Sample Paper-03
Physics (Theory)
Class – XI

Answers

1. $9.11 \times 10^{-31} \times n = 1$ kgp
   Therefore, $n = 1.1 \times 10^{30}$
2. Any force is called conservative force if,
   (a) Work done against is independent of path.
   (b) Work done in a closed path is zero
3. The liquid comes to rest due to the viscous force, due to internal fluid friction between its different layers.
4. A molecule of diatomic gas possesses five degrees of freedom at room temperature which is due to translational motion and rotational motion.
5. Within elastic limit, the slope of stress-strain curve gives the value of modulus of elasticity of the given material.
6. (i) It does not tell us about the direction of flow of heat
   (ii) It fails to explain why heat cannot be spontaneously converted into work.

   Or

   Increase in surface area = $2[4\pi(3r)^2 - 4\pi r^2]$
   Increase in surface energy = $\sigma \times 2 \times 4\pi \times 8r^2 8W$
   Additional work done = 8W
7. $x = \dfrac{ab^2}{c^3}$

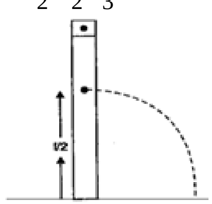
   $$\left(\frac{\Delta x}{x}\right)_{max} = \frac{\Delta a}{a} + 2\frac{\Delta b}{b} + 3\frac{\Delta c}{c}$$

   $$\frac{\Delta a}{a} = \pm 1\%, \frac{\Delta b}{b} = \pm 2\%, \frac{\Delta c}{c} = \pm 3\%$$

   $$\left(\frac{\Delta x}{x}\right)_{max} = 1\% + 2 \times 2\% + 3 \times 1.5\%$$

   = (1 + 4 + 4.5)%
   = 9.5%
8. Loss in potential energy = Gain in rotational Kinetic energy

   $$mg\frac{1}{2} = \frac{1}{2}\frac{Ml^2}{3}.\omega^2$$

   $$\omega = \sqrt{\frac{3gl}{l^2}} - \sqrt{\frac{3g}{l}}$$

   v = lm
   $= \sqrt{3gl}$

9. The laws of limiting friction are as follows:
   (a) The value of limiting friction depends on the nature of the two surfaces in contact and on the state of their smoothness.
   (b) The force of friction acts tangential to the surfaces in contact in a direction opposite to the direction of relative motion.
   (c) The value of limiting friction is directly proportional to the normal reaction between the two given surfaces.
   (d) For any two given surface and for a given value of normal reaction the force of limiting friction is independent of the shape and surface area of surfaces in contact. Coefficient of limiting friction for two given surfaces in contact is defined as the ratio of the force of normal reaction N.
   $\mu_r = \frac{f_1}{N}$

10. Volume of the one hydrogen atom = $\frac{4}{3}$ πr³= $\frac{4}{3}$ x 3.14 x (0.5 x 10^{-10}) m^3
   =5.23 x $10^{-31}m^3$
   According to Avogadro's hypothesis, one mole of hydrogen contains 6.023 x 10^{23} atoms.
   Atomic volume of 1 mole of hydrogen atom = 6.023 x 10^{23} x 5.23 x 10^{-31}
   = 3.15 x $10^{-7}m^3$.

11. Average speed = $\frac{\text{Total Distance}}{\text{Timetaken}}$
   Let x be the distance to be covered,
   Average speed = $\frac{x}{\frac{x}{2v_1}+\frac{x}{2v_2}}$
   Where $\frac{x}{2v_1}$ = time taken to cover first half of the distance, $\frac{x}{2v_2}$ = time taken to cover the second half of the distance,
   Average speed = $\frac{x}{\frac{x(v_1+v_2)}{2v_1v_2}}$
   $= \frac{x\ (x)\ 2v_1v_2}{x(v_1v_2)} = \frac{2v_1v_2}{v_1v_2}$
   $V_{av} = \frac{2\text{ x }40\text{m/s x }60\text{m/s}}{100\text{m/s}}$
   = 48 ms^{-1}

