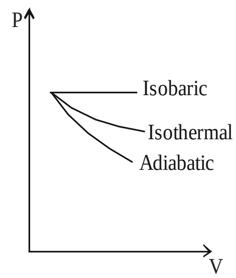
THERMODYNAMICS

EXERCISE-I (MHT CET LEVEL)

Q.1 (3)

Q.2 (2)



Area of P-V curve gives work done by gas. Clearly, area of P-V curve is maximum for isobaric process.

Q.3 (1)

ΔW = area under the p – V curve

$$= \frac{1}{2} \times 3p \times 2V = 3pV$$

Q.4 (2)

work done = | area under P–V curve |

$$= \frac{1}{2}(4p_1 - p_1)(3V_1 - V_1)$$

$= 3p_1V_1$

for anti-clockwise P-V curve, work done is negative

$\Rightarrow w = -3\,p_1V_1$

Q.5 (3)

Q.6 (3)

According to first law of thermodynamics,

Q = W+dU

Thus, only option 3 may be possible.

Q.7 (4)

For all process

$$\Delta U = \Delta Q - \Delta W$$

does not change as it depends on initial final states.

Q.8 (3)

Given ΔQ = -20J, W = -8J

Using I[st] law $\Delta Q = \Delta U + \Delta W$

$$\Rightarrow \Delta U = \Delta Q - \Delta W = -20 - (-8)$$

$= -12$ J

$\Rightarrow U_f - 30 = -12$

$U_f = 18$ J

Q.9 (1)

PV = constant represents isothermal process.

Q.10 (4)

As the bubble rises the pressure gets reduced for constant temperature, if P is the standard atmospheric pressure, then

$$(P + \rho gh)V_0 = PV$$

$$\text{or } V = V_0\left(1 + \frac{\rho gh}{P}\right)$$

Q.11 (4)

work done in isothermal process,

$$W = -nRT\log_e\frac{V_2}{V_1}$$

$$= -1 \times 8.31 \times (273+0)\log\frac{22.4}{11.2}$$

$= -1572.5$ J

Q.12 (1)

$T_1 = 300K$ $V_A = 2$ $V_C = 16$

$T_2 = 200K$ $V_B = 8$

$T_1V_B^{\gamma-1} = T_2V_C^{\gamma-1}$ (Adiabatic)

$T_1V_A^{\gamma-1} = T_2V_D^{\gamma-1}$

$$\left(\frac{8}{2}\right)^{1.5-1} = \left(\frac{16}{V_D}\right)^{1.5-1}$$

$$\Rightarrow 2 = \frac{4}{\sqrt{V_D}} \Rightarrow V_D = 4\text{unit}$$

Q.13 (2)

Q.14 (4)

Q.15 (1)

Q.16 (4)

Q.17 (1)

Q.18 (2)

Q.19 (1)

Q.20 (3)

Q.21 (2)

$$T_2 = 273 - 13 = 260,$$

$$K = \frac{T_2}{T_1 - T_2}; \quad 5 = \frac{260}{T_1 - 260}$$

$$\text{or } T_1 - 260 = 52; \quad T_1 = 312K,$$

$T_2 = 312 - 273 = 39$ºC

Q.22 (1)

The efficiency of the heat engine is

$$\eta = 1-\frac{T_2}{T_1} = 1-\left(\frac{273+27\,K}{273+427\,K}\right) = \frac{4}{7}$$

But $\eta = \frac{W}{Q_1}$

$$\therefore Q_1 = \frac{W}{\eta} = \frac{1.0\,kW}{4/7} = 1.75\,kW = 0.417\,kcal/s$$

[4.18J=1 cal]

Thus, the engine would require 417 cal of heat second, to deliver the requisite amount of per work.

Q.23 (2)
Q.24 (4)
Q.25 (4)
Q.26 (3)
Q.27 (2)
Q.28 (1,2)
Q.29 (2)
Q.30 (1)

$$\eta = \left(1-\frac{T_2}{T_1}\right)\times 100 \qquad T_2 = 0^\circ C = 273\,K$$

$$= \left(1-\frac{273}{373}\right)\times 100 \qquad T_1 = 100^\circ C = 373\,K$$

$$= 26.81\%$$

EXERCISE-II (NEET LEVEL)

Q.1

dQ = dW + dU

dQ = PdV + dU

dQ = nRdT + dU

$$dQ = \frac{2dU}{f} + dU$$

$$\frac{dU}{dQ} = \frac{1}{\left(\frac{2}{f}+1\right)}$$

$$\frac{dU}{dQ} = \frac{5}{7}$$

Q.2 (1*)

As f = 5

$$dU = nC_v\,dT = \frac{nfRdT}{2}$$

$$C_v = \frac{fR}{2}$$

$$\therefore C_v = \frac{5R}{2}$$

Q.3 (4)

Degree of freedom f = 3 (Translatory) + 2(rotatory) + 1 (vibratory) = 6

$$\Rightarrow \frac{C_P}{C_V} = \gamma = 1+\frac{2}{f} = 1+\frac{2}{6} = \frac{4}{3} = 1$$

Q.4 (1)

$(\Delta Q)_v = \mu C_v \Delta T \Rightarrow (\Delta Q)_v = 1\times C_v \times 1 = C_v$

For monoatomic gas $C_v = \frac{3}{2}R \Rightarrow (\Delta Q)_v = \frac{3}{2}R$

Q.5 (1)

$$y_{mix} = \frac{\frac{\mu_1\gamma_1}{\gamma_1-1}+\frac{\mu_2\gamma_2}{\gamma_2-1}}{\frac{\mu_1}{\gamma_1-1}+\frac{\mu_2}{\gamma_2-1}} = \frac{\frac{1\times\frac{5}{3}}{\left(\frac{5}{3}-1\right)}+\frac{1\times\frac{7}{5}}{\left(\frac{7}{5}-1\right)}}{\frac{1}{\left(\frac{5}{3}-1\right)}+\frac{1}{\left(\frac{7}{5}-1\right)}} = \frac{3}{2} = 1.5$$

Q.6 (4)

$$\gamma_{mixture} = \frac{\frac{\mu_1\gamma_1}{\gamma_1-1}+\frac{\mu_2\gamma_2}{\gamma_2-1}}{\frac{\mu_1}{\gamma_1-1}+\frac{\mu_2}{\gamma_2-1}}$$

$$\mu_1 = \text{moles of helium} = \frac{16}{4} = 4$$

$$\mu_2 = \text{moles of oxygen} = \frac{16}{32} = \frac{1}{2}$$

$$\gamma_{mix} = \frac{\frac{4\times 5/3}{\frac{5}{3}-1}+\frac{1/2\times 7/5}{\frac{7}{5}-1}}{\frac{4}{\frac{5}{3}-1}+\frac{1/2}{\frac{7}{5}-1}} = 1.62$$

Q.7 (1)

For cyclic process. Total work done $= W_{AB} + W_{BC} + W_{CA}$

$\Delta W_{AB} = P\Delta V = 10\,(2-1) = 10$ J and $\Delta W_{BC} = 0$

(as V = constant)

From FLOT, $\Delta Q = \Delta U + \Delta W$

$\Delta U = 0$ (Processs ABCA is cyclic)

$\Rightarrow \Delta Q = \Delta W_{AB} + \Delta W_{BC} + \Delta W_{CA}$

$\Rightarrow 5 = 10 + 0 + \Delta W_{CA} \Rightarrow \Delta W_{CA} = -5$ J

Q.8 (4)

As $\Delta U = nR\Delta T$ For closed path

$\Delta T = 0$

$\therefore \Delta U = 0.$

Q.9 (2)
The cyclic process 1 is clockwise where as process 2 is anticlockwise. Clockwise area represents positive work and anticlockwise area represents negative work. Since negative area (2) > positive area (1), hence net work done is negative.

Q.10 (2)
$\Delta U = 0$
$\therefore$ T = constant
clearly, option B is correct.

Q.11 (4)
Work done $= \frac{1}{2} \times 2P_1 \times 2V_1 = 2P_1V_1$

Q.12 (3)
$\frac{V}{T} = \frac{nR}{P}$
$\frac{1}{P}$ α slope or P α $\frac{1}{\text{slope}}$ 1
$\therefore$ $P_2 < P_1$

Q.13 (4)
work done on the gas = negative work
W = PdV when V → decreases
then W = – ve
hence option D is correct.

Q.14 (1)
$\Delta Q = AU + \Delta W$ and $\Delta W = P\Delta V$

Q.15 (2)
In process AB
T = constant
P = increases P α $\frac{1}{V}$
or V = decreases $\Delta Q = \Delta W$.
ΔW = – ve. or
ΔQ = – ve
$\therefore$ heat is rejected out of the system

Q.16 (2)
B → A
$\Delta Q = 0$
$0 = -30 + \Delta U_{BA}$
$\Delta U_{BA} = 30$ J
$\therefore \Delta U_{AB} = -\Delta U_{BA} = -30$ J

Q.17 (2)
$\Delta Q = \Delta U + \Delta W$; $\Delta Q = 200$ J and $\Delta W = -100$ J
$\Rightarrow \Delta U = \Delta Q - \Delta W = 200 - (-100) = 300$ J

Q.18 (4)
Heat given $\Delta Q = 20$ cal $= 20 \times 4.2 = 84$ J.

Work done $\Delta W = -50$ J
[As process is anticlockwise]
By first law of thermodynamics $\Rightarrow \Delta U = \Delta Q - \Delta W = 84 - (-50) = 134$ J

Q.19 (2)
L → M P = constant V α T.
MN T = constant
Here, option B is constant

Q.20 (2)

Q.21 (3)
$$\frac{\Delta Q}{\Delta t} = \frac{\Delta W}{\Delta t} = \text{work done per unit time} = \frac{\text{k}\, a\,\theta}{L}$$
$$\frac{dW}{dt} = p\frac{dv}{dt} = \text{k}\frac{a\theta}{L},\; P = \frac{nRT}{V}$$
$$\Rightarrow \frac{0.5R(300)}{V} A.\frac{d\ell}{dt} = \frac{k\,a\,\theta}{L}$$
$$\Rightarrow \frac{0.5R(300)}{A.\frac{L}{2}} A.v = \frac{\text{k}\,a\,\theta}{L}$$
$$\Rightarrow v = \frac{\text{k}a}{R}\left(\frac{27}{300}\right) = \frac{\text{k}}{100R}$$

Q.22 (a)
Process AB is isobasic an BC is isothermal, CD isochoric and DA isothermic compression.

Q.23 (1)
As W.D. is isobaric > W.D. in Isothermal > W.D in adiabatic
or $W_2 > W_1 > W_3$
Hence option (1) is correct.

Q.24 (1)
Process ...(i) is isobatic
$\Delta U_1 = \Delta Q - \Delta W$ = positive
process (ii) is isothermal
$\Delta U_2 = 0$
Process (iii) is adiabatic
$\Delta Q = 0$
$\Delta U = -\Delta W$ = negative
$\therefore$ $\Delta U_1 > \Delta U_2 > \Delta U_3$

Q.25 (4)

For polytropic process

$$C=\frac{R}{\gamma-1}+\frac{R}{1-x}\Rightarrow \text{As } PV^{\gamma}=K$$

$\Rightarrow$ Put $x=\gamma \quad \therefore C=0$

Q.25 (3)

Isothermal $P\propto \frac{1}{V}$

Adiabatic $P\propto \frac{1}{V^{\gamma}}$

Also, slope of adiabatic is more as compare to isothermal

$\therefore$ option (3) is correct.

Q.27 (4)

$B=\gamma P$ (for adiabatic process

$B=1.4\times 1\times 10^{5}=1.4\times 10^{5}\ N/m^{2}$

Q.28 (2)

$$\frac{T_2}{T_1}=\left(\frac{V_1}{V_2}\right)^{\gamma-1}\Rightarrow T_2=300\left(\frac{27}{8}\right)^{\frac{5}{3}-1}=300\left(\frac{27}{8}\right)^{\frac{2}{3}}$$

$$=300\left\{\left(\frac{27}{8}\right)^{1/3}\right\}^{2}=800\left(\frac{3}{2}\right)^{2}=675\,K$$

$\Rightarrow \Delta T=675-300=375\,K$

Q.29 (2)

$$\text{Slope}=-\gamma\frac{dP}{dV}$$

As slope of A > slope of B

$\therefore \gamma$ of A > γ of B

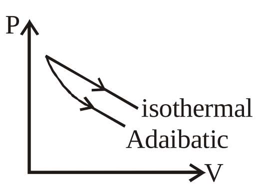
or A $\to$ Helium

B $\to$ Hydrogen

Q.30 (1)

In thermodynamic processes.

Work done = Area covered by PV diagram with V-axis



From graph it is clear that $(\text{Area})_{iso}$ > (Area) adi

$\Rightarrow W_{iso}>W_{adi}$

Q.31 (3)

Adiabatic process

$\Delta Q=0$

For any process

$\Delta_V=nC_V\Delta T$

Hence, option (3) is correct.

Q.32 (2)

$$W_{adi}=\frac{R}{\gamma-1}(T_i-T_f)=\frac{R}{\gamma-1}(T-T_1)$$

Q.33 (4)

$$\eta=1-\frac{T_2}{T_1}=1-\frac{400}{500}=\frac{1}{5}\therefore \eta=\frac{W}{Q}\Rightarrow\frac{1}{5}=\frac{W}{Q}$$

$$\Rightarrow W=\frac{Q}{5}=\frac{6}{5}\times 10^{4}=1.2\times 10^{4}\,J$$

Q.34 (1)

Initial and final states are same in all the process.

Hence $\Delta U=0$; in each case.

By FLOT; $\Delta Q=\Delta W$ = Area enclosed by curve with volume axis.

$\because (\text{Area})_1<(\text{Area})_2<(\text{Area})_1\Rightarrow Q_1<Q_2<Q_3$- .

Q.35 (2)

In first case, $(\eta_1)=1-\frac{500}{800}=\frac{3}{8}$

and in Second case, $(\eta_2)=1-\frac{600}{x}$

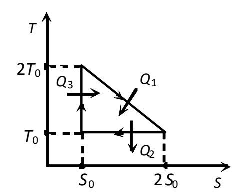
Since $n_1=n_2$ therefore $\frac{3}{8}=1\ \frac{600}{x}$

or $\frac{600}{x}=1\ \frac{2}{8}=\frac{5}{8}$ or $x=\frac{600\times 8}{5}=960\,K$

Q.36 (1)

$$Q_1=T_0S_0+\frac{1}{2}T_0S_0=\frac{3}{2}T_0S_0$$

$Q_2=T_0S_0$ and $Q_3=0$



$$\eta=\frac{W}{Q_1}=\frac{Q_1-Q_2}{Q_1}=1-\frac{Q_2}{Q_1}=1-\frac{2}{3}=\frac{1}{3}$$

Q.37 (2)

$$\eta=\left(1-\frac{T_2}{T_1}\right)\times 100 \qquad =\left(1-\frac{273}{473}\right)\times 100$$

$$=\frac{200}{473}\times 100 \text{ in \% or } \eta=\frac{200}{473}\text{ in fraction}$$

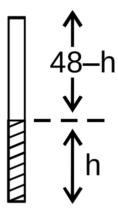
EXERCISE-III (JEE MAIN LEVEL)

Q.1 (2)
As ΔU is a state function i.e., it depends initial and final position
in process A and B initial and final temp are same.
$\therefore \quad \Delta U_1 = \Delta U_2$.

Q.2 (3)
Gas has different specific heat for different processes
$\therefore$ gas has infinite number of specific heats.

Q.3 (3)
As compare to gas solid expand very less.
$\therefore$ C_p is slightly greater then C_v.

Q.4 (3)
In the final condition.
Let atmospheric pressure is P and ht of liquid column is h.



$P + h = 76$
$P_1V_1 = P_2V_2$
$76 \times 5 = P(43 - h)$

$380 = (76 - h)(43 - h)$
$h = 38$ cm
So, 48 - h = 10 cm = 0.1 m.

Q.5 (1)
$P + 50 = 75$
$P = 25$ cm of H_g

$\frac{10^5}{75} \times 25 = 33.3$ kPa

Q.6 (1)
As volume increases
$\therefore$ WD continuously increases

Q.7 (1)

Q.8 (4)
ΔU = same is both process
$Q_{acb} - W_{acb} = Q_{adb} - W_{adb}$.
$200 - 80 = 144 - W_{adb}$.
$W_{adb} = 24$ J.

Q.9 (2)
$\Delta U = Q_{acb} - W_{acb} = 200 - 80 = 120$ J
$\Delta U = Q_{ba} - W_{ba}, -120 = Q_{ba} + 52, Q_{ba} = -172$ J.

Q.10 (4)
$U_b - U_a = 120$
$U_b = 120 + 40 = 160$J

Q.11 (2)
in db.
$W_{db} = 0$
$U_b - U_d = Q_{db}$.
$160 - 88 = Q_{db}$

$Q_{db} = 72$J.

Q.12 (1)
$\Delta Q = \Delta W + 3\Delta W$
$= 4\Delta W$
$\because \; n = \frac{\Delta W}{\Delta Q} = \frac{\Delta W}{4\Delta W} = 0.25$

Q.13 (4)
I[st] Process
$\Delta U_1 = \Delta Q_1 - \Delta W_1$
$= 16 - 20 = -4$ KJ
II[nd] Process
$\Delta W_2 = \Delta Q_2 - \Delta U_2$
$\Delta U_1 = \Delta U_2 \qquad (\therefore \Delta T = \text{same})$
So, $\Delta W_2 = [9 - (-4)] = 13$KJ

Q.14 (2)
$\Delta U = 0$
$\therefore \quad T$ = constant
or PV = constant or P-V curve is a rectangular hyperbola.
clearly, option B is correct.

Q.15 (4)
In isothermal expansion
T = constant $\qquad \Delta U = 0$
$W = \Delta Q$
$\therefore$ option (4) is correct.

Q.16 (3)
W.D. = π × Pressure Radius × volume Radius (area of ellipse)

$W = \pi\left(\frac{P_2 - P_1}{2}\right)\left(\frac{V_2 - V_1}{2}\right) = \frac{\pi}{4}(P_2 - P_1)(V_2 - V_1)$

Q.17 (2)
$L \rightarrow M$
P = constant
$V \alpha T$.
MN T = constant
Here, option B is constant

Q.18 (1)
AB → isothermal
$P_A V_A = P_B V_B$ ...(i)
BC → Adiabatic
$P_B V_B^{\gamma} = P_C V_C^{\gamma}$ ...(ii)
CD → Isothermal
$P_C V_C = P_D V_D$ ...(iii)
DA → Adiabatic
$P_D V_D^{\gamma} = P_A V_A^{\gamma}$ ...(iv)
From (i), (ii), (iii) and (iv)
$$\frac{V_B}{V_C} = \frac{V_A}{V_D}$$

Q.19 (1)
For adiabatic
$T V^{\gamma-1} = C \ (\gamma > 1)$ ....(i)
For isothermal T = const ....(ii)
From (i) and (ii)
$T_2 < T_1$

Q.20 (3)
For isothermal
$PV = C$. or $P_1 \ \alpha \ \frac{1}{V_1}$ ...(i)
For adiabatic
$PV^{\gamma} = C$, $P_2 \ \alpha \ \frac{1}{V_2^{\gamma}}$ ...(ii)
from (i) and (ii)
$P_1 > P_2$

Q.21 (1)
Self explainatory

Q.22 (1)
As $\Delta Q = \Delta U + W$
$\Delta U = -W$ (given)
or $\Delta Q = 0$
∴ Process is adiabatic

Q.23 (3)
PT = constant
$$P\left(\frac{PV}{nR}\right) = \text{constant}$$
P^2V= constant. Therefore the graph C is suitable.

Q.24 (1)
From the graph shown.
$$V_{av} \propto \sqrt{T} \propto \sqrt{PV}$$
$$V_{av_1} : V_{av_2} : V_{av_3}$$
$$\sqrt{V_oP_o} : \sqrt{V_o.4P_o} : \sqrt{4V_oP_o}$$
1 : 2 : 2

Q.25 (1)
$$T_1^{\gamma} P_1^{1-\gamma} = T_2^{\gamma} P_2^{1-\gamma}$$
$$T_2 = T_1\left(\frac{P_1}{P_2}\right)^{1-\gamma/\gamma} = 300\left(\frac{1}{4}\right)^{\frac{1-\frac{4}{3}}{\frac{4}{3}}} = 300\sqrt{2}$$

EXERCISE-IV

Q.1 [0435]
Q.2 [2329]
Q.3 [0005]
Q.4 [0002]
Q.5 [0100]
Q.6 [0000]
Q.7 [0217]
Q.8 [0126]
Q.9 [0435]
Q.10 [0300]
Q.11 (3)

Q.12 (1)
From first law of thermodynamics,
$dQ = dU + dW$
At constant pressure, $dQ = nC_p dT$
$dU = nC_v dT$
$$\Rightarrow \text{Fraction} = \frac{dU}{dQ} = \frac{C_v}{C_p} = \frac{f}{f+2}$$

Q.13 (1)
First law of thermodynamics,
$\delta Q = \delta U + \delta W$
At constant pressure, $\delta Q = nC_p \delta T = n\left(\frac{f}{2}+1\right)R\delta T$
Work done = $P\delta V = nR\delta T$

Q.14 (1)
In isothermal process, temperature = constant and internal energy, U = f(T)
⇒ internal energy remains constant
From first law of thermodynamics,
$dQ = dW + dU$
$\Rightarrow dQ = dW$ (∵ dU = zero)
So, for isothermal compression, dW = –ve
⇒ dQ = –ve
and for isothermal expansion, dW = +ve
⇒ dQ = +ve

Q.15 (1)

(a) Isothermal expansion $\Rightarrow$ T = constant

$\Rightarrow$ dU = zero

(b) Workdone in isothermal process

$$= nRT \ln \frac{V_f}{V_i}$$

(c) $dQ = nCdT \Rightarrow C = \frac{dQ}{ndT}$

For isothermal process, dT = zero

$\Rightarrow C = \infty$

(d) Isothermal compression $\Rightarrow$ dU = zero and dW = –ve

$\Rightarrow$ dQ = dU + dW = dW = –ve

Q.16 (4)

dQ = dU + dW

(a) Adiabatic expansion $\Rightarrow$ dQ = 0 and dW = +ve

(b) Isobaric expansion $\Rightarrow$ dW = +ve and pressure is constant

(c) Isothermal expansion $\Rightarrow$ dU = zero and dW = +ve

(d) Isochoric process $\Rightarrow$ dV = 0 (where V = volume)

$\Rightarrow$ dW = 0

$\Rightarrow$ dQ = dV

PREVIOUS YEAR'S

MHT CET

Q.1 (1)

Q.2 (3)

Q.3 (3)

Q.4 (3)

Q.5 (2)

According to first law of thermodynamics,

$\Delta U = \Delta Q - dW$

It is given that, dW = 0 and $\Delta Q < 0$

Thus, $\Delta U = C_v dT = \Delta Q$ is negative.

