CSSC PRE-NATIONAL EXAMINATION FORM SIX FEB - 2025
PHYSICS 1 – MARKING GUIDE

1. (a) i. No because this is not dimensionally true ………2marks

ii. solution

T= $\sqrt{\rho^x r^y \gamma^z} = \rho^{x/2} r^{y/2} \gamma^{z/2}$

M0L0T =$[ML^{-3}]^{x/2}[L]^{y/2}[MT^{-2}]^{z/2}$ ……..1marks

0 = -3X/2 +Y/2 …………...1marks

-3x +y=0

Y=3(1)=3

Y=3 …………1marks

(b) i. Yes, an instrument can be precise without being accurate, but measurement cannot be accurate without being precise. ……2 marks

ii. solution

accuracy of measurement =6m

length of the rectangle l=42m

Breadth of the rectangular b = 22m

Area A= lb

lnA = lnlb

$\frac{\Delta A}{A} = \frac{\Delta L}{L} + \frac{\Delta B}{B}$ …………….1marks

$= \frac{6}{42} + \frac{6}{22}$

=0.4156X100% ……………1marks

$\frac{\Delta A}{A}$% = 41.56% ………….1marks

2. (a) (i) Factors determining the span of the jump

- Angle of projection ………………..01 mark
- Initial velocity ………………...01 mark

(ii) ***For zero speed***

Zero speed can be attained when throwing a projectile vertically upwards, it will decelerate due to gravity until it reaches its peak height where its vertical velocity becomes zero momentarily before descending again. …………………01 mark

For non-zero speed

Non zero speed can be attained if you throw a projectile at an angle (not purely vertical), it will have both horizontal and vertical components of velocity. At the peak height, while the vertical component becomes zero, the horizontal component remains non-zero throughout its flight (assuming no air resistance). …………………01 mark

(b) $Given$

$Height of the\ building (h) = 30m$

$Initial velocity (u) = 20m/s$

$Angle\ of\ projection\ (\theta)\ = 52°$

(i) Time of flight

Resolve initial velocity into components:

$U_y = 20sin(52°) = 15.76m/s$

$U_x = 20cos(52°) = 12.31m/s$

From the equation …………01 mark

$h = U_y T - \frac{1}{2} g T^2$, where g = 9.8m/s^2

on solving quadratically

T = 4.55s ……………………………………01 mark

(ii) Horizontal distance

By using the horizontal component of velocity

$R = U_x \times T$ ……………………….01 mark

$R = 12.31 m/s \times 4.55 s = 56\ m$ …………………….. 01 mark

(iii) Velocity and direction with which the stone strikes the ground

From V= $\sqrt{v_x^2 + V_y^2}$

But $V_y = U_y - gT$

$V_y = 20 sin(52°) - 9.8 \times 4.55 = -28.9 m/s$

$V_x = 20 cos(52°) = 12.31 m/s$

Therefore

V= $\sqrt{(12.31)^2 + (-28.9)^2}$

V= 31.4 m/s …………………………………………………..01 mark

Direction

$\theta = tan^{-1}\left(\frac{V_y}{V_x}\right)$

$\theta = tan^{-1}\left(\frac{-28.9}{12.31}\right)$

$\theta = 66.95°$ ………………………………………………………… 01 mark

3. (a) (i) No; it is because g=o at the centre of the earth. …….. 01.5marks

(ii) No; change it is because the time period of a loaded spring is independent of acceleration due to gravity. ……… 01.5marks

(b) (i) Force and acceleration are in phase since they are directly proportional. . ………. 02marks

(ii) solution

mv = (M+m)V

V= mv/m+M = 0.00095X630/(5.4+0.00095) ……………………….0.5mark

V = 1.1m/s …………………… 01mark

0.5(m+M)V^2 = 0.5kx^2

X = $\sqrt{\frac{m+M}{K}}$ X V = $\sqrt{\frac{5.4+0.00095}{6000}}$ X 1.1 ………………………………………..0.5mark

X = 0.033m ………………………………………01marks

4. (a) (i) This is due to the fact that velocity of the stone is much less than that of the bullet. Due to low speed the stone remains in contact with the window pane for a long time consequently the window pane is smashed into pieces.

