SHRI VIDHYABHARATHI. MAT. HR. SEC. SCHOOL,

SAKKARAMPALAYAM, AGARAM (PO), ELACHIPALAYAM
TIRUCHENGODE (TK), NAMAKKAL (DT) - 637202

99655-31727, 94432-31727

XI-BOOK BACK ONE MARK SOLUTION-NUMERICAL PROBLEMS

PHYSICS-VOLUME-2

LESSON-06-GRAVITATION:

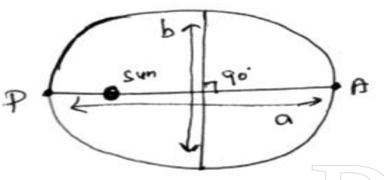
B. B. 1 MARK SOLUTION

LN: 6. GRAVITATION- ஈர்ப்பியல்

① a) $L = mv \times r$

$\vec{L} = \vec{p} \times \vec{r}$ $(mv \perp r)$

Here, L, r and v are mutualy perpendicular. So, A and p are 90° in two position because it is elliptical orbit.



② c) If mass of earth and sun is doubled, then the force?

$$F_1 = \frac{G M_E M_s}{R^2}$$

$$F_2 = \frac{G (2M_E)(2M_s)}{R^2} = 4\frac{G M_E M_s}{R^2}$$

$$F_2 = 4F_1$$

③ a) $L_1 = mv_1 r_1$; $L_2 = mv_2 r_2$

$L_1 = L_2$

$mv_1 r_1 = mv_2 r_2$

$$\frac{v_1}{v_2} = \frac{r_2}{r_1} \quad (\because v \propto \frac{1}{r})$$

④ b) $T = 2\pi\sqrt{\frac{R_e}{g}}$

Independent of mass of the satellite

⑤ b) $T^2 \propto a^3$

$T_1^2 = \text{const}.\, a_1^3 \Rightarrow \frac{T_1^2}{a_1^3} = \text{const}.$ —①

$T_2^2 = \text{const}.\, a_2^3 \Rightarrow \frac{T_2^2}{a_2^3} = \text{const}.$ —②

① = ②

$$\frac{T_1^2}{a_1^3} = \frac{T_2^2}{a_2^3} \qquad a_1 = a,\ a_2 = 2a$$

$$T_2^2 = T_1^2\left(\frac{2a}{a}\right)^3$$

$$T_2^2 = 2\times2\times2 \times T_1^2$$

$$T_2 = \sqrt{4\times2} \times 365$$

$$T_2 = 2\times\sqrt{2}\times365$$

$$T_2 = 1032.22 \text{ days}$$

⑥ b) ⑦ b)

⑧ a) $KE = \frac{G M_E M_s}{(R_E + h)}$

$\uparrow KE \propto \frac{1}{R_E \downarrow}$

$K_A > K_B > K_C$

⑨. c)

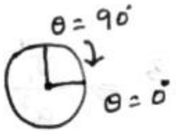
⑩. b) $g = \frac{GM}{R^2}$

$$g' = \frac{G(2M)}{(2R)^2} = \frac{2GM}{4R^2} = \frac{1}{2}\left(\frac{GM}{R^2}\right)$$

$$g' = \frac{g}{2}$$

(11). c)

(12). b)



Chennai 13°

Trichy 11°

$g \propto \frac{1}{R}$

[Ref: 15 Numerical problems]

(13) b)

(14) b) $V_e = \sqrt{2gR}$ $g = 9.8\,ms^{-2}$

$V_e' = \sqrt{2(4g)R}$

$V_e' = 2\sqrt{2gR} = 2V_e$

(15). b) $KE = \frac{1}{2}\frac{GM_EM_s}{(R_e+h)}$

$U = -\frac{GM_EM_s}{(R_E+h)}$

$\therefore KE = \frac{U}{2}$

$KE < U$

LN: 6. GRAVITATION

NUMERICAL PROBLEMS

① The earth's time period $= T_1$

Semi major axis distance (earth) known planet $\} = a_1$

Time period of Unknown planet $= T_2$

Semi major axis of Unknown planet $\} = 2a_1$

According to Keppler's IIIrd law:

$T_1^2 \propto a_1^3$; $T_2^2 \propto a_2^3$

$T_1^2 = \text{const}.\ a_1^3$ $\quad$ $T_2^2 = \text{const}.\ a_2^3$

$\frac{T_1^2}{a_1^3} = \text{const}. — ①$ $\quad$ $\frac{T_2^2}{a_2^3} = \text{const}. — ②$

$① = ② \Rightarrow \frac{T_1^2}{a_1^3} = \frac{T_2^2}{a_2^3}$

$$T_2^2 = T_1^2 \left(\frac{a_2}{a_1}\right)^3$$

$$T_2^2 = \left(\frac{2a_1}{a_1}\right)^3 T_1^2$$

$T_2^2 =$ [illegible] T_1^2

$$T_2 = 2\sqrt{2}\, T_1$$

② $a \propto 2T^2$

$T_1 = 2$

$a_1 \propto 2(2)^2$

$a_1 \propto 8$

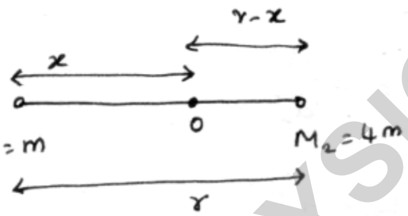
$T_? = 4, \ldots\ldots$

③ $F = \frac{G M_1 M_2}{R^2}$

$$F' = \frac{G (2M_1\, 2M_2)}{(2R)^2} = \frac{4\, G M_1 M_2}{4R^2}$$

$F' = F$ [Remains same]

④



Gravitational field $= -\frac{GM}{R^2}$

$$E_1 = -\frac{Gm}{x^2}$$

$$E_2 = -\frac{4Gm}{(r-x)^2}$$

$E_1 = E_2$

$$\frac{Gm}{x^2} = \frac{4Gm}{(r-x)^2}$$

$$\frac{1}{x} = \frac{2}{r-x}$$

$r - x = 2x$

$r = 3x \Rightarrow \therefore x = r/3$

Gravitational potential $V = -\frac{Gm}{r}$

$V = V_1 + V_2$

$$V = -\left[\frac{Gm}{x} + \frac{4Gm}{r-x}\right]$$

$$V = -\left[\frac{Gm}{r/3} + \frac{4Gm}{r - r/3}\right]$$

$$V = -\frac{G}{r}\left[3m + \frac{12m}{2}\right]$$

$$\boxed{\therefore V = \frac{-9Gm}{r}}$$

(5) $\frac{d_1}{d_2} = 2$; $\frac{E_1}{E_2} = ?$

Sol:

$$E_1 = \frac{GM}{d_1^2} \quad ; \quad E_2 = \frac{GM}{d_2^2}$$

$$\frac{E_2}{E_1} = \frac{GM}{d_2^2} \times \frac{d_1^2}{GM}$$

$$\frac{E_2}{E_1} = \frac{d_1^2}{d_2^2}$$

$$E_2 = 4E_1$$

(6) Time period of moon $T_0 = 1.769$ days

$$T_0 = 1.769 \times 24 \times 60 \times 60 \text{ s}$$

orbital radius of the moon (r)

$$r = 4.217 \times 10^8 \text{ m}$$

Sol:-

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

$$M = \frac{4\pi^2 r^3}{GT^2}$$

$$M = \frac{4 \times 3.14 \times 3.14 \times (4.217 \times 10^8)^3}{6.67 \times 10^{-11} (1.769 \times 24 \times 60 \times 60)^2}$$

$$M = \frac{4 \times 9.8596 \times 74.9912 \times 10^{24}}{6.67 \times 10^{-11} \times (152841.6)^2}$$

$$M = \frac{2957.5329 \times 10^{24}}{1.5581}$$

$$\boxed{M = 1.898 \times 10^{27} \text{ kg}}$$

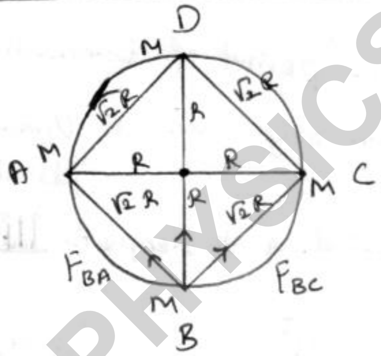
(7) $\vec{L} = 5t^2\hat{i} - 6t\hat{i} + 3\hat{k}$