Since, C_v is specific heat, which remains constant, the temperature will decrease.

Q.6 (4)

From ideal gas equation, pV = nRT

For isothermal process, temperature remain constant, So, if pressure decrease, then volume increase.

$p_1V_1 = p_2V_2$

Here, $p_2 = p_1\left(1 - \frac{1}{10}\right) = \frac{9}{10}p_1$

$$\Rightarrow v_2 = \frac{10}{9}v_1$$

$\therefore$ Percentage increase in volume

$$= \left(\frac{V_2 - V_1}{V_1}\right) \times 100$$

$$= \left(\frac{10}{9} - 1\right) \times 100$$

$$= \frac{1}{9} \times 100 = 11.1\%$$

Q.7 (3)

According to first law of dynamics.

$\Delta Q = \Delta U + \Delta W$

$0 = \Delta U + \Delta W \Rightarrow \Delta W = -\Delta U$

In adiabatic process, work done does not depend on the path,

i.e., it independent with path.

Q.8 (1)

For adiabatic process

$$p_2V_2^\gamma = p_1V_1^\gamma$$

$$\Rightarrow \quad p_2 = p_1\left(\frac{V_1}{V_2}\right)^\gamma$$

Here, $V_1 = V,\ V_2 = \frac{V}{4}, p_1 = p$ and $\gamma = \frac{5}{2}$

$$\Rightarrow p_2 = p\left(\frac{V}{\frac{V}{4}}\right)^{5/2} = (4)^{5/2} p = 2^5 p = 32p$$

Q.9 (2)

According to first law of thermodynamics,

$Q = \Delta U + W$

In adiabatic process, Q = 0

$\therefore \quad \Delta U = -W$

Q.10 (2)

Internal energy does not change in isothermal process. As entropy is a measure of disorder of molecular motion of system. ΔS can be zero for adiabatic process. Work done in adiabatic may be non-zero. However, internal energy and entropy are state functions.

NEET/AIPMT

Q.1 (3)

Given process is isobaric

$dQ = n\,C_p\,dT$

$dQ = n\left(\frac{5}{2}R\right)dT$

$dW = P\,dV = n\,RdT$

Required ratio $= \frac{dw}{dQ} = \frac{nRdT}{n\left(\frac{5}{2}R\right)dT} = \frac{2}{5}$

Q.2 (3)

Efficiency of ideal heat engine, $\eta = \left(1 - \frac{T_2}{T_1}\right)$

T_2 : Sink temperature
T_1 : Source temperature

$$\% \eta = \left(1-\frac{T_2}{T_1}\right)\times 100$$

$$= \left(1-\frac{273}{373}\right)\times 100$$

$$= \left(1-\frac{100}{373}\right)\times 100 = 26.8\%$$

Q.3 (2)
$\Delta A = \Delta U + \Delta W$
$\Rightarrow 54 \times 4.18 = \Delta U + 1.013 \times 10^5 (167.1 \times 10^{-6} - 0)$
$\Rightarrow \Delta U = 208.7$ J

Q.4 **(1)**
Q.5 **(1)**

Q.6 **(1)**
1 : Isochoric
2 : Adiabatic
3 : Isothermal
4 : Isobaric

JEE MAIN

Q.1 (2)

$$\text{efficiency} = \left(1-\frac{T_1}{T_2}\right)\times 100$$

(T_2) source temperature
(T_1) sink temperature

$$\frac{25}{100} = 1-\frac{(273+27)}{T_2} \quad T_1 = 27°C + 273 = 300\text{ K}$$

$$0.25 = 1-\frac{300}{T_2} \Rightarrow \frac{300}{T_2} = 0.75$$

$$T_2 = \frac{300}{0.75} = 400\text{ K}$$

Now making 100% efficiency from original to, so increases in efficiency = 100% of 25

$$= \frac{100}{100}\times 25 = 25\%$$

$n' = 25 + 25 = 50\%$

$$n' = \left(1-\frac{T_1}{T_2'}\right)100$$

$$\frac{50}{100} = 1-\frac{300}{T_2'}$$

$$0.5 = 1-\frac{300}{T_2'}$$

$$0.5 = \frac{300}{T_2'} \Rightarrow T_2' = 600\text{ K}$$

So increase in temp.
$\Delta T_2 = T_2' - T_2 = 600 - 400 = 200$ K or 200°C
®

Q.2 **(3)**

$$\eta = 1-\frac{T_L}{T_H} = 1-\frac{400}{1000} = 1-\frac{2}{5} = \frac{3}{5}$$

$$\eta = \frac{w}{Q_{given}}; w = \eta Q = \frac{3}{5}\times 5000 = 3000\text{ K cal}$$

$w = 3000 \times 10^3 \times 4.2$ J
$w = 12.6 \times 10^6$J

Q.3 (2)
1^{st} law = dQ = dw + du

$$Q = \frac{Q}{4} + du$$

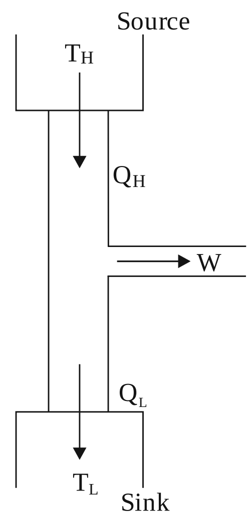
$$du = Q - \frac{Q}{4} = \frac{3Q}{4}$$

$$nC_V dT = \frac{3}{4} nCdT$$

$$n\frac{3}{2}RdT = \frac{3}{4}nCdT$$

C = 2R

Q.4 (1)
Q.5 **[540]**
$T_C = 324$ K
$T_H = ?$
$Q_H = 300$ J
$Q_L = 180$ J



$$1 - \frac{Q_L}{Q_H} = 1 - \frac{T_L}{T_H}$$

$$\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$$

$$T_H = \frac{Q_H}{Q_H} \times T_L = \frac{300_L}{180} \times 324 = 540K$$

Q.6 **(16)**

$(T_2)\ T_{sink} = 200\ K$
$(T_1)\ T_{Reservoir} = 527 + 273 = 800\ K$
$W = 12000\ KJ = 12 \times 10^6 J$
$Q_1 = ?$

$$\eta = 1 - \frac{T_2}{T_1} = \frac{W}{Q_1} = 1 - \frac{200}{800} = \frac{12 \times 10^6}{Q_1}$$

$$\frac{3}{4} = \frac{12 \times 10^6}{Q_1} = Q_1 = 16 \times 10^6\ J$$

Q.7 (1400)

$$Q = nC_p\Delta t = \frac{n\gamma}{\gamma - 1} R\Delta T$$

$$Q = \frac{\gamma}{\gamma - 1} W = \frac{1.4}{0.4} \times 400 = 1400J$$

Q.8 (1)

$$W_{adiabatic} = \frac{\mu R(T_2 - T_1)}{1 - \gamma} \rightarrow \text{Statemetnt 1}$$

$Q = W + \Delta U$
$0 = W + \Delta U$
$\Delta U = -W$
If work is done on the gas i.e. work is negative.
$\therefore$ ΔU is positive
$\therefore$ Temperature will increase.
Both statement - I & statement – 2 are true.

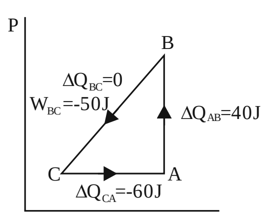
Q.9 (7479)

No. of moles = 2
Monoatomic gas
Temp = 300 K
R = 8.31 J/mol K
$U = nc_vT$

$$= 2 \times \frac{3}{2} R \times 300$$

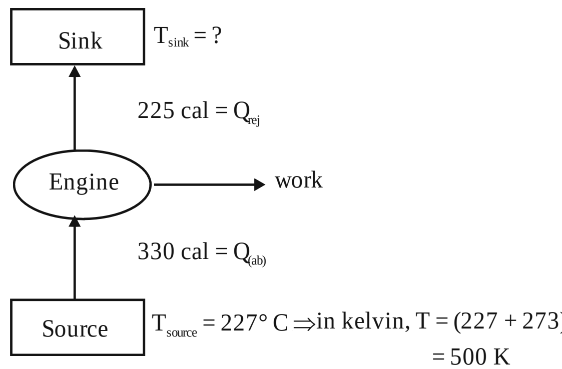
$= 900 \times 8.31$
$= 7479$ Joule

Q.10 (2)



$\Delta Q_{cycle} = 40 - 60 = \Delta W$
$\Rightarrow \Delta W = -20\ J = W_{BC} + W_{CA}$
$\Rightarrow W_{CA} = -20J - W_{BC}$
$= -20 - (-50)$
$= 30\ J$

Q.11 (102)



$$\frac{Q_{rej}}{Q_{ab}} = \frac{T_{sink}}{T_{source}}$$

$$\frac{225}{300} = \frac{T_{sink}}{500}$$

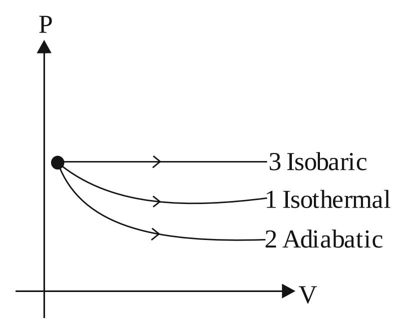
$$T_{sink} = \frac{5}{3} \times 225$$

$= 375\ K$

$\boxed{T_{sink} = 102°C}$

Q.12 **(4)**

We know that work done is given by the areas under P-V curve.



Clearly Area 3 > Area 1 > Area 2
$\Rightarrow w_3 > w_1 > w_2$

Q.13 (2)

For isothermal process
$P_1V_1 = P_2V_2$
$2 \times 10^7\ V = P_2(2V)$
$P_2 = 1 \times 10^7\ N/m^2$
For adiabatic process

$P_2 = V_2{}^{\gamma} = P_3 V_3{}^{\gamma}$

$1 \times 10^7 (2V)^{1.5} = P_3(4V)^{1.5}$ (Volumn further duubled)

$P_3 = \frac{10^7}{2^{3/2}} \Rightarrow P_3 = 3.536 \times 10^6\ N/m2$

Q.14 (2)

$\eta_1 = 1 - \frac{T_2}{T_1}$ $\quad\quad$ $\eta_2 = 1 - \frac{T'_2}{T'_1}$

$= 1 - \frac{147+273}{447+273}$ $\quad\quad$ $= 1 - \frac{47+273}{947+273}$

$= 1 - \frac{420}{720}$ $\quad\quad$ $= 1 - \frac{320}{1220}$

$= 1 - \frac{7}{12}$ $\quad\quad$ $= 1 - \frac{16}{61}$

$= \frac{5}{12}$ $\quad\quad$ $= \frac{45}{61}$

$\therefore \frac{\eta_1}{\eta_2} = \frac{5 \times 61}{12 \times 45} = 0.56$

Q.15 (3)

Constant entropy means process is adiabatic

$V_1 = V$ $\quad\quad$ $\Delta S = \frac{\Delta Q}{T}$

So

$V_2 = \frac{v}{8}$ $\quad\quad$ $\because \Delta S = 0$... [as S = constant]

$P_1 V_1^r = P_2 V_2^r$ $\quad\quad$ $\therefore \Delta Q = 0 \Rightarrow$ Adiabatic

$P_1 V^{5/3} = P_2 \left(\frac{v}{8}\right)^{5/3}$

$P_2 = 32 P_1$

Q.16 (3)

We know $n = \left(1 - \frac{T_2}{T_1}\right) \times 100$

So $n_1 = \left(1 - \frac{2}{3}\right) \times 100 \Rightarrow \frac{1}{3} \times 100 = 33\%$

$n_2 = \left(1 - \frac{1}{2}\right) \times 100 = \frac{1}{2} \times 100 = 50\%$

Q.17 (3)

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

$\frac{1}{2} = 1 - \frac{T_L}{T_H}$

$\frac{1}{2}(1.3) = 1 - \left(\frac{T_L - 40}{T_H}\right)$

$\frac{1}{2}(1.3) = \frac{1}{2} + \frac{40}{T_H}$

$T_H = 266.7\ K$

Q.18 (750)

Degree of freedom = 8

WD by gas = 150 J at constant pressure

Heat observed by gas = ??

$Q = \omega + \Delta U$

$= nR\Delta T + \frac{f}{2} nR\Delta T$

$(nR\Delta T = 150)$

$= 150 + \frac{8}{2} \times 150$

Q = 750 Joule

Q.19 (4)

$PV^{\gamma} = const$ $\quad\quad$ $d = \frac{m}{v}$

$P\left(\frac{m}{d}\right)^{\gamma} = const$

$\frac{P}{d^{\gamma}} = const$ $\quad\quad$ $\frac{d_2}{d_1} = 32$

$\frac{P_1}{P_2} = \left(\frac{d_1}{d_2}\right)^{\gamma} = \left(\frac{1}{32}\right)^{\frac{7}{5}} = \frac{1}{128}$

$\frac{T_1}{T_2} = \frac{P_1 V_1}{P_2 V_2} = \frac{1}{128} 32 = \frac{1}{4}$

Q.20 (2)

$W_{DE} = \frac{1}{2}(600 + 300)\, 3J$

$= 1350\ J$

$W_{EF} = -300 \times 3 = -900J$

$W_{DEF} = 450J$

KINETIC THERORY OF GASES

EXERCISE-I (MHT CET LEVEL)

Q.1 (1)

$$\frac{V_{rms,2}}{V_{rms,1}} = \sqrt{\frac{400}{300}} = \frac{2}{\sqrt{3}}$$

$$\Rightarrow V_{rms,2} = \frac{2}{\sqrt{3}} \times 200 = \frac{400}{\sqrt{3}} ms^{-1}$$

Q.2 (2)

$$\gamma = 1 + \frac{2}{f} \Rightarrow \gamma - 1 = \frac{2}{f}$$

$$\Rightarrow \frac{f}{2} = \frac{1}{\gamma - 1} \Rightarrow f = \frac{2}{\gamma - 1}$$

Q.3 (4)

We know, $V_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow$ % increase in

$$V_{rms} = \frac{\sqrt{\frac{3RT_2}{M}} - \sqrt{\frac{3RT_1}{M}}}{\sqrt{\frac{3RT_1}{M}}} \times 100$$

$$= \frac{\sqrt{T_2} - \sqrt{T_1}}{\sqrt{T_1}} \times 100$$

$$= \frac{\sqrt{400} - \sqrt{300}}{\sqrt{300}} \times 100$$

$$= \frac{20 - 17.32}{17.32} \times 100 = 15.5\%$$

Q.4 (3)

$$V_{rms} = \sqrt{\frac{3RT}{M_0}} = \nu$$

for oxygen $V_{rms} = \sqrt{\frac{3R \times 2T}{M_0 / 2}} = 2\nu.$

Q.5 (2)

$$V_{avg} \propto \frac{1}{\sqrt{M_0}}$$

$\because M_0 > M_H$

$\Rightarrow V_0 < V_H$

$\therefore$ oxygen molecule hits the wall with smaller average speed

Q.6 (4)

$$PV = \frac{M}{M_0} RT.$$

$$PV = \frac{M}{M_0} KN_A T$$

$\frac{MKT}{PV} = \frac{M_0}{N_A}$ = mass of each molecule it depends nature of gas.

N_A = constant number

Q.7 (2)

$$V_{avg} = \left[\frac{500 + 600 + 700 + 800 + 900}{5}\right]$$

= 700 m/s

and $\sqrt{\frac{500^2 + 600^2 + 700^2 + 800^2 + 900^2}{5}}$

= 714 m/s

Thus V_{rms} is greater than average speed by 14 m/s.

Q.8 (2)

Let 'n' be the degree of freedom

$$\gamma = \frac{C_P}{C_V} = \frac{\left(\frac{n}{2} + 1\right)R}{\left(\frac{n}{2}\right)R} = \left(1 + \frac{2}{n}\right) = 1.66$$

$$= \frac{5}{3} = \left(1 + \frac{2}{3}\right)$$

$\Rightarrow n = 3 \Rightarrow$ gas must be monoatomic.

Q.9 **(2)**

Let 'n' be the degree of freedom

$$C_V = \frac{n}{2} R$$

also, $C_P - C_V = R$
$C_P = C_V + R$

$$C_P = \frac{n}{2}R + R$$

$$C_P = \left(\frac{n}{2}+1\right)R$$

$$\text{so, } \gamma = \frac{C_P}{C_V} = \frac{\left(\frac{n}{2}+1\right)R}{\left(\frac{n}{2}\right)R} = \left(1+\frac{2}{n}\right)$$

Q.10 (1)

We know, $V_{rms} \propto \sqrt{T} \quad V_2 = \frac{V_1}{2}$

$$\Rightarrow \frac{V_1^2}{V_2^2} = \frac{T_1}{T_2}$$

$$\Rightarrow \left(\frac{V_1}{\frac{V_1}{2}}\right)^2 = \frac{T_1}{T_2}$$

$$\Rightarrow T_2 = \frac{T_1}{4} = \frac{(327+273)}{4}$$

=150 K
=150 – 273 = –123 ºC

Q.11 (1)

We know, $V_{rms} \propto \sqrt{T} \quad V_2 = \frac{V_1}{2}$

$$\Rightarrow \frac{V_1^2}{V_2^2} = \frac{T_1}{T_2}$$

$$\Rightarrow \left(\frac{V_1}{\frac{V_1}{2}}\right)^2 = \frac{T_1}{T_2}$$

$$\Rightarrow T_2 = \frac{T_1}{4} = \frac{(327+273)}{4}$$

=150 K
=150 – 273 = –123 ºC

Q.12 (2)
For an ideal gas undergoing isothermal process, PV=constant
$\therefore$ PV does not vary with V.

Q.13 (2)

$$E_1 = 3\left(\frac{3}{2}R\times 300\right) = \frac{2700R}{2}$$

Energy possessed by the ideal gas at 227ºC is

$$E_2 = 2\left(\frac{3R}{2}\times 500\right) = 1500R$$

If T be the equilibrium temperature, of the mixture, then its energy will be

$$E_m = 5\left(\frac{3RT}{2}\right)$$

Since, energy remains conserved,
$E_m = E_1 + E_2$

$$\text{or } 5\left(\frac{3RT}{2}\right) = \frac{2700R}{2} + 1500R$$

or T = 380 K or 107ºC

Q.14 (3)
Applying gas equation, pV=nRT
We can write, $p_1 V = n_1RT_1$ *and* $p_2 V = n_2RT_2$

$$\Rightarrow \frac{p_2}{p_1} = \frac{n_2}{n_1}\times\frac{T_2}{T_1} = \frac{1}{1}\times\frac{2T}{T} = 2$$

$$\Rightarrow p_2 = 2p$$

Q.15 (2)
We know that

$$P_AV_A = n_ART, P_BV_B = n_BRT$$
$$\text{and } P_f(V_A+V_B) = (n_A+n_B)RT$$
$$P_f(V_A+V_B) = P_AV_A + P_BV_B$$
$$P_f = \left(\frac{P_AV_A+P_BV_B}{V_A+V_B}\right)$$
$$= \frac{1.4\times0.1+0.7\times0.15}{0.1+0.15}\text{MPa} = 0.98\text{MP}_8$$

Q.16 (2)
Assuming the balloons have the same volume, as pv = nRT. if p, V and T are the same, whether it is He or air. Hence, Number of molecules per unit volume will be same in both the balloons.

Q.17 (4)
Let there are n_1 moles of hydrogen and n_2 moles of helium in the given mixture. As PV = nRT
Then the pressure of the mixture

$$P = \frac{n_1 RT}{V} + \frac{n_2 RT}{V} = (n_1 + n_2)\frac{RT}{V}$$

$$\Rightarrow 2 \times 101.3 \times 10^3 = (n_1 + n_2) \times \frac{(8.3 \times 300)}{20 \times 10^{-3}}$$

$$\text{or, } (n_1 + n_2) = \frac{2 \times 101.3 \times 10^3 \times 20 \times 10^{-3}}{(8.3)(300)}$$

or, $n_1 + n_2 = 1.62$ ....(1)
The mass of the mixture is (in grams)
$n_1 \times 2 + n_2 \times 4 = 5$

$\Rightarrow (n_1 + 2n_2) = 2.5$ ...(2)
Solving the eqns. (1) and (2), we get
$n_1 = 0.74$ and $n_2 = 0.88$

Hence, $\frac{m_H}{m_{He}} = \frac{0.74 \times 2}{0.88 \times 4} = \frac{1.48}{3.52} = \frac{2}{5}$

Q.18 (2)
Q.19 (1)
Q.20 (4)
Q.21 (3)
Q.22 (4)

EXERCISE-II (NEET LEVEL)

Q.1 (2)

$\vec{P} = M\vec{V}av$, As $\vec{V}av = 0$ (in equilibrium)

$\therefore \vec{P}_{av} = 0$

Q.2 (3)

Mean free path $\lambda = \frac{1}{\sqrt{2}\pi d^2 n} \Rightarrow \lambda \propto d^{-2}$

Q.3 (2)
Red gas behave as an ideal gas at high temperature and low pressure.

Q.4 (2)
The collision of molecules of ideal gas is elastic collision

Q.5 (1)

$$\frac{Pm}{\rho} = nRT$$

slope of T_1 > slope of T_2

Q.6 (3)
one molecule has some single value of speed which is equal average speed and rms speed of the gas
$\therefore V_a = V_{rms}$.

