}) \times \pi \times (52m)^2 \times (12m/s)^3 \times (0.4)(\mathbf{01\ mark}) \\ P_{ext} &= 3.61 \times 10^6 w \quad \mathbf{or} \quad 361 Mw(\mathbf{01\ mark}) \end{aligned}$$

8. (a) (i) No, as the voltage across the lamp is varied, the temperature of the filament also changes. This in turn changes the resistances of the filament. The essence of Ohm's law is that relation between V and I is linear if R is independent of the magnitude of V. **(02 marks)**

(ii) The free electrons in a conductor are free only to the extent that they may transfer from ne atom to another within the conductor. It is because the free electrons that start at the surface of a conductor find behind them the positive ions pulling them back and none pulling, forward, thus at the surface of a conductor, a free electron encounter forces that prevent it to leave the conductor surface. External energy is required for the free electrons to escape the conductor surface. **(02 marks)**

(b) (i) It is the maximum value of current that a fuse wire can vary without getting melted. Under such conditions, the rate of production of heat in the fuse wire is equal to the rate of loss of heat. **(02 marks)**

(ii) Consider



Let I_1, I_2 and I_3 be the current through the cells E_1, E_2 and E_3 respectively.
Apply Kirchoff's current law to the junction A

$$I_1 + I_2 + I_3 = 0$$

$$I_3 = -(I_1 + I_2) \ldots\ldots\ldots\ldots\ldots\ldots (i) \quad (\mathbf{00\frac{1}{2}\ mark})$$

Loop BE_1AE_2B
Apply Kirchoff's voltage law

$$-4I_1 + 2 + 3I_2 I - I = 0$$

$$4I_1 - 3I_2 = 1 \ldots\ldots\ldots\ldots\ldots\ldots (ii) \quad (\mathbf{00\frac{1}{2}\ mark})$$

Loop BE_1AE_3B
Apply Kirchoff's voltage law

$$-4I_2 + 2 + 2I_3 - 4 = 0$$

$$3I_1 + I_2 = -1 \ldots\ldots\ldots\ldots\ldots\ldots (iii) \quad (\mathbf{00\frac{1}{2}\ mark})$$

Solving eqn (i), (ii) and (iii)

$$\begin{aligned} I_1 &= -\frac{2}{13}A(\mathbf{00\frac{1}{2}\ mark}) \\ I_2 &= -\frac{7}{13}A(\mathbf{00\frac{1}{2}\ mark}) \\ I_3 &= \frac{9}{13}A(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

(c) (i) Capacitance reactance $X_c = \frac{1}{2\pi fc}$

As frequency f is increased, X_c decreases. Therefore for a very high frequency, X_c will be nearly zero and capacitor behaves as a conductor.

(02 marks)

(ii) From

$$\begin{aligned} Z_1 &= \frac{100V}{1A} \\ Z_1 &= 100\Omega(\mathbf{00\frac{1}{2}\ mark}) \\ Z_2 &= \frac{100V}{0.5A} \\ Z_2 &= 200\Omega(\mathbf{00\frac{1}{2}\ mark}) \\ R^2 + X_L^2 &= {V_L}^2 \\ R^2 + (2\pi \times 25L)^2 &= (100)^2 .....(i)(\mathbf{00\frac{1}{2}\ mark}) \\ R^2 + (2\pi \times 75L)^2 &= (200)^2 .....(ii)(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

Solving eqn (i) and (ii)

$$\begin{aligned} R &= 79\Omega \\ L &= 0.39H(\mathbf{01\ mark}) \end{aligned}$$

9. (a) (i) A room condition only few valence electrons are free and most of them are engaged in the formation of covalent bond. The presence of few electrons makes semiconductors virtually insulator at room condition. **(02 marks)**

(ii) **Physical properties of semiconductors**

* They have negative temperature coefficient of resistance.
* They do not obey Ohm'slaw (that is are non-Ohmic materials)
* They are formed by covalent bonds
* Conductivity of semiconductors can be changed appreciably by doping
* They have resistivity higher than that of conductor but less to those of insulators.
* Some semiconductors are sensitive to light.