$\tau = ?$

$$\tau = \frac{dL}{dt} = \frac{d}{dt}(5t^2\hat{i} - 6t\hat{i} + 3\hat{k})$$

$$\tau = 10t\hat{i} - 6\hat{j}$$

(8)



$$F_G = -\frac{Gm_1 m_2}{R^2}\hat{r}$$

$$F = \frac{GM^2}{R^2}$$

$$F_{BA} = \frac{GM^2}{(\sqrt{2}R)^2} = \frac{GM^2}{2R^2}$$

$$F_{BA} = F_{BC} = \frac{GM^2}{2R^2} \longrightarrow (1)$$

Resultant force of F_{BC} and F_{BA}

$$F_1 = \sqrt{F_{BC}^2 + F_{BA}^2}$$

$$F_1 = \sqrt{\left(\frac{GM^2}{2R^2}\right)^2 + \left(\frac{GM^2}{2R^2}\right)^2}$$

$$F_1 = \frac{GM^2}{2R^2}\sqrt{2} \longrightarrow (2)$$

$$F_{BD} = \frac{GM^2}{(2R)^2} = \frac{GM^2}{4R^2}$$

Total force $F_{Tot} = F_1 + F_{BD}$

$$F_{Tot} = \frac{GM^2}{2R^2}\sqrt{2} + \frac{GM^2}{4R^2}$$

$$F_T = \frac{GM^2}{R^2}\left[\frac{\sqrt{2}}{2} + \frac{1}{4}\right]$$

$$\frac{mv^2}{R} = \frac{GM^2}{R^2}\left[\frac{2\sqrt{2}+1}{4}\right]$$

$$v^2 = \frac{GM}{4R}(2\sqrt{2}+1)$$

$$V = \sqrt{\frac{GM}{4R}(2\sqrt{2}+1)}$$

$$V = \frac{1}{2}\sqrt{\frac{GM}{2}(2\sqrt{2}+1)}$$

9. $g = \frac{GM}{R^2}$ — (1)

$g' = \frac{G'M}{R^2}$ — (2)

Given data:

$G = 6.67 \times 10^{-11}$

$G' = 6.67 \times 10^{11}$

$(1)/(2) \Rightarrow \frac{g'}{g} = \frac{G'M}{R^2} \times \frac{R^2}{GM}$

$$\frac{g'}{g} = \frac{G'}{G} = \frac{6.67 \times 10^{11}}{6.67 \times 10^{-11}} = 10^{22}$$

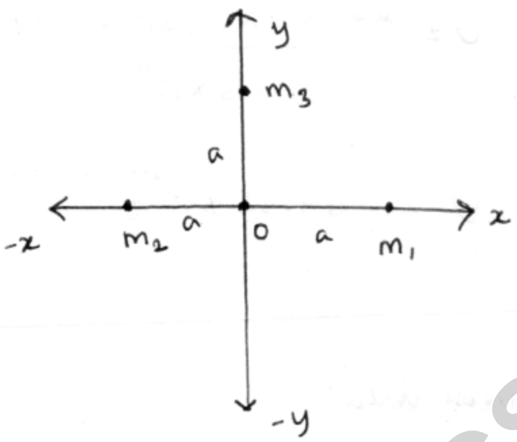
$g' = g\,10^{22}$

$W = mg \qquad W' = mg'$

$W' = 10^{22} mg$

$$\boxed{W' = 10^{22} W}$$

10.



$$\vec{E} = -\frac{GM}{R^2}\hat{r}$$

$$\vec{E}_1 = \frac{Gm_1}{a^2}\hat{i}$$

$$\vec{E}_2 = \frac{Gm_2}{a^2}(-\hat{i})$$

$$\vec{E}_3 = \frac{Gm_3}{a^2}(\hat{j})$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$$

$$E = \frac{Gm_1}{a^2}\hat{i} - \frac{Gm_2}{a^2}\hat{i} + \frac{Gm_3}{a^2}\hat{j}$$

$$E = \frac{G}{a^2}\left[(m_1 - m_2)\hat{i} + m_3\hat{j}\right]$$

If $m_1 = m_2$

$$E = \frac{G}{a^2}[m_3\hat{j}]$$

11. Given data: $R = 150 \times 10^6 \times 10^3\,m$

$R = 150 \times 10^8\,m$

$M_E = 5.9 \times 10^{24}\,kg$

$M_S = 1.9 \times 10^{30}\,kg$

Sol:

$$U = \frac{-GM_E M_S}{R_S}$$

$$U = \frac{-6.67\times10^{-11}\times5.9\times10^{24}\times1.9\times10^{30}}{1.5\times10^{11}}$$

$$U = -49.85\times10^{32}\ J$$

(12) Given data:

$V = 30\ km s^{-1} = 30\times10^{4}\ m s^{-1}$

$KE = ?$

Sol:-

$KE = \frac{1}{2}mv^2$

$KE = \frac{1}{2}(5.9\times10^{24}\times(3\times10^{4})^2$

$KE = \frac{1}{2}\times5.9\times10^{24}\times9\times10^{8}$

$KE = 26.5\times10^{32}\ J$

$TE = U + KE$

$TE = -49.85\times10^{32} + 26.5\times10^{32}$

$TE = -23.35\times10^{32}\ J$

(13) $E_i = E_f$

$U_i + KE_i = KE_f + U(\infty)$

$$-\frac{GM_EM_s}{R_E} + \frac{1}{2}mV_i^2 = \frac{1}{2}mV_\infty^2 + 0$$

$$\frac{1}{2}mV_e^2 = \frac{1}{2}mV_\infty^2 + \frac{GM_Em}{R_E}$$

$\div \frac{m}{2}$

$$V_e^2 = V_\infty^2 + \frac{2GM_E}{R_E}$$

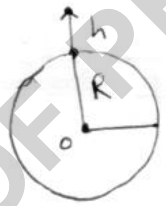
$$V_e^2 = V_\infty^2 + \frac{2GM_E}{R_E^2}\cdot R_E$$

$$V_e^2 = V_\infty^2 + 2gR_E$$

$$V_e = \sqrt{V_\infty^2 + 2gR_E} \quad (or)$$

$$V_e = V_\infty^2 + \sqrt{2gR_E}$$

(14)



$h = 200\ km$

$d = h = 2\times10^{5}\ m$

$g_h' = ?\ ;\ g_d' = ?$

i) Variation of 'g' at height

$$g' = g\left(1 - \frac{2h}{R_E}\right)$$

$$g' = g\left(1 - \frac{2\times2\times10^{5}}{6.4\times10^{6}}\right)$$

$$g' = g\left(1 - \frac{4\times10^{5}}{64\times10^{5}}\right)$$

$$g' = g\left(1 - \frac{1}{16}\right)$$

$$g' = g\left(\frac{15}{16}\right) = 9.8\times\frac{15}{16}$$

$$g' = 0.949$$

Variation of g at $g'_d = ?$

$$g' = g\left(1 - \frac{d}{R_e}\right)$$

$$g' = g\left(1 - \frac{2\times10^5}{6.4\times10^6}\right)$$

$$g' = g\left(1 - \frac{2\times10^5}{64\times10^5}\right)$$

$$g' = g\left(1 - \frac{1}{32}\right)$$

$$g' = g\left(\frac{31}{32}\right)$$

$$g' = 0.96\,g$$

(15)

$$g' = g - \omega^2 R\cos^2\lambda$$

$$\omega^2 R = \left(\frac{2\pi}{T}\right)^2 \times R$$

$$\omega^2 R = \left(\frac{2\times3.14}{86400}\right)^2 \times 64\times10^5$$

$$\omega^2 R = 3.4\times10^{-2}$$

Chennai:

$$\cos^2\lambda = (\cos 13°)^2 = (0.9743)^2$$

$$\cos^2\lambda = 0.9492$$

$$g' = 9.8 - (3.4\times10^{-2}\times0.9492)$$

$$g' = 9.8 - 0.0323$$

$$g' = 9.7677$$

Kanyakumari: $\lambda = 8°$

$$\cos^2\lambda = (0.9902)^2 = 0.9804$$

$$g' = 9.8 - (3.4\times10^{-2}\times0.9804)$$

$$g' = 9.8 - 0.0333$$

$$g' = 9.7667$$

LESSON-7-PROPERTIES OF MATTER

LN:T. பருப்பொருட்களின் பண்புகள் / Properties of Matter

Book back one mark

1. (c)