Q.7 (1)

$$P \propto T \Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2} \Rightarrow \frac{P_2 - P_1}{P_1} = \frac{T_2 - T_1}{T_1}$$

$$\Rightarrow \left(\frac{\Delta P}{P}\right)\% = \left(\frac{251 - 250}{250}\right) \times 100 = 0.4\%$$

Q.8 (1)

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

$$\frac{(1.64 \times 10^{-3} \times 1.01 \times 10^5) \times (1 \times 10^{-6})}{1.38 \times 10^{-23} \times 200} 0.23 \times 10^{16}$$

Q.9 (1)

$$V_{avr} = \bar{V} = \sqrt{\frac{8\,RT}{\pi M}} = \sqrt{\frac{8\,RT}{\pi M}}$$

$$\frac{\bar{V}_{H_2}}{\bar{V}_{N_2}} = \sqrt{\frac{1/2}{1/28}} = \sqrt{\frac{14}{1}}$$

Q.10 **(2)**

$$V_{av} = \sqrt{\frac{8RT}{\pi M_0}},\ V_{AV}\ \alpha\ \sqrt{T}$$

For same temp in vessel A, B and C, Average speed of O_2 molecule is same in vessel A and C and is equal to V_1.

Q.11 (4)
PV = mrT since P,V,r $\rightarrow$ remains same

Hence $m \propto \frac{1}{T} \Rightarrow \frac{m_1}{m_2} = \frac{T_2}{T_1}$

$$\Rightarrow \frac{13}{m_2} = \frac{(273 + 52)}{(273 + 27)} = \frac{325}{300}$$

$\Rightarrow m_2 = 12$ gm
i.e., mass released = 13 gm – 12 gm = 1 gm

Q.12 (3)
According to the Dalton's law of partial pressures, the total pressure will be $P_1 + P_2 + P_3$

Q.13 (2)
As ΔU is a state function i.e., it depends initial and final position in process A and B initial and final temp are same.
$\therefore \Delta U_1 = \Delta U_2$.

Q.14 (2)

$$\frac{PV}{T} = R(\text{constant}) \Rightarrow \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\Rightarrow \frac{200 \times V}{(273+22)} = \frac{P_2 \times 1.02V}{(273+42)} \quad (V_2 = V + 0.02V)$$

$$\Rightarrow P_2 = \frac{200 \times 317}{275 \times 1.02} = 209 \text{ kPa}$$

Q.15 (4)

Q.16 (2)

Q.17 (2)

$$T_2 = \left(\frac{V_2}{V_1}\right)T_1 = \left(\frac{1.5V}{V}\right) \times (273+27) = 450\,K$$

$\Rightarrow 177°C$

Q.18 (1)

$$v_{rms} = \sqrt{\frac{3RT}{M}} \Rightarrow M = \frac{3RT}{v_{rms}^2} \;\therefore M = \frac{3 \times 8.3 \times 300}{(1920)^2}$$

$= 2 \times 10^{-3}$ kg = 2gm $\Rightarrow$ Gas is hydrogen

Q.19 (2)

$v_{rms} \propto \sqrt{T}$

Q.20 (2)

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.3 \times 10^7 \times 300}{28}} = 517 \text{ m/sec}$$

Q.21 (3)

$$V \propto T \Rightarrow \frac{V_1}{V_2} = \frac{T_1}{T_2} \Rightarrow \frac{V}{2V} = \frac{(273+27)}{T_2} = \frac{300}{T_2}$$

$T_2 = 600\,K = 327°C$

Q.22 (1)

As initial and final state are same

$\therefore$ $T_I = T_F$ As V_{rms}, $\vec{P}_{av}$ and $\vec{K}_{av}$ depends on temperature

$\therefore$ all are equal.

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (3)

$V_{av} = \sqrt{\frac{8KT}{\pi m}}$, as T = constant

$\therefore$ V_{av} = constant

Q.2 (4)

$\vec{P}_{av} = M\vec{V}_{av}$, as the average momentum of an ideal gas is zero

$\therefore$ option D is correct.

Q.3 (1)

$$\sqrt{\frac{3RT}{32}} = \sqrt{\frac{3R \times 273}{28}}$$

$$T = \frac{273 \times 32}{28} = 426.3\text{ k.}$$

Q.4 (2)

Real gas behaves as an ideal gas at low pressure and high temperature

Q.5 (3)

$$V_{AV} = \sqrt{\frac{8RT}{\pi M_0}} = v$$

for nitrogen

$$V_{AV} = \sqrt{\frac{8R \times 2T}{\pi M_0/2}} = v\,.$$

Q.6 (2)

$$V_{av}\, \alpha\, \frac{1}{\sqrt{M_0}}$$

$\therefore$ oxygen molecule hits the wall with smaller average speed

Q.7 (2)

$$V_{av} = \sqrt{\frac{8RT}{\pi M_0}},\ V_{AV}\, \alpha\, \sqrt{T}$$

For same temp in vessel A, B and C, Average speed of O_2 molecule is same in vessel A and C and is equal to V_1.

Q.8 (1)

As translation K.E is = $\frac{3}{2}$nRT

$$E = \frac{3}{2} PV$$

where E = total translational K.E.

Q.9 (3)
For an ideal gas, the no of molecules of equal moles of gas is same .

Q.10 (1)

Average rotational K. E. = $\frac{1}{2}KT \times 2 = KT$

So it will be same for both the gases.

Q.11 (1)

We are given $P = \frac{2E}{3V}$.

$$PV = \frac{2}{3}E$$

$$E = \frac{3}{2}n\,RT.$$

Here E is the Translational K.E. for all the particles.

Q.12 (1)
We know that

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{1.3\times10^5 \times \left[7\times\left(10^{-2}\right)^3 \times 10^3\right]}{8.3\times273}$$

So, Number of molecules is

$$= \frac{1.3\times10^5 \times 7\times10^{-3}}{8.3\times273}\times 6.023\times10^{23} = 2.4\times10^{23}$$

Q.13 (3)
$PV = nRT$
$\therefore$ temperature remains same for all ideal gas

EXERCISE-IV

Q.1 [0075]

$$\Delta V = \frac{f}{2}nR\Delta T = \frac{5}{2}(P_2V_2 - P_1V_1) = 63\text{ J}$$

$$mgx + \frac{1}{2}kx^2 + P_0Ax = \omega_{gas}$$

$\omega_{gas} = 12\text{ J}$ $\Rightarrow \Delta Q = 75\text{ J}$

Q.2 [0006]
$\Delta W = 0$
$\therefore \Delta Q = U_f - U_i$

$$= \left\{\frac{2N}{3}\times\frac{5RT}{2} + \frac{2N}{3}\cdot\frac{3RT}{2}\right\} - \left\{\frac{5NRT}{2}\right\}$$

$$= \frac{8NRT}{3} - \frac{5NRT}{2} = \frac{NRT}{6}$$

Q.3 [0040]

$$PV = \frac{m}{M}RT$$

$$m = \frac{PVM}{RT} = \frac{500\times10^3\times5000\times10^{-6}\times40\times10^{-3}}{\frac{25}{3}\times300} =$$

$$\frac{4}{100}\text{kg} = 40\text{ gm}$$

Q.4 [0020]

$$p_i = p_0 + \frac{kx}{A} = 2\times10^5\text{ P}$$

$p_f = 2\times10^5 + 10^6 x$
$v_i = 1A$
$v_f = (1+x)A$

$$\frac{PV}{T} = \text{const.}$$

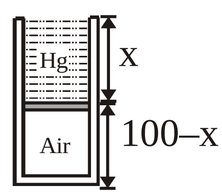
$$\frac{2\times10^5\times1A}{T_0} = \frac{2\times10^5+10^6x}{2T_0}\times(1+x)A$$

$$2.4 = \frac{(2+10x)(1+x)}{2}$$

$2.4 = (1+5x)(1+x)$
$2.4 = 1 + 5x^2 + 6x$
$5x^2 + 6x - 1.4 = 0$

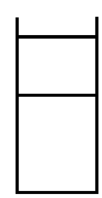
$$x = \frac{-6+\sqrt{36+4\times5\times1.4}}{10} = 0.2\text{ m} = 20\text{ cm}$$

Q.5 [0076]



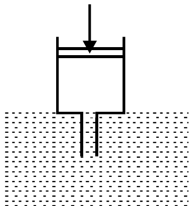
$P_1V_1 = P_2V_2$
$(76)(100) = (76+x)(100-x)$
or $x = 24$ cm
gas column length = 76 cm

Q.6 [0072]



$(p_0 + h_{\rho g})\,v_0 = (p_0 - h_{\rho g})v$
$(H+8)\times4 = (H-8)\times5$
$4H + 32 = 5H - 40$
$72 = H$

Q.7 [0075]



$$\frac{P_0V_0}{n_0} = \frac{P_1V_1}{n_1}$$

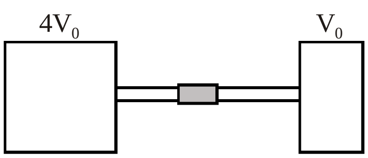
$$\frac{10^5 \times A_1h_0}{n_0} = \frac{10^5 + 5\times10^3 \times 10 \times 0.2 \times V_1}{0.4n_0}$$

$$\frac{10^5 \times 4 \times 10^{-4} \times h_0}{n_0}$$

$$= \frac{(10^5 + 0.2 \times 10 \times 5 \times 10^3)V_1}{0.4n_0}$$

$V_1 = 4 \times 10^{-4} [h_0 - h] + 0.2 \times 1 \times 10^{-4}$
$h_0 = 1.1 \times 10^5 \times [4 \times 10^{-4} (h_0 - h) + 2 \times 10^{-5}]$
$= 1.1 [40h_0 - 40h + 2]$
$16h_0 = 44h_0 - 44h + 2.2$
$44h = 28h_0 + 2.2$
$44h = 28 \times 1.1 + 2.2 = 33$
$h = 0.75$ m

Q.8 [0125]



$$n_1 = \frac{P_0 \times V_0}{R \times 300}\ ;\ n_2 = \frac{P_0 \times 4V_0}{R \times 300}\ ;\ n = \frac{5P_0V_0}{300R}$$

$$n_1' = \frac{P \times V_0}{R \times 300}\ ;\ n_2' = \frac{P \times 4V_0}{400R}\ ;\ n = \frac{P \times 4V_0}{400R}$$

$$\Rightarrow \frac{5}{4}P_0 = P \qquad ; P = 125 \text{ kPa}$$

Q.9 (4)
Q.10 (1)

$$C_P = \left(\frac{f}{2} + 1\right)R$$

$$C_V = \frac{fR}{2}$$

work done = $\int PdV = P\int dV$ ($\because$ prssure is constant)
$= P\Delta V$

Q.11 (3)
As PV = nRT
$\Rightarrow$ at constant temperature Pv = constant

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

Q.12 (3)

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

$$V_{mps} = \sqrt{\frac{2RT}{M}}$$

$$V_{avg} = \sqrt{\frac{8RT}{\pi M}}$$

Maxwell distribution curve is unsymmetrical.

Q.13 (1)
Boyle's law is PV = constant
Charle's law is $V \propto T$ (For P = constant)
Gay - Lussac's law is $P \propto T$ (For V = constant)

Avogadro's law is $V \propto n \left(\text{For } \frac{P}{T} = \text{constant}\right)$

Q.14 (4)

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

$$V_{mps} = \sqrt{\frac{2RT}{M}}$$

$$V_{avg} = \sqrt{\frac{8RT}{\pi M}}$$

$$V_{sound} = \sqrt{\frac{\gamma RT}{M}}$$

PREVIOUS YEAR'S

MHT CET
Q.1 (1)
Q.2 (1)
Q.3 (2)
Q.4 (1)
Q.5 (1)
Q.6 (2)
Q.7 (2)
Q.8 (3)
Q.9 (4)
Q.10 (2)
Q.11 (3)
Q.12 (4)
Q.13 (3)

Q.14 (1)
Q.15 (2)
Q.16 (1)
Q.17 (4)
Q.18 (3)
Q.19 (1)
Q.20 (3)
Q.21 (3)
Q.22 (4)
Q.23 (3)
Q.24 (4)

The rms velocity of gas molecule,

$$v_{rms} = \sqrt{\frac{3RT}{m}}$$

As, $K = \frac{1}{2}mv_{rms}^2 = \frac{1}{2}m\left(\frac{3RT}{m}\right) = \frac{3}{2}RT$

$$\Rightarrow K = \frac{3}{2}RT$$

From ideal gas equation for one mole,
$pV = RT$
(From Eqs. (i) and (ii), we get,

$$p = \frac{2}{3}\frac{K}{V}$$

Hence, pressure is $\left(\frac{2}{3}\right)$rd of kinetic energy per unit volume of gas.

Q.25 (3)
Given, $\gamma = 1.5$
rms velocity of gas molecule,

$$v_{rmm} = \sqrt{\frac{3RT}{m}} \Rightarrow T \propto v^2$$

$$\Rightarrow \frac{T_2}{T_1} = \frac{v_2^2}{v_1^2}$$

Here, $v_2 = \frac{v_1}{2}$

$$\therefore \frac{T_2}{T_1} = \frac{(v_1/2)^2}{v_1^2} = \frac{1}{4} \quad \text{....(i)}$$

For adiabatic process,
$TV^{\gamma-1}$ = constant

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

$$\Rightarrow \frac{V_2}{V_1} = \left(\frac{T_1}{T_2}\right)^{\frac{1}{\gamma-1}} = (4)^{\frac{1}{1.5-1}} \text{ [using Eq. (i)]}$$

$= (4)^2 = 16$
Hence, gas has to be expanded to 16 times.

Q.26 (2)
Molecular weight of the mixture,

$$M_{mix} = \frac{n_1M_1 + n_2M_2}{n_1 + n_2}$$

$$= \frac{1\times 4 + 2\times 32}{1+2} = \frac{68}{3}\times 10^{-3}\text{ kg mol}^{-1}$$

For helium, $C_{v1} = \frac{3}{2}R$

For oxygenmix $C_{v2} = \frac{5}{2}R$

$$(C_v)_{mix} = \frac{n_1C_{v1} + n_2C_{v2}}{n_1 + n_2}$$

$$= \frac{1 + \frac{3R}{2} + 2\times\frac{5R}{2}}{1+2} = \frac{13R}{6}$$

Now $(C_p)_{mix} = (C_v)_{mix} + R$

$$= \frac{13R}{6} + R = \frac{19}{6}R$$

$$r_{mix} = \frac{(C_p)_{mix}}{(C_V)_{mix}} = \frac{19}{13}$$

Speed of sound in the mixture, $v = \sqrt{\frac{r_{mix}\times RT}{M_{mix}}}$

$$= \sqrt{\frac{19}{13}\times\frac{8.31\times 300}{\frac{68}{3}\times 10^{-3}}}$$

$\approx 401\ ms^{-1}$

Q.27 (3)
Given, $T_1 = 27 + 273 = 300$ K
$T_2 = 927 + 273 = 1200$ K
$(V_{rms})_1 = 100$ m/s
$(V_{rms})_2 = ?$
We know that,

$$v_{rms} \propto \sqrt{T}$$

$$\Rightarrow \frac{(v_{rms})_2}{(v_{rms})_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{1200}{300}} = 2$$

$(v_{rms})_2 = 2\times(v_{rms})_1 = 2\times 100 = 200$ m/s

Q.28 (1)
We know that, according to Mayer's formula,
$Cp = Cv + R$

$$= \frac{3}{4}R + R = \frac{7}{4}R = 1.75R$$

Q.29 (3)

Roots mean square velocity, $v_{rms} = \sqrt{\frac{3RT}{M}}$

Initial rms velocity, $v_{rms} \propto \sqrt{T}$

suppose, $v_{rms_1} = v_{rms}$ and $T_1 = T$

$v_{rms_2} = ?$ and $T_2 = 5T$

$\therefore \quad \frac{v_{rms_2}}{v_{rms_1}} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{5T}{T}}$

$\therefore \quad v_{rms_2} = \sqrt{5}\, v_{rms}$

Q.30 (4)

For kinetic energy,

$KE = \frac{3}{2}kT \Rightarrow KE \propto T \Rightarrow \frac{KE_A}{KE_B} = \frac{T_A}{T_B}$

Given, $T_1 = 360K, T_2 = 420\,K$

$\frac{KE_B}{KE_A} = \frac{T_B}{T_A} = \frac{420}{360} \qquad \therefore \frac{KE_B}{KE_A} = \frac{7}{6}$

Hence, $KE_B : KE_A = 7 : 6$

Q.31 (1)

We know that, rms speed is directly proportional to square root of temperature.

$v_{rms} \propto \sqrt{T}$

Hence, $\frac{v_{rms(1)}}{v_{rms(2)}} = \sqrt{\frac{T_1}{T_2}}$

Given, $T_1 = 27°C = (27 + 273) = 300\,K$

$T_2 = 227°C = (227 + 273) = 500K$

$v_{rms(2)} = 400\ ms^{-1}$

$\Rightarrow \frac{v_{rms(1)}}{v_{rms(2)}} = \sqrt{\frac{300}{500}} \Rightarrow v_{rms(2)} = \sqrt{\frac{500}{300}}v_{rms(1)}$

$\Rightarrow v_s \simeq 516ms^{-1} \qquad \left[\because v_{rms_2} = v_s\right]$

NEET/AIPMT

Q.1 (2)

KE $\propto$ Temp.

i.e. increasing temperature, increases KE of gas filled in container.

Q.2 **(1)**

Q.3 **(1)**

Q.4 (2)

JEE MAIN

Q.1 (2)

Q.2 (12)

(n = No. of moles)

$= \frac{0.056 \times 10^3}{28}$

$= 2$

Gas enclosed in a container so volume is constant

Heat energy $\Delta Q = nC_v\Delta T$

Degree of freedom = 3 + 2 (3 → translation, 2 → rotational)

$C_v = \frac{5}{2}R \qquad \left[C_V = \frac{f}{2}R\right]$

velocity $\Rightarrow v^2 = \frac{3KT}{m}$

$v \propto \sqrt{T}$

$\Rightarrow v_2 = 2v_1$ [according to question]

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

$T_2 = 4T_1$

$\Delta Q = nC_v\Delta T \qquad T_1 = 127°C$ or $400\,K$

$\Delta Q = nC_v(T_2 - T_1) \qquad T_2 = 1600\,K$

$\Delta Q = nC_v(4T_1 - T_1)$

$= nC_v(3T_1)$

$= 2 \times \frac{5}{2} \times 2 \times 3 \times (400)$

$\Delta Q = 12000$ cal $= 12 \times 10^3$ cal $\qquad (R = 2$ cal $mole^{-1}\,k^{-1})$

$\Delta Q = 12$ K cal

Q.3 (2)

$v_{rms} = \sqrt{\frac{3RT}{M}}$ and $v_{mp} = \sqrt{\frac{2RT}{M}}$

Thus $v_{rms} = \sqrt{\frac{3}{2}}v_{mp}$

Q.4 (2)

$\frac{C_P}{C_v} = \frac{C_v + R}{C_v} = 1 + \frac{R}{C_v}$ ....(1)

We know $C_v = \frac{fR}{2}$ So From eq.2

$$\boxed{\frac{C_p}{C_v} = 1 + \frac{2R}{fR} = 1 + \frac{2}{f}}$$

Q.5 (250)

Q.6 (Bonus)

Average K.E. / molecule $= \frac{f}{2}kT$

$$\text{So, } \frac{K_{Ar}}{K_{O_2}} = \frac{\frac{3}{2}kT}{\frac{5}{2}kT} = \frac{3}{5}$$

Q.7 (2)

PV = nRT

$$n = \frac{100 \times 10^3 \times 2000 \times 10^{-6}}{\frac{25}{3} \times 300}$$

$n = 80 \times 10^{-3}$

$n_1 + n_2 = 0.08$

$n_1 \times 2 + n_2 \times 32 = 0.76$

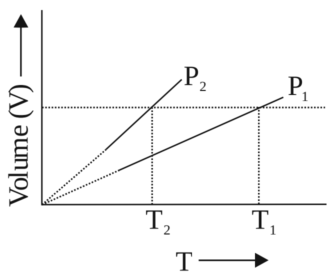
$(0.08 - n_2)\,2 + n_2(32) = 0.76$

$n_2 = 0.02$

$n_1 = 0.06$

$$\frac{n_1}{n_2} = \frac{3}{1}$$

Q.8 (1)



PV = nRT

$$\frac{V}{T} = \frac{nR}{P}$$

$$\frac{nR}{P_1} < \frac{nR}{P_2}$$

$P_2 < P_1$

Q.9 (2)

$$\lambda = \frac{kT}{\sqrt{2}\pi d^2 P}$$

Q.10 (2)

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

$$T \to 2T$$

$$M \to \frac{M}{2}$$

$$V_{rms} \propto \sqrt{\frac{T}{M}}$$

$$\Rightarrow (V_{rms})_{atomic} = (V_{rms})_{molecular} \times \sqrt{\frac{2}{1/2}} = 2(V_{rms})_{molecular}$$

Q.11 (3)

Given

22.4 L volume of gas = 1 mole

$\Rightarrow 44.8\ L_{(He)} = 2$ mole

n = no. of mole = 2

$C_v = \frac{3}{2}R$ (He) $\rightarrow$ monoatomic

$\therefore \Delta Q = nC_V\Delta T$

$= 2 \times \frac{3}{2}R \times 20 = 60 \times 8.3 = 498$ J

$\Delta Q = 498$ J

Q.12 (3)

No. of moles of hydrogen $= \frac{16}{2}$

No. of moles of oxygen = $= \frac{128}{32}$

Total no. of moles = 8 + 4 = 12

At STP

Pressure = 1 atm, Temperature = 273 K

$= 1.013 \times 10^5$ Pa

Using Ideal gas equation

PV = nRT

$\Rightarrow 1.013 \times 10^5 \times V = 12 \times 8.314 \times 273$

$$\Rightarrow V = \frac{12 \times 8.314 \times 272}{1.013 \times 10^5}\ m^3$$

$$= \frac{12 \times 8.314 \times 273 \times 10^6}{1.013 \times 10^5}\ cm^3$$

$V = 27 \times 10^4\ cm^3$

Q.13 (***)

Given 1 (A and D) only

Average kinetic energy of a gas molecule

$k.E_{avg} = \frac{f}{2}kT\ \{f = \text{degree of freedom}\}$

(A) $T \downarrow \Rightarrow K.E_{avg} \downarrow$

(B) T = constant $\Rightarrow$ K. E_{avg} = constant

(C) Not necessary

(D) Pressure is constant given

(E) Not necessary

Q.14 (2)

