PROPOSED MARKING SCHEME

PHYSICS 1

1. (a) (i) It means that the dimension of fundamental quantities in the equation are the same **01 mark**

(ii) Given that

$$V = Xt^2 + Yt + Z$$

Applying the principle of homogeneity

$$[V] = [Xt^2]$$

$$[X] = \frac{[V]}{[t^2]} = \frac{M^0LT^{-1}}{M^0L^0T^2}$$

$$[X] = M^0LT^{-3}$$

**The unit of $X$ is $ms^{-3}$** **02 marks**

Also;

$$[V] = [Yt]$$

$$[Y] = \frac{[V]}{[t]} = \frac{M^0LT^{-1}}{M^0L^0T}$$

$$[Y] = M^0LT^{-2}$$

**The unit of $Y$ is $ms^{-2}$** **02 marks**

Also

$$[V] = [Z]$$

$$[Z] = M^0LT^{-1}$$

**The unit of $Z$ is $ms^{-1}$** **01 marks**

(b) given $W_a = (10 \pm 0.1)kg$, $W_w = (5.0 \pm 0.1)kg$

Required maximum percentage error in specific gravity

Recall:

$$S.g = \frac{W_a}{W_a - W_w}$$ **01 mark**

$$S.g = \frac{(10 \pm 0.1)}{(10 \pm 0.1) - (5.0 \pm 0.1)}$$

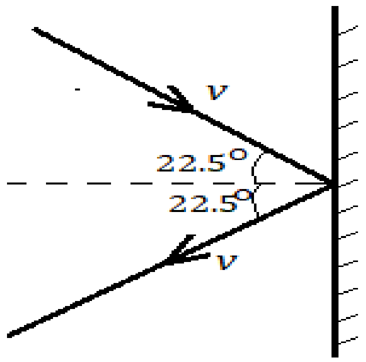
$$S.g = \frac{(10 \pm 0.1)}{(5.0 \pm 0.2)}$$ **01 mark**

$$\frac{\Delta S.g}{S.g} = \left(\frac{0.1}{10} \times 100\%\right) + \left(\frac{0.2}{5} \times 100\%\right)$$

$$\frac{\Delta S.g}{S.g} = 5\%$$ **02 marks**

2. (a) (i) Momentum $p = mv$. Since P is constant, the body with smaller mass will move faster **02 marks**

(ii) The given situation can be represented as shown in the following figure.




**01 mark**

Initial and final velocities of the ball = v
Horizontal component of the initial velocity = vcos θ
Vertical component of the initial velocity = vsin θ
Horizontal component of the final velocity = vcos θ
Vertical component of the final velocity = vsin θ
The horizontal components of velocities suffer no change. The vertical components of velocities are in the opposite directions.

∴Impulse imparted to the ball = Change in the linear momentum of the ball

$$= mvcos\,\theta - (-mvcos\,\theta)$$
$$= 2mvcos\theta$$

∴ Impulse $= 2 \times 0.15 \times 15\, cos\, 22.5° = 4.16$ kg m/s **02 marks**

(b) Illustration of the problem

At point of collision $X_A = X_B$
But $X = (V_0 \cos\theta)t$

$$X_A = (V_A \cos\theta_A)t, X_B = (V_B \cos\theta_B)t,$$

Hence

$$(V_A \cos\theta_A)t = (V_B \cos\theta_B)t,$$ **01 mark**

$$V_A = \frac{(V_B \cos\theta_B)}{\cos\theta_A}$$

$$V_A = \frac{30\times\cos 60°}{\cos 30°} = \mathbf{17.32}\boldsymbol{m/s}$$ **01 mark**

Also

$$y = (V_0 \sin\theta)t + \tfrac{1}{2}gt^2$$

$$y_A = y_0 + (V_A \sin\theta_A)t - \tfrac{1}{2}gt^2$$

$$y_B = (V_B \sin\theta_B)t - \tfrac{1}{2}gt^2$$ **01 mark**

At point of collision $y_A = y_B$

$$y_0 + (V_A \sin\theta_A)t - \tfrac{1}{2}gt^2 = (V_B \sin\theta_B)t - \tfrac{1}{2}gt^2$$ **01 mark**

$$[(V_B \sin\theta_B) - (V_A \sin\theta_A)]t = y_0$$
$$t = \frac{y_0}{[(V_B \sin\theta_B) - (V_A \sin\theta_A)]}$$
$$t = \frac{2}{30 \sin 60° - 17 \sin 30°}$$
$$\boldsymbol{t = 0.115sec}$$