12. Escape velocity from the surface of earth is
   $v_{es} = \sqrt{\frac{2GM}{R}}$
   K.E of a body K_{es}=1/2 mv^2_{es} = $\frac{GMm}{R}$
   The body is projected from the surface of earth with a K.E half of that needed to escape from earth surface hence
   Initial K.E. of body $K = \frac{K_{es}}{2} = \frac{GMm}{2R}$

And its potential energy $\mu = -\frac{GMm}{R}$

Total initial energy of body $-\frac{GMm}{2R}$

The body goes up to a maximum height h from surface of earth, where the final K.E. =0 and P.E = $-\frac{GMm}{(R+h)}$

Total energy = $-\frac{GMm}{(R+h)}$

From conservation law of mechanical energy,

$-\frac{GMm}{2R} = -\frac{GMm}{(R+h)}$

On simplifying, h =R.

13. Hence $\rho = 0.09$ kg m^{-3}

S.T.P pressure P = 101 x 10^5 Pa.

According to K.E of gases

$P=\frac{1}{3}\rho C^2$ or $C=\sqrt{\frac{3P}{\rho}}$

$\sqrt{\frac{3x1.01x10^5}{0.09}}$ = 1837.5 ms^{-1}

Volume occupied by one mole of hydrogen at S.T.P = 22.4 litres = 22.4 x $10^{-3}m^3$

Mass of hydrogen M = volume x density

= 22.4 x 10^{-3} x 0.09

= 2.016 x 10^{-3} kg

Average K.E / mole = ½ MC^2

= ½ x (2.016 x 10^{-3}) x $(1837.5)^2$

= 3403.4 J

14. (i) The Sun's Mass replaced by the Martian mass M_m

$$T^2 = \frac{4\pi^2}{GMm}R^3$$

$$Mm = \frac{4\pi^2}{G} x \frac{R^3}{T^2}$$

$$Mm = \frac{4x(3.14)^2 x(9.4)^3 x10^{18}}{6.67x10^{-11} x(459x60)^2}$$

$$= \frac{4x(3.14)^2 x(9.4)^3 x10^{18}}{6.67x(4.59x6)^2 x10^{-5}}$$

= 6.48 x 10^{23}kg

(ii) Using Kepler's third law

$$\frac{T_M^2}{T_E^2} = \frac{R_{MS}^3}{R_{ES}^3}$$

Where R_{MS} is the Mars (Earth) – Sun distance

$$T_M = \left(\frac{R_{MS}}{R_{ES}}\right)^{3/2} - T_E^2$$

= $(1.52)^{3/2}$ x 365 = 684 days

15. At depth = $\frac{R}{2}$, value of acceleration due to gravity

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

At height x,

$$g' = g\left(1 - \frac{2x}{R}\right)$$

$$g\left(1 - \frac{2x}{R}\right) = \frac{g}{2}$$

$$\frac{1}{2} = \frac{2x}{R} \Rightarrow x = \frac{R}{4}$$

16. Consider components of tensions T_1 and T_2 along the horizontal and vertical directions

$- T_1 \cos\alpha + T_2 \cos\beta = 0$ ……………………… (i)

$T_1 \cos\alpha = T_2 \cos\beta$ ………………………… (ii)

$T_1 \sin\alpha + T_2 \sin\beta = mg$

From (i)

$T_2 = \frac{T_1 \cos\alpha}{\cos\beta}$ And substituting if in (ii) we get

$$T_1 \sin\alpha + \left(\frac{T_1 \cos\alpha}{\cos\beta}\right)\sin\beta = mg$$

$$T_1 \frac{\sin(\alpha + \beta)}{\cos\beta} = mg$$

$$T_1 = \frac{mg\cos\beta}{\sin(\alpha + \beta)}$$

Hence,

$$T_2 = \frac{T_1 \cos\alpha}{\cos\beta} = \frac{mg\cos\beta}{\sin(\alpha+\beta)} \cdot \frac{\cos\alpha}{\cos\beta}$$

$$T_2 = \frac{mg\cos\alpha}{\sin(\alpha + \beta)}$$

17. Assume that earth to be a solid sphere. We know that the moment of inertia of a solid sphere about its axis is

$I = \frac{2}{5} MR^2 = \frac{2}{5}$ x $(6.0 \times 10^{24} kg) \times (6.4 \times 10^6 m)^2$