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

$$V_{sound} = \sqrt{\frac{\gamma RT}{m}}$$

$$V_{rms} = \sqrt{2}V_{sound} \text{ (given)}$$

$$\sqrt{\frac{3RT}{m}} = \sqrt{2}\cdot\sqrt{\frac{\gamma RT}{m}} \qquad \sqrt{3} = \sqrt{2}\sqrt{\gamma} \qquad 3 = 2\gamma$$

$$r_{max} = \frac{3}{2}$$

$$\frac{n_1Cp_1 + n_2Cp_2}{n_1Cv_1 + n_2Cv_2} = \frac{3}{2} \qquad \frac{2\times\frac{5}{2}R + n\times\frac{7}{2}R}{2\times\frac{3}{2}R + n\frac{5}{2}R} = \frac{3}{2}$$

$$\frac{10+7n}{6+5n} = \frac{3}{2}$$

$20 + 14n = 18 + 15n$

$2 = n$

Q.15 (2)

$n = 7$

$\Delta T = 40$ K

$$\Delta U = \frac{nfR\Delta T}{2} = \frac{7\times3\times8.3\times40}{2} = 21\times166 = 3486J$$

Q.16 (1)

$$C_v = \frac{nR}{2}$$

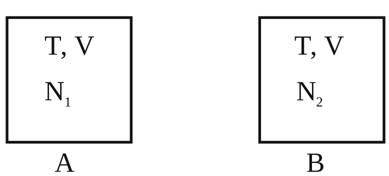
$$C_p = \frac{nR}{2} + R = \frac{n+2}{2}R$$

$$\frac{C_v}{C_p} = \frac{n}{n+2}$$

Q.17 (3)

$PV = nRT$

Same gas, same volume and same temperature



(1) $V_{rms} = \sqrt{\frac{3RT}{M}}$ (T and M (molar mass) are same so $V_{rms} \rightarrow$ same)

(2) $P \propto n$ $\qquad \frac{P_1}{P_2} = \frac{n_1}{n_2} = \frac{N_1/N_A}{N_2/N_A} = \frac{N_1}{N_2} = \frac{1}{4}$

(3) $\frac{P_1}{P_2} = \frac{1}{1}$ $\qquad$ (4) $\frac{(V_{rms})_1}{(V_{rms})_2} = \frac{1}{1}$

Option $\rightarrow$ A and B are correct

Q.18 (2)

By theory

Q.19 (4)

$[P_{avg} = 0]$ (due to random motion)

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

$T_{new} = 2T$

$$M_{new} = \frac{M}{2} \qquad \frac{v_{new}}{v} = \frac{\sqrt{\frac{2T}{M/2}}}{\sqrt{\frac{T}{M}}}$$

$v_{new} = 2v$

Q.20 (3)

$v_{rms} \propto \sqrt{T}$

$$\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$

if $v_2 = 2v_1$

$$\frac{v_1}{2v_1} = \sqrt{\frac{T_1}{T_2}} \Rightarrow \frac{1}{4} = \frac{T_1}{T_2}$$

$\Rightarrow T_2 = 4T_1$

Heat supplied $\qquad$ $R = 8.32$ Jm/molk

$Q = nC_v\Delta T$ $\qquad$ $T_1 = 300$ K

$$\frac{14}{28}\times\frac{5}{2}R\times(T_2 - T_1) \qquad T_2 = 4\times300$$

$$\frac{14}{28}\times\frac{5}{2}\times8.32\times(1200-300) \qquad = 1200 \text{ K}$$

$= 9360$ Joule

Q.21 (3)

$$C_v/\text{mix} = \frac{n_1Cv_1 + n_2Cv_2}{n_1 + n_2}$$

$$= \frac{1\cdot\frac{3R}{2} + 3\cdot\frac{5R}{2}}{1+3}$$

$$= \frac{9R}{4} = \frac{\alpha^2}{4}R$$

$\alpha = 3$

Q.22 (3)

$$V_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3\times1.38\times10^{-23}\times293}{5\times10^{-17}}}$$

≈ 15 mm/s

OSCILLATIONS

EXERCISE-I (MHT CET LEVEL)

Q.1 (4)

In linear S.H.M., the restoring force acting on particle should always be proportional to the displacement of the particle and directed towards the equilibrium position.

i.e., $F \propto x$

or $F = -bx$ where b is a positive constant.

Q.2 (1)

Velocity, $v = \dfrac{dx}{dt} = -A\omega \sin(\omega t + \pi/4)$

Velocity will be maximum, when

$\omega t + \pi/4 = \pi/2\$or\$\omega t = \pi/2 - \pi/4 = \pi 4$

or $t = \pi/4\omega$

Q.3 (1)

Maximum velocity = $a\omega = 16$

Maximum acceleration = $\omega^2 a = 24$

$\Rightarrow a = \dfrac{(a\omega)^2}{\omega^2 a} = \dfrac{16\times16}{24} = \dfrac{32}{3}$ m

Q.4 (1)

For S.H.M. $F = -kx$.

$\therefore$ Force = Mass $\times$ Acceleration $\propto -x$

$\Rightarrow F = -Akx$; where A and k are positive constants.

Q.5 (2)

$x_1 = a\sin(\omega t + \phi_1), x_2 = a\sin(\omega t + \phi_2)$

$\Rightarrow$

$$|x_1 - x_2| = 2a\sin\left(\omega t + \frac{\phi_1+\phi_2}{2}\right)\cos\left(\frac{\phi_1-\phi_2}{2}\right)$$

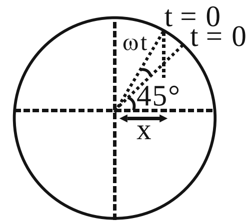
To maximize $|x_1 - x_2| : 2a\sin\left(\omega t + \dfrac{\phi_1+\phi_2}{2}\right) = 1$

$$\Rightarrow a\sqrt{2} = 2a\times1\times\cos\left(\frac{\phi_1-\phi_2}{2}\right)$$

$$\Rightarrow \frac{1}{\sqrt{2}} = \cos\left(\frac{\phi_1-\phi_2}{2}\right) \Rightarrow \frac{\pi}{4} = \frac{\phi_1-\phi_2}{2}$$

$$\Rightarrow \phi_1 - \phi_2 = \frac{\pi}{2}$$

Q.6 (a)



$$x = a\cos\left(\omega t + \frac{\pi}{4}\right)$$

or $x = a\cos\left(\dfrac{2\pi t}{4} + \dfrac{\pi}{4}\right)$

Q.7 **(1)**

For an SHM, the acceleration $a = -\omega^2 x$

Where, ω is a constant $= \dfrac{2\pi}{T}$

$$a = -\frac{4\pi^2}{T^2}\cdot x \Rightarrow \frac{aT}{x} \Rightarrow -\frac{4\pi^2}{T}$$

The period of oscillation T is constant.

$\therefore \dfrac{aT}{x}$ is a constant.

Q.8 (2)

Q.9 (2)

Q.10 (2)

Q.11 (2)

Q.12 (2)

Q.13 (1)

Q.14 (3)

$$n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \Rightarrow \frac{n_S}{n_P} = \sqrt{\frac{k_S}{k_P}} \Rightarrow \frac{n_s}{n_p} = \sqrt{\frac{\left(\frac{k}{2}\right)}{2k}} = \frac{1}{2}$$

Q.15 (2)

Force constant $k = \dfrac{F}{x} = \dfrac{0.5\times10}{0.2} = 25$ N/m

Now $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.25}{25}} = 0.628$ sec

Q.16 (1)

$$n = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \Rightarrow \frac{n}{n'} = \sqrt{\frac{k}{m}\times\frac{m'}{K'}} = \sqrt{\frac{k}{m}\times\frac{2m}{2K}} = 1 \Rightarrow n' = n$$

Q.17 (2)

Q.18 (2)

The kinetic energy of a particle executing S.H.M. is given by

$$K = \frac{1}{2}ma^2\omega^2 \sin^2 \omega t$$

Now, average

$$K.E. = < K > = < \frac{1}{2}m\omega^2 a^2 \sin^2 \omega t >$$

$$= \frac{1}{2}m\omega^2 a^2 < \sin^2 \omega t >$$

$$= \frac{1}{2}m\omega^2 a^2 \left(\frac{1}{2}\right)\left(\because < \sin^2 \theta > = \frac{1}{2}\right)$$

$$= \frac{1}{4}m\omega^2 a^2 = \frac{1}{4}ma^2(2\pi v)^2 \left(\because \omega = 2\pi v\right)$$

or, $< K > = \pi^2 ma^2 v^2$

Q.19 (1)

The two springs are in parallel.

$\therefore$ Effective spring constant,

$k = k_1 + k_2$

Now, frequency of oscillation is given by

$$f = \frac{1}{2p}\sqrt{\frac{k}{m}}$$

or, $f = \frac{1}{2p}\sqrt{\frac{k_1 + k_2}{m}}$ …(i)

When both k_1 and k_2 are made four times their original values, the new frequency is given by

$$f' = \frac{1}{2p}\sqrt{\frac{4k_1 + 4k_2}{m}}$$

$$f' = \frac{1}{2\pi}\sqrt{\frac{4k_1 + 4k_2}{m}} = 2\left(\frac{1}{2\pi}\sqrt{\frac{k_1 + k_2}{m}}\right) = 2f$$

Q.20 (1)

Q.21 (2)

$F = kx \Rightarrow mg = kx \Rightarrow m \propto kx$

Hence $\frac{m_1}{m_2} = \frac{k_1}{k_2}\times\frac{x_1}{x_2} \Rightarrow \frac{4}{6} = \frac{k}{k/2}\times\frac{1}{x_2}$

$\Rightarrow x_2 = 3$ cm

Q.22 (1)

$$t \propto \frac{1}{\sqrt{9.8}}, t' \propto \frac{1}{\sqrt{12.8}}$$

$$(\because g' = 9.8 + 3 = 12.8)$$

$$\therefore \frac{t'}{t} = \sqrt{\frac{9.8}{12.8}} \Rightarrow t' = \sqrt{\frac{9.8}{12.8}}t$$

Q.23 (2)

At B, the velocity is maximum using conservation of mechanical energy

$$\Delta PE = \Delta KE \Rightarrow mgH = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2gH}$$

Q.24 (1)

If v is velocity of pendulum at Q

and 10% energy is lost while moving from P to Q

Hence, by applying conservation of energy between P and Q

$\frac{1}{2}mv^2 = 0.9$ (mgh) $\Rightarrow v^2 = 2\times 0.9\times 10\times 2 \Rightarrow v = 6$ m/sec

Q.25 (2)

Q.26 **(2)**

Q.27 **(3)**

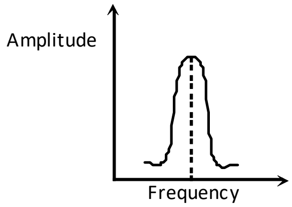
Q.28 (3)

If first equation is $y_1 = a_1 \sin \omega t \Rightarrow \sin \omega t = \frac{y_1}{a_1}$ ... (i)

then second equation will be $y_2 = a_2 \sin\left(\omega t + \frac{\pi}{2}\right)$

Q.29 (4)

Less damping force gives a taller and narrower resonance peak



Q.30 (4)

EXERCISE-II (NEET LEVEL)

Q.1 (4)

Standard equation of S.H.M. $\frac{d^2y}{dt^2} = -\omega^2 y$, is not satisfied by y = a tan ωt.

Q.2 (4)

At mean position velocity is maximum

i.e., $v_{max} = \omega a \Rightarrow \omega = \frac{v_{max}}{a} = \frac{16}{4} = 4$

$\therefore\ v = \omega\sqrt{a^2 - y^2} \qquad \Rightarrow 8\sqrt{3} = 4\sqrt{4^2 - y^2}$

$\Rightarrow 192 = 16(16 - y^2) \qquad \Rightarrow 12 = 16 - y^2$

$\Rightarrow y = 2$ cm

Q.3 (3)

Velocity $v = \omega\sqrt{A^2 - x^2}$ and acceleration = $\omega^2 x$

Now given, $\omega^2 x = \omega\sqrt{A^2 - x^2} \Rightarrow \omega^2.1 = \omega\sqrt{2^2 - 1^2}$

$\Rightarrow \omega = \sqrt{3} \quad \therefore\ T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{3}}$

Q.4 (1)

Since maximum value of $\cos^2 \omega t$ is 1.

$\therefore\ K_{max} = K_0 \cos^2 \omega t - K_0$

Also $K_{max} = PE_{max} = K_0$

Q.5 (4)

Kinetic energy $T = \frac{1}{2}m\omega^2(a^2 - x^2)$ and potential energy, $V = \frac{1}{2}m\omega^2 x^2$

$\therefore\ \frac{T}{V} = \frac{a^2 - x^2}{x^2}$

Q.6 (1)

$E = \frac{1}{2}ma^2\omega^2 = \frac{1}{2}ma^2\left(\frac{4\pi^2}{T^2}\right) \Rightarrow E \propto \frac{a^2}{T^2}$

Q.7 (2)

Ball execute S.H.M. inside the tunnel with time period

$T = 2\pi\sqrt{\frac{R}{g}} = 84.63$ min

Hence time to reach the ball from one end to the other end of the tunnel $t = \frac{84.63}{2} = 42.3$ min

Q.8 (4)

When the spring undergoes displacement in the downward direction it completes one half oscillation while it completes another half oscillation in the upward direction. The total time period is:

$$T = \pi\sqrt{\frac{m}{k}} + \pi\sqrt{\frac{m}{2k}}$$

Q.9 (2)

Phase change π in 50 oscillations phase change 2π in 100 oscillations

So frequency different ~ 1 in 100.

Q.10 (1)

Q.11 (4)

Given spring system has parallel combination, so

$k_{eq} = k_1 + k_2$ and time period $T = 2\pi\sqrt{\left(\frac{m}{k_1 + k_2}\right)}$

Q.12 (2)

With respect to the block the springs are connected in parallel combination.

$\therefore$ Combined stiffness $k = k_1 + k_2$ and $n = \frac{1}{2\pi}\sqrt{\frac{k_1 + k_2}{m}}$

Q.13 (4)

For the given figure $f = \frac{1}{2\pi}\sqrt{\frac{k_{eq}}{m}} = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$

….(i)

If one spring is removed, then $k_{eq} = k$ and

$f' = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

….(ii)

From equation (i) and (ii), $\frac{f}{f'} = \sqrt{2} \Rightarrow f' = \frac{f}{\sqrt{2}}$

Q.14 (3)

Given elastic energies are equal i.e., $\frac{1}{2}k_1x_1^2 = \frac{1}{2}k_2x_2^2$

$\Rightarrow \frac{k_1}{k_2} = \left(\frac{x_2}{x_1}\right)^2$ and using $F = kx$ $\Rightarrow$

$$\frac{F_1}{F_2} = \frac{k_1 x_1}{k_2 x_2} = \frac{k_1}{k_2} \times \sqrt{\frac{k_2}{k_1}} = \sqrt{\frac{k_1}{k_2}}$$

Q.15 (4)

$T = 2\pi\sqrt{\frac{m}{k}} \Rightarrow \frac{T_2}{T_1} = \sqrt{\frac{m_2}{m_1}} = \sqrt{\frac{4m}{m}} = 2 \Rightarrow T_2 = 2 \times 2 =$ 4s

Q.16 (2)

By using $K \propto \frac{1}{l}$

Since one fourth length is cut away so remaining length is $\frac{3}{4}th$, hence k becomes $\frac{4}{3}$ times i.e., $k' = \frac{4}{3}k$.

Q.17 (3)

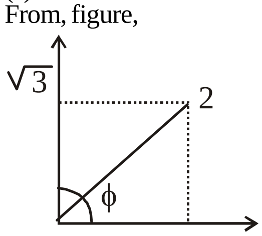
$$\frac{1}{k_{eff}} = \frac{1}{k} + \frac{1}{2k} + \frac{1}{4k} + \frac{1}{8k} + ...$$

$$= \frac{1}{k}\left[1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + ...\right] = \frac{1}{k}\left(\frac{1}{1-1/2}\right) = \frac{2}{k}$$

(By using sum of infinite geometrical progression $a + \frac{a}{r} + \frac{a}{r^2} + ...\infty$ sum $(S) = \frac{a}{1-r}$)

$\therefore k_{eff} = \frac{k}{2}$

Q.18 (1)
From, figure,



$$A_R = \sqrt{\left(\sqrt{3}\right)^2 + (1)^2} = 2$$

$$\theta = \tan^{-1}\left(\frac{\sqrt{3}}{1}\right) = \frac{\pi}{3}$$

$$\therefore\ y = 2\sin\left(\omega t + \frac{\pi}{3}\right)$$

$$\frac{d^2y}{dt^2} = a = -2\omega^2 \sin\left(\omega t + \frac{\pi}{3}\right)$$

$a_{max} = -2\omega^2 = g$
Ffor which mass just breaks off the plank

$\omega = \sqrt{g/2}$
This will be happen for the first time when

$\omega t + \frac{\pi}{3} + \frac{\pi}{2}$ or $\omega t = \frac{\pi}{6}$

$$\therefore\ t = \frac{\pi}{6\omega} = \frac{\pi}{6}\sqrt{\frac{2}{g}}$$

Q.19 (3)

$$T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow T \propto \sqrt{l}$$

Q.20 (2)

As we know $g = \frac{GM}{R^2}$

$$\Rightarrow \frac{g_{earth}}{g_{planet}} = \frac{M_e}{M_p} \times \frac{R_\rho^2}{R_e^2} \Rightarrow \frac{g_e}{g_p} = \frac{2}{1}$$

Also $T \propto \frac{1}{\sqrt{g}} \Rightarrow \frac{T_e}{T_p} = \sqrt{\frac{g_p}{g_e}} \Rightarrow \frac{2}{T_p} = \sqrt{\frac{1}{2}}$

$\Rightarrow T_p = 2\sqrt{2}$ sec

Q.21 (3)

In stationary lift $T = 2\pi\sqrt{\frac{l}{g}}$

In upward moving lift $T' = 2\pi\sqrt{\frac{l}{(g+a)}}$

($a =$ Acceleration of lift)

$$\Rightarrow \frac{T'}{T} = \sqrt{\frac{g}{g+a}} = \sqrt{\frac{g}{\left(g + \frac{g}{4}\right)}} = \sqrt{\frac{4}{5}} \Rightarrow T' = \frac{2T}{\sqrt{5}}$$

Q.22 (1)

$$T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow \sqrt{\frac{l}{g}} = \text{constant}$$

$$\Rightarrow l \propto g \Rightarrow \frac{l_m}{1}\frac{1}{6}\frac{g}{g} \Rightarrow l_m = \frac{1}{6}\text{m}$$

Q.23 (3)
According to the principle of conservation of energy,

$\frac{1}{2}mv^2 = mgh$ or $v = \sqrt{2gh} = \sqrt{2\times9.8\times0.1} = 1.4$ m/s

Q.24 (1)
The displacement of the particle is given by:
$x = A\sin(-2\omega t) + B\sin^2\omega t$

$= -A\sin 2\omega t + \frac{B}{2}(1-\cos 2\omega t)$

$= -(A\sin 2\omega t + \frac{B}{2}\cos 2\omega t) + \frac{B}{2}$

This motion represents SHM wtih an apmlitude: $\sqrt{A^2 + \frac{B^2}{4}}$, and mean position $\frac{B}{2}$.

Q.25 (1)
$U = mV = kmr$

force, $F = -\frac{dU}{dr} = -km$

Now, $\frac{mv^2}{r} = km \Rightarrow v \propto r^{1/2}$

$\therefore T = \frac{2\pi r}{v} = \frac{2\pi r}{cr^{1/2}} \Rightarrow T \propto r^{1/2}$

Q.26 (2)

Q.27 (3)

Resultant amplitude $= \sqrt{3^2+4^2} = 5$

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (2)

$\vec{V}_{max}$ only $\vec{V}_{max}$

If initial velocity is $\vec{V}_{max}$
then after one time period particle acquires same speed V_{max} in same direction means same velocity $\vec{V}_{max}$

Q.2 (3)
$y = a\cos\omega t$

$\frac{a}{2} = a\cos\omega t$

$\omega t = \frac{\pi}{3}$

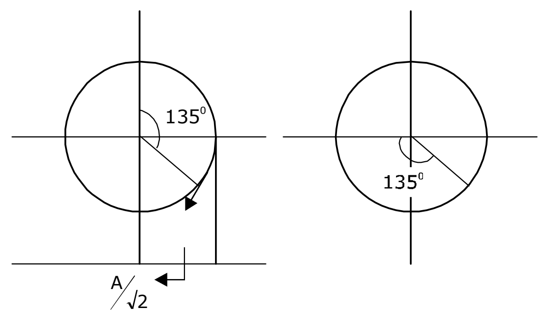
$\frac{2\pi}{24}t = \frac{\pi}{3}$

t = 4 sec.

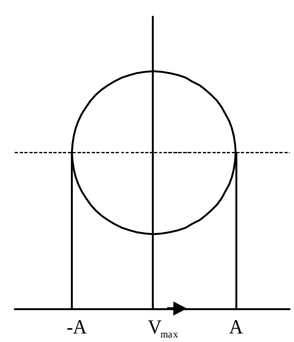
Q.3 (4)
$a = -\omega^2 x$
$= -\omega^2 A\sin\omega t$

$$\langle a\rangle = \frac{-\omega^2 A\int_0^T(\sin\omega t)dt}{\int_0^T dt} = \frac{-\omega^2 A\left[\frac{-\cos\omega t}{\omega}\right]_0^T}{T-0} = 0$$

Q.4 (3)
Let particle A be the particle shown with initial phase 135° and B be the particle at extreme. Hence the phase difference between them is 135°.



Q.5 (1)
A particle has same velocity between 0 & V_{max} and 0 and $-V_{max}$ twice in its motion. Only V_{max} is a velocity which a particle attains once in its one oscillation.



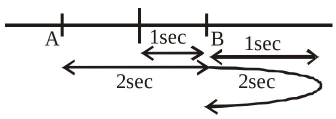
Q.6 (3)
$V = \omega\sqrt{A^2 - x^2}$
$(50\pi)^2 = (10\pi)^2(10^2 - x^2)$
$\Rightarrow x = \pm\sqrt{75} = \pm 5\sqrt{3}$
So, separation between points is
$\therefore \Delta x = 2\times 5\sqrt{3} = 10\sqrt{3} = 17.32$ cm.

Q.7 (3)

$$\frac{1}{2}kx^2 = \frac{1}{2}k(A^2 - x^2)$$

or $x = \frac{A}{\sqrt{2}}$.

Q.8 (2)



Hence $\frac{T}{4}$ = 2 sec. T = 8 sec.