**The time taken is is 0.115 sec** **01 mark**

3. (a) (i) In order to convert sliding friction into rolling friction **01 mark**

(ii) Given;

$$\omega_1 = 1\, r.p.s, I_1 = I,\ I_2 = 0.4I,\ \omega_2 = ?$$

From the principle of conservation of angular momentum

$$I_1\omega_1 = I_2\omega_2$$ **01 mark**

$$\omega_2 = \frac{I_1\omega_1}{I_2}$$

$$\omega_2 = \frac{1\times1}{0.4I}$$ **01 mark**

$$\omega_2 = 2.5\, r.P.S$$

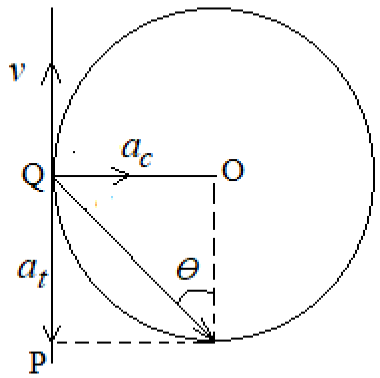
**The new rate of revolution is 2.5 r.p.s** **02 marks**

(b) Centripetal acceleration is given as:

$$a_c = \frac{v^2}{r}$$

$$a_c = \frac{(7.5)^2}{80} = \mathbf{0.7\ m/s^2}$$ **01 mark**

The situation is shown in the given figure:




Suppose the cyclist begins cycling from point P and moves toward point Q. At point Q, he applies the breaks and decelerates the speed of the bicycle by 0.5 m/s$^2$. This acceleration is along the tangent at Q and opposite to the direction of motion of the cyclist. **01 mark**

Since the angle between $a_c$ and $a_t$ is 90°, the **magnitude** of the resultant acceleration a is given by:

$$a = \sqrt{a_c^2 + a_t^2}$$

$$a = \sqrt{0.7^2 + 0.5^2}$$

$$a = 0.86\ \text{m/s}^2$$ **01.5 marks**

**Direction**

$$\theta = \tan^{-1}\left(\frac{a_c}{a_t}\right)$$

Where Θ is the angle of the resultant with the direction of velocity.

$$\Theta = \tan^{-1}(0.7/0.5) = 54.46^\circ$$ **01.5 marks**

4. (a) (i) Yes. It is because the time period of wrist watch (spring controlled) does not depend upon the value of g but depends upon the potential energy stored in the spring **01 mark**

(ii) Given m = 5kg, A= 0.1m, T=3.14sec

From Hooke's' law;

$$F_{max} = kA \text{ but } k = m\omega^2$$

$$F_{max} = mA\omega^2$$ **01 mark**

$$= mA \times \left(\frac{2\pi}{T}\right)^2$$ **01 mark**

$$F_{max} = 5 \times 0.1 \times \left(\frac{2\pi}{3.14}\right)^2$$

$$F_{max} = 2N$$ **02 marks**

(b) (i) The energy needed to launch the satellite of mass, m from the earth's surface is given by:

$$E_T = PE + KE \ldots\ldots\ldots\ldots\ldots (i)$$ **0.5 mark**

But, $PE$ = work done (Energy required to take an object from infinity to a point near the surface.

$$d(PE) = Fdr$$

$$\int d(PE) = \int Fdr$$

$$PE = \int_{\propto}^{r} \frac{GMm}{r^2} dr$$

$$PE = GMm \int_{\propto}^{r} \frac{1}{r^2} dr$$

$$PE = GMm \left[\frac{1}{r}\right]_{\propto}^{r} = GMm \left[\frac{1}{r} - \frac{1}{\propto}\right] \text{ negative}$$ **0.5 mark**

$$PE = \frac{GMm}{r} (negative) \ldots\ldots\ldots\ldots\ldots\ldots\text{(ii)}$$

But $F_C = F_G$

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$mv^2 = \frac{GMm}{r}$$

$$\frac{1}{2}mv^2 = \frac{GMm}{2r}, \quad KE = \frac{GMm}{2r} \ldots\ldots\ldots\ldots\ldots\ldots\text{(iii)}$$ **01 mark**