(ii) A rocket works on the principle of conservation of linear momentum. ……01 mark

Solution

Thrust of a rocket $F = V\frac{dm}{dt}$

v = 3 x 10^3 m/s and $\frac{dm}{dt} = 50kgs^{-1}$

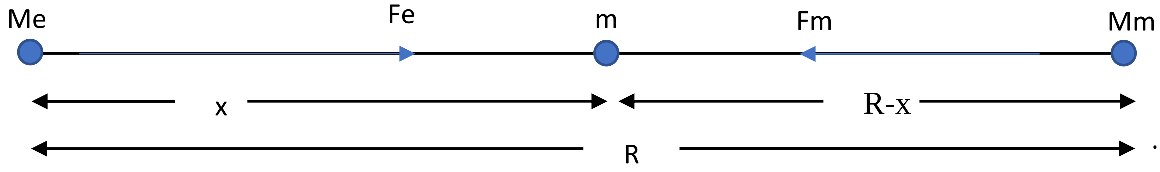
F= 3 x 10^3 m/s x $50kgs^{-1}$ = 1.5 x 10^5 N …………………………………. 01 mark

Upward force = F – mg …………………………………. 01 mark

Initial acceleration, a = $\frac{F-mg}{m} = \frac{F}{m} - g$

a = $\frac{1.5 \text{ x } 10^5 \text{ N}}{5 \text{ x } 10^3 \text{ N}} - 9.8 = 20ms^{-1}upward$ ………………………….. 01 mark

(b) solution



……01 mark

The net gravitational force on mass m,

$$\sum F = F_m + (-F_e), but \sum F = 0$$

Hence $F_e = F_m$

$\frac{Gm_e m}{X^2} = \frac{Gm_m m}{(R-X)^2}$ ….01 mark

Solving for x gives, $x = (R-x)\left(\frac{m_e}{m_m}\right)^{\frac{1}{2}}$

, $x = (3.8 \times 10^8 - x)\left(\frac{6.0\times10^{24}kg}{3.35\times10^{22}kg}\right)^{\frac{1}{2}}$ ………………………………………………………………. 01 mark

$x = 3.54 \times 10^8\ m$

The position of an object with respect to the earth is 3.54 x 10^8 m …………………………..01 mark

5. (a) (i) solution

Using the centripetal force equation

$F_c = \frac{mv^2}{r} = mg$ ………………………………………………………… 0.5 mark

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

$v^2 = rg$

$v = \sqrt{30\ x\ 9.8}$ ………………………………………………………… 0.5 mark

v = 17.15 m/s

So, the maximum speed with which a car can cross the bridge without leaving contact with the ground at the highest point is **17.15 m/s**. ………………………………………………………… 01 mark

(ii) solution

Speed of the car v = 54km/h = 15m/s ………………………………………………………… 0.5 mark

Frictional force = centripetal force

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

$\mu N = \frac{mv^2}{r}$

$\mu mg = \frac{mv^2}{r}$

$\mu = \frac{v^2}{rg}$

$\mu = \frac{15^2}{20\ x\ 9.8}$ ………………………………………………………… 0.5 marks

$\mu = 1.15$

The least coefficient of friction between the tires and the road that can prevent slipping is approximately 1.15**.** ………………………………………………………… 01 mark

(b) (i) Changing the axis of rotation of an object changes its moment of inertia because the moment of inertia depends on both the distribution of the object's mass relative to the axis and the distance of each mass element from the axis. When the axis is shifted, the distances of the mass elements from the new axis change, altering the sum of the squared distances multiplied by the mass elements. This results in a different moment of inertia, as described by the parallel axis theorem, which adds the product of the total mass and the square of the distance between the new and original axes to the moment of inertia about the center of mass. ………………………………………………………… 01 mark

(ii)

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

$$\begin{aligned} K_r &= \frac{1}{2}I\varpi^2 \\ \text{but } \varpi &= \frac{V}{R} \\ &= \frac{1}{2}\left(\frac{2}{5}MR^2\right)\left(\frac{V}{R}\right)^2 \\ K_r &= \frac{MV^2}{5}(\mathbf{01\ mark}) \end{aligned}$$