$= 9.8 \times 10^{37}$ kg m^2

In one day the earth completes one revolution. Hence the angular velocity is given by

$$\omega = \frac{2\pi}{24 \times 60 \times 60} = 7.27 \times 10^{-5} \text{rad/sec}$$

Angular momentum $I\omega = (98 \times 10^{37}$ kg $m^2)$ $(7.27 \times 10^{-5}$ $s^{-1})$

$= 7.1 \times 10^{33}$ kg m^2 / sec.

The rotational energy

$\frac{1}{2} I\omega^2 = \frac{1}{2}$ $(9.8 \times 10^{37}$ kg $m^2)$ $(7.27 \times 10^{-5}$ $s^{-1})^2$

$= 2.6 \times 10^{29}$ J

Power supplied by this energy

$P = \frac{\text{Energy}}{\text{Time}} = \frac{2.6 \times 10^{29}}{t}$ watt

$= \frac{2.6 \times 10^{29}}{10^{39} t}$ KW

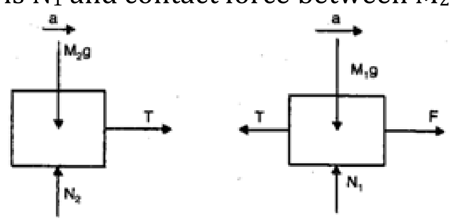
Power required by 3.5×10^9 persons = $3.5 \times 10^9 \times 1$ kilowatt

$\frac{2.6 \times 10^{29}}{10^{3} t} = 3.5 \times 10^{9}$

$t = \frac{2.6 \times 10^{29}}{10^{3} \times 3.5 \times 10^{9}}$ sec

$= 2.35 \times 10^9$ years

18. As the string is inextensible acceleration of two blocks will be same. Also string is massless so tension throughout the string will be same. Contact force will be normal force only.
Acceleration of each block is a , tension in string is T and connect force between M_1 and surface is N_1 and contact force between M_2 and surface is N_2



Applying Newton's second law for the blocks:

$F - T = M_1 a$ ………………………………….. (i)

$M_1 g - N_1 = 0$ ………………………………. (ii)

$T = M_2 a$ ………………………………. (iii)

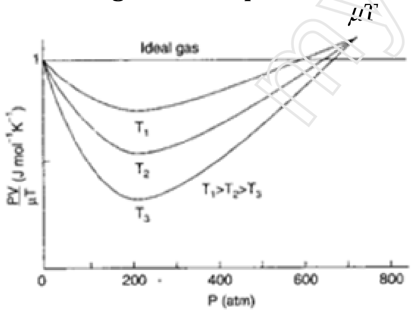
$M_2 g - N_2 = 0$ ……………………….. (iv)

Solving equation (i) and (iii)

$a = \frac{F}{M_1 + M_2}$

$T = \frac{M_2 F}{M_1 + M_2}$

19. According to the ideal gas equation PV = μ RT
According to this equation $\frac{PV}{\mu T}$ = R

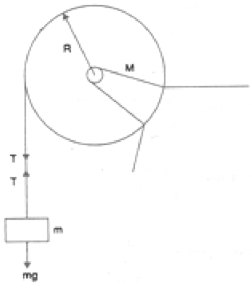


Experimentally value of $\frac{PV}{\mu T}$ for real gas was calculated by altering the pressure of gas at different temperatures. The graphs obtained have been shown in the diagram. Here for the purpose of comparison, graph for an ideal gas has also been drawn, which is a straight line parallel to pressure axis.