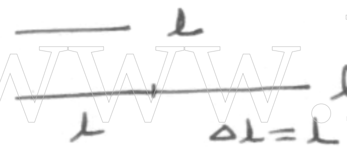
$\sigma_x \propto \frac{1}{r_x^2}$; $\sigma_y \propto \frac{1}{r_y^2}$

$\frac{\sigma_x}{\sigma_y} = \left(\frac{r_y}{r_x}\right)^2 = \left(\frac{r_y}{3r_y}\right)^2$

$\frac{\sigma_x}{\sigma_y} = \left(\frac{1}{3}\right)^2 = \frac{1}{9}$

$\sigma_y = 9\sigma_x$

2. Ans: (a)



$\varepsilon = \frac{\Delta l}{l} = \frac{l}{l} = 1$

3. Ans: (a)

If slope is high the elongation will be less

4. Ans: (d)

$\eta = \frac{1}{3}Y$ $\quad Y = 2\eta(1+\mu)$

$Y = \frac{2Y}{3}(1+\mu)$

$\frac{3}{2} = 1+\mu$

$\mu = 3/2 - 1 = \frac{1}{2}$

$\mu = 0.5$

5. Ans: (d)

$\frac{dQ}{dt} = \frac{E}{t} = \text{Power}$

$\text{Power} = P = F \times V_t$

$F = 6\pi\eta r v_t$

$P = \frac{dQ}{dt} = 6\pi\eta r v_t \times v_t$

$\frac{dQ}{dt} = 6\pi\eta r v_t^2$

$v_t = \frac{2}{9}\frac{(\rho-\sigma)}{\eta} g \times r^2$

$\frac{dQ}{dt} = 6\pi\eta r \times \frac{2}{9}\left[\frac{\rho-\sigma}{\eta} g\right]^2 \times r^4$

$\frac{dQ}{dt} \propto r^5$

6. Ans: (b)

$Y = \frac{Fl}{\Delta l \times A} = \frac{F/\cancel{l}\,\cancel{A}/A}{\Delta\cancel{l} \times A}$

$Y = \frac{Fl}{A\Delta l} \times \frac{A}{A} = \frac{F \cdot V}{\Delta l \times A^2}$

$F \propto A^2$

$\frac{F_2}{F_1} = \frac{(2A)^2}{A^2} = 4$

$F_2 = 4F_1$

7. Ans: (c)

8. Ans: (d)

$Y = \frac{Fl}{\Delta l A} = \frac{Fl}{0 \times A} = \frac{Fl}{0}$

$Y = \infty$

9. Ans : (d)

10. Ans : (b)

$$Y = \frac{F}{A \cdot \Delta t} \Rightarrow Y \propto \frac{1}{\Delta l}$$

11. Ans: (c)

$$Y = \frac{Fl}{A \cdot \Delta l} = \frac{Fl}{V}$$

$\Delta l \propto F$

12. Ans : (c)

13. Ans : (a)

$$\Delta l = \frac{Fl}{AY} = \frac{Fl}{\pi r^2 Y}$$

$\Delta l \propto \frac{1}{r^2}$; $\Delta l \propto \frac{1}{d^2}$

14. Ans : (d)

15. Ans : (b)

$$a_1 v_1 = a_2 v_2$$

$$\frac{\pi d_1^2}{4} v_1 = \frac{\pi d_2^2}{4} \cdot v_2$$

$$d_1^2 v_1 = d_2^2 v_2$$

$$d_2^2 = \frac{v_1}{v_2} d_1^2$$

$$d_2^2 = \frac{1}{1.5} \times 400 \times 10^{-4}$$

$$d_2^2 = 266 \times 10^{-4}$$

$$d_2 = 16.3 \times 10^{-2} \simeq 16 \text{ cm}$$

Numerical Problems.

1. Given

$r_1 = d/2\,mm$; $r_2 = 2/3\, r_1$

$h_1 = 30\,mm$; $h_2 = ?$

Solution

$h \propto \frac{1}{r}$; $hr = \text{constant}$

$h_1 r_1 = h_2 r_2$

$h_2 = h_1 \times \frac{r_1}{r_2}$

$h_2 = h_1 \times \frac{r_1}{2/3\, r_1} = \frac{3h_1}{2}$

$h_2 = \frac{3 \times 30}{2} = 45\,mm.$

Ans: $h_2 = 45\,mm$

3. Solution:

$\Delta P_{Big} = \Delta P_B = \frac{4T}{R}$

$R = 4$

$\Delta P_B = T$

$\Delta P_{small} = \Delta P_s = \frac{4T}{R}$

$R = 2$

$\Delta P_s = \frac{4T}{2} = 2T$

Total Excess pressure ΔP

$\Delta P = \Delta P_B + \Delta P_s$

$\Delta P = 2T + T = 3T = \Delta P_{new}$

$\Delta P_{new} = \frac{4T}{R_{new}}$

$R_{new} = \frac{4T}{3T} = 4/3 = 1.333\,cm$

$R_{new} < R_A$; $R_{new} < R_B$

5. Given

Pressure in pressure Meter $P_1 = 5 \times 10^5\, Nm^{-2}$

$P_2 = 4.5 \times 10^5\, Nm^{-2}$

$P = P_1 - P_2$; $\rho = 1000\, kg\,m^{-3}$

Solution:

$P = \frac{1}{2}\rho v^2$

$v^2 = \frac{2P}{\rho}$; $v = \sqrt{\frac{2P}{\rho}}$

$v = \sqrt{\frac{2(5-4.5) \times 10^5}{1000}}$

$v = \sqrt{10^5/10^3} = \sqrt{10^2} = \sqrt{100}$

$v = 10\, ms^{-1}$

2. Given:

$l = 1.5/2\ 1.5\,m$

$d = 4\,cm$; $\eta = 6 \times 10^{10}\, Nm^{-2}$

$F = 4 \times 10^5\, N$

Solution:

$\eta = \frac{F/A}{\theta}$; $\theta = \frac{F}{\eta \cdot A}$

$\theta = \frac{F}{\eta \times \pi r^2}$

$\theta = \frac{4 \times 10^5}{6 \times 10^{10} \times 3.14 \times (2 \times 10^{-2})^2}$

$\theta = 0.005307\, rad$

LESSON-8-HEAT AND THERMODYNAMICS

வெப்பமும் வெப்ப இயக்கவியலும் Lesson - 8 - HEAT AND THERMODYNAMICS

I. Multiple choice questions:

1. a) internal energy decreases
   ∵ Temperature decreases, so internal energy decreases.

2. c) a straight line
   P - constant, $V \propto T$

3. b) adiabatic

4. b) $T_1 = \frac{T_2}{6}$
   $$P_1V_1 = NKT_1$$
   $$2P_1\,3V_1 = NKT_2$$
   $$6P_1V_1 = NKT_2$$
   $$P_1V_1 = NK\frac{T_2}{6}$$
   $$\cancel{NK}T_1 = \cancel{NK}\frac{T_2}{6}$$
   $$\boxed{T_1 = \frac{T_2}{6}}$$

5. d) moment of inertia
   ∵ $I = mr^2$
   Due to thermal expansion, $r\uparrow, I\uparrow$

6. a) $Q > 0$, $W > 0$
   ∵ Heat is given to the system
   system gains heat → $Q > 0$.
   Lid pushes upwards → Workdone by the system → $W > 0$.