Total K.E of ball K

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

(iii) M.I of the body about the given axis is I= MK^2(here K= 10cm)

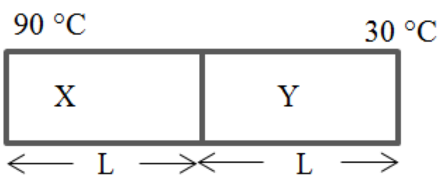
M.I of the body through a parallel axis through centre of mass is $I_{cm}=Mk^2$

According to theorem of parallel axis

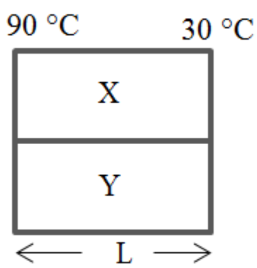
$$\begin{aligned} I &= I_{cm} + Mh^2 (\textbf{01 mark}) \\ MK^2 &= Mk^2 + Mh^2 \\ K^2 &= k^2 + h^2 (\textbf{00}\tfrac{\textbf{1}}{\textbf{2}}\ \textbf{mark}) \\ k^2 &= K^2 - h^2 \\ k &= \sqrt{10^2 - 6^2} \\ k &= 8\text{cm} (\textbf{01 mark}) \end{aligned}$$

6 (a) (i) On shaking a bottle containing hot liquid, its temperature increases and some of the liquid is converted into vapour. The vapour pressure inside the bottle may become high enough to blow off the cork. **(01 mark)**

(ii) solution



Series arrangement



Parallel arrangement

(a) Heat flow through bar x

$$\frac{Q}{t} = A \times K_x \times \frac{(90^0C - \theta)}{L_1}$$

$\frac{Q}{t} = 400\ Wm^{-1}K^{-1} \times A \times \frac{(90^0C - \theta)}{L_1}$ .... (i) ....0.5 mark

For bar y

$\frac{Q}{t} = 200\ Wm^{-1}K^{-1} \times A \times \frac{(\theta - 90^0C)}{L_2}$.......................... (ii) ....0.5 mark

Since the bars are lagged , heat flow is constant

Thus $\left(\frac{dQ}{dt}\right)_x = \left(\frac{dQ}{dt}\right)_y$ ....0.5 mark

Equating equations (i) and (ii), and solving $\theta = 70°$

Therefore the rate of heat in series is given by

$$\left(\frac{Q}{t}\right)_s = 400\ Wm^{-1}K^{-1} \times \frac{A}{L} \times (90^0C - \theta)$$

$\left(\frac{Q}{t}\right)_s = 800\ Wm^{-1}K^{-1}\ \times \frac{A}{L}$ ....0.5 mark

For parallel

$$\left(\frac{Q}{t}\right)_p = \left(\frac{dQ}{dt}\right)_x + \left(\frac{dQ}{dt}\right)_y$$

$$\left(\frac{Q}{t}\right)_p = 400Wm^{-1}K^{-1} \times \frac{A}{L} \times (90^0C - 30^0C) + 200Wm^{-1}K^{-1} \times \frac{A}{L} \times (90^0C - 30^0C)$$

$\left(\frac{Q}{t}\right)_p = 36000Wm^{-1}K^{-1} \times \frac{A}{L}$ .... 01 mark

The ratio of the rate of heat flow in the lagged parallel bars to that in series

$$\frac{\left(\frac{Q}{t}\right)_p}{\left(\frac{Q}{t}\right)_s} = \frac{36000Wm^{-1}K^{-1} \times \frac{A}{L}}{800\ Wm^{-1}K^{-1}\ \times \frac{A}{L}}$$

$\frac{\left(\frac{Q}{t}\right)_p}{\left(\frac{Q}{t}\right)_s} = 9:2$\`...01 *mark*

(b) The specific heat capacities of air are different at constant pressure (C_P) and constant volume (C_V) because, at constant pressure, the gas does work to expand against the external pressure as it is heated. This requires additional energy compared to heating at constant volume, where no work is done.