Substituting eqn (ii) and (iii) into (i) we get

$$\boldsymbol{E_T = \frac{GMm}{2r} - \frac{GMm}{r}}$$ **01 mark**

**(ii)** Given

Mass of the satellite, m = $1000kg$

Radius of orbit, $r_o = 7000km$

Radius of the earth $6400km$

$$\boldsymbol{E_T = \frac{GMm}{2r} - \frac{GMm}{r}}$$

At the surface of the earth,

$$GM_e = g{r_e}^2$$

$$\boldsymbol{E_T = \frac{gr^2 m_s}{2r_e} - \frac{gr_e m_s}{r_o}}$$

$$E_T = \left(\frac{9.8(6.4\times10^6)^2\times1000}{2(6.4\times10^6)}\right) - \left(\frac{9.8\times(6.4\times10^6)\times1000}{7000\times10^3}\right)$$

$$E_T = 3.13\times10^{12} J$$ **02marks**

5. (a) (i) The temperature 273.16 K is the triple point of water. It is not the melting point of ice. The temperature 0°C on Celsius scale is the melting point of ice. Its corresponding value on Kelvin scale is 273.15 K. **02 marks**

(ii) Given the equation;

$$E = A\theta + B\theta^2$$

Required; values of A and B

Case I; when $E = 4.28mV, \theta = 100°\text{C}$

$$4.28\times10^{-3} = A(100) + B(100)^2$$

$$100A + 10000B = 0.00428 \ldots\ldots\ldots\ldots(i)$$ **01 mark**

Case II: when $E = 9.229V, \theta = 200°\text{C}$

$$9.229 = A(200) + B(200)^2$$

$$200A + 40000B = 9.229 \ldots\ldots\ldots\ldots\ldots(ii)$$ **01 mark**

On solving simultaneously

$$\boldsymbol{A = -0.04606V/°\text{C}, B = 4.61022\times10^{-4}V/°\text{C}^2}$$ **01 mark**

**(b)** Side of the given cubical ice box, s = 30 cm = 0.3 m

Thickness of the ice box, l = 5.0 cm = 0.05 m
Mass of ice kept in the ice box, m = 4 kg
Time gap, t = 6 h = 6 × 60 × 60 s
Outside temperature, T = 45°C
Let m' be the total amount of ice that melts in 6 h.
The amount of heat lost by the food:

$$Q = \frac{KA(T-0)t}{l}$$ **01 mark**

Where,
A = Surface area of the box = 6s² = 6 × (0.3)² = 0.54 m² **01 mark**

$$Q = \frac{0.01\times0.54\times(45)\times6\times60\times60}{0.05} = 104{,}976 J$$

But $\theta = m'L$ **01 mark**

$$\therefore \quad m' = \frac{\theta}{L}$$

$$m' = \frac{104976}{335\times10^3} = 0.313 kg$$

Mass of ice left = 4 – 0.313 = 3.687 kg
**Hence, the amount of ice remaining after 6 h is 3.687 kg.** **02 marks**

6. (a) (i) The total energy radiated by a body is directly proportional to the surface area of the of the body. When the animals feel cold, they curl their bodies into the ball so as to decrease the surface area of their bodies. As a result, the loss of heat due to radiation is reduced **02 marks**

(ii) Given;

Power $P = 100W$
Area $A = 1cm^2 = 1 \times 10^{-4}m^2$
Required Temperature T;
From Stefan's law;

$$P = \varepsilon\sigma AT^4$$

$$T = \left(\frac{P}{\varepsilon A\sigma}\right)^{\frac{1}{4}}$$ **01 marks**

Where $\varepsilon = 1$ for perfect black body

$$T = \left(\frac{100}{1\times5.67\times10^{-8}\times10^{-4}}\right)^{\frac{1}{4}}$$

$\boldsymbol{T = 2049K}$ **02 marks**

(b) (i) The value is different because; at constant pressure, energy supplied goes to rise both internal energies, $\Delta U$ and work done, W while at constant volume, the energy supplied goes to raise the internal energy only. Hence $C_P > C_v$ **02 marks**

(ii) given

$n = 5moles, T = 20°\text{C} = 293K, P = 1atm, V_1 = V, V_2 = \frac{1}{10}V, C_v = \frac{5}{2}R$