7. b) $\Delta U < 0$, $W > 0$
   Workdone by the system, $W > 0$
   Heat flows outward → $\Delta U \downarrow$

8. c) $\Delta U > 0$, $Q > 0$

9. b) Process B

10. b)

11. a) 8280 K
    $$\lambda_m = \frac{b}{T} \Rightarrow T = b/\lambda_m$$
    $$= \frac{2.898 \times 10^{-3}}{350 \times 10^{-9}}$$
    $$\boxed{\lambda_m = 8280\,K}$$

12. b) P, T, U

13. a) $W = 0$
    $\Delta V = 0$, $W = 0$

14. c) 26.8%
    $T_H = 100^\circ C$
    $T_H = 373\,K$
    $T_L = 0^\circ c$
    $T_L = 273\,K$
    $$\frac{T_H - T_L}{T_H} = \eta$$
    $$= \frac{373 - 273}{373} \times 100$$
    $$= \frac{100}{373} \times 100$$
    $$\boxed{\eta = 26.8\%}$$

(15). c) $40.2^\circ C$

$T_L = -12^\circ C + 273\,K$

$T_L = 261\,K$, $\beta = 5$, $T_H = ?$

$\beta = \dfrac{T_L}{T_H - T_L} \Rightarrow T_H = \dfrac{T_L}{\beta} + T_L$

$= \dfrac{261}{5} + 261$

$= 52.5 + 261$

$= 313.2\,K$

$T_H = 313.2\,K - 273^\circ C$

$\boxed{T_H = 40.2^\circ C}$

IV. Numerical Problems :-

(1). $R = 10 \times 10^{-2}\,m$, $P = 180\,KPa$

$T = 300\,K$, $\mu = ?$, $P = 1.8 \times 10^5\,Pa$

soln:-

$PV = \mu RT$ | $V = \frac{4}{3}\pi R^3$

$\mu = \dfrac{PV}{RT}$

$\mu = \dfrac{1.8 \times 10^5 \times 4/3 \times 3.14 \times [10 \times 10^{-2}]^3}{8.314 \times 300}$

$= \dfrac{7.3476 \times 10^2}{2519.142}$

$= 0.002916 \times 10^2$

$\boxed{\mu \cong 0.3\,mol}$

(2). $T = -53^\circ C$, $P = 0.9 \times 10^3\,Pa$

$V = 1\,m^3$, $\mu_M = ?$, $\mu_E = ?$

$PV = \mu RT$, $T = -53 + 273$

i) $\mu_M = \dfrac{PV}{RT} = \dfrac{0.9 \times 10^3 \times 1}{8.314 \times 220}$

$= \dfrac{0.9 \times 10^3}{1829.08}$

$= 0.0004920 \times 10^3$

$\boxed{\mu_M = 0.49\,mol}$

ii) $\mu_E = \dfrac{PV}{RT} = \dfrac{1.01 \times 10^5 \times 1}{8.314 \times 300}$

$= \dfrac{1.01 \times 10^5}{2494.2}$

$= 0.0004049 \times 10^5$

$\boxed{\mu_E > \mu_M}$ $\boxed{\mu_E = 40.4\,mol}$

(3). I^{st} system $\rightarrow P_1 V_1 T_1$, $2^{nd} \rightarrow P_2 V_2 T_2$

$T = ?$

From Ideal gas eqn,

$PV = NRT$, $\Rightarrow N_1 = \dfrac{P_1 V_1}{RT_1} \rightarrow (1)$, $N_2 = \dfrac{P_2 V_2}{RT_2} \rightarrow (2)$

combined,

$N = N_1 + N_2$

$N_1 + N_2 = \dfrac{P_1 V_1}{RT_1} + \dfrac{P_2 V_2}{RT_2} \rightarrow (3)$

$N_1 + N_2 = \dfrac{P(V_1 + V_2)}{RT} \rightarrow (4)$

$\dfrac{P(V_1+V_2)}{RT} = \dfrac{1}{R}\left[\dfrac{P_1 V_1}{T_1} + \dfrac{P_2 V_2}{T_2}\right]$

$\dfrac{P(V_1+V_2)}{T} = \dfrac{P_1 N_1 T_2 + P_2 V_2 T_1}{T_1 T_2}$

$T = \dfrac{T_1 T_2 \times P(V_1+V_2)}{P_1 V_1 T_2 + P_2 V_2 T_1}$ | $P_1 V_1 = P_2 V_2$

$T = \dfrac{T_1 T_2 [P_1 V_1 + P_2 V_2]}{P_1 V_1 T_2 + P_2 V_2 T_1}$

(4) $I = \frac{Ml^2}{12}$

rod heated, $\rightarrow \Delta T, \Delta l \uparrow$

$\Delta l = l \alpha_L \Delta T \qquad l' = l + \Delta l$

New Moment of Inertia,

$$I' = \frac{M}{12}[l + \Delta l]^2$$

$$= \frac{M}{12}[l + l\alpha_L \Delta T]^2$$

$$= \frac{Ml^2}{12}[1 + \alpha_L \Delta T]^2.$$

$$\boxed{I' = I[1 + \alpha_L \Delta T]^2}$$

(5).

a) Isochoric Process:-

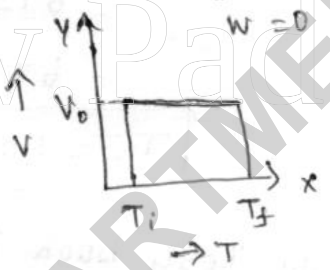
TP diagram: VT diagram:

V - const

$P \propto T$

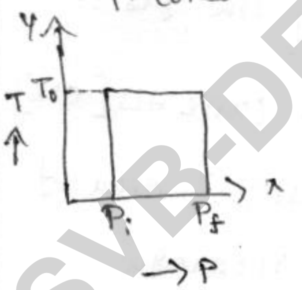
$\Delta V = 0$

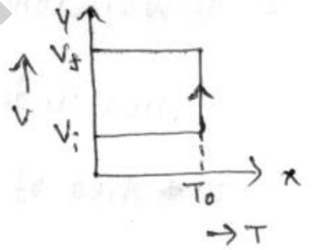
$W = 0$



b) Isothermal :-

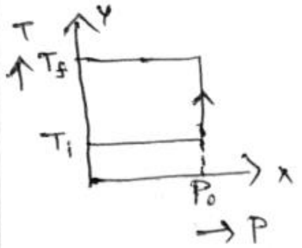
T - constant

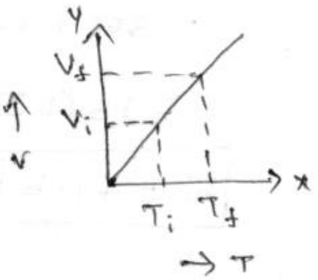




c) Isobaric :-

P - constant





(6) $P_1 = 500\,KPa$

$T_1 = 25^\circ C + 273 = 298\,K$

$\uparrow P_2 = 520\,KPa, \quad \uparrow T_2 = ?$

Soln:-

$PV = \mu RT$

$\frac{PV}{T} = \mu R = \text{constant}$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$V_1 = V_2 = V$