From the graph it is clear that behaviour of real gases is differ from an ideal gas. However at high temperatures and low pressures behaviours is nearly same as that of an ideal gas.

20. Let T be the tension in the chord

mg – T = ma, ………………………………….. (i)



Where a is the tangential acceleration of appoint on the rim of the disc.

$\tau = I\alpha$

But the resultant torque on the disc = TR and the rotational inertia

I = ½ MR^2

$$TR = \frac{1}{2}MR^2\left(\frac{a}{R}\right)$$

2TR = Ma

$$a = \frac{2T}{M} \text{ ……………………………… (ii)}$$

From the equation (i) and (ii)

$$\text{mg} - \left(\frac{\text{Ma}}{2}\right) = \text{ma}$$

$$\text{a} = \left(\frac{\text{2m}}{\text{M + 2M}}\right)\text{g}$$

$$\text{mg - T} = \text{m x}\left(\frac{\text{2T}}{\text{M}}\right)$$

$$\text{T} = \left(\frac{\text{mM}}{\text{M+2m}}\right)\text{g}$$

21. The equation of stationary wave is $y = 4\cos\frac{\pi x}{3}\sin 40\pi t$

$$y = 2 \times 2\cos\frac{2\pi x}{6}\sin\frac{2x(120)t}{6}$$

We know that $y = 2a\cos\frac{2\pi x}{\lambda}\sin\frac{2xvt}{\lambda}$

By comparing tow equations we get,

a= 2cm, λ=6cm and v=220 cm/sec.

The component waves are

$$y_1 = a\sin\frac{2\pi}{\lambda}(vt-x)$$

$$y_2 = a\sin\frac{2\pi}{\lambda}(vt+x)$$

Distance between two adjacent nodes

$= \frac{\lambda}{2} = \frac{6}{2} = 3cm$

Particle velocity $\frac{dy}{dt} = 4\cos\frac{\pi x}{3}\cos(40\pi t).\ 40\pi$

$= 160\cos\frac{\pi x}{3}\cos 40\pi t$

$= 160\pi\cos\frac{\pi x}{3}\cos\left(40\pi \times \frac{1}{8}\right)$

$=160\pi$

Particle velocity = 160 cm/sec.

22. $l = l_1 + l_2$ ………………………………… (i)

$l_1 = n l_2$ ……………………………… (ii)

$k = \frac{Mg}{l}$ ……………………………… (iii)

$k_1 = \frac{Mg}{l_1}$ ……………………………… (iv)

$k_2 = \frac{Mg}{l_2}$ ………………………………… (v)

Dividing the equation (iv) by (iii),

$\frac{k_1}{k} = \frac{l}{l_2} = 2\frac{l_1 + l_2}{l_1} = 1 + \frac{l_2}{l_1}$

From the equation (ii) we find $\frac{l_1}{l_2} = n$

$\frac{k_1}{k} = 1 + \frac{1}{n}$

From equation (v) and (iii)

$\frac{k_2}{k} = \frac{l}{l_2} = \frac{l_1 + l_2}{l_2} = \frac{l_1}{l_2} + 1$

From equation (ii) we have $\frac{l_1}{l_2} = n$

$\frac{k_2}{k} = (n+1)$

$k_2 = k(n+1)$

Or

(a) Stress = $\frac{F}{A} = \frac{F}{\pi r^2} = 3.18 \times 10^8\ N/m^2$

(b) Elongation $\Delta L = \frac{\left(\frac{F}{A}\right)L}{Y} = 1.59$ mm

(c) Strain = $\frac{\Delta L}{L} = 0.16\%$

23. (a) Crash diet should not be taken as it makes body weak and less immune to diseases. It makes the body deficient in certain nutrients which is harmful for body.