Required;

Work done, W (Isothermal process)

$$\int_{V_1}^{V_2} PdV$$ **0.5 mark**

But $PV = nRT$

$$W = \int_{V_1}^{V_2} \frac{nRT}{V} dV$$

$$W = nRT \ln\left(\frac{V_2}{V_1}\right)$$ **0.5 mark**

$$W = 5 \times 8.314 \times 293 \times \ln\left(\frac{\frac{1}{10}V}{V}\right)$$

$$W = -28032J$$

**The work required is $\boldsymbol{-28032J}$** **02 marks**

7. (a) (i) Air temperature
   - ❖ Air temperature is a decreasing factor in plant growth
   - ❖ Each plant has its optimum maximum and minimum temperature for their growth and development
   - ❖ Some plants grow better in a colder temperature like wheat, while some prefer warmer temperature like red millet
   - ❖ Air temperature influences the rate of physical and chemical reactions that determines a plant's rate of growth and development
   - ❖ Regulated most of plant's processes like germination, flowering, photosynthesis, transpiration and respiration.
   - ❖ High temperature increases loss of moisture from soil and from plants by evaporation and transpiration **any three points @ 1mark**

(ii) Wind

- wind exchange moist air around the plant with drier air
- having drier air near the leaf increases the rate of evaporation which cause more water to be taken up from the roots to replace that lost from the leaf surface ie. The faster the wind the greater the uptake
- high speed wind in one direction creates the tree to grow in a bend shape in the direction of wind.
- Wind also dehydrates causing plants to be stressed and become dwarf

**any three points @ 1mark**

(b) Kinetic energy of air = $\frac{1}{2}mv^2$

$= \frac{1}{2}(\rho Avt)v^2$

$= \frac{1}{2}\rho Av^3t$

Electric energy produced = 25% of the wind energy

$= \frac{25}{100} \times Kinetic\ energy\ of\ air$

$= \frac{1}{8}\rho Av^3t$ **02 marks**

Electrical power = $\frac{Electrical\ energy}{time}$

$= \frac{1}{8}\frac{\rho Av^3t}{t}$

$= \frac{1}{8} \times 1.2 \times 30 \times 10^3$

= **$4.5 \times 10^3$ W = 4.5 kW** **02 marks**

8. (a) (i) Resistors are said to be connected in series when the current flowing through each resistor is the same **01 mark**

(ii) Given

$A = 100mm^2 = 100 \times 10^{-6}m^2$, $n = 2 \times 10^{35}$ electrons per $m^3$, $I = 13A$

Required; Drift velocity, $V_d$

$$V_d = \frac{I}{neA}$$ **01 mark**

$$V_d = \frac{13}{(2 \times 10^{35})(1.6 \times 10^{-19})(100 \times 10^{-6})}$$

$$V_d = 4.0625 \times 10^{-12}m/s$$ **02 marks**

(b) (i) Resonance angular frequency is given as: $\omega_r = \frac{1}{\sqrt{LC}}$

$$\omega_R = \frac{1}{\sqrt{5 \times 80 \times 10^{-6}}} = 50\,rad/s$$

**01 mark**

Hence, the circuit will come in resonance for a source frequency of 50 rad/s.

(ii) Impedance of the circuit is given by the relation: $Z = \sqrt{R^2 + (X_L - X_C)^2}$

At resonance, $X_L = X_C$

$\Rightarrow \quad Z = R = 40\ \Omega$ **01 mark**

Amplitude current at resonant frequency is given as: $I_o = \frac{V_o}{Z}$

Where, $V_o = \sqrt{2}V$

$\Rightarrow \quad I_o = \frac{\sqrt{2}V}{Z}$

$$\therefore \qquad I_o = \frac{\sqrt{2}\times 230}{40} = 8.13\ A$$ **01 mark**

(iii) *Rms* potential drop across the inductor, $(V_L)_{rms} = I_{rms}X_L = I_{rms}\times\omega_r L$