Thus $(C_P) > (C_V)$.

(i)

(i) Isothermal Process

For an isothermal process, the temperature remains constant, so the work done (W) is given by:

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

Since $V_2 = \frac{V_1}{10}$:

$W = 5 \times 8.314 \times 293 \times \ln(10)$ ....0.5 mark

$W \approx 5 \times 8.314 \times 293 \times 2.3026 \approx 28054.4\text{ J}$ .... 01 mark

So, the work required for the isothermal process is approximately **28054.4 Joules**.

(ii) Adiabatic Process

For an adiabatic process, no heat is exchanged, so the work done is related to the change in internal energy. Using the formula for work done in an adiabatic process:

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

Where $\gamma = \frac{C_p}{C_v}$. Given $C_v = \frac{5}{2}R$ and $C_p = C_v + R = \frac{7}{2}R$:

$$\gamma = \frac{\frac{7}{2}R}{\frac{5}{2}R} = \frac{7}{5} = 1.4$$ ... .0.5 mark

Using the adiabatic condition $P_1V_1^\gamma = P_2V_2^\gamma$:

$$P_2 = P_1\left(\frac{V_1}{V_2}\right)^\gamma = P_1\,(10)^{1.4}$$ ... .0.5 mark

Substitute the values:

$$W = \frac{1 \times V_1 - 1\,(10)^{1.4} \times \frac{V_1}{10}}{1.4 - 1} \Rightarrow W = \frac{1 - 10^{0.4}}{0.4}$$ ....0.5 mark

Which simplifies to:

$$W \approx \frac{1 - 2.5119}{0.4} \approx -3.7797$$

$$W = 3.7797 \times 293 \approx 1107.35\,\text{J}$$ ... .0.5 mark

So, the work required for the adiabatic process is approximately **1107.35 Joules**.

7(a) (i) Soil Temperature and Crop Growth

- Optimal Temperature Range: Crops thrive within a specific temperature range; temperatures too low can slow down enzymatic activities and physiological processes, causing stunted growth and reduced yield. ………………………………………………………… **01 mark**
- Cold Stress: Prolonged exposure to low soil temperatures can cause root damage, hinder nutrient uptake, and increase susceptibility to diseases. ………………………………………. **01 mark**

(ii) Importance of Mulching

1. Moisture Retention: Mulching helps retain soil moisture by reducing evaporation, ensuring that plants have consistent access to water.

2. Temperature Regulation: Mulch insulates the soil, keeping it cooler during hot weather and warmer during cold weather, promoting favorable conditions for plant growth.

3. Weed Suppression: By covering the soil, mulch reduces the amount of sunlight reaching weed seeds, thus inhibiting their growth and reducing competition for resources.

@ Point 01mark = 03 marks

(b) (i) Formation of Earthquakes - Elastic Rebound Theory

Tectonic plates move and accumulate stress along faults due to friction. When the stress exceeds the frictional resistance, the stored energy is suddenly released, causing the plates to snap back to their original shape, producing seismic waves that result in an earthquake. ……………... **03 marks**

(ii) Engineering Precautions for Earthquake-Resistant Buildings

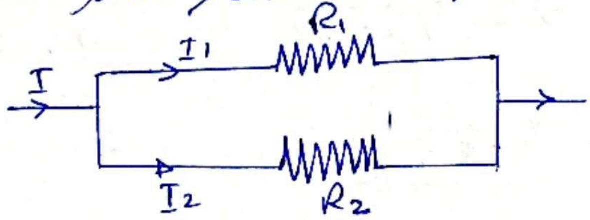
1. Flexible Structures: Engineers design buildings with flexible materials and joints to absorb and dissipate seismic energy, reducing the risk of collapse.
2. Base Isolation: Incorporating base isolators that decouple the building from ground motion helps to minimize the transfer of seismic forces to the structure, enhancing its stability during an earthquake.

@ Point 01mark = 02 marks

8 a (i) This is because we can switch On or off any appliance without affecting the Operation of other appliance.
- Reduce the dependence operation on One appliance to another. (02 marks)

a (ii) In parallel, the resultant resistance is relative low compared to when are in Series (01 mark)

Consider two resistors R_1 and R_2 in parallel.