Q.9 (2)
From question

$$\frac{1}{2}m\omega^2A^2 = 8 \times 10^{-3} \Rightarrow \frac{1}{2} \times 0.1 \times \omega^2 \times (0.1)^2 = 8 \times 10^{-3} \Rightarrow$$

$\omega = 4$

So, equation of SHM is $x = A\sin(\omega t + \phi) = 0.1 \sin\left(4t + \frac{\pi}{4}\right)$.

Q.10 (1)
Total Energy of S.H.M. remains constant so average energy = Total energy

Q.11 (3)

$$E_1 = \frac{1}{2}Kx^2$$

$$E_2 = \frac{1}{2}Ky^2$$

$$E = \frac{1}{2}K(x+y)^2$$

$$\Rightarrow E = \frac{1}{2}K(x^2 + y^2 + 2xy)$$

$$= E_1 + E_2 + K\,xy$$

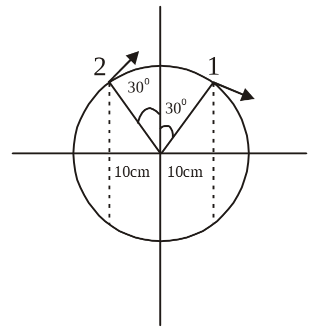
$$= E_1 + E_2 + K\sqrt{\frac{2E_1}{K}}\sqrt{\frac{2E_2}{K}}$$

$$= E_1 + E_2 + 2\sqrt{E_1E_2}$$

Q.12 (3)

$$\frac{4d^2y}{dt^2} + 9y = 0 \Rightarrow \omega^2 = \frac{9}{4} \Rightarrow \omega = \frac{3}{2}$$

Q.13 (3)



Particle 1 and 2 are as shown and their phase difference is 60°.

Q.14 (2)
Slope of F-x curve gives K

$$\text{slope} = \frac{13.5}{1.5} \quad F = -Kx \Rightarrow K = 9$$

$$\omega^2 = \frac{K}{m} = 9 \quad \omega = 3, \quad T = 2\pi/3$$

Q.15 (3)

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{K}{m_1}}$$

$$f_2 = \frac{1}{2\pi}\sqrt{\frac{K}{m_2}}$$

$$f_2 = \frac{f_1}{2} \text{ or } m_2 = 4m_1 \text{ or ; k } \quad m_2 - m_1 = 3\text{ kg}$$

Q.16 (1)

$\omega = \sqrt{\frac{K}{m}}$ and Ke = mg (at mean position)

or $\omega = \sqrt{\frac{g}{e}}$

Q.17 (2)

$$k_{eq} = 2k + k + \frac{2k \times 2k}{2k + 2k} = 4k$$

so, frequency, $f = \frac{1}{2\pi}\sqrt{\frac{K_{eq}}{M}} = \frac{1}{2\pi}\sqrt{\frac{4K}{M}}$

Q.18 (4)

Total M.E.= T.E. at M.P.+Total oscillation energy 9 = 5 + 4

Total oscillation energy = $\frac{1}{2}Ka^2 = 4$

$\Rightarrow K = 8\times10^4 \Rightarrow T = 2\pi\sqrt{M/K} \Rightarrow T = \pi/100$

Q.19 (3)

In spring mass system time period depends only on k and m, not on g

Q.20 (1)

We know that

$x = A \sin \omega t$

$\frac{a}{2} = a \sin \omega t$

$\omega t = \frac{\pi}{6}$

$t = \frac{\pi}{6\omega}$

Now v = aω cosωt

$a\omega \cos\frac{\pi}{6} = \frac{\sqrt{3}}{2}\frac{a\,2\pi}{T} = \frac{a\pi\sqrt{3}}{T}$

Q.21 (4)

$g_{Moon} = \frac{g_{Earth}}{6} \quad \therefore T_{Moon} = \sqrt{6}\ T_{Earth}$

Q.22 (1)

Given time for both are same

$9T_1 = 7T_2$

$9\times 2\pi\sqrt{\frac{\ell_1}{g}} = 7\times 2\pi\sqrt{\frac{\ell_2}{g}}$

$\Rightarrow 9\sqrt{\ell_1} = 7\sqrt{\ell_2} \Rightarrow \frac{\ell_1}{\ell_2} = \frac{49}{81}$

Q.23 (4)

Let $x_1 = A_1 \sin \omega_1 t$ and $x_2 = A_2 \sin \omega_2 t$

Two pendulums will vibrate in same phase again when there phase difference $(\omega_2 - \omega_1)t = 2\pi$

$\Rightarrow \left(\frac{2\pi}{T_2} - \frac{2\pi}{T_1}\right)t = 2\pi$

$\Rightarrow \left(\sqrt{\frac{g}{1}} - \sqrt{\frac{g}{1.44}}\right)n\times T_1 = 2\pi$ (where n is number of vibrations completed by longer pendulum)

$\Rightarrow \left(\sqrt{\frac{g}{1}} - \sqrt{\frac{g}{1.44}}\right)n\times 2\pi\sqrt{\frac{1.44}{g}} = 2\pi \Rightarrow n = 5$

Thus after 5 vibrations of longer pendulum they will again start swinging in same phase.

Q.24 (3)

$T_{max} = mg + m\omega^2\ell = mg + m\frac{v^2}{\ell} = mg + m\frac{(\omega A)^2}{\ell} = mg + m\frac{g}{\ell}\times\frac{A^2}{\ell}\left(\because \omega = \sqrt{\frac{g}{\ell}}\right)$

or $T_{max} = mg + mg\left(\frac{A}{\ell}\right)^2 = mg\left[1+\left(\frac{A}{\ell}\right)^2\right]$

Q.25 (3)

$T = 2\pi\sqrt{\frac{\ell}{g}}$, At high altitude value of g decreases

∴ length of pendulum must be decreased to keep correct time.

Q.26 (4)

$I = \frac{2}{5}mR^2 = \frac{2}{5}\times 25\times(0.2)^2 = \frac{2}{5}$

$\tau = C\theta \quad c = \frac{\tau}{\theta} = \frac{0.1}{1} = 0.1$

$T = 2\pi\sqrt{\frac{I}{C}} = 2\pi\sqrt{\frac{2}{5\times 0.1}} = 2\pi\times 2 = 4\pi$ secs

Q.27 (1)

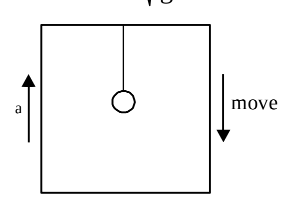
Q.28 (1)

When the lift is going down with constant velocity the acceleration is zero.

When there is a retardation of 'a' the $g_{effective}$ is g + a.

V = constant $\Rightarrow a = 0$ So there is no effect.

$T_1 = T = 2\pi\sqrt{\frac{\ell}{g}} \quad g_{eff} = (g + a)$



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

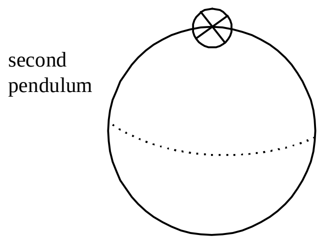
$T_1 > T_2$

Q.29 (1)

T = 2 sec.

$$T = 2\pi\sqrt{\frac{I}{mgd}}$$

Time period of a second's pendulum is two seconds.



$$2 = 2\pi\sqrt{\frac{2mR^2}{mgR}} \quad R = .5m$$

Q.30 (3)

$y = A(1+\cos 2\omega t)$ $y = 2A\sin\left(\omega t + \pi/3\right)$

$y = A + A\cos 2\omega t$ $V_{max} = 2A\omega$

$V_{max} = A \times 2\omega$ Ratio = 1:1

Q.31 (1)

$x = 2\sin\omega t$

$$y = 2\sin\left(\omega t + \frac{\pi}{4}\right)$$

from Lissajous figures if $\phi = \frac{\pi}{4}$ then the path of particle is an ellipse.

Q.32 (4)

$$y = 10\left(\frac{1}{2}\sin 3\pi t + \frac{\sqrt{3}}{2}\cos 3\pi t\right) = 10\sin(3\pi t + \frac{\pi}{3})$$

thus amplitude is 10 m or 1000 cm

Q.33 (2)

$x = A\sin\omega t$, $y = A\cos\omega t$ or $x^2 + y^2 = A^2$

Thus the motion of the particle is on a circle.

Q.34 (2)

$$y = 4\cos^2\left(\frac{t}{2}\right)\sin(1000\,t)$$

$$y = 2\cos\left(\frac{t}{2}\right)\left[\sin\left(\frac{2001t}{2}\right) + \sin\left(\frac{1999t}{2}\right)\right]$$

$y = \sin(1001\,t) + \cos(1000\,t) + \sin(1000\,t) + \cos(1999\,t)$

$y = \sin(1001\,t) + \sqrt{2}\sin(1000\,t + \pi/4) + \cos(1999\,t)$

So the given expression is composed by three equation of S.H.M.

Q.35 (3)

$a_1 = 1, a_2 = 1$ $\theta = \frac{\pi}{3}$

$$a = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\theta} \Rightarrow a = \sqrt{3}$$

EXERCISE-IV

Q.1 [0.25 m]

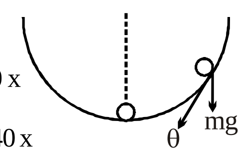
Q.2 [0.248 m]

Q.3 [0.2 kg]

Q.4 [0.136]

Q.5 [0020]

$F = mg\sin\theta \simeq mg\tan\theta$



$\tan\theta = \frac{dy}{dx} = 40\,x$

$-m\omega^2 x = -mg \times 40\,x$

$\omega = \sqrt{400} = 20$ rad/s

Q.6 [0375]

$$T = 2\pi\sqrt{\frac{I}{mg\,\ell/2}} = 2\pi\sqrt{\frac{\frac{m\ell^2}{3}}{mg\ell/2}} = \pi$$

$$\frac{2\ell}{30} = \frac{1}{4} \quad \Rightarrow \quad \ell = \frac{15}{4}\,m = 3.75\,m = 375\,cm$$

Q.7 [0080]

$2mg = kx_1$

$$x_1 = \frac{2mg}{k}$$

$mg = kx_0 \rightarrow$ mean

$$x_0 = \frac{mg}{k} = \frac{20}{200} = \frac{1}{10}\ m$$

highest point = $2x_0$ above initial position.

$$\text{time taken} = \pi\sqrt{\frac{m}{k}} = \pi\sqrt{\frac{2}{200}} = \frac{\pi}{10}$$

$$S = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times \frac{\pi^2}{100} = 50\ cm$$

$\Rightarrow$ distance = 10 + 50 + 20 = 80 cm

Q.8 [0002]

$$T = 2\pi\sqrt{\frac{I}{C}} \Rightarrow 2\pi\sqrt{\frac{10}{10\pi^2}} = 2\ \text{sec.}$$

Q.9 [0003]

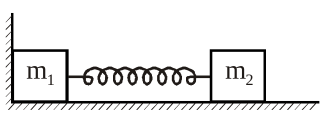
$$T = \pi\sqrt{\frac{k_1}{m}} + \pi\sqrt{\frac{k_2}{m}} + \frac{60cm}{120cm/s} \times 2$$

$$= \pi\sqrt{\frac{1.8}{0.2}} + \pi\sqrt{\frac{3.2}{0.2}} + 1 = 3\pi + 4\pi + 1$$

$$= 7\pi + 1 = 7 \times \frac{22}{7} + 1 = 23\ \text{sec.}$$

Q.10 [0001]

Initially, only m_2 oscillates



$$\Rightarrow t = \frac{T}{2} = \pi\sqrt{\frac{m_2}{k}} = \frac{\pi}{5\sqrt{2}}$$

next both m_1 and m_2 oscillate about their CM.

$$t' = \frac{T'}{2} = \pi\sqrt{\frac{\mu}{k}} = \pi\sqrt{\frac{m_1 m_2}{(m_1+m_2)k}} = \frac{\pi}{10\sqrt{2}}$$

$$m_2 = \frac{k}{50} = 3kg$$

$$\frac{m_1 \times 3}{(3+m_1)} \times 150 = \frac{1}{200}$$

$4m_1 + 3 + m_1 \Rightarrow m_1 = 1$ kg

PREVIOUS YEAR'S

MHT CET

Q.1	(1)
Q.2	(3)
Q.3	(3)
Q.4	(3)
Q.5	(2)
Q.6	(4)
Q.7	(4)
Q.8	(3)
Q.9	(2)
Q.10	(2)
Q.11	(4)
Q.12	(2)
Q.13	(3)
Q.14	(2)
Q.15	(1)
Q.16	(4)
Q.17	(1)
Q.18	(1)
Q.19	(2)
Q.20	(4)
Q.21	(2)
Q.22	(3)
Q.23	(1)
Q.24	(3)
Q.25	(3)
Q.26	(1)
Q.27	(4)
Q.28	(4)
Q.29	(1)
Q.30	(1)
Q.31	(3)
Q.32	(2)
Q.33	(4)
Q.34	(1)
Q.35	(1)
Q.36	(4)
Q.37	(2)
Q.38	(4)
Q.39	(4)
Q.40	(2)
Q.41	(2)
Q.42	(1)
Q.43	(1)
Q.44	(1)
Q.45	(3)
Q.46	(2)
Q.47	(1)
Q.48	(2)
Q.49	(4)
Q.50	(4)

Q.51 (2)
Q.52 (1)
Q.53 (2)
Q.54 (2)

Given, mass, m = 0.25 kg
Force constant, k = 400 N/m
Amplitude of oscilations, A = 4 cm = 0.04 m

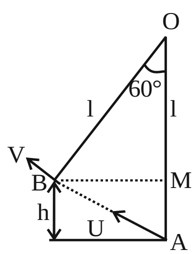
Angular frequency, $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{400}{0.25}}$

$= \sqrt{1600} = 40$ rad/s

Velocity at equilibrium position = ωA
$= 40 \times 0.04 = 1.6$ m/s

Q.55 (2)

Given, l = 0.5 m, u = 3 ms-1
The situation is a shown below



Applying energy conservation at points A and B

$$\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + mgh$$

$\Rightarrow u^2 = v^2 + 2gh$
$v^2 = u^2 - 2gh = u^2 - 2g(l - l\cos 60°)$
[since, h = MA = OA - OM = l - OBcos60° = l-lcos60°]

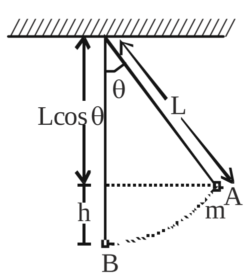
$$= (3)^2 - 2(9.8)\left(0.5 - 0.5 \times \frac{1}{2}\right)$$

$v^2 \approx 4$
$\therefore v = 2ms^{-1}$

Q.56 (4)

When bob reaches at point B from point A as shown below, then vertical heigth travelled by the bob,

$$h = L - L\cos\theta \Rightarrow h = L(1 - \cos\theta)$$



Velocity of bob at point B is v and at A is u, which is zero at extreme point, i.e. u = 0 then from equation,

$v^2 = u^2 + 2gh$

$\therefore \quad v^2 = 2gh = 2gL(1 - \cos\theta) = 2gL(2\sin^2\theta/2)$

$$\left[\because 1 - \cos\theta = 2\sin^2\frac{\theta}{2}\right]$$

$\Rightarrow \quad v = 2\sqrt{gL}\sin\frac{\theta}{2}$

Thus, maximum emf induced,

$$e_{max} = BvL = B \times 2\sqrt{gL}(\sin\theta/2)L$$
$$= 2BL(\sin\theta/2)(gL)^{1/2}$$

Q.57 (2)

When $t = \frac{T}{12}$, then $x = A\sin\omega t = A\sin\frac{2\pi}{T}.t$

$$A\sin\frac{2\pi}{T} \times \frac{T}{12} = A\sin\frac{\pi}{6} = \frac{A}{2}$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2\left(A^2 - x^2\right)$$

$$= \frac{1}{2}m\omega^2\left(A^2 - \frac{A^2}{4}\right) = \frac{3}{4}\left(\frac{1}{2}m\omega^2A^2\right)$$

and $\quad PE = \frac{1}{2}m\omega x^2 = \frac{1}{4}\left(\frac{1}{2}m\omega^2A^2\right)$

$\because \quad \frac{KE}{PE} = \frac{3}{1}$

Q.58 (2)

Given, $f_1 : f_2 = 3 : 2$

As we know, $f = \frac{1}{2\pi}\sqrt{\frac{g}{\ell}}$

$\Rightarrow \quad f \propto \frac{1}{\sqrt{\ell}}$

$\therefore \quad \frac{f_1}{f_2} = \sqrt{\frac{\ell_2}{\ell_1}} \Rightarrow \frac{\ell_1}{\ell_2} = \left(\frac{f_2}{f_1}\right)^2 = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$

Q.59 (3)

In the arrangement shown in Fig. (i), the two springs are in series combination. The effective spring constant K_s of this arrangement,

$$\frac{1}{k_s} = \frac{1}{k} + \frac{1}{2k} \text{ or } \frac{1}{k_s} = \frac{2+1}{2k} = \frac{3}{2k} \Rightarrow k_s = \frac{2k}{3}$$

In the arrangement shown in Fig. (ii), the two springs are in parallel. The effective spring constant K_p of this arrangement,

$k_p = k_1 + k_2 = k + 2k = 3k$

$$\therefore \frac{k_s}{k_p} = \frac{\frac{2k}{3}}{3k} = \frac{2}{9}$$

Q.60 (3)

Given, $y = 4\cos^2\left(\frac{t}{2}\right)\sin(1000\,t)$

$= 2 \times 2\cos^2\left(\frac{t}{2}\right)\sin(1000\,t)$

$= 2(1 + \cos t)\sin(1000t)$ ($\because 2\cos^2\theta = 1 + \cos\theta$)

$= 2\sin(1000\,t) + 2\cos t.\sin(1000\,t)$

$= 2\sin(1000\,t) + \sin(1000\,t + t) + \sin(1000\,t - t)$

$= 2\sin(1000\,t) + \sin(1001\,t) + \sin(999)\,t$

So, n = 3

($\because$ above equation shows three independent oscillations passed with each other).

NEET/AIPMT

Q.1 (2)

$|a| = \omega^2 y$

$\Rightarrow 20 = \omega^2(5)$

$\Rightarrow \omega = 2\text{rad}/\text{s}$

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

Q.2 (2)

$y = A_0 + A\sin\omega t + B\cos\omega t$

Hence 2 SHM's are super imposed with phase difference of $\frac{\pi}{2}$

Amplitude = $\sqrt{A^2 + B^2 + 2AB\cos\Delta\phi}$

$\Delta\phi = \frac{\pi}{2} = \sqrt{A^2 + B^2}$

Q.3 (4)

As displacement in are complete vibration is zero. Therefore average velocity is zero.

Q.4 (4)

$T = \frac{2\pi}{\omega} = 4,\ \omega = \frac{\pi}{2}$

Y co-ordinate starts from maximum

So $y = A\cos(\omega t)$

$y = 3\cos\left(\frac{\pi}{2}t\right)$

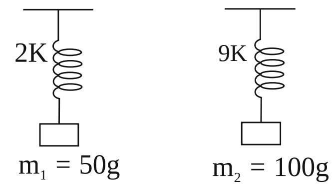
Q.5 (4)

Q.6 (1)

Q.7 (3)

JEE MAIN

Q.1 (2)



Given : $V_{1\,max} = V_{2\,max}$

$\omega_1 A_1 = \omega_2 A_2$

$\sqrt{\frac{k_1}{m_1}}A_1 = \sqrt{\frac{k_2}{m_2}}A_2$

$\frac{A_1}{A_2} = \sqrt{\frac{k_2}{m_2} \times \frac{m_1}{k_1}} = \sqrt{\frac{9K}{2K} \times \frac{50}{100}} = \frac{3}{2}$

$A_1 : A_2 = 3 : 2$

Q.2 (3)

Q.3 (4)

$X = A\sin\omega t (t = 3, X = \frac{A}{2})$

$\Rightarrow \frac{A}{2} = A\sin 3\omega$

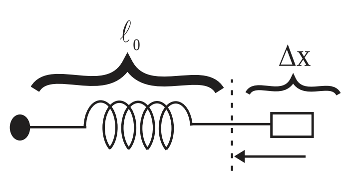
$\Rightarrow \sin 3\omega = \frac{1}{2}$

$\Rightarrow \sin 3\omega = \frac{\pi}{6}$

$\Rightarrow \omega = \frac{\pi}{18} = \frac{2\pi}{T}$

$\Rightarrow T = 36\ s$

Q.4 (3)



$K\Delta x = m(\ell_0 + \Delta x)w^2$

$K\Delta x = m\ell_0\omega^2 + m\omega^2\Delta x$

$\Delta x = \frac{m\ell_0\omega^2}{k - m\omega^2}$

Q.5 (2)

$$x = \sin\pi\left(t+\frac{1}{3}\right)$$

$$x = \sin\left(\pi t+\frac{\pi}{3}\right)$$

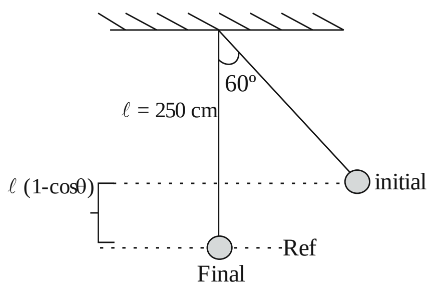
$$V = \frac{dx}{dt} = \cos\left(\pi t+\frac{\pi}{3}\right)\pi$$

$$x = \pi\times\frac{1}{2} = 157 \text{ cm/s}$$

Q.6 (1)

$$t = \frac{\Delta\phi}{\omega} = \frac{\pi/2 - \pi/6}{2\pi/6} = \frac{\pi/3}{\pi/3} = 1\text{sec.}$$

Q.7 [5]



M = 200 gm

Apply conservation of Energy

$U_i + k_i = U_f + K_f$

$$mg\ell(1-\cos\theta) = 0 + \frac{1}{2}MV^2$$

$2g\ell(1-\cos\theta) = v^2$

$2\times10\times2.5(1-\cos60) = v^2$

v = 5 m/s

Q.8 [700]

$V^2 = \omega^2(A^2 - x^2)$ A = 10 cm Given

$$V^2 = \omega^2\left(A^2 - \left(\frac{A}{2}\right)^2\right) \text{.... (i)} \quad x = 5\text{ cm} = \frac{A}{2}$$

$$(3v)^2 = \omega^2\left(A'^2 - \left(\frac{A}{2}\right)^2\right) \text{.....(ii)}$$