But $I_{rms} = \frac{I_o}{\sqrt{2}} = \frac{8.13}{\sqrt{2}} = \frac{23}{4}$

$$\Rightarrow \qquad (V_L)_{rms} = \frac{I_o}{\sqrt{2}}\times\omega_r L$$

$$(V_L)_{rms} = \frac{8.13}{\sqrt{2}}\times 50\times 5 = 1437.5\ V$$ **01 mark**

Rms potential drop across the capacitor: $(V_C)_{rms} = I_{rms}X_C = I_{rms}\times\frac{1}{\omega_r C}$

$$\Rightarrow \qquad (V_C)_{rms} = I_{rms}\times\frac{1}{\omega_r C}$$

$$\therefore \qquad (V_c)_{rms} = \frac{23}{4}\times\frac{1}{50\times 80\times 10^{-6}} = 1437.5\ V$$

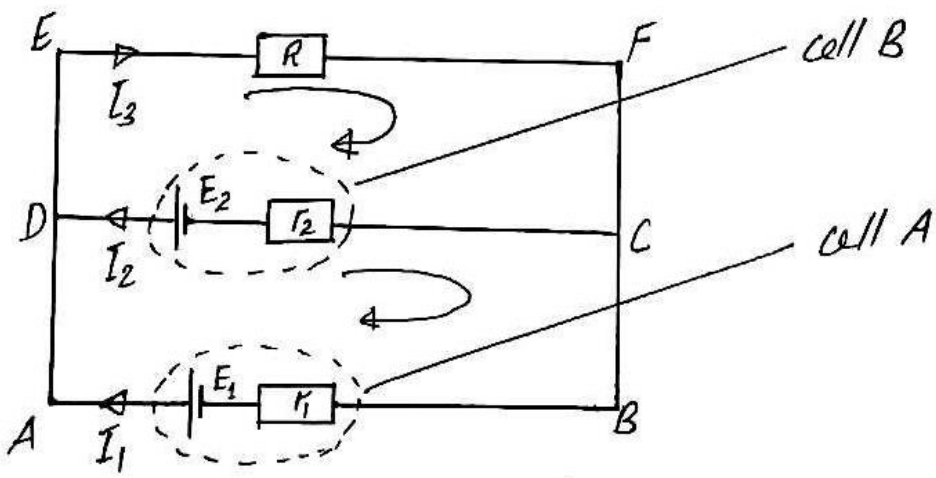
Rms potential drop across the resistor: $(V_R)_{rms} = I_{rms}R$

$$\therefore (V_R)_{rms} = \frac{23}{4}\times 40 = 230\ V$$ **01 mark**

Potential drop across the LC combination: $V_{LC} = I_{rms}(X_L - X_C)$

At resonance, $X_L = X_C \Rightarrow V_{LC} = 0$

(c) Illustration of the problem




Given; $E_1 = 12V, r_1 = 0.5\Omega$

$E_2 = 6V, r_2 = 1.5\Omega, R = 10\Omega$

Required; $I_1, I_2$ and $I_3$

Applying KCL

$; I_1 + I_2 = I_3 \ldots\ldots\ldots\ldots.(i)$ **01 mark**

Applying KVL Loop DEFCD

$E_2 - I_2r_2 - I_3R = 0$

$6 - (I_2\times 1.5) - (I_3\times 10) = 0$

$1.5I_2 + 10I_3 = 6 \ldots\ldots\ldots..(ii)$ **01 mark**

Applying KVL Loop ADCBA

$E_1 - I_1r_1 - E_2 + I_2r_2 = 0$

$12 - 0.5I_1 - 6 + 1.5I_2 = 0$

$0.5I_1 - 1.5I_2 = 6$ **01 mark**

Solving the three equations simultaneously

$\boldsymbol{I_1 = 3.76A, I_2 = -2.75A, I_3 = 1.01A}$

The current through cell A is 3.76A **01 mark**

The current through cell B is 2.75A **01 mark**

the current through the external resistor is 1.01A **01 mark**

9. (i) The forward biased resistance of the diode is low as compared to the reverse bias resistance. The diode conducts only when its forward biased and it is not conducting when its reverse biased. This properly of the diode is called unidirectional conducting property. **02 marks**

(ii) The unidirectional conducting property of the diode is used for rectification. It means diode allows current only when it is forward biased. An alternating voltage is applied across the diode the current flows only in that of cycle when the diode is forward biased. **02 marks**