(01 mark)

By KCL.

$$I = I_1 + I_2.$$

And p.d across R_1 and R_2 is equal

$$V = V_1 = V_2.$$

$$I_1 R_1 = I_2 R_2.$$

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$ (01 mark)

Hence from $P = I^2 R$.

8b (i) From the relation

$$P = \frac{V^2}{R}.$$

$$300 = \frac{(100V)^2}{R}.$$

$$R = 33.33\Omega$$ (01 mark)

$$P = I^2 R.$$

$$I = \sqrt{\frac{P}{R}} \Rightarrow I = \sqrt{\frac{300}{33.33}} \Rightarrow I = 3A$$

(01 mark)

8b Again

$$Z = \frac{V}{I}$$

$$Z = \frac{240V}{3A}$$

$$Z = 80\Omega$$

$$X_c = \sqrt{Z^2 - R_2}$$ --- (01 mark)

$$X_c = \sqrt{80^2 - (33.33)^2}$$

$$X = 72.7\Omega$$ --- (01 mark)

from $X_c = \frac{1}{2\pi f c}$.

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

$$C = \frac{1}{2\pi \times 50 \times 72.7\Omega}$$

$$C = 4.38 \times 10^{-5} F.$$ --- (01 mark)

c) From the diagram

R_3 and R_4 are parallel

Therefore $R_{34} = ?$

$$\frac{1}{R_{34}} = \frac{1}{R_3} + \frac{1}{R_4}$$

$$\frac{1}{R_{34}} = \frac{1}{15} + \frac{1}{30}.$$

$$R_{34} = 10\Omega.$$ --- (01 mark)

Then R_{34} and R_2 are in parallel

Therefore

8 c)
$$\frac{1}{R_{234}} = \frac{1}{R_{34}} + \frac{1}{R_2}$$

$$\frac{1}{R_{234}} = \frac{1}{10} + \frac{1}{15}.$$

$$R_{234} = 6\Omega.$$ --- (01 mark)

Again

R_{234} and R_1 are in series

$$R_{1234} = R_{234} + R_1$$

$$R_{1234} = 6 + 4$$

$$R_{1234} = 10\Omega$$ (00 1/2 mark)

Equivalent Resistance of the Circuit $= 10\Omega$.

$$I_1 = \frac{V}{R_T}$$

$$I_1 = \frac{10V}{10\Omega}$$

$$I_1 = 1.0A$$

Potential drop at R_1

$$V = I_1 R_1$$

$$V = 1.A \times 4\Omega$$

$$V = 4V$$ -- (00 1/2 mark)

By KCL

$$I_1 = I_2 + I_3 + I_4.$$

Potential at R_2 R_3 and R_4

$$V_{234} = 1 \times 6.$$

$$V_{234} = 6V$$. (00 1/2 mark)

$$I_2 = \frac{V_{234}}{R_2}$$

$$I_2 = \frac{6v}{15\Omega}$$

$$I_2 = 0.4A.$$ --- (00 1/2 mark)

$$I_3 = \frac{V_{234}}{15}\Omega$$

$$I_3 = 0.4A.$$ --- (00 1/2 mark)

$$I_4 = \frac{V_{234}}{R_4}$$

$$I_4 = \frac{6v}{30\Omega}$$

$$I_4 = 0.2A.$$ --- (00 1/2 mark)

9. (a)(i) In configuring a transistor circuit, the emitter is forward bias and reverse bias the collector because: In a transistor, the charge carriers move from emitter to collector. The emitter sends the charge carriers and collector collects them. This can happen only if emitter is forward biased and the collector is reverse biased so that it may attract the carriers. (2 marks)

(ii) The base region of a transistor is lightly doped to ensure that only a small number of charge carriers are present. This light doping allows most of the charge carriers injected from the emitter to pass through the base and reach the collector, minimizing recombination within the base. As a result, the transistor achieves higher current gain, improving its overall efficiency and performance. (03 mark)