$P_1 T_2 = P_2 T_1$

$T_2 = \frac{P_2 T_1}{P_1} = \frac{520 \times 10^3 \times 298}{500 \times 10^3}$

$T_2 = \frac{154960}{500} = 309.92\,K$

$= 309.92 - 273$

$\boxed{T_2 = 36.9^\circ C}$

(7). $T = 98.6^\circ F$

F to °C

$\Rightarrow C = (F - 32) \div 1.8$

$= (98.6 - 32) \div 1.8$

$= 66.6 \div 1.8$

$\boxed{C = 37^\circ C}$

Convert centigrade to kelvin,

$37^\circ C + 273 = 310\,K$

i) $\lambda_m = \frac{a}{T}$

$= \frac{2.898 \times 10^{-3}}{310}$

$= 9348 \times 10^{-9}$

$\boxed{\lambda_m = 9348\,nm}$

$104^\circ F$

convert to $^\circ C$,

$c = (104-32) \div 1.8$

$= 72 \div 1.8$

$c = 40^\circ C$ to Kelvin,

$T = 40 + 273 = 313\,K$

$\lambda_m = \frac{a}{T} = \frac{2.898 \times 10^{-3}}{313}$

$= 9259 \times 10^{-9}$

$\boxed{\lambda_m = 9259\,nm}$

⑧. Volume V is ↑ by 4%,

i.e, $\frac{\Delta V}{V} \times 100 = 4\%$, $\gamma = 1.4$

$PV^\gamma = $ constant

$\frac{\Delta P}{P} + \gamma \frac{\Delta V}{V} = 0$ Taking log on both sides,

$\log(PV^\gamma) = \log(\text{const})$

$\log P + \gamma \log V = 0$

Differentiate,

$\left(\frac{1}{P}\right)\Delta P + \gamma\left(\frac{1}{V}\right)\Delta V = 0$

$\frac{\Delta P}{P} + \gamma\left(\frac{\Delta V}{V}\right) = 0$

$\frac{\Delta P}{P} = -\gamma\left(\frac{\Delta V}{V}\right)$

$\frac{\Delta P}{P} = -1.4 \times 4\%$

$\boxed{\frac{\Delta P}{P} = -5.6\%}$

-ve sign implies that the Pressure is ↓.

⑨. 1 atm $= 1.013 \times 10^5$ Pa

$T_1 = 20^\circ C + 273 = 293\,K$

$V_2 = \frac{V}{8}$, $V_1 = V$, $T_2 = ?$

$TV^{\gamma-1} = $ constant

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

$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$

$= 293\left[\frac{V}{V/8}\right]^{1.4-1}$

$= 293(8)^{0.4}$

$= \log\left[293 \times (8)^{0.4}\right]$

$= \log 293 + 0.4 \log 8$

$= 673\,K$

$= 673 - 273$

$\boxed{T_2 = 400^\circ C}$

⑩. Refer book page No: 161

⑪ a) Workdone by the gas :-

= Area under the curve AB [clk]

= Area of triangle + Area of rectangle

$= \frac{1}{2} \times 3 \times 200 + (3 \times 400)$

$= 300 + 1200$

$= 1500\,J$

$\boxed{W = +1.5\,kJ}$

b) Work done on the system :-

= Area under the curve BC [C1K]

= Area of rectangle

$= -3 \times 400$

$= -1200\ J$

$\boxed{W = -1.2\ kJ}$

c) Net work done :-

$W = (1.5 - 1.2)\ kJ$

$\boxed{W = +300\ J}$

(12). $Q = 6 \times 10^5\ J$, $V_1 = 4 m^3$, $V_2 = 6 m^3$

$\Delta V = V_2 - V_1 = 6 - 4 = 2 m^3$

$W = ?$, $\Delta U = ?$, Graph = ?

a) Workdone by the gas,

$W = P dV$

$= 1.013 \times 10^5 \times 2$

$W = 2.026 \times 10^5\ J$

$\boxed{W = 202.6\ kJ}$

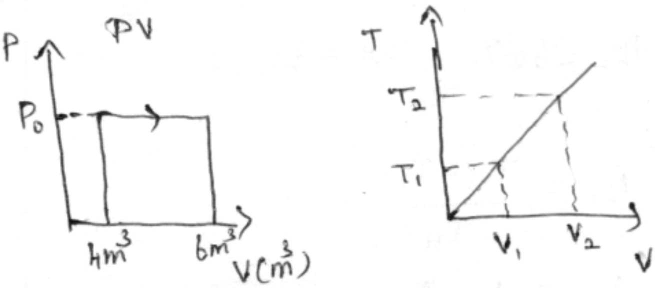
b) $\Delta U = Q - W$

$= 6 \times 10^5 - 2.026 \times 10^5$

$= 3.974 \times 10^5\ J$

$\boxed{\Delta U = 397.4\ kJ}$

Graph :-



(13). $T_L = 100^\circ C \Rightarrow 373 K$

$T_H = 300^\circ C \Rightarrow 573 K$

$\eta = ?$

a) $T_L = 50^\circ C$, $T_H = 300^\circ C$, $\eta_a = ?$

b) $T_L = 100^\circ C$, $T_H = 350^\circ C$, $\eta_b = ?$

$$\eta = \frac{T_H - T_L}{T_H}$$

$$= \frac{573 - 373}{573} = \frac{200}{573} \times 100$$

$\eta = 34.9\%$

$\boxed{\eta = 35\%}$

a) $$\eta_a = \frac{T_H - T_L}{T_H} = \frac{573 - 323}{573}$$

$$= \frac{250}{573} \times 100$$

$= 0.436 \times 100$

$\boxed{\eta_a = 43.6\%}$

b) $$\eta_b = \frac{623 - 373}{623} = \frac{250}{623} \times 100$$

$\boxed{\eta_b = 40.1\%}$ $\eta_a > \eta_b$

First method is suitable for ↑ the efficiency

14. $\eta_1 = 45\%$, $T_H = 327^\circ C \rightarrow 600K$

$\eta_2 = 60\%$, $T_H = ?$

Soln:-

a) $\eta_1 = \frac{T_H - T_L}{T_H}$

$\eta_1 = 1 - \frac{T_L}{T_H}$

$\frac{T_L}{T_H} = 1 - \eta$

$T_L = (1-\eta) T_H$

$= \left[1 - \frac{45}{100}\right] \times 600$

$= \frac{55}{100} \times 600$

$T_L = 330K$

$\boxed{T_L = 57^\circ C}$

b) $\eta_2 = 1 - \frac{T_L}{T_H}$

$\frac{T_L}{T_H} = 1 - \eta_2$

$T_H = \frac{T_L}{1-\eta_2}$

$= \frac{330}{\left[1 - \frac{60}{100}\right]}$

$T_H = \frac{330 \times 100}{40}$

$T_H = 825K$

$\boxed{T_H = 552^\circ C}$

15. $T_L = 0^\circ C$, $T_H = 27^\circ C$

$T_L = 273K$, $T_H = 300K$

$\beta = \frac{T_L}{T_H - T_L}$

$= \frac{273}{300-273}$

$= \frac{273}{27}$

$\boxed{\beta = 10.11}$

x

LESSON-9-KINETIC THEORY OF GASES

L.N: 09 : KINETIC THEORY OF GASES / வாயுக்களின் இயக்கவியற் கொள்கை

ONE MARK - ANSWER

1. a) Ans:

$$\Delta P_x = 2mu\cos 60^\circ$$
$$= -2mu \times \frac{1}{2} = \frac{-\cancel{2}mu}{\cancel{2}} = -mu$$
$$\Delta P_y = 0$$

2. Ans: c

3. b) ANS:

$$V_{rms} = \sqrt{\frac{3RT}{m}}$$
$$V_{rms} \propto \sqrt{T}$$
$$V_{rms} \propto \sqrt{100}$$
$$V'_{rms} \propto \sqrt{1000}$$
$$\frac{V'_{rms}}{V_{rms}} = \sqrt{\frac{1000}{100}}$$
$$V'_{rms} = \sqrt{10}\,.\,V_{rms}$$

4. Ans: a) Room A

5. Ans: a:

$$K.E = \frac{3}{2}kT \quad (k = 4R)$$
$$= \frac{3}{2}4RT$$

6. Ans: b:

$$P = \frac{2}{3}\frac{U}{V}$$
$$P' = \frac{2}{3} \times \frac{2U}{2V}$$
$$P' = P$$