(b) (i)Voltage gain, $A_v = \frac{V_o}{V_i} = \beta\frac{R_C}{R_B}$

Input signal voltage, $V_i = \frac{R_B}{\beta \times R_C} \times V_o$

$V_i = \frac{1000}{100 \times 2000} \times 2$

$\boldsymbol{V_i = 0.01\ V}$ ***03 marks***

(ii) Base resistance, $R_B = \frac{V_i}{I_B}$

$R_B = \frac{0.01}{1000} = 10 \times 10^{-6} A$

$\therefore$ The base current of the amplifier is ***10 μA*** ***03 marks***

(c) Required; to show that $\gamma > \beta$

Recall $\gamma = \frac{I_E}{I_B}$, but $I_E = I_B + I_c$

$\gamma = \frac{I_B + I_c}{I_B} = 1 + \frac{I_C}{I_B}$ **02 marks**

But $\frac{I_C}{I_B} = \beta$

$\gamma = 1 + \beta$

Hence $\gamma > \beta$ **02 marks**

**Reason:** The load resistance of the common collector transistor receives both the base and collector currents hence giving large current gain ($\gamma$) and therefore provide good current amplification with very little voltage gain **01 mark**

10. (a) (i) Assumptions made for analysing ideal op-amp are:

- Infinite open-loop gain
- Infinite input impedance
- Zero output impedance
- Infinite frequency bandwidth
- Infinite slew rate
- Characteristics not drifting with temperature **any 4 assumptions @ 0.5 mark**

(ii) Given

$$A_v = 100, V_0 = \pm 9V, f = 50hz, V_m = 0.6V$$

Required; time of saturation, t

$$A_v = \frac{V_o}{V_{in}} = \frac{\pm 9}{100}$$

$$V_{in} = \frac{V_o}{A_v} = \frac{\pm 9}{100}$$

$$V_{in} = \pm 0.09V$$ **01 mark**

From $V_{in} = V_m \sin(2\pi f t)$

$$t = \frac{1}{2\pi f} sin^{-1}\left(\frac{V_{in}}{V_m}\right)$$

$$t = \frac{1}{2\pi \times 50} sin^{-1}\left(\frac{0.09}{0.06}\right)$$

$$t = 4.79 \times 10^{-4} sec$$

**The time, t of saturation is $4.79 \times 10^{-4} sec$** **02 marks**

(b) Let;

- S be the switch: 0 for OFF and 1 for ON
- T be the thermostat: 0 for OFF and 1 for ON
- F be the frost outside: 0 for OFF and 1 for ON
- B be the boiler: 0 for OFF and 1 for ON **01 mark**

A truth table,

| S | T | F | B |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |

**04 marks**

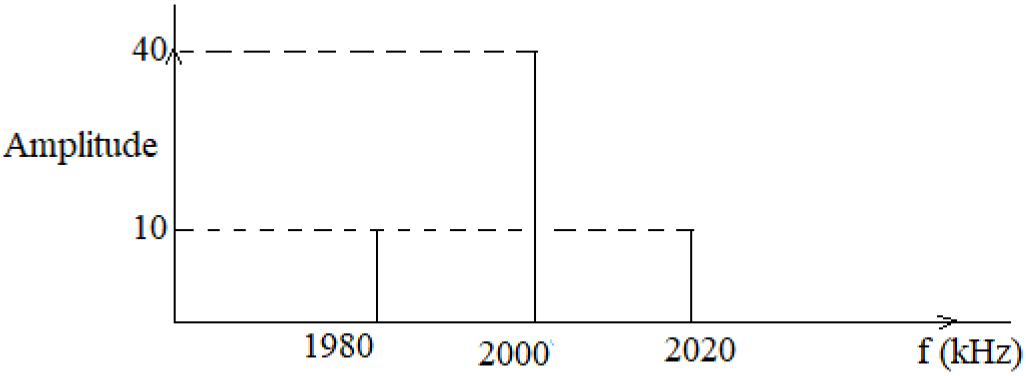
(c) (i) Modulation Index = $A_m / A_c = \frac{20}{40} = 0.5$ **01 mark**

(ii) The side bands are (2000 + 20) kHz = 2020 kHz, and (2000 - 20) kHz = 1980 kHz **02 marks**

(iii) Amplitude versus ω for amplitude modulated signal:

$A_c$ = 40 volts,

$$\frac{\mu A_c}{2} = 10\ V$$




**02 marks**