(Any 4@00$\frac{1}{2}$ = 02 marks)

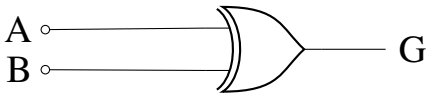
(b) (i) Truth table for the logic gate

INPUTS		OUTPUTS				
A	B	C	D	E	F	G
0	0	1	1	1	0	0
0	1	1	0	0	0	1
1	0	0	1	0	0	1
1	1	0	0	0	1	0

(04 marks)

(ii) The equivalent gate is EXCLUSIVE OR gate **(01 mark)**

(iii) EXCLUSIVE OR gate



(01 mark)

(c) (i) During the working of the transistor, most of the heat is produced at the collector junction. The collector is made larger to dissipate heat.

(02 mark)

(ii) Current=charge /time

Emitter current,

$$I_E = \frac{N_e}{t}$$
$$= \frac{10^{10\times 1.6\times 10^{-19}}}{10^{-6}}$$
$$= 1.6\text{mA}(\mathbf{00\frac{1}{2}\ mark})$$

Base current

$$\begin{aligned} I_B &= 2\% \text{of } I_E \\ &= \frac{2}{10} \times 1.6 \\ &= 0.032\text{mA}(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

In a transistor, the currents relation is

$$\begin{aligned} I_E &= I_B + I_C(\mathbf{00\frac{1}{2}\ mark}) \\ I_C &= I_E - I_C \\ &= 1.6 - 0.032 \\ &= 1.568\text{mA}(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

Current amplification factor,

$$\begin{aligned} \beta &= \frac{I_C}{I_B}(\mathbf{00\frac{1}{2}\ mark}) \\ &= \frac{1.568}{0.032} \\ \beta &= 49(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

10. (a) (i) An **OP-amp** is an integrated circuit that amplifies the difference in voltage between two inputs. **(02 marks)**

Three properties of Op-amp(can be any of the following)

* It has infinite open loop gain ($A_\circ = \frac{V_{out}}{V_{in}}$)
* Has infinite input impendenceR_{in}
* It has infinite output voltage range
* It has very low output impendence
* It has infinite low output bandwidth

(ii) The three elements of communication system are **Receiver, channel and Transmitter**

Transmitter it takes informations/signals and converts into transmitted signal

* **Channel (Transmission medium)** is a medium that carries the information /signals
* **Receiver** is an element of communication system that takes the signals from the channel and converts it back into the information for the recipient **(03 mark)**

(b) Required are the values of R_2 and R_3 respectively

From

$$\begin{aligned} I_{in} &= -I_{out}(I_1 \text{across} R_1) \\ \text{but} I_{in} &= I_2(\text{across} R_2) + I_3(\text{across} R_3) \\ -\frac{V_\circ}{R_1} &= \frac{V_2}{R_2} + \frac{V_3}{R_3} \\ V_\circ &= -R_1\left(\frac{V_2}{R_2} + \frac{V_3}{R_3}\right) \end{aligned}$$

But

$$\begin{aligned} R_1 &= 10\text{k}\Omega \\ V_\circ &= -(4V_1 + 0.5V_2).....(i) \end{aligned}$$

Then

$$\begin{aligned} V_\circ &= -R_1\left(\frac{V_2}{R_2} + \frac{V_3}{R_3}\right) \\ V_\circ &= -10\text{k}\Omega\left(\frac{V_2}{R_2} + \frac{V_3}{R_3}\right) \end{aligned}$$

By comparing eqn (i) and (ii)

$$\begin{aligned} +4V_1 &= +\frac{10k\Omega V_1}{R_2} \\ R_2 &= \frac{10k\Omega V_1}{4V_1} \\ R_2 &= 2.5k\Omega \end{aligned}$$