Equation (ii) divided by (i)

$$9 = \frac{4A'^2 - A^2}{4A^2 - A^2} \qquad A = \sqrt{x}\text{ cm}$$

$9(3A^2) = 4A'^2 - A^2$

$28A^2 = 4A'^2$

$A' = \sqrt{7}\,A$

$A' = 10\sqrt{7}$

$\boxed{A' = \sqrt{700}\text{cm}}$

On comparison of A′ with $\sqrt{x}$

$\boxed{x = 700\text{ cm}}$

Q.9 (3)

Time period of simple pendulum medium

$Y = A\sin(\pi + \theta)$

Comparing with

$Y = A\sin(\omega t + \theta)$

$\Rightarrow \omega = \pi \text{ rad s}^1$

Time period of pendulum

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

= 2 seconds

We know that

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

$$\Rightarrow 2 = 2\pi\sqrt{\frac{l}{g}}$$

$$\Rightarrow 1 = \pi^2\sqrt{\frac{l}{g}}$$

$$\Rightarrow l = \frac{g}{\pi^2} \approx 99.4\text{ cm}$$

Q.10 (1)

$$T = 2\pi\sqrt{\frac{3m}{k_{eq}}}\ \{k_{eq} = 2k\}$$

$$T_1 = 2\pi\sqrt{\frac{3m}{2k}}$$

$$T_2 = 2\pi\sqrt{\frac{m}{3k}}$$

$$\therefore \frac{T_1}{T_2} = \sqrt{\frac{9}{2}} \Rightarrow \frac{T_1}{T_2} = \frac{3}{\sqrt{2}}$$

Q.11 (4)

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

$$T^2 = \frac{4\pi^2 l}{g'} \quad \text{... (1)}$$

$$g' = g\left(\frac{R}{R+2R}\right)^2$$

$$g' = \frac{g}{9} \quad \text{... (2)}$$

$$T^2 = \frac{4\pi^2 l}{g/9}$$

$$\frac{2^2 \times g}{9 \times 4\pi^2} = 1$$

$$1 = \frac{1}{9}m$$

Q.12 [60]

$$R = \sqrt{A^2 + A^2 + 2A^2 \cos\Delta\phi}$$

$$R = \sqrt{3}A = \sqrt{A^2 + A^2 + 2A^2 \cos\Delta\phi}$$

$A_1 = A_2 = A$

$$\sqrt{3}A = \sqrt{2A^2 + 2A^2 \cos\Delta\phi}$$

$\Rightarrow (\cos\theta = 2\cos 2\theta - 1)$

$$\sqrt{3}A = \sqrt{2A^2\left(2\cos^2\frac{\Delta\phi}{2}\right)}$$

$$\sqrt{3}A = 2A\cos\frac{\Delta\phi}{2}$$

$$\cos\frac{\Delta\phi}{2} = \frac{\sqrt{3}}{2}$$

$$\frac{\Delta\phi}{2} = 30^\circ$$

$\Delta\phi = 60^\circ$

Q.13 (2)

$v = \omega\sqrt{A^2 - x^2}$

$v^2 = \omega^2 A^2 - \omega^2 x^2$

$v^2 + \omega^2 x^2 = \omega^2 A^2$

$$\frac{v^2}{(\omega A)^2} + \frac{x^2}{A^2} = 1 \rightarrow \text{Elliptical}$$

Q.14 (2)

$Ki + Ui = K_f + U_f$

$$2\left(\frac{1}{2}mv^2\right) + 0 = 0 + \frac{1}{2}(2)(X_{max})^2$$

$$x_{max}^2 = mv^2 = 0.25v^2 = \frac{v^2}{4}$$

$$x_{max} = \frac{v}{2}$$

Q.15 (2)

$$T_1 = 2\pi\sqrt{\frac{3m}{2k}}$$

Here,

$$\Rightarrow 3 = 2\pi\sqrt{\frac{3m}{2k}}$$

And for 2nd System,

$K_{eq} = 2k + k = 3k$

$$\therefore T_2 = 2\pi\sqrt{\frac{m}{3k}}$$

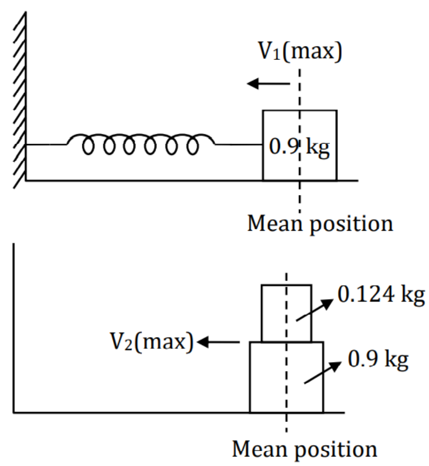
Hence,

$$\frac{T_1}{T_2} = \frac{3}{T_2} = \sqrt{\frac{3}{2} \times \frac{3}{1}}$$

$\Rightarrow T_2 = \sqrt{2}$

$\Rightarrow x = 2$

Q.16 [16]



$m_1 v_1 = m_2 v_2$

$0.9v_1 = (0.9 + 0.124)v_2$

$$0.9v_1 = (1.024)v_2 \Rightarrow \boxed{v_2 = \frac{0.9}{1.024}V_1} \text{ ------- (1)}$$

Now

$v_1 = A_1\omega_2$ and

$v_2 = A_2\omega_2$

From (1)

$$A_2\omega_2 = \frac{0.9}{1.024}(A_1\omega_1)$$

$$A_2\sqrt{\frac{k}{1.024}} = \frac{0.9}{1.024}.A_1\sqrt{\frac{k}{0.9}}$$

$$A_2 = A_1\sqrt{\frac{0.9}{1.024}}.A_1\frac{30}{32}$$

$$\frac{A_1}{A_2} = \frac{32}{30} = \frac{\alpha}{\alpha-1} \Rightarrow 32\alpha - 32 = 30\alpha$$

$$2\alpha = 32$$

$$\alpha = 16$$

Q.17 (3)

$T_1 = 4s$ $T_2 = 6s$

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

$$\text{So, } \frac{T_1}{T_2} = \sqrt{\frac{g_2}{g_1}} \quad .....(1)$$

$$g_1 = \frac{GM}{R^2}$$

$$g_2 = \frac{GM}{(R+h)^2}$$

$$\text{So, } \frac{g_2}{g_1} = \frac{R^2}{(R+h)^2}$$

From equation (1)

$$\frac{T_1}{T_2} = \sqrt{\frac{R^2}{(R+h)^2}}$$

$$\Rightarrow \frac{4}{6} = \frac{R}{R+h}$$

$4R + 4h = 6R$

$4h = 2R$

$h = R/2$

$$= \frac{6400}{2} = 3200\text{ km}$$

Q.18 [2]

$m = 4$ kg

$u = 4(1 - \cos 4x)$ given $\sin\theta \approx \theta$

$$\text{So, } F = -\frac{dU}{dx} = -4[0 + (\sin 4x)\times 4]$$

$= -16\sin 4x$

$F = -64x \rightarrow$ equation of SHM

$$a = \frac{F}{m} = -\frac{64}{4}x = -16x = -\omega^2 x$$

$$\omega = \sqrt{16} = 4$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{4} = \frac{\pi}{2}$$

So, K = 2

Q.19 [5]

$mg' = mg - F_B$

$$g' = \frac{mg - F_B}{m}$$

$$= \frac{\rho_B Vg - \rho_w Vg}{\rho_B V}$$

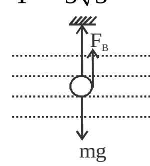
$$= \left(\frac{\rho_B - \rho_w}{\rho_B}\right)g \qquad T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$= \frac{5-1}{5}\times g = \frac{4}{5}g$$

$$\frac{T'}{T} = \sqrt{\frac{g}{g'}} = \sqrt{\frac{g}{\frac{4}{5}g}} = \sqrt{\frac{5}{4}}$$

$$T' = T\sqrt{\frac{5}{4}} = \frac{10}{2}\sqrt{5}$$

$$T' = 5\sqrt{5}$$



Waves

EXERCISE-I (MHT CET LEVEL)

Q.1 (4)

$$y = x_0 \cos 2\pi\left(nt - \frac{x}{\lambda}\right)$$

$$y = x_0 \cos\frac{2\pi}{\lambda}(vt - x) \quad [\because v = n\lambda]$$

$$\left(\frac{dy}{dt}\right)_{max} = x_0 \times \frac{2\pi}{\lambda}v = 2v(\text{given})$$

$$\Rightarrow \lambda = \pi x_0$$

Q.2 (2)

Q.3 (1)

Q.4 (1)

Q.5 (1)

$y_1 = 10\sin(3\pi t - 0.03x)$

$y_2 = 5[\sin(3\pi t - 0.03x) + \sqrt{3}\cos[3\pi t - 0.03x]$

$$= 5 \times 2\left[\frac{1}{2}\sin(3\pi t - 0.03x) + \frac{\sqrt{3}}{2}\cos(3\pi t - 0.03x)\right]$$

$$= 10[\cos\frac{\pi}{3}(3\pi t - 0.03x) + \sin\frac{\pi}{3}\cos(3\pi t - 0.03x)$$

$$= 10\sin\left(3\pi t - 0.03x + \frac{\pi}{3}\right)$$

$$\Rightarrow \frac{A_2}{A_1} = \frac{10}{10} = 1:1$$

Q.6 (3)

Resultant amplitude is given

by $a_{res} = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\theta}$

$$\theta = \frac{\pi}{2} = 90^o$$

$$\Rightarrow a_{res} = \sqrt{a_1^2 + a_2^2}$$

Q.7 (2)

Let amplitudes of waves be a_1 and a_2

$$\Rightarrow \frac{a_1}{a_2} = \sqrt{\frac{I_1}{I_2}} = \frac{\sqrt{I}}{\sqrt{2I}} = \frac{1}{\sqrt{2}}$$

$$\Rightarrow a_2 = \sqrt{2}a_1$$

Resultant amplitude, $A_R = \sqrt{a_1^2 + a_2^2}$

$= \sqrt{a_1^2 + 2a_1^2}$

$= \sqrt{3}a_1$

Intensity, $\frac{I_R}{I_1} \propto \frac{A_R^2}{a_1} = 3 \Rightarrow I_R = 3I_1 = 3I$

Q.8 (2)

Equation of a wave

$y_1 = a\sin(\omega t - kx)$.......(i)

Let equations of another wave may be,

$y_2 = a\sin(\omega t + kx)$.......(ii)

$y_3 = -a\sin(\omega t + kx)$.......(iii)

If Eq. (i) propagate with Eq. (ii), we get

$y = 2a\cos kx \sin \omega t$

If Eq. (i), propagate with Eq. (iii), we get

$y = -2a\cos kx \sin \omega t$

At $x = 0$, $y = 0$, wave produce node

So, Eq. (iii) is the equation of unknown wave

Q.9 (1)

Q.10 (1)

Q.11 (3)

Q.12 (1)

Q.13 (1)

$$y = 10\sin\frac{\pi x}{4}\cos\pi t$$

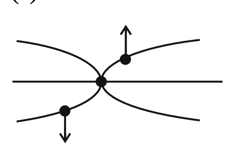
At nodes, $\sin\frac{\pi x}{4} = 0$

$$\Rightarrow \frac{\pi x}{4} = 0, \pi, 2\pi$$

$\Rightarrow x = 0, x = 4, x = 8$

$\therefore$ Option 1 is correct

Q.14 (3)



The two particles are on two sides of a node, their directions are opposite to each other. Thus phase difference between them is π or 180^o.

Q.15 (1)

In Melde's experiment

$T\rho^2 = \text{constant}$

$$\frac{P_1^2}{P_2^2} = \frac{T_2}{T_1} = \frac{4T_1}{T_1}$$

$$\Rightarrow P_2^2 = \frac{P_1^2}{4} = \frac{(8)^2}{4} = \frac{64}{4}$$

$P_1^2 = 16$

$\Rightarrow P_2 = 4$

Q.16 (2)
Q.17 (4)
Q.18 (3)
Q.19 (4)
Q.20 (4)
Q.21 (4)
Q.22 (1)
Q.23 (4)
Q.24 (1)
Q.25 (1)

For open pipe, $n = \frac{v}{2k\ell}$, where n_0 is the fundamental frequency of open pipe.

$$\therefore \ell = \frac{v}{2n} = \frac{330}{2\times 300} = \frac{11}{20}$$

As freq. of 1st overtone of open pipe = freq. of 1st overtone of closed pipe

$$\frac{2\ v}{2\ \ell} = \frac{3\ v}{4\ \ell\ '}$$

$$\Rightarrow \ell' = \frac{3\ell}{4} = \frac{3}{4}\times\frac{11}{20} = 41.25cm$$

Q.26 (1)
Q.27 (1)
Q.28 (1)

$\lambda_0 = 60\text{ cm} = 0.6\text{ m}$

$$f_{app} = f\left(\frac{v}{v - v_s}\right)$$

$$\Rightarrow \frac{v}{\lambda_{app}} = \frac{v}{\lambda_0}\left(\frac{v}{v - v_s}\right)$$

$$\Rightarrow \lambda_{app} = \lambda_0\frac{(v - v_s)}{v} = 60\left(\frac{320 - 20}{320}\right)$$

$= 56.25\text{ cm}$

$\simeq 56\text{cm}$

Q.29 (2)

$$v_s = \frac{V}{10} \qquad n' = n\frac{v}{v - v_s}$$

$$\frac{n'}{n} = \frac{v}{\left(v - \frac{v}{10}\right)} = \frac{10}{9}$$

Q.30 (4)

$$f' = f\left(\frac{v + v_0}{v - v_s}\right)$$

Here, f = 600 Hz v^0 = 15 m/s
v_s = 20 m/s, v = 340 m/s

$$f' = 600\times\left[\frac{340 + 15}{340 - 20}\right]$$

$$\therefore f' = 600\left(\frac{355}{320}\right) \approx 666Hz$$

Q.31 (4)
Q.32 (2)
Q.33 (3)

EXERCISE-II (NEET LEVEL)

Q.1 (3)
Q.2 (1)

$\lambda = 5\text{ cm}$
n = 2
$v = n\lambda = 10$ cm/s

Q.3 (3)

$$\Delta\phi = \frac{2\pi}{\lambda}\cdot\Delta x$$

$$\Delta\phi = \frac{\pi}{2}$$

$\Delta x = 1\text{ m}$

$$\frac{\pi}{2} = \frac{2\pi}{\lambda}\cdot(1)$$

$\lambda = 4\text{m}$

$V = n\lambda = 120\times 4 = 480\text{ m/s}$

Q.4 (1)

$y(x, t) = e^{-(ax^2+bt^2+2\sqrt{ab}xt)} = e^{-(\sqrt{ax}+\sqrt{bt})^2}$

It is a function of type $y = f(\omega t + kx)$

$\therefore$ y (x, t) represents wave travelling along – x direction.

Speed of wave $= \frac{\omega}{k} = \frac{\sqrt{b}}{\sqrt{a}} = \sqrt{\frac{b}{a}}$.

Q.5 (3)

The given equation representing a wave travelling along –y direction (because '+' sign is given between t term and x term). On comparing it with $x = A\sin(\omega t + ky)$

We get $k = \frac{2\pi}{\lambda} = 12.56 \Rightarrow \lambda = \frac{2\times 3.14}{12.56} = 0.5$ m

Q.6 (4)

$y = f(x^2 - vt^2)$ doesn't follows the standard wave equation

Q.7 (1)

Comparing with $y = (x, t) = a\sin(\omega t - kx)$

$k = \frac{2\pi}{\lambda} = 0.01\pi \Rightarrow \lambda = 200$ m

Q.8 (4)

Comparing with standard wave equation

$y = a\sin\frac{2\pi}{\lambda}(vt - x)$,

we get, v = 200 m/s

Q.9 (1)

$v = \frac{\omega}{k}$

$v = \frac{0.1}{1/20} = 2$m/s

Q.10 (4)

$V_{max} = A\omega$

$V_{max} = 3V_{wave}$

$A\omega = 3n\lambda$

$A \cdot 2\pi n = 3n\lambda$

$\lambda = \frac{2nA}{3}$

Q.11 (4)

$V = \frac{\omega}{k}$

$V = \frac{80}{2} = 30$ m/s

and in –X direction

Q.12 (1)

Velocity of particle

$v = A\omega$

$= 2\pi n A$

$= 2\pi \times 300 \times 0.1$

$= 60\pi$ cm/s

Q.13 (2)

$I \propto a^2$

$\frac{a_1}{a_2} = \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{1}{16}} = \frac{1}{4}$

Q.14 (3)

Resultant amplitude may be

$R_{max} = A + B$

$R_{min} = A - B$

Q.15 (3)

Fundamental frequency is given by

$v = \frac{1}{2t}\sqrt{\frac{T}{\mu}} \Rightarrow v\alpha\frac{1}{t} \Rightarrow p\alpha\frac{1}{v}$

Since, P divided into l_1, l_2 and l_3 segments

Here, $l = l_1 + l_2 + l_3$

Q.16 (2)

As we know, frequency

$f \propto \sqrt{mg}$ or $f \propto \sqrt{g}$

In water, $f_w = 0.8 f_{air}$

$\frac{g'}{g}(0.8)^2 = 0.64$

$\Rightarrow 1 - \frac{\rho_w}{\rho_m} = 0.64$

$\Rightarrow \frac{\rho_w}{\rho_m} = 0.36$

In liquid, $\frac{g'}{g} = (0.6)^2 = 0.36$

$$1 - \frac{\rho_1}{\rho_m} = 0.36 \frac{\rho_1}{\rho_m} = 0.64$$

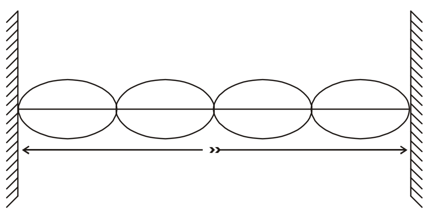
From eq. (1) and (2)

$$\frac{\rho_1}{\rho_n} = \frac{0.64}{0.36} \therefore \rho_l = 1.77$$

Q.17 (3)

For a string vibrating in its n^{th} overtone $(n \div 1)^{th}$

$$y = 2A \sin\left(\frac{n+1\pi x}{L}\right)\cos \omega t$$



For $x = \frac{\ell}{3}]2A = a \;\&\; n = 3:$

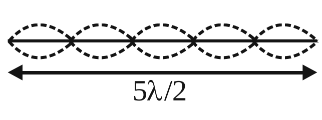
$$y = y = \left[a \sin\left(\frac{4\pi}{\ell}\frac{\ell}{3}\right)\right]\cos \omega t$$

$$a \sin \frac{4\pi}{3} \cos \omega t = -a\left(\frac{\sqrt{3}}{2}\right)\cos \omega t$$

i.e. at $x = \frac{\ell}{3}$, the amplitude is $\frac{\sqrt{3}a}{2}$

Q.18 (1)

$$f = \frac{5}{2\ell}\sqrt{\frac{F}{\mu}} = \frac{5}{2\ell}\sqrt{\frac{9g}{\mu}} \quad ......(i)$$



and $f = \frac{3}{2\ell}\sqrt{\frac{Mg}{\mu}}$ .....(ii)

From above equationss, weget M = 25 kg.

Q.19 (1)

Q.20 (4)

$$n \propto \frac{1}{l} \Rightarrow \frac{n_2}{n_1} = \frac{l_1}{l_2} \Rightarrow n_2 = \frac{l_1}{l_2} n_1 = \frac{1 \times 256}{1/4} = 1024\,Hz$$

Q.21 (1)

(1)

$n \propto \sqrt{T}$

Q.22 (3)

$n \propto \sqrt{T}$

Q.23 (4)

$n \propto \sqrt{T}$

$\Rightarrow n_1 : n_2 : n_3 : n_4 = \sqrt{1} : \sqrt{4} : \sqrt{9} : \sqrt{16} = 1 : 2 : 3 : 4$

Q.24 (3)

$n_1 l_1 = n_2 l_2 \Rightarrow 800 \times 50 = 1000 \times l_2 \Rightarrow l_2 = 40$ cm

Q.25 (2)

When medium changes, velocity and wavelength changes but frequency remains constant.

Q.26 (4)

$$n = \frac{3600}{60} = 60 \text{ Hz} \Rightarrow \lambda = \frac{v}{n} = \frac{960}{60} = 16\,m$$

Q.27 (1)

In transverse waves medium particles vibrate perpendicular to the direction of propagation of wave

Q.28 (3)

$$I \propto \alpha^2 \propto \frac{1}{d^2} \Rightarrow \alpha \propto \frac{1}{d}$$

Q.29 (1)

Velocity of sound is independent of frequency. Therefore it is same (v) for frequency n and 4n.

Q.30 (1)

The quality of sound depends upon the number of harmonics present. Due to different number of harmonics present in two sounds, the shape of the resultant wave is also different

Q.31 (4)

$$I \propto \frac{1}{r^2} \Rightarrow \frac{\Delta I}{I} = -2\frac{\Delta r}{r} = -2\times 2 = -4\%$$

Hence intensity is decreased by 4%.

Q.32 (4)

$A_{max} = \sqrt{A_2 + A_2} = A\sqrt{2}$, frequency will remain same i.e. ω

Q.33 (2)

$$\frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2 = \frac{1}{16} \Rightarrow \frac{a_1}{a_2} = \frac{1}{4}$$

Q.34 (4)
This is a case of destructive interference

Q.35 (3)

Let the frequency of the first fork be f_1 and that of second be f_2.

We than have, $f_1 = \dfrac{v}{4\times 24}$ and $f_2 = \dfrac{v}{4\times 25}$

We also see that $f_1 > f_2$

$\Rightarrow f_1 - f_2 = 6$ ...(i)

And $\dfrac{f_1}{f_2} = \dfrac{24}{25}$ ...(ii)

Solving (i) and (ii), we get

F_1=150Hz and f_2=144Hz

Q.36 (3)
The frequency of tuning fork, f = 392 Hz

Also $392 = \dfrac{1}{2\times 50}\sqrt{F/\mu}$ ......(i)

After decresing the length by 2%, we have

$f' = \dfrac{1}{2(49)}\sqrt{F/\mu}$ .....(ii)

From above equations,
f' = 400 Hz.
$\therefore$ Beats frequency = 8 Hz.