7. ANS: c

$$\gamma = \frac{C_P}{C_V} = \frac{5\mu_1 + 7\mu_2}{3\mu_1 + 5\mu_2}$$
$$= \frac{5\times2 + (7 \times 1/2)}{3\times2 + (5\times 1/2)}$$
$$= \frac{10 + 7/2}{6 + 5/2} = \frac{27/2}{17/2}$$
$$\gamma = 27/17$$

8. Ans: d:

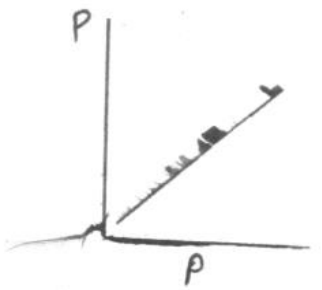
$$\gamma = \frac{C_P}{C_V}$$
$$C_V = \frac{3}{2}R = \frac{f}{2}R$$
$$C_P = \frac{5}{2}R = \left[\frac{f+2}{2}\right]R$$
$$\gamma = \frac{\cancel{R}\left[\frac{f+2}{\cancel{2}}\right]}{f/\cancel{2}\,\cancel{R}}$$
$$\gamma = \frac{f+2}{f}$$

9. Ans: a:

$$\lambda = \frac{kT}{\sqrt{2}\pi d^2 P}$$
$$\lambda' = \frac{k(\cancel{2}T)}{\sqrt{2}\pi d^2(\cancel{2}P)}$$
$$\lambda = \lambda'$$

10. Ans: d:

$$P = \frac{1}{3}\rho v^2, \quad P \propto \rho$$



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11. Ans: a:

→ For a monoatomic molecule, $f = 3$

→ For a diatomic molecule, $f = 7$ (H.T)

→ For a triatomic molecule, $f = 7$ (L.Ty)

→ Total degrees of freedom $= [3\mu_1 + 7(\mu_2 + \mu_3)] N_A$

12. Ans: b:

13. Ans: d:

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$V_{rms} \propto \frac{1}{\sqrt{m}}$$

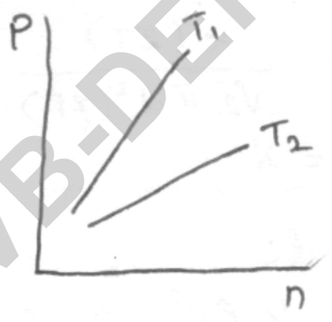
14. Ans: a:

$$PV = NKT$$

$$N = \frac{PV}{KT}$$

15. Ans: b:

$$P = \frac{2}{3}U, \quad U \propto T, \quad P \propto T$$



12.b. $U = \mu C_V \Delta T$; $V = \mu C_p \Delta T$

$$m S_V = \mu C_V$$

$$\frac{m}{\mu} S_V = C_V$$

$$M S_V = C_V$$

For $N_2 \rightarrow M = 28$

$$28 S_V = C_V$$

$$28 S_P = C_P$$

$$C_P - C_V = R$$

$$28(S_P - S_V) = R$$

$$S_P - S_V = R/28$$

NUMERICAL PROBLEMS :

1. Solution:

For Nitrogen,

Molar mass $m = 0.0280$ kg/mol

Temperature $T_{20°c} = 20 + 273$

$= 293$ k

$R = 8.314$ J/mol k

$$V_{rms} = \sqrt{\frac{3RT}{M}}$$

$$= \sqrt{\frac{3 \times 8.31 \times 293}{0.0280}}$$

$$= \sqrt{2610 \times 10^2}$$

$= 511$ m/s

For O_2

Molar mass $M = 0.0320$ kg/mol

$$V_{rms} = \sqrt{\frac{3 \times 8.31 \times 293}{0.0320}} = \sqrt{2280 \times 10^2}$$

$= 478$ m/s

2. Solution:

RMS speed of methane gas

$= 472.8\ ms^{-1} = V_{rms}$

Sub - zero temperature

Molar mass of the methane gas

$= 16.04 \times 10^{-3}$ kg/mole

Surface temperature of

Jupiter $T = ?$

Gas constant $R = 8.31$

$$V_{rms} = \sqrt{\frac{3RT}{M}} = \frac{V_{rms}^2 M}{3R}$$

$$= \frac{(471.8)^2 \times 16.04 \times 10^{-3}}{3 \times 8.31}$$

$$= \frac{3.549456 \times 10^{-3}}{24.9}$$

$T = 143$ K (or) $-273 + 143$

$T = -130°$c

3. Solution:

Temp at S.T.P $= T_1 = 273$ K

V_{rms} of gas $V_{rms1} = V$

RMS velocity of gas triples ie V_{rms2} $\Big\} = 3V$

New temperature at $V_{rms2} = ?$

$T_2 = ?$

$$V_{rms} = \sqrt{\frac{3RT}{m}} \quad (\text{i.e } V_{rms} \propto T)$$

$$\frac{V_{rms1}^2}{V_{rms2}^2} = \frac{V^2}{(3V)^2}$$

$$= \frac{273}{T_2}$$

$T_2 = 273 \times 9$

$T_2 = 2457$ K

4. Solution:

Temperature of gas $T = 80^\circ c = 80 + 273$
$= 353 k$

Pressure of gas $P = 5 \times 10^{-10}\ Nm^{-2}$

Boltzmann's constant $k = 1.38 \times 10^{-23}\ JK^{-1}$

Volume of gas $V = 1 m^3$

No. of molecules $n = ?$ $(PV = NKT)$

$$N = \frac{PV}{KT} = \frac{5 \times 10^{-10} \times 1}{1.38 \times 10^{-23} \times 353}$$

$$= \frac{5 \times 10^{-10}}{483 \times 10^{-23}}$$

$$N = 0.01026 \times 10^{13}$$
(or)
$$N = 1.02 \times 10^{11}$$

5. Solution:

Rms speed of gas molecules in moon V_{rms} $\}$ $= ?$

$$\frac{1}{2} m V_{rms}^2 = \frac{3}{2} kT$$

$$V_{rms} = \sqrt{\frac{3KT}{m}}$$

Boltzmann constant $k = 1.38 \times 10^{-23}\ J/k$

Temperature $T = 0^\circ c = 273 k$

$m = 3.33 \times 10^{-27}\ kg$

$$V_{rms} = \sqrt{\frac{3 \times 1.38 \times 10^{-23} \times 273}{3.33 \times 10^{-27}}}$$

$$= 18.422 \times 10^2 \text{ (or) } 1.842 \times 10^3$$

$$V_{rms} = 1.842 \times 10^3\ ms^{-1}$$

6. Solution:

Mass of 1 atom $= 1.67 \times 10^{-27}\ kg$

Mass of O_2 atom $= 1.67 \times 10^{-27}\ kg$

$1.67 \times 16 = 26.72 \times 10^{-7}\ kg$

Momentum $P = mv$

$= 26.72 \times 10^{-7} \times 8 \times 2 \times 10^3$

$= 427.5 \times 10^{-4}\ kgm\ s^{-1}$

Component of momentum normal to wall is 30°

$= 427.5 \times 10^{-4} \times \cos 30^\circ$

$= 427.5 \times 10^{-4} \times \frac{\sqrt{3}}{2}$

$= 370.2 \times 10^{-4}\ kgm\ s^{-1}$

Pressure $= \frac{F}{A} = \frac{\text{Change in momentum}}{\text{area}}$

$$= \frac{370.2 \times 10^{-4}}{4 \times 10^{-4}}$$

$$P = 92.55\ Nm^{-2}$$

7. Solution:

In an adiabatic process $P^{1-\gamma} T^{\gamma} = const$

$P \propto T^3$

$[T^3]^{1-\gamma} \cdot T^{\gamma} = const$

$T^{3-3\gamma} \cdot T^{\gamma} = const$

$T^{3-3\gamma+\gamma} = const$

$T^{3-2\gamma} = const$

$3 - 2\gamma = 0$

$3 = 2\gamma$

$\gamma = 3/2$

8. Solution:

Diameters N_2 & O_2

$d = 3 \times 10^{-10}$ m

n = number density using ideal gas law

$$n = \frac{N}{V} = \frac{P}{KT} = \frac{101.3 \times 10^3}{1.381 \times 10^{-23} \times 273}$$