Also forR_3

$$\begin{aligned} +0.5V_2 &= +\frac{10k\Omega V_2}{R_3} \\ R_3 &= \frac{10k\Omega V_2}{0.5V_2} \\ R_3 &= 20k\Omega \end{aligned}$$

Hence the values of R_2 and R_3 respectively are 2.5kΩ and 20kΩ **(04 mark)**

(c) (i) **The three factors which contributes the effective transmission of signals are**

- Size of antennae or aerial **($00\frac{1}{2}$ mark)**
- Effective power radiated by an antennae **($00\frac{1}{2}$ mark)**
- Mixing u of signals from different transmitters **($00\frac{1}{2}$ mark)**

(ii) Given wave equation

$y = 10\cos(1800\pi t) + 20\cos(2000\pi t) + 10\cos(2200\pi t)$

Required μ and all 3 modulated frequencies.

From the expression of the amplitude of modulated wave

$$\begin{aligned} C_m(t) &= (A_c + A_m \cos\omega_m t)\cos\omega_c t \ldots\ldots\ldots\ldots\ldots\ldots (i) \\ y &= 10[\cos(1800\pi t) + \cos(2200\pi t)] + 20\cos(2000\pi t) \end{aligned}$$ **($00\frac{1}{2}$ mark)**

By factor formula.

$$\begin{aligned} \cos(1800\pi t) + \cos(2200\pi t) &= 2\cos\left(\frac{1800+2200}{2}\right)\pi t \times \cos\left(\frac{1800-2200}{2}\right) \\ \cos(1800\pi t) + \cos(2200\pi t) &= 2\cos(2000\pi t)\cos(200\pi t) \end{aligned}$$

Then

$$\begin{aligned} y &= 10[2\cos(2000\pi t)\cos(200\pi t)] + 20\cos(2000\pi t) \\ &= 20\cos(2000\pi t)\cos(200\pi t) + 20\cos(2000\pi t) \\ y &= [20 + 20\cos(200\pi t)]\cos(2000\pi t) \ldots\ldots\ldots\ldots\ldots\ldots (ii) \end{aligned}$$

Compare eqn (i) and (ii)

$$\begin{aligned} y &= [20 + 20\cos(200\pi t)]\cos(2000\pi t) \\ C_m(t) &= (A_c + A_m \cos\omega_m t)\cos\omega_c t \end{aligned}$$

But

A_c=amplitude of the signal wave=20

A_M=Amplitude of the modulated=20

ω_c=Angular velocity of the signal wave= 2000π

ω_m=Angular velocity of the modulated wave200π

Modulation index

$$\begin{aligned}\mu &= \frac{A_m}{A_c}\\ &= \frac{20}{20}\\ \mu &= 1(\mathbf{00\frac{1}{2}\ mark})\end{aligned}$$

Hence the value of modulation index (μ) is 1

Central frequency (f_c)

From

$$\begin{aligned}2\pi f_c &= \omega_c\\ f_c &= \frac{\omega_c}{2\pi}\\ &= \frac{2000\pi}{2\pi}\\ f_c &= 1000\text{Hz}\end{aligned}$$

Frequency of modulated wave (f_m)

$$\begin{aligned}f_m &= \frac{\omega_m}{2\pi}\\ &= \frac{200\pi}{2\pi}\\ f_m &= 100\text{Hz}\end{aligned}$$

Left side frequency

$$\begin{aligned}&= f_c - f_m(\mathbf{00\frac{1}{2}\ mark})\\ &= 1000\text{Hz} - 100\text{Hz}\\ &= 900\text{Hz}(\mathbf{00\frac{1}{2}\ mark})\end{aligned}$$

Right side frequency

$$\begin{aligned}&= f_c + f_m(\mathbf{00\frac{1}{2}\ mark})\\ &= 1000\text{Hz} + 100\text{Hz}\\ &= 1100\text{Hz}(\mathbf{00\frac{1}{2}\ mark})\end{aligned}$$

$\therefore f_c, f_c - f_m$ and $f_c + f_m$ respectively are $1000\text{Hz}, 900\text{Hz}$ and 1100Hz

(01 mark)