(b) The SI unit of heat = Joule and the CGS unit of heat = Calorie
1 calorie = 4.18 J
(c) Substituting the values for ΔQ = cmΔT, we get
$\Delta T = 40.16^0C$

24. The tunnel is dug along the diameter of the earth. Consider the case of a particle of mass m at a distance y from the Centre of the earth. There will be a gravitational attraction of the earth on this particle due to the portion of matter contained in a sphere of radius y. the mass of the sphere of radius y is given by

M = $volume \times density$

$$M = \frac{4}{3}\pi y^3 \text{x } d$$

This mass can be regarded as concentrated at the centre of the earth. The force F between this mass and the particle of mass m is given by

$$F = -\frac{GMm}{y^2}$$

Negative sign shows that the force is of attraction

$$F = -G\left(\frac{4}{3}\pi y^3 d\right)\frac{m}{y^2} = -G\text{x}\left(\frac{4}{3}\pi yd\right)y$$

$$F \infty y$$

The force is directly proportional to the displacement hence the motion is simple harmonic motion.

The constant k = $\frac{4}{3}\pi mdG$

The time period $T = 2\pi\sqrt{(m/k)}$

$$T = 2\pi\sqrt{\left(\frac{3m}{4\pi mdG}\right)} = 2\pi\sqrt{\left(\frac{3}{4\pi dG}\right)}$$

$$T = \sqrt{\left(\frac{3\pi}{dG}\right)} = \sqrt{\left(\frac{3 \text{ x } 3.14}{5.51 \text{ x } 10^5 \text{ x } 6.67 \text{ x } 10^{-11}}\right)}$$

T = 42.2 minutes

Or

(a) A sound wave decrease in displacement node cause an increase in the pressure there. Also an increase in displacement is due to the increase in pressure.
(b) Bats emit ultrasonic waves of high frequency from their mouths. These waves after being reflected back from the obstacles on their path are observed by the bats. Using these waves' bats can find the direction, distance, nature and size of the object.
(c) This is due to the fact that gases have only the bulk modulus of elasticity whereas solids have both the shear modulus as well as the bulk modulus of elastically.
(d) A pulse of sound consists of a combination of waves of different wavelength. In a dispersive medium these waves travel with different velocities giving rise to the distortion in the wave.

25. Mass of the diamond = 175 g
Density = 3.5 gcm^{-3}

Volume = $\frac{175}{3.5}$ = $50cm^3$

If the original volume of the diamond were V, then

V = 50 + ΔV
Where ΔV is the increase in volume under the pressure during its formation,

Bulk modulus = B = $\frac{PV}{\Delta V}$

Substituting (V – 50) for ΔV and the values of P and B, we have

$\frac{B}{P} = \frac{62 \times 10^{10}}{1.55 \times 10^{10}} = \frac{40V}{V - 50}$

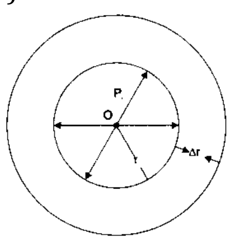
V = 40V – 2000
39V = 2000
V = 51.28 cm^3
$-\Delta V$ can be calculated as,

$(-\Delta V) = \frac{PV}{B} = \frac{1.55 \times 10^{10} \times 50}{62 \times 10^{10}} = 1.25 cm^3$

Now adding this value to the present value giving V = 51.25 cm^3. The difference is only in the second decimal place, less than 0.06%. Hence the original volume of the diamond must have been equal to 51.3 cm^3.

Or

(a)



Let r =radius of a spherical liquid drop of Centre O, T = surface tension of the liquid.
Let P_i and P_0 be the value of pressure inside and outside the drop.

Excess pressure inside the liquid drop = $P_i - P_0$

Let Δr be the increase in its radius due to excess pressure. It has one free surface outside.

Increase in surface area of the liquid drop = $4\pi(r+\Delta r)^2 - 4\pi r^2$

$= 4\pi\left[r^2 + (\Delta r)^2 + 2r\Delta r - r^2\right]^2$

$= 8\pi r\Delta r$

Increase in surface energy of the drop is W = surface tension$\times$increase in area = $T \times 8\pi r\Delta r$
W = force due to excess of pressure x displacement …………………… (i)
= Excess pressure x area of drop$\times$increase in radius
= $(P_i - P_0)4\pi r^2\Delta r$ ……………………… (ii)

From equation (i) and (ii) we get,
$(P_i - P_0) \times 4\pi r^2\Delta r = T \times 8\pi r\Delta r$

$P_i - P_0 = \frac{2T}{r}$

(a) Inside the liquid Bubble: A liquid bubble has air both inside and outside it therefore it has two free surfaces.