$$= \frac{101.3 \times 10^3}{377.01 \times 10^{-23}} = 0.2687 \times 10^{26}$$

$$\lambda = \frac{1}{\sqrt{2}\, \pi n d^2}$$

$$\lambda = \frac{1}{3.14 \times 1.414 \times 0.2687 \times 10^{26} \times (3 \times 10^{-10})^2}$$

$$= \frac{1}{10.74 \times 10^{6}} = 0.0931 \times 10^{-6}$$

$$\lambda = 9.31 \times 10^{-8} \text{ m}$$

9. Solution:

$$U = \frac{n_1 f_1}{2} RT + \frac{n_2 f_2}{2} RT$$

f - Number of degrees of freedom

f_1 - For diatomic gas = 5

f_2 - For monoatmic gas = 3

$$U = \frac{2 \times 5}{2} RT + \frac{4 \times 3}{2} RT$$

$$= 5RT + 6RT$$

$$U = 11 RT$$

10. Solution:

Volume of the room $V = 25.0 \text{ m}^3$

Temperature of the room $\}$ $T = 27°C = 300 K$

Pressure in the room P = estimate

$= 1 \times 1.013 \times 10^5$ pa

The ideal gas equation relating pressure (P), Volume (V) absolute temprature (T) Can be written is

$$PV = k_B NT$$

$$= \frac{1.013 \times 10^5 \times 25}{1.38 \times 10^{-23} \times 300}$$

$$N = 6.11 \times 10^{26} \text{ molecules.}$$

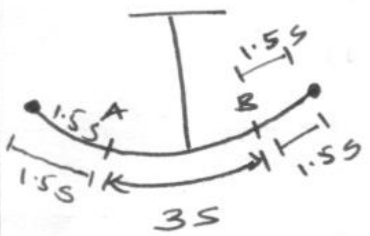
LESSON-10-OSCILLATIONS

LN: 10: அலைவுகள் / OSCILLATIONS

ONE MARK - Answer

1. Ans: (d)

2. Ans: (c)



Total time taken to complete one oscillation is $= 2(1.5+3+1.5)\,s$
$= 2(6)\,s$
$= 12\,s$

3. Ans: (a)

$T = 2\pi\sqrt{l/g}$; $l \propto g$

$l_x \propto g_x$; $l_E \propto g_E$

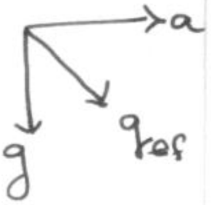
$\frac{l_x}{l_E} = \frac{n g_E}{g_E}$

$l_x = l_E \cdot n$

$l_x = 0.9\,n$

4. Ans: (b)

$T \propto \sqrt{\frac{1}{\sqrt{g^2+a^2}}}$



$g_{ef}^2 = a^2+g^2$; $g_{ef} = \sqrt{a^2+g^2}$

5. Ans: (b)

$A = \sqrt{\frac{2E}{K}}$; $E = \frac{1}{2}mv^2$

$\frac{A_A}{A_B} = \sqrt{\frac{m_A v_A^2}{K_A} \times \frac{K_B}{m_B v_B^2}}$

$\frac{A_A}{A_B} = \sqrt{\frac{mv^2}{K_A} \times \frac{K_B}{2m(4v^2)}}$

$\frac{A_A}{A_B} = \sqrt{\frac{K_B}{8K_A}}$

6. Ans: (b)

$T = 2\pi\sqrt{l/g}$

$T' = 2\pi\sqrt{\frac{l}{2} \times \frac{1}{g}}$

$T' = \frac{T}{\sqrt{2}}$

7. Ans: (b)

8. Ans: (c)

$a = \frac{d^2y}{dt^2} = 2K = 2(1) = 2\,ms^{-2}$

$T_1 = 2\pi\sqrt{l/g} = 2\pi\sqrt{l/10}$

$T_2 = 2\pi\sqrt{\frac{l}{g+a}} = 2\pi\sqrt{\frac{l}{12}}$

$\frac{T_1^2}{T_2^2} = \frac{12}{10} = 6/5$

9. Ans : (c)

$mgx = \frac{1}{2}Kx^2$

$mg = \frac{1}{2}Kx$

$x = 2\frac{Mg}{K}$

$x = 2\frac{Mg}{K}$

10. Ans: (d)

$a = -\omega^2 y$

$\omega = \sqrt{a/y} = \sqrt{\frac{16}{4}}$

$\omega = 2\ rad\ s^{-1}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{2} = \pi\ s$

11. Ans: (a)

$T = \frac{2\pi}{\omega}$

$\omega = \sqrt{K/m}$

$T = \frac{2\pi}{\sqrt{K/m}} = 2\pi\sqrt{m/K}$

$T \propto \sqrt{m}$

12. Ans: (c)

$F \propto V$

$F = KV$

$K = F/V$

$K = \frac{kg\,ms^{-2}}{ms^{-1}}$

$K = kg\,s^{-1}$

13. Ans: (d)

14. Ans : (b)

15. Ans: (a)

$T = 2\pi\sqrt{I/K}$

$I = m_i$

$\frac{m}{K} = l/g$

$K = mg/l$

$T = 2\pi\sqrt{\frac{m_i}{\frac{m_g g}{l}}}$

$T = 2\pi\sqrt{\frac{m_i l}{m_g g}}$

LESSON-11-WAVES

LN: 11: அலைகள் / WAVES

Onemark – Answer

1. Ans: (b)

$n = |f_1 - f_2|$

$3 = 120 - f_2$

$f_2 = 117$

2. Ans: (d)

$f = \frac{v}{\lambda}$; $f_A = \frac{V_A}{\lambda_A}$

$f_A = \frac{500}{5} = 100\,Hz$

When a wave moves from one medium to another medium frequency remains constant

$f_A = f_B = 100\,Hz$

$\frac{V_A}{\lambda_A} = \frac{V_B}{\lambda_B}$; $\lambda_B = \frac{V_B}{V_A} \times \lambda_A$

$\lambda_B = \frac{600}{500} \times 5$

$\lambda_B = 6\,m$

3. Ans: (b)

From data Let us take open pipe

$f_1 : f_2 : f_3 : f_4 : f_5 : f_6 = 1:2:3:4:5:6$

$f_1 : f_2 : f_3 = f_1 : 2f_1 : 3f_1$

4. Ans (a)

5. Ans (c)

6. Ans (a)

$f_{air} = f_{water}$

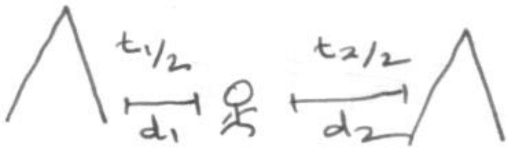
$\frac{V_A}{\lambda_A} = \frac{V_W}{\lambda_W}$