Q.37 (2)

$\lambda_1 = 50cm$

$$v \propto \sqrt{T} \Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{273+20}{273}}$$

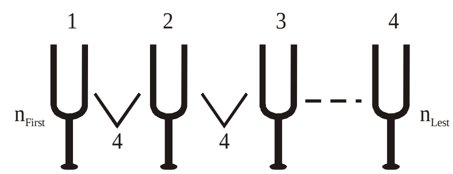
$\Rightarrow v_2 = 319.23$

$$= v_1 = \frac{v_2}{\lambda_1} = \frac{319.23}{0.50} = 640Hz.$$

$$v_2 = \frac{v_2}{\lambda_1} = \frac{319.23}{51\times 10^{-2}} = 625.94 = 626Hz.$$

No. of beats $= v_2 - v_1 = 14Hz$

Q.38 (4)



Using $n_{Lest} = n_{First} + (N-1)x$
where N=Number of tuning forks in series
x = beat frequency between two successive forks

$\Rightarrow 2n = n + (10-1)\times 4$

$\Rightarrow n = 36Hz$

Q.39 (3)
Q.40 (2)
Q.41 (4)
Q.42 (3)
Intensity $\propto$ (amplitude)^2
as $A_{max} = 2\alpha_0$ (a_o= amplitude of one source) so $I_{max} = 4I_0$.

Q.43 (2)
With temperature rise frequency of tuning fork decreases. Because, the elastic properties are modified when temperature is changed
also, $n_t = n_0(1 - 0.00011\ t)$
where n_t = frequency at t°C, n_0 = frequency at 0°C

Q.44 (4)
Particles have kinetic energy maximum at mean position

Q.45 (1)

Required distance $=\frac{\lambda}{4}=\frac{v/n}{4}=\frac{1200}{4\times 300}=1\text{ m}$

Q.46 (3)

For closed pipe in general $n=\frac{v}{4l}(2N-1)\Rightarrow n\propto\frac{1}{l}$

i.e. if length of air column decreases frequency increases.

Q.47 (1)

Fundamental frequency of open pipe

$n_1=\frac{v}{2l}=\frac{350}{2\times 0.5}=350\text{ Hz.}$

Q.48 (2)

Minimum audible frequency = 20 Hz.

$\Rightarrow \frac{v}{4l}=20\Rightarrow l=\frac{336}{4\times 20}=4.2\text{m}$

Q.49 (2)

For closed pipe

$n_1=\frac{v}{4l}\Rightarrow 250=\frac{v}{4\times 0.2}\Rightarrow v=200\text{m/s}$

Q.50 (3)

For closed organ pipe $n_1:n_2:n_3$ .... = 1 : 3 : 5 : ....

Q.51 (2)

Let the base frequency be n for closed pipe then notes are n, 3n, 5n.......

∴ note 3n = 255 ⇒ n = 85, note 5n = 85 × 5 = 425
note 7n = 7 × 85 = 595

Q.52 (2)

$n'=n\left(\frac{v}{v-v_0}\right)=450\left(\frac{340}{340-34}\right)=500$ cycles / sec

Q.53 (4)

Since there is no relative motion between observer and source, therefore there is no apparent change in frequency

Q.54 (3)

$n'=n\left(\frac{v}{v-v_S}\right)=1200\times\left(\frac{350}{350-50}\right)=1400\text{ cps}$

Q.55 (3)

Since there is no relative motion between the listener and source, hence actual frequency will be heard by listener.

Q.56 (1)

$\lambda=\frac{c+u}{f}$

Q.57 (4)

Q.58 (1)

Let v = speed of sound and vs = speed of tuning forks. Apparent frequency of fork moving towards the observer is $n_1=\left(\frac{v}{v-v_S}\right)n$

Apparent frequency of the fork moving away from the observer is $n_2=\left(\frac{v}{v+v_S}\right)n$

If is the number of beats heard per second. then $f=n_1-n_2$

$\Rightarrow f=\left(\frac{v}{v-v_S}\right)n-\left(\frac{v}{v+v_S}\right)n$

$\Rightarrow f=\frac{v(v+v_S)-v(v-v_S)}{v^2-v_S^2}(n)$

$\Rightarrow \frac{2vv_Sn}{v^2-v_S^2}=f\Rightarrow 2\left(\frac{v_S}{v}\right)n=f\{\text{if } v_S<<v\}$

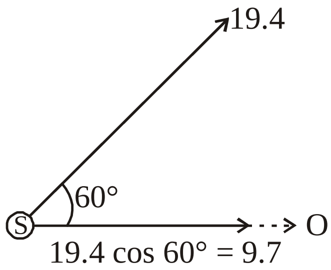
$\Rightarrow v_S=\frac{fv}{2n}$

Putting v = 340 m/s. f = 3, n = 3, 340 Hz we get,

$v_S=\frac{340\times 3}{3\times 340}=1.5\text{m/s}$

Q.59 (1)

Here, original frequency of sound, f_0 = 100 Hz Speed of source V_s = 19.4 cos 60° = 9.7
Form Doppler's formula



$$f^1 = f_0\left(\frac{V-V_0}{V-V_s}\right)$$

$$f^1 = 100\left(\frac{V-V}{V-(+9.7)}\right)$$

$$f^1 = 100\frac{V}{V\left(1-\frac{9.7}{V}\right)}$$

$$f^1 = 100\left(1+\frac{9.7}{330}\right) = 10Hz$$

Apparent frequencuy f^1 = 103 Hz

Q.60 (3)
Q.61 (3)
Q.62 (4)
Q.63 (4)

EXERCISE-III (JEE MAIN LEVEL)

Q.1 (1)

As $\frac{5\lambda}{2} = 20 \Rightarrow \lambda = 8$ cm

$$K = \frac{2\pi}{\lambda} = \frac{314}{4}$$

$$\omega = KV\ \frac{2\pi}{8\times10^{-2}} \times 350 = 27475$$

$$\therefore\ y = 0.05 \sin\left(\frac{314}{4}x - 27475t\right)$$

Q.2 (2)

$$V_{P_{max}} = A\omega = Y_0 2\pi f = 4V_\omega$$

$$Y_0 2\pi f = 4\ \frac{2\pi f}{\frac{2\pi}{\lambda}}$$

$$\therefore\ \lambda = \frac{\pi Y_0}{2}$$

Q.3 (2)

$\omega = 2\pi f = 4\pi\ sec^{-1}$

$$K = \frac{2\pi}{\lambda} = 2\pi\ m^{-1}$$

$\therefore$ y = 0.5 cos (2πx + 4πt)

Q.4 (4)

$v = \lambda f$

$10 = \lambda 100$

$$\lambda = \frac{1}{10}m$$

$$\Delta\phi = \frac{2\pi}{1}\times10\times\frac{2.5}{100} = \frac{\pi}{2}$$

Q.5 (3)

The length 0.25 m corresponds to 2.5 λ

$0.25 = 0.25\lambda$

$\lambda = 0.1$ m

$$k = \frac{2\pi}{0.1}$$

$V = \lambda f$

$330 = 0.1 f$

$\Rightarrow\ f = 3300$

$\Rightarrow\ \omega = 2\pi \times 3300$

y = A sin (ωt - kx)

$$= 0.25 \sin\left(3300\times2\pi t - \frac{2\pi}{0.1}x\right)$$

$$= 0.25 \sin 2\pi(3300t - 10x)$$

Q.6 (4)

Path difference is λ between B and G.

Q.7 (1)

$$V_{AB} = \sqrt{\frac{6.4g}{10\times10^{-3}}} = \sqrt{6400} = 80\ \frac{m}{sec}$$

$$V_{CD} = \sqrt{\frac{3.2g}{8\times10^{-3}}} = \sqrt{4000} = 20\sqrt{10}\ \frac{m}{sec}$$

$$V_{DE} = \sqrt{\frac{1.6g}{10\times10^{-3}}} = \sqrt{1600} = 40\ m/s$$

Q.8 (2)

Distance between boat = $\frac{\lambda}{2}$ = 10 m

$\Rightarrow$ $\lambda = 20m$

time penod, T = 4 sec .

$\therefore$ $V = \lambda / T = 20 \text{ m} / 4\text{sec.}$

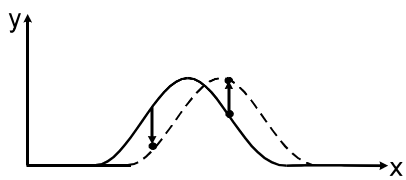
$= 5\text{m/s.}$

Q.9 (2)

$R_A = \frac{V}{V_A}$, $R_B = \frac{V}{V_B}$

as $V_A > V_B$, $R_A < R_B$

Q.10 (2)



Dotted shape shows pulse position after a short time interval. Direction of the velocities are decided according to direction of displacements of the particles.

at x = 1.5 slope is +ve

at x = 2.5 slope is –ve

Q.11 (1)

$y = \frac{10}{\pi}\sin\left(200\pi t - \frac{\pi x}{17}\right)$

comparing with

$y = A\sin(\omega t - kx)$

$\omega = 2000\pi = \frac{2\pi}{T}$ $\Rightarrow$ $T = 10^{-3}$ sec

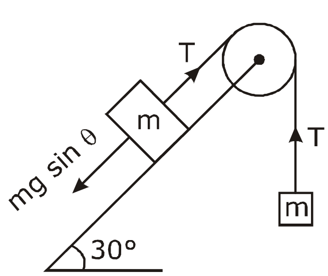
Maximum velocity = $A\omega$

$\Rightarrow$ $\frac{10}{\pi} \times 2000\pi \times 10^{-2}$

= 200 m/s

Q.12 (3)

$100 = \sqrt{\frac{T}{10^{-2}}}$ $\Rightarrow$ T = 100 N



T = mg sin 30º = 100

m = 20 kg

Q.13 (3)

As $\langle P \rangle = 2\pi^2 f^2 A^2 \mu v$ put values

$90 = 2 \times 10 \times f^2 \times 25 \times 10^{-4} \times 4 \times 10^{-2} \sqrt{\frac{100}{4 \times 10^{-2}}}$

$\Rightarrow$ f = 30 Hz

Q.14 (4)

$P \propto A^2$ $\frac{P}{0.40} = \frac{4^2}{2^2} \Rightarrow P = 1.6$ watt

Q.15 (1)

$A^2_{net} = (y_m + y_m)^2$ for $\phi = o$

$\therefore A_{net} = 2y_m$ $\Rightarrow$ $I_{net} \propto A^2_{net} \propto 4y_m^2 \propto 4I$

where I $\Rightarrow$ Intensity of either wave

Q.16 (4)

Resultant wave amplitude $\rightarrow$ depends on phase difference

If p.d = $2n\pi$ $\Rightarrow$ $A_{max} = 2A$

p.d = $(2n+1)\pi$ $\Rightarrow A_{max} = 0$

Q.17 (4)

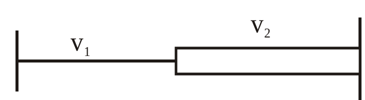
The waves will pass through each other without any change in their shape.

Q.18 (3)

Second string is denser so speed will decreases.

Q.19 (3)

$V_2 < V_1$



$\Rightarrow$ $\lambda' < \lambda$

Q.20 (2)

As x = 0 is node $\Rightarrow$ standing wave should be y = 2a sin kx sin ωt

Now solve

Q.21 (3)

$\frac{n}{2\ell}\sqrt{\frac{T}{\mu}} = 350$ and $\frac{n+1}{2\ell}\sqrt{\frac{T}{\mu}} = 420$

$\therefore$ $\frac{n}{n+1} = \frac{350}{420} \Rightarrow n = 5 \therefore \frac{5\lambda}{2} = \ell \Rightarrow \lambda = \frac{2\lambda}{5}$

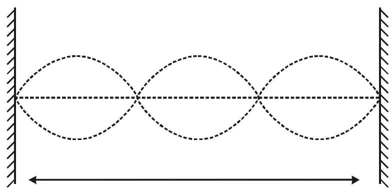
$\frac{v}{f} = \frac{2\ell}{5} \Rightarrow \frac{v}{2\ell} = \frac{f}{5} \Rightarrow f' = \frac{f}{5} = 70$ Hz

Q.22 (3)

$f = \frac{4V}{2L} \Rightarrow \lambda = \frac{v}{f} = \frac{L}{2} = 40$ cm

Q.23 (2)

$\therefore \quad v = \frac{2}{3} \times 300 = 200$ m/s



$L = \frac{3\lambda}{2} = 1 \quad \Rightarrow \quad \lambda = \frac{2}{3}$

Q.24 (2)

$y = 10 \sin 2\pi (100t - 0.02x) + 10 \sin 2\pi (100t + 0.02x)$
$= 2 \times 10 \sin 200 \pi t \cos 2\pi (0.02)x$
$200\pi = \omega$

$2\pi \times 0.002 = \frac{2\pi}{\lambda}$

loop length $= \frac{\lambda}{2}$

Q.25 (2)

$\frac{\lambda_1}{2} = 2$ cm $\Rightarrow \lambda_1 = 4$ cm

$\frac{\lambda_2}{2} = 1.6$ cm $\Rightarrow \lambda_2 = 3.2$ cm

$f_1 = \frac{n}{2\ell} v_w = \frac{v_w}{\lambda_1} \Rightarrow \frac{1}{\lambda_1} = \frac{n}{2\ell}$

$f_2 = \frac{(n+1)}{2\ell} v_w = \frac{v_w}{\lambda_2} \Rightarrow \frac{1}{\lambda_2} = \frac{(n+1)}{2\ell}$

$\Rightarrow \frac{1}{\lambda_2} - \frac{1}{\lambda_1} = \frac{1}{2\ell}$

$\Rightarrow \ell = \frac{\lambda_1 \times \lambda_2}{\lambda_1 - \lambda_2}$ 8 cm

Q.26 (1)

$n = \frac{V}{\lambda} = \frac{.21}{15 \times 10^{-3}} = \frac{210}{15}$

$V_{max} = A\omega = 5 \times 10^{-3} \times \frac{210}{15} \times 2\pi$

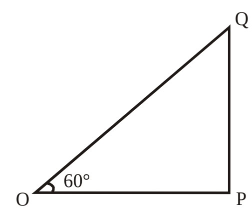
$= 70 \times 2 \times \frac{22}{7} \times 10^{-3} \qquad = .44$m/sec.

Q.27 (1)

$f_1 \lambda_1 = f_2 \lambda_2$
$(300)(1) = (f_2)(1.5)$
$200 \text{ Hz} = f_2$

Q.28 (3)

$OQ = 8 \times 330$
$= 2640$ m
$\therefore PQ = OQ \sin 60°$



$PQ = 2640 \times \frac{\sqrt{3}}{2} = 2286$ m

Q.29 (1)

$v = \sqrt{\frac{\gamma RT}{M}}$

γ for monoatomic = 1.67
γ for triatomic = 1.3

$= \sqrt{\frac{\gamma_1}{M_1} \times \frac{M_2}{\gamma_2}}, = \sqrt{\frac{1.67 \times 1.8 \times 10^{-2}}{1.3 \times 2.02 \times 10^{-2}}} = 1.067$

Q.30 (1)

The speed of sound in air is $v = \sqrt{\frac{\gamma RT}{M}}$

$\frac{\gamma}{M}$ of H_2 is greatest in the given gases, hence speed of sound in H_2 shall be maximum.

Q.31 (1)

$v_{rms} = \sqrt{\frac{3RT}{M}} \quad v_s = \sqrt{\frac{\gamma RT}{M}} \quad v_{avrage} = \sqrt{\frac{8RT}{\pi M}} \quad v_{mp} = \sqrt{\frac{2RT}{M}}$

Q.32 (4)

$(90 - 40) = 10 \log \frac{I_1}{I_2}$

$5 = \log \frac{I_1}{I_2} \Rightarrow \frac{I_1}{I_2} = 10^5$

Q.33 (4)

$\Delta x = 12 = \frac{\lambda}{2}, \lambda = 24 \text{ cm}$

$f = \frac{v}{\lambda} = \frac{330}{24 \times 10^{-2}} = 1375 \text{ Hz}$

Q.34 (4)

∵ frequency is same

∴ energy remains conserved

⇒ Redistribution is stable with time.

Q.35 (2)

$I_1 = I \; I_2 = 4I$

$I_A = I_1 + I_2 = 5I$

$I_B = 9I$

$\Delta I = (I_A - I_B) = 4I$

Q.36 (4)

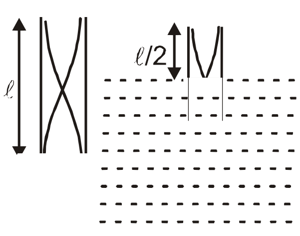
For displacement→ Phase change π at close end

For pressure → No phase change at close end

Q.37 (3)

Now the tube becomes a closed pipe with length $\ell/2$

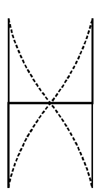
Fundamental frequency of B = $\frac{v_{sound}}{4(\ell/2)} = \frac{v_{sound}}{2\ell}$



which is fundamental frequency of A.

Q.38 (2)

at the middle of the pipe



Q.39 (2)

Q.40 (2)

$\frac{\lambda}{4} = \ell_1 + e$

......(1)

$\frac{3\lambda}{4} = \ell_2 + e$

.......(2)

from (1) and (2) e = 2 cm

Q.41 (1)

Beats

Frequency of tuning fork is 512 Hz. Frequency of sonometer wire either 512 + 6 or 512 – 6

As tension increases frequency of sonometer wire increases $n \propto \sqrt{T}$

No. of beat reduces. So that frequency of sonometer wire is = 512 – 6 = 506 Hz

Q.42 (2)

$|262 - f| = |256 - f| \times 2$

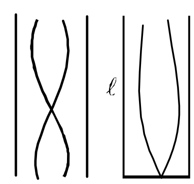
$\Rightarrow (262 - f) = \pm (256 - f) \times 2$

$\Rightarrow f = 250, 258 \text{ Hz}$

Unknown Frequency can not be greater than 262 Hz. because no. of beats heard with 262 Hz is more then the no. of beats heard with 256 Hz.

Q.43 (1)

$\eta_1 = \frac{V}{2\ell} \; \eta_2 = \frac{V}{4\ell}$



no. of beat heard $n_1 - n_2 = \frac{V}{4\ell} = 4$

if length of pipes are doubled. no of beats heard $n_1' - n_2' = \frac{V}{8\ell} = \frac{4}{2} = 2$

Q.44 (2)

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

water poured into pipe then

$\lambda \downarrow$ so $f \uparrow$

then Input water = output water

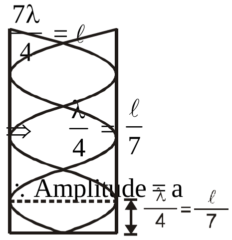
Hence f constant.

Q.45 (4)

$1750 = \frac{350}{\lambda} \quad \Rightarrow \quad \lambda = \frac{1}{5} = 20\text{ cm}$

should be raised by $\frac{\lambda}{2} = 10$ cm.

Q.46 (2)



Q.47 (2)

$\frac{\nu}{\lambda_1} - \frac{\nu}{\lambda_2} = 6 \Rightarrow \frac{\nu}{1} - \frac{\nu}{1.02} = 6$

$\nu = \frac{6 \times 1.02}{0.02} = 306 \approx 300$ m/s.

Q.48 (4)
Doppler effect in Frequency appears when there is relative motion between source and observer

Q.49 (4)
Doppler effect in Frequency depends upon relative velocity between source and observer

Q.50 (3)

$f' = \left(\frac{\nu + gt}{\nu}\right) f$

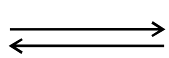
$f' = f + \frac{gt}{\nu}\, .\, t \Rightarrow \; f' = 1000 + \frac{g \times 1000}{\nu}\, .\, t$

t = 30 s.
f' = 2000 Hz $\Rightarrow$ ν = 300 m/s.