Increase in surface area = $2\left[4\pi(r+\Delta r)^2 - 4\pi r^2\right]$

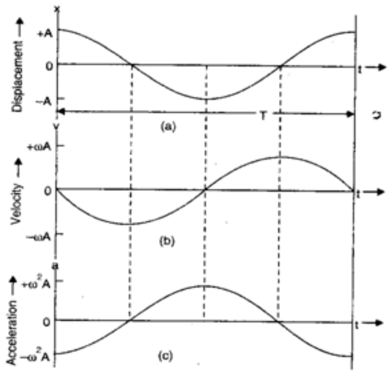
$= 2\times 8\pi r\Delta r$
$= 16\pi r\Delta r$
W = $T\times 16\pi r\Delta r$ ……………………….. (1)
W= $(P_i - P_0)4\pi r^2 \times \Delta r$ ……………………….. (2)
From equation (1) and (2)
$(P_i - P_0)\times 4\pi r^2 \times \Delta r$
= $T\times 16\pi r\Delta r$
$P_i - P_0 = \frac{4T}{r}$

(b) Inside an air bubble: Air bubble is formed inside the liquid, thus air bubble has one free surface inside it and liquid is outside.
r = radius of the air bubble, Δr = increase in its radius due to excess of pressure $(P_i - P_0)$ inside it, T = surface tension of the liquid in which bubble is formed
Increase in surface area = $8\pi r\Delta r$
W = $T\times 8\pi r\Delta r$
W = $(P_i - P_0)\times 4\pi r^2\Delta r$
$(P_i - P_0)\times 4\pi r^2\Delta r$
$= T\times 8\pi r\Delta r$
$P_i - P_0 = \frac{2T}{r}$.

26. Let x = $A\cos(\omega t + \varphi)$ and if phase angle φ is zero
x = $A\cos\omega t$,
v = $\frac{dx}{dt}$ = $-A\omega\sin\omega t$
a = v = $\frac{dv}{dt}$ = $-A\omega^2\cos\omega t$
$= -\omega^2 x$
The values of 'x', 'v' and 'a' at different times over one complete cycle as follow:

Time t	0	T/4	T/2	3T/4	T
ωt	0	$\frac{\pi}{2}$	π	$\frac{3\pi}{2}$	2π
x	A	0	-A	0	A
v	0	$-A\omega$	0	$A\omega$	0
a	$-A\omega^2$	0	$A\omega^2$	0	$-A\omega^{2s}$

Using the given data, x – t, v – t and a – t graphs are plotted as shown below:



Or

For closed column l = 15 cm or 0.15 m

For open column l = 30.5 cm or 0.305m

Let v_1 and v_2 be the frequencies of the tuning fork A and B.

As tuning fork A resounds with a closed column

$$v_1 = \frac{v}{4l} = \frac{v}{4\text{x } 0.15} = \frac{v}{0.60} \quad \text{.................................. (i)}$$

The fork B resounds with an open air column

$$v_2 = \frac{v}{2l} = \frac{v}{2\text{x } 0.305} = \frac{v}{0.61} \quad \text{.................................. (ii)}$$

Fork A and B produces $\frac{9}{3}$ = 3 beats per second.

$v_1 - v_2 = 3$

$$\frac{v}{0.60} - \frac{v}{0.61} = 3$$

$v(0.61 - 0.60) = 3 \text{ x } 0.60 \text{ x } 0.61$

$$v = \frac{3 \text{ x } 0.60 \text{ x } 0.61}{0.01} = 109.8\text{ms}^{-1}$$