(b)(i) Current=charge /time

Emitter current,

$$\begin{aligned} I_E &= \frac{N_e}{t} \\ &= \frac{10^{10\times1.6\times10^{-19}}}{10^{-6}} \\ &= 1.6\text{mA}(\mathbf{00\frac{1}{2}\ mark}) \end{aligned}$$

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,

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

(ii) A transistor behaves like an open switch when it is in the cutoff region. In this state, the transistor is not conducting current between the collector and emitter

For a NPN transistor: Ensure that the base-emitter junction is not forward biased by keeping the base voltage lower than the emitter voltage (typically less than the base- emitter threshold voltage, around 0.7 V for silicon transistors).

For a PNP transistor: Ensurethatthebase-emitterjunctionisnotforwardbiasedby keeping the base voltage higher than the emitter voltage. (03 marks)

(c) Applying the KVL to the collector circuit:

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

$I_C=\frac{V_{CC}-V_{CE}}{R_C}=\frac{(5-0)V}{1.5\times10^{3}\Omega}=3.3\times10^{-3}A$ (2 marks)

Then,

$I_B=\frac{V_{BB}}{R_B}=\frac{5V}{2\times10^{5}\Omega}=2.5\times10^{-5}A$ (1 mark)

Therefore,

$\beta=\frac{I_C}{I_B}$ (1 mark)

$\beta=\frac{3.3\times10^{-3}A}{2.5\times10^{-5}A}=132$ (1 mark)

10 (a) (i) Difference between exclusive-OR gate and exclusive-NOR gate.

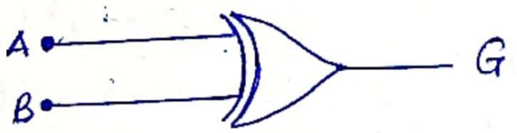
The exclusive-OR (XOR) gate outputs a high signal when its inputs are different while the exclusive-NOR (XNOR) gate outputs a high signal when its inputs are the same. ...(01 mark)

(ii) 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

(03 marks)

(iii)



(01 mark)

b (i) Because negative feedback provides stability, allowing for precise control of gain and improved performance by reducing distortion, noise, and sensitivity to component variations.
(02 marks)

c (ii) Given

Feedback resistance $(R_f) = 20\Omega$

$(R_1, R_2, R_3) = 12\Omega$ each

$V_1 = +6V$

$V_2 = +5V$

$V_3 = +10V$

$V_o = ?$

From. $V_{out} = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f V_2}{R_2} + \frac{R_f}{R_3}V_3\right)$ ——— (01 mark)

$V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$

$V_{out} = -20\left(\frac{6}{12} + \frac{5}{12} + \frac{10}{12}\right)$ ——— (01 mark)

$V_{out} = -35V$ ——— (01 mark)

d (i) Bandwidth refers to the range of frequencies within a given band that can be used for transmitting a signal. It's measured in Hertz (Hz) and indicates the capacity of a communication channel to carry information (02 marks)

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d (ii)

1. Bandwidth of the modulated signal
The bandwidth of an amplitude-modulated (AM) signal is twice the maximum frequency of the modulating signal.
Given the frequency range of the modulating signal is 300Hz to 3400Hz

$BW = 2 \times (3400 - 300)$ ----- (00½ mark)

$BW = 2 \times 3100$

$BW = 6200Hz = 6.2 KHz$ --- (00½ mark)

2. Frequency of the lower side band (LSB).

$f_{LSB} = f_c - f_m$ where f_m is the frequency range of the modulating signal (300Hz to 3400Hz) ——— (00½ mark)

$f_{LSB} = 200KHz - 3400Hz$ to $200kHz - 300Hz$

frequency of the lower side band is 196.6KHz to 199.7KHz. ——— (00½ mark)

3. Frequency range of the upper side band

$f_{USB} = f_c + f_m$ ——— (00½ mark)

$= 200KHz + 300Hz$ to $200KHz + 3400Hz$ (~~3400Hz~~)

$= 200.3KHz$ to $203.4 KHz$. ——— (00½ mark)

∴ The range of frequency of the upper side band is 200.3KHz to 203.4 KHz.