EXERCISE-IV

Q.1 [0080]

$\Delta t = \frac{L}{v} = 0.1$



$v = 40 \text{ m/s} = \sqrt{\frac{T}{\mu}}$

$T = \frac{0.2}{4} \times 16000 = 80$ N

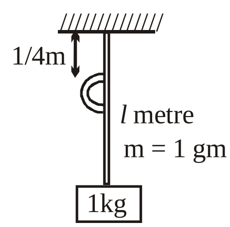
Q.2 [0006]
$nf_0 = 720\; f_0 = 120,\; n = 6$
$(n+1)f_0 = 840$

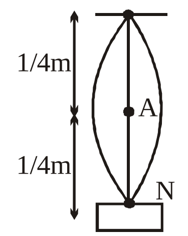
Q.3 [1]

Aseem $\quad \mu = \frac{10^{-3}\text{kg}}{l\text{ (metre)}} = \frac{10^{-3}}{l}\text{kg/m}$

$T \approx mg = (1)(10) = 10\text{N}$

$\therefore v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{10}{10^{-3}/l}} = \sqrt{10^4/l} = 10^2\sqrt{l}$





$\frac{1}{4} = \frac{\lambda}{4} \qquad \therefore \lambda = 1\text{m}$

$v = \nu\lambda \Rightarrow \qquad 10^2\sqrt{l} = 100\lambda$

$\therefore \ell = 1\text{m}$

Q.4 [0007]

$340 - V_m = \frac{3015}{9}$

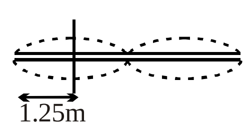
$340 + V_T = \frac{855}{5} \times 2 = 342$

$V_T = 2$ m/s, $V_m = 5$ m/s
$V_{rel} = 7$ m/s

Q.5 [0004]
When student stands at middle

$\frac{\lambda}{2} = 5\text{m}, \lambda = 10\text{ m}$

wave velocity $v = \nu\lambda = 20$ m/s
when student stands at 1.25 m



$\lambda/4 = 1.25\,m$; $\lambda = 5m$

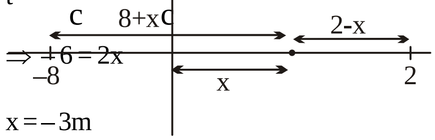
$$\nu = \frac{v}{\lambda} = \frac{20}{5} = 4\,Hz$$

Q.6 [0005]

$$\Delta\phi = k\Delta x = \frac{2\pi}{\lambda}[10-5] = \frac{2\pi\times 5}{2} = 5\pi$$

Q.7 [0004]

$$t = \frac{8+x}{c} = \frac{2-x}{c}$$

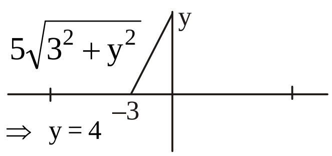


$\Rightarrow 6 = 2x$ [page shows "+6 = 2x"]

$x = -3m$

$$\Rightarrow t = \frac{5}{c}$$

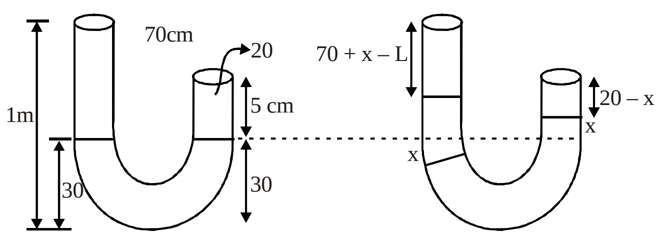
$$5\sqrt{3^2+y^2}$$



$\Rightarrow y = 4$

Q.8 [0060]

$$2x \times \rho \times g = L \times \frac{\rho}{2} g$$



$\Rightarrow L = 4x$

frequency same $\Rightarrow \lambda$ = same

$$20 - x = \frac{\lambda}{4}$$

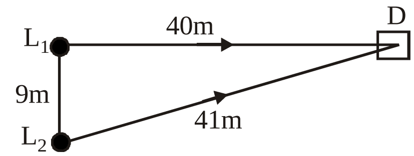
$$70 + 3x = \frac{5\lambda}{4}$$

$70 - 3x = 100 - 5x$

$2x = 30$; $x = 15$

$L = 4x = 60\,cm$

Q.9 [0330]



$\Delta x = 1\,m$

$n\lambda = 1$

$$f = \frac{C}{\lambda} = C \times n \quad ; n = 1;\ f = 330\,Hz$$

Q.10 [0050]

SAN $\Rightarrow$ P Node $\Rightarrow \Delta\phi = \pi$

$$\Delta\phi = \pi \Rightarrow \Delta x = \frac{\lambda}{2}$$

$$\Delta x = \frac{L}{2} + x\left(\frac{L}{2} - x\right)$$

$$2x = \frac{\lambda}{2} \quad \Rightarrow \quad x = \frac{\lambda}{4}$$

$\lambda = 2m \Rightarrow x = 50\,cm$

PREVIOUS YEAR'S

MHT CET

Q.1 (1)
Q.2 (1)
Q.3 (4)
Q.4 (1)
Q.5 (3)
Q.6 (4)
Q.7 (3)
Q.8 (1)
Q.9 (2)
Q.10 (4)
Q.11 (4)
Q.12 (2)
Q.13 (1)
Q.14 (2)
Q.15 (3)
Q.16 (4)
Q.17 (1)
Q.18 (4)
Q.19 (2)
Q.20 (2)
Q.21 (2)
Q.22 (1)
Q.23 (2)

Q.24 (3)
Q.25 (1)
Q.26 (3)
Q.27 (3)
Q.28 (3)
Q.29 (4)
Q.30 (3)
Q.31 (1)
Q.32 (2)
Q.33 (4)
Q.34 (2)
Q.35 (3)

Given, v = 360 ms^{-1}
v = 500 Hz

$$\Delta\phi = 60° = \frac{\pi}{3}$$

Since, velocity of a wave, v = ν λ.

$$\lambda = \frac{v}{\nu} = \frac{360}{500} = 0.72m$$

As, phase difference, $\Delta\phi = 60° = \frac{\pi}{3}$

Since, velocity of a wave, v=νλ

⇒ m.

As, phase difference, $\Delta\phi = \frac{2\pi}{\lambda}$ ×path difference (Δx)

$$\Rightarrow \Delta x = \frac{\lambda}{2\pi}\times\Delta\phi$$

$$= = \frac{0.72}{2\pi}\times\frac{\pi}{3} = 0.12$$

Q.36 (2)

Given $\lambda_p = 100\,mm = 0.10\,m$
$\lambda_Q = 0.25$ m
$\lambda_p = 80\ cms^{-1} = 0.80\ ms^{-1}$

Since, frequency of wave remains same in the two media,

$$\frac{v_p}{\lambda_p} = \frac{v_Q}{\lambda_Q} \qquad \left(\because \nu = \frac{v}{\lambda}\right)$$

$$\Rightarrow v_Q = \frac{\lambda_Q}{\lambda_p}\times v_p = \frac{0.25}{0.10}\times 0.80 = 2ms^{-1}$$

Q.37 (1)

Let m be the total mass of the rope of length l. Tension in the rope at a height h from lower end = weight of rope length h,

i.e., $T = \frac{mg}{L}h$

As $v = \sqrt{\frac{T}{\left(\frac{m}{L}\right)}}$

$$v = \sqrt{\frac{mg(h)}{L\left(\frac{m}{L}\right)}} = \sqrt{gh}$$

$\Rightarrow v^2 = gh$

Which represents a parabola symmetric along h-axis.

Thus, option (1) is represents the correct graph.

Q.38 (4)

The displacement of wave,

$$y = 10^{-4}\sin\left(600t - 2x + \frac{\pi}{3}\right)m$$

Comparing with standard equation
$y = a\sin(\omega t - kx + \phi)$ we get
$\omega = 600, k = 2$

As we know, $k = \frac{2\pi}{\lambda} = \frac{2\pi\nu}{\lambda\nu} = \frac{\omega}{v} \qquad [\because v = \nu\lambda]$

$$\Rightarrow v = \frac{\omega}{k} = \frac{600}{2} = 300\,ms^{-1}$$

Q.39 (2)

$\because T_2 = T_1 + 69\%$ of $T_1 = 1.69T_1$

$$\Rightarrow \frac{T_2}{T_1} = 1.69 = \frac{169}{100}$$

The fundamental frequency of a stretched string,

$$f = \frac{1}{2\pi}\sqrt{\frac{T}{\ell}}$$

$$\Rightarrow f \propto \sqrt{T} \Rightarrow \frac{f_2}{f_1} = \sqrt{\frac{T_2}{T_1}} = \sqrt{\frac{169}{100}} = \frac{13}{10}$$

$\because$ % increase in frequency $= \frac{f_2 - f_1}{f_1}\times 100$

$$= \left(\frac{f_2}{f_1} - 1\right)\times 100 = \left(\frac{13}{10} - 1\right)\times 100$$

= 30%

So, frequency increases by 30%.

Q.40 (3)

Given, f = 512 Hz

$$\frac{d_A}{d_B} = 2 \text{ and } \frac{T_A}{T_B} = 2$$

Since, both wires are of same material, so there densities are equal. But their area are different, so their mass per unit length will be different.

$$\Rightarrow \quad \rho_A = \rho_B$$

$$\frac{\mu_A}{A_A} = \frac{\mu_B}{A_B}$$

$$\Rightarrow \quad \frac{\mu_A}{\mu_B} = \frac{A_A}{A_B} = \left(\frac{d_A}{d_B}\right)^2 = 4$$

Since, velocity of wave in a wire is given by

$$v = \sqrt{\frac{T}{\mu}}$$

$$\Rightarrow \frac{v_A}{v_B} = \sqrt{\frac{T_A}{T_B} \times \frac{\mu_B}{\mu_A}} = \sqrt{2 \times \frac{1}{4}} = \frac{1}{\sqrt{2}} \text{ or } 1:\sqrt{2}$$

Q.41 (1)
The frequency of vibration

$$n = \frac{1}{2\ell}\sqrt{\frac{T}{m}} \quad \text{......(i)}$$

Given, $n' = n + \frac{3}{2}$

and $T' = T + 1\% \text{ of } T = T + \frac{T}{100} = \frac{101T}{100}$

$$n' = \frac{1}{2\ell}\sqrt{\frac{T'}{m}} \quad \therefore \quad n + \frac{3}{2} = \frac{1}{2\ell}\sqrt{\frac{101T}{100}}$$

$$\Rightarrow n + \frac{3}{2} = 1.005 \times \frac{1}{2\ell}\sqrt{\frac{T}{m}} \quad \text{.....(ii)}$$

From Eqs. (i) and (ii), we get

$$n + \frac{3}{2} = 1.005 + n$$

$$\Rightarrow n = 300\text{Hz}$$

Q.42 (1)
Q.43 (3)
Q.44 (3)
Q.45 (4)
Q.46 (3)
Q.47 (1)
Q.48 (3)
Q.49 (1)
Q.50 (1)
Q.51 (3)
Q.52 (2)
Q.53 (1)
Q.54 (1)
Q.55 (1)
Q.56 (2)
Q.57 (2)
Q.58 (2)
Q.59 (2)
Q.60 (4)
Q.61 (2)
Q.62 (2)
Q.63 (3)
Q.64 (4)
Q.65 (1)
Q.66 (1)
Q.67 (3)
Q.68 (4)
Q.69 (4)
Q.70 (3)
Q.71 (4)
Q.72 (4)
Q.73 (2)
Q.74 (3)
Q.75 (2)
Q.76 (3)
Q.77 (4)
Q.78 (1)
Q.79 (3)
As we know the, frequency of sound wave produced in a stretched wire is directly proportional to square root of tension in the wire

i.e., $f \propto \sqrt{T}$

Let T be the initial tension

Therefore, for air column, $f_C \propto \sqrt{T}$ ....(i)

According to question, first overtone

i.e., $3f_C \propto \sqrt{T+8}$ .....(ii)

From Eq. (i) and Eq. (ii), we get

$$\frac{f_C}{3f_C} = \frac{\sqrt{T}}{\sqrt{T+8}}$$

$\Rightarrow T + 8 = 9T$

$\Rightarrow T = 1N$

Q.80 (3)
The Doppler's effect in sound is given by

$$f_0 = \frac{v + v_0}{v + v_s} f_s$$

where, f_o = observer frequency of sound,
v= speed of sound waves,
v_0 = observer velocity,
v_s = source velocity
and f_s = actual frequency of sound wave.
Thus, according to question

$$2n = \left(\frac{v+0}{v+v_s}\right)n$$

$\Rightarrow$ **2(v + v_s) = v**
$\Rightarrow$ **2v + 2v_s = v**
-2v_s = v

$$v_s = -\frac{v}{2}$$

where -ve sign shows that source is approaching to the listener.

Q.81 (3)
As we know the, frequency of sound wave produced in a stretched wire is directly proportional to square root of tension in the wire

i.e., $f \propto \sqrt{T}$

Let T be the initial tension

Therefore, for air column, $f_C \propto \sqrt{T}$ ....(i)

According to question, first overtone

i.e., $3f_C \propto \sqrt{T+8}$ .....(ii)

From Eq. (i) and Eq. (ii), we get

$$\frac{f_C}{3f_C} = \frac{\sqrt{T}}{\sqrt{T+8}}$$

$\Rightarrow T + 8 = 9T$
$\Rightarrow T = 1N$

Q.82 (1)
Initially, fundamental frequency,

$$n = \frac{1}{2L}\sqrt{\frac{T}{\mu}} \quad .....(i)$$

Finally, fundamental frequency becomes,

$$n' = 3n = \frac{1}{2L}\sqrt{\frac{T+8}{\mu}} \quad .....(ii)$$

Dividing Eq. (ii) by Eq. (i), we get

$$\frac{3n}{n} = \frac{\frac{1}{2L}\sqrt{\frac{T+8}{\mu}}}{\frac{1}{2L}\sqrt{\frac{T}{\mu}}} \Rightarrow 3 = \sqrt{\frac{T+8}{T}}$$

$\Rightarrow 9T = T + 8$ or $T = 1N$

Q.83 (1)

Here, $f_c = \frac{(2n-1)v}{4\ell_c}$ and $f_0 = \frac{nv}{2\ell_0}$

Also, $f_c = f_0 \Rightarrow \frac{(2n-1)}{4\ell_c} = \frac{n}{2\ell_0} \Rightarrow \frac{\ell_c}{\ell_0} = \frac{(2n-1)}{2n}$

$= \frac{[2(3)-1]}{2(3)}$ ($\because$ for second overtone, n = 3)

$= \frac{5}{6}$

Q.84 (4)
Given, speed of sound, v_s = 350 m/s
Since, pitch of sound produced by whistle depends on frequency (f).

Hence, $f' = f - 20\%$ of $f' = \frac{4}{5}f \Rightarrow \frac{f'}{f} = \frac{4}{5}$

Also, $\frac{f'}{f} = \frac{v_s}{v_s + v_e}$

where, v_e = speed of engine

$$\Rightarrow \frac{4}{5} = \frac{350}{350+v_e} \Rightarrow 350 + v_e = \frac{5}{4}\times 350$$

$$\Rightarrow v_e = 350\left(\frac{5}{4}-1\right) = \frac{350}{4} = 87.5 \text{ m/s}$$

Q.85 (1)
Frequency observed by observer is given by

$$f = \frac{v - v_w - v_0}{v - v_w + v_s}\times f_0 = \frac{340-5-20}{340-5+10}\times 300$$

$f = 274$ Hz

NEET/AIPMT

Q.1 (2)

Q.2 (2)
$v = 2(\nu)[L_2 - L_1]$
$= 2\times 320\,[73-20]\times 10^{-2}$
$= 339$m/s

Q.3 (4)
$n(T)_\ell = (n+1)T_s$

$(n)\ 2\pi\sqrt{\frac{1.21}{g}} = (n+1)2\pi\sqrt{\frac{1}{g}}$

$(n)(1.1) = n + 1$
$n = 10$
No. of oscillation of smaller one
$= n + 1$
$= 10 + 1$
$= 11$

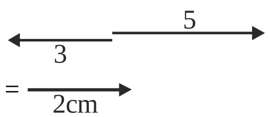
JEE MAIN

Q.1 (1)

$y^2 = 3\sin[2\pi x - 2\pi vt + 3\pi]$

as $\Delta\phi = 3\pi$

so,



Q.2 [5 cm]

$$y = 10\cos(\pi x)\sin\left(\frac{2\pi t}{T}\right)\text{ cm}$$

$$y = 2A\cos(kx)\sin\left(\frac{2\pi t}{T}\right)$$

$$\text{Amplitude} = \left|10\cos\left(\pi\times\frac{4}{3}\right)\right| = 10\cos\left(\pi+\frac{\pi}{3}\right)$$

$$= \left|-10\cos\left(\frac{\pi}{3}\right)\right|$$

$$= \left|-10\times\frac{1}{2}\right| = 5\,cm$$

Q.3 (2)

$$y = 10\sin 2\pi\left(nt - \frac{x}{\lambda}\right)\text{cm}$$

Given;

Maximum particle velocity = 4 × velocity of wave

$V_p(\max) = A\omega = 10\,(2\pi n)$

$$V_{wave} = \frac{\omega}{K} = \frac{2\pi n}{\frac{2\pi}{\lambda}} = \frac{2\pi n\lambda}{2\pi} = n\lambda$$

$10(2\pi n) = 4\,(n\lambda)$

$$\frac{20\pi}{4} = \lambda \quad \boxed{\lambda = 5\pi}$$

Q.4 (1)

$v_{max} = v_{wave}$

$$\Rightarrow A\omega = \frac{\omega}{k}$$

$$\Rightarrow A = \frac{1}{k}$$

$$\Rightarrow 2 = \frac{\lambda}{2\pi}$$

$\Rightarrow \lambda = 4\pi$

Q.5 [3]

$$\frac{n+1}{2l}\sqrt{\frac{T}{\mu}} = 400 \qquad ...(1)$$

$$\frac{n}{2l}\sqrt{\frac{T}{\mu}} = 300 \qquad ...(2)$$

Or

$$\frac{n}{n+1} = \frac{3}{4}$$

So

N = 3

By 2

$$300 = \frac{3}{2\times30\times10^{-2}}\sqrt{\frac{2700}{\mu}}$$

$\mu = 3$

Q.6 (3)

$$y = 0.5\sin\left(\frac{2\pi}{\lambda}400t - \frac{2\pi}{\lambda}x\right)$$

$$\omega = \frac{2\pi}{\lambda}400$$

$$K = \frac{2\pi}{\lambda}$$

$$v = \frac{\omega}{k}\ [v = 400\text{ m/s}]$$

Q.7 [15]

$$V_w = \sqrt{\frac{T}{\mu}}$$

$$60 = \sqrt{\frac{T}{10\times10^{-3}}\times0.5}$$

$$T = \frac{(60)^2\times10^{-2}}{0.5} = 72N$$

$$\Delta\ell = \frac{F\ell}{AY} = \frac{72\times0.5}{2\times10^{-6}\times1.2\times10^{11}}$$

$$= \frac{72\times5}{24}\times10^{-5} = 15\times10^{-5}$$

Q.8 [80]

$$n_1 = \frac{2v}{2l_1} \qquad \text{(first overtone of open organ pipe)}$$

$$n_2 = \frac{v}{4l_2} \qquad \text{(fundamental frequency of closed organ pipe)}$$

$n_1 = n_2$

$= \frac{2v}{2l_1} = \frac{v}{4l_2}$

$l_1 = 4l_2 = 80$ cm

Q.9 [152]

$f_1 = f$

$f_2 = f + 4$

$f_3 = f + 2 \times 4$

$f_4 = f + 3 \times 4$

$f_{20} = f + 19 \times 4$

$f + (19 \times 4) = 2 \times f$

$f = 76$ Hz.

Frequency of last tuning forks = 2f

= 152 Hz

Q.10 (4)

$$f_0 = \left(\frac{v+v_0}{v}\right)f_s$$

$$f_0\left(\frac{v+\frac{v}{5}}{v}\right)f_s$$

$$f_0 = \frac{6}{5}f_s$$

$$\%\ \text{chage} = \frac{f_0 - f_s}{f_s} \times 100$$

$$= \frac{1}{5} \times 100 = 20\%$$

Q.11 (4)

Beat frequency $= \frac{40}{12}$

$\lambda_1 = 4.08$ m $\lambda_2 = 4.16$ m

$$f_b = f_1 - f_2 = \frac{40}{12}$$

$$\frac{v}{\lambda_1} - \frac{v}{\lambda_2} = \frac{40}{12}$$

$$v\left(\frac{1}{4.08} - \frac{1}{4.16}\right) = \frac{40}{12}$$

$$v\left(\frac{4.16 - 4.08}{4.08 \times 4.16}\right) = \frac{40}{12}$$

$$v = \frac{40}{12} \times \frac{4.08 \times 4.16}{(4.16 - 4.08)}$$

v = 707 m/s

Q.12 [50]

Assumption: Ignore word "**fundamental mode**" in question

$$\lambda = \frac{V}{f} = \frac{340}{340} = 1\text{m}$$

First resonating length $= \frac{\lambda}{4} = 25\text{cm}$

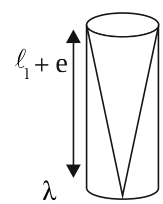
Second resonating length $= \frac{3\lambda}{4} = 75\text{cm}$

Third resonating length $= \frac{5\lambda}{4} = 125\text{cm}$

Height of water required=125-75 = 50 cm

Q.13 [104]

First resonance will occurs when



$\ell_1 + e = \frac{\lambda}{4}$

$\therefore v = f\lambda$

$$\Rightarrow \lambda = \frac{v}{f} = \frac{336}{400}$$

= 0.84 m

= 84 m

$$\ell_1 + e = \frac{84}{4}$$

20 + e = 21 cm $\Rightarrow$ e = 1 cm

e is end correction

Third resonance will occur

When $\ell_2 + e = \frac{5\lambda}{4}$

Where ℓ_2 is length of water column

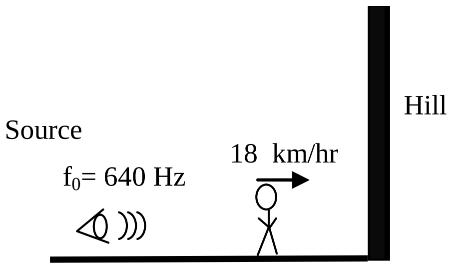
$\Rightarrow \ell_2 + e = 5 \times 21$

$\Rightarrow \ell_2 + e = 105$

$\Rightarrow \ell_2 = 104$

$\Rightarrow 104$

Q.14 [20]



$V_{observer}$ = 18Km/hr
= 5 m/s

Frequency received by observer direct

$$f_1 = \left(\frac{v - v_0}{v}\right) f_0 \Rightarrow f_1 = \left(\frac{320 - 5}{320}\right) f_0$$

$$f_1 = \frac{315}{320} \times 640 \Rightarrow f_1 = 630\,\text{Hz}$$

Frequency received by hill as same frequency of sourec = f_0

frequency received by observer after reflection from hill

$$f_2 = \left(\frac{v + v_0}{v}\right) f_0 \Rightarrow f_2 = \left(\frac{320 + 5}{320}\right) 640$$

$f_2 = 650\,\text{Hz}$

Beats heard by observer = $f_2 - f_1$

= 650 - 630

= 20 Hz

Q.15 [200]

$$f = f_0 \left(\frac{V}{V - V_s}\right) \quad \text{U = speed of second}$$

$$100 = f_0 \left(\frac{V}{V - V_s}\right) \text{...(1) } V_s = \text{speed of car (source)}$$

$$50 = f_0 \left(\frac{V}{V + V_s}\right) \text{...(2)}$$

(1) ÷ (2)

$$2 = \frac{U + U_s}{V + V_s}$$

$2V - 2V_s = V + V_s$

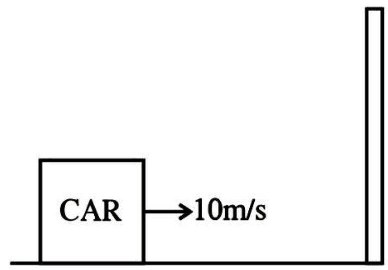
$V = 3V_s$

$$100 = f_0 \left(\frac{v}{v + \frac{v}{3}}\right) = f_0 \left(\frac{3}{2}\right)$$

$$f_0 = \frac{200}{3} = \frac{x}{3} \therefore \boxed{x = 200}$$

Q.16 [340]

The hill will be a secondary source.



f_1 = frequency of the car w.r.t. the hill

$$f_1 = \left(\frac{v}{v - v_S}\right) f = \left(\frac{330}{320}\right) \times 320 = 330\,\text{Hz}$$

f_2 = Frequency of the sound reflected by hill w.r.t. the car (echo) $f_2 = \left(\frac{v + v_0}{v}\right) f_1$

$$= \frac{(330 + 10)}{330} \times 330 = 340\,\text{Hz}$$