$\frac{\lambda_W}{\lambda_A} = \frac{V_W}{V_A} = \frac{1493}{343}$

$\frac{\lambda_W}{\lambda_A} = 4.35$

$= 4.3$

7. Ans: (d)



$d_1 = v\frac{t_1}{2}$; $d_2 = v\frac{t_2}{2}$

$d = d_1 + d_2$

$d = v\frac{t_1}{2} + v\frac{t_2}{2}$

$d = v\left[\frac{t_1}{2} + \frac{t_2}{2}\right]$

$d = \frac{v(t_1 + t_2)}{2}$

8. Ans: (c)

$$f_1 = \frac{v}{4L}$$

$$L = \frac{v}{4f_1} = \frac{332}{4 \times 83}$$

$$L = \frac{332}{332} = 1.0\ m$$

9. Ans: (a)

$$\frac{\Delta x}{\Delta t} = \frac{\omega}{K} = V$$

from Q.s $\omega = 300\ rad\,s^{-1}$

$K = 2$

$$V = \frac{\Delta x}{\Delta t} = \frac{300}{2} = 150\ ms^{-1}$$

10. Ans: (b)

$f \propto \frac{1}{l}$ $f_1 \propto \frac{1}{l_1}$, $f_2 \propto \frac{1}{l_2}$

$$\frac{f_1}{f_2} = \frac{l_2}{l_1} = \frac{y}{x}$$

$n = |f_1 - f_2|$

$10 = 360 - f_2$

$f_2 = 350$; $f_1 = 360$

$$\frac{y}{x} = \frac{f_1}{f_2} = \frac{360}{350} = \frac{36}{35}$$

$$\frac{x}{y} = \frac{35}{36}$$

11. Ans (d)

12. Ans (a)

13. Ans (b)

$$V = \frac{\Delta x}{\Delta t}$$

From Q.s

$\Delta x = x_1 - x_2$

$= x - x + 2$

$\Delta x = 2\ m$

$\Delta t = 2\ s$

$$V = \frac{2}{2} = 1.0\ ms^{-1}$$

14. Ans: (d)

15. Ans: (c)

$$\frac{V}{4L_A} = \frac{3V}{2L_B}$$

$$\frac{L_A}{L_B} = \frac{2V}{12V} = 1/6$$

$$\frac{L_A}{L_B} = \frac{1}{6}$$

IV. Numerical Problems :- Lesson : 11 - WAVES / அலைகள்

(2). 2 mol of helium, 4 mol of O_2

$V = ?$, $T = 300K$

Soln :-

He & O_2 are mixed, hence molecular weight of the mixture of gases.

$$M_{mix} = \frac{n_1 M_1 + n_2 M_2}{n_1 + n_2}$$

$$= \frac{2 \times 4 + 4 \times 32}{2+4} = \frac{136}{6}$$

$$M_{mix} = \frac{136}{6} \ g/mol$$

$$\boxed{M_{mix} = 136/6 \times 10^{-3} \ kg/mol}$$

He - mono atomic, O_2 - diatomic

$CV_1 = 3/2 R$, $CV_2 = 5/2 R$

$$(C_v)_{mix} = \frac{n_1 CV_1 + n_2 CV_2}{n_1 + n_2}$$

$$= \frac{\cancel{2} \times \frac{3}{\cancel{2}} R + \cancel{4}^{2} \times \frac{5}{\cancel{2}} R}{6}$$

$$C_{v\,mix} = \frac{3R + 10R}{6} = \boxed{\frac{13R}{6}}$$

$$\therefore C_{p\,mix} = CV + R$$

$$= \frac{13R}{6} + R$$

$$\boxed{C_{p\,mix} = \frac{19R}{6}}$$

$$\gamma = \frac{C_P}{C_V} = \frac{19\cancel{R}}{\cancel{6}} \times \frac{\cancel{6}}{13\cancel{R}}$$

$$\boxed{\gamma = \frac{19}{13}}$$

$$V = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{19}{13} \times \frac{8.31 \times 300 \times 6}{136 \times 10^{-3}}}$$

$$= \sqrt{\frac{28420}{1768} \times 10^{4}}$$

$$\boxed{V = 400.9 \ m/s}$$

(3). $v = 1500 \ m/s$, $2t = 3.5s$, $t = 1.75s$

$\Delta d = ?$

$d_1 = v \times t = 1500 \times 1.75$

$d_1 = 2625 m$

After moving 100 km,

$2t = 2s$

$t = 1s$

$d_2 = v \times t = 1500 \times 1$

$d_2 = 1500 m$

$\Delta d = d_1 - d_2 = 2625 - 1500$

$$\boxed{\Delta d = 1125 m}$$

(4) $\lambda = 50.0 m$, $R = ?$

Soln :-

i) The path length of ~~w~~ sound wave passing through the curved is equal to half the circumference

$$L_1 = \frac{2\pi R}{2} = \pi r$$

ii) The path length of sound wave passing through the diameter.

$L_2 = 2R$

Path difference,

$\Delta L = L_1 - L_2 = \pi R - 2R$

$\Delta L = R[\pi - 2] \rightarrow ①$

Given Minimum intensity heard at the detector.

$\Delta L = \lambda/2 \rightarrow ②$

① = ② $R[\pi-2] = \lambda/2$

$R = \dfrac{\lambda}{2[\pi-2]}$

$= \dfrac{50}{2 \times 3.14 - 4}$

$= \dfrac{50}{2.28}$

$\boxed{R = 21.9\,m}$

⑤ No. of tuning forks = N

frequency of 1st is double to be last, freq. of 1st tuning fork = f

Successive tuning forks give,

$\rightarrow n$ beats / s

$f_L = f_{first}\,(N-1)n$

$f_L = 2f$

$2f = f(N-1)n$

$2f - f = (N-1)n$

$\boxed{f_{first} = (N-1)n}$

⑥ I_{old}, $A' = 2A$, $f' = \frac{1}{4}f$

$I_{new} = ?$

Soln:-

$I = 2\pi^2 \rho v^2 f^2 A^2$

$\boxed{I_{old} \propto f^2 A^2}$

$I_{new} \propto f'^2 A'^2$

$I_{new} \propto \left(\frac{1}{4}f\right)^2 (2A)^2$

$I_{new} \propto \frac{1}{\cancel{16}_{4}} f^2 \cdot \cancel{4} A^2$

$I_{new} \propto \frac{1}{4} f^2 A^2$

$\boxed{I_{new} \propto \frac{1}{4} I_{old}}$

⑦ Fundamental frequency of closed organ pipe = 250 Hz

$f_c = \dfrac{v}{4L}$

$f_{open} = \dfrac{v}{2L}$

$\dfrac{f_o}{f_c} = \dfrac{\cancel{v}}{\cancel{2L}} \times \dfrac{\cancel{4L}^{\,2}}{\cancel{v}}$

$\dfrac{f_o}{f_c} = 2$

$f_o = 2 \times f_c$

$f_o = 2 \times 250$

$\boxed{f_o = 500\,Hz}$

9. a) $y = x^2 + 2\alpha t x$

$$\frac{\partial y}{\partial x} = 2x + 2\alpha t$$

$$\frac{\partial^2 y}{\partial x^2} = 2 \rightarrow (1)$$

$$\frac{\partial y}{\partial t} = 2\alpha x$$

$$\frac{\partial^2 y}{\partial t^2} = 0 \rightarrow (2)$$

from,
wave equation.

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

$$2 = \frac{1}{v^2} \cdot 0$$

$$\boxed{2 = 0}$$

function is not describing wave

b) $y = (x + vt)^2$

$$y = x^2 + v^2t^2 + 2xvt$$

$$\frac{\partial y}{\partial x} = 2x + 2vt$$

$$\frac{\partial^2 y}{\partial x^2} = 2 \rightarrow (1)$$

$$\frac{\partial y}{\partial t} = 2v^2t + 2xv$$

$$\frac{\partial^2 y}{\partial t^2} = 2v^2 \rightarrow (2)$$

From wave eqn.

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

$$2 = \frac{1}{\cancel{v^2}} \cdot 2\cancel{v^2}$$

$$\boxed{2 = 2}$$

satisfies wave equation.

11) $v = 900\,m/s$, $t = 2\,min$ (or) $= 120\,s$

$f = \frac{3000}{120} = 25\,Hz$, $\lambda = ?$

Soln:-

$$v = f\lambda$$

$$\lambda = \frac{v}{f}$$

$$\lambda = \frac{900}{25}$$

$$\boxed{\lambda = 36\,m}$$

Department of Physics
SHRI VIDHYABHARATHI MATRIC HR.SEC.SCHOOL
SAKKARAMPALAYAM, AGARAM (PO) ELACHIPALAYAM
TIRUCHENGODE(TK), NAMAKKAL (DT) PIN-637202
Cell : 98423-11320, 91596-70535, 97862-92701