Sample Paper-04
Physics (Theory)
Class – XI

Answers

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1. (a) Stress and Young's Modulus
   (b) Work and Energy
2. (i) Apparent weight = m(g+a)
   (ii) Apparent weight = m(g-a)
3. Here, the centre of gravity of the system is raised and as such the whole system is in an unstable equilibrium. When the running bus suddenly stops due to inertia of motion, the passengers fall forward on each other and cause stampede.
4. (i) Atomicity
   (ii) Temperature
5. (i) Kinetic energy of the system remains conserved.
   (ii) Linear momentum of the system remains conserved.
6. $\frac{1}{2}mv^2 = \frac{3}{2}kT$
   $T = \frac{mv^2}{3k}$
   m = 5.34 x 10^{-26} kg
   v = 11.0 km/s = 11 x $10^3 ms^{-1}$
   k = 1.38 x $10^{-23} JK^{-1}$
   $T = \frac{5.34 \text{ x} 10^{-26} \text{x} \left(11 \text{ x } 10^3\right)^2}{3 \text{ x } 1.38 \text{ x } 10^{-23}}$
   = 1.56 x 10^5K
7. $C_p - C_v = R$ .... (i)
   $\frac{C_p}{C_v} = \gamma$ .... (ii)
   From equation (ii) $C_p = \gamma C_v$ and substituting this value in (i)
   $\gamma C_v - C_v = R \Rightarrow C_v = \frac{R}{(\gamma - 1)}$
   $C_v = \gamma C_p = \frac{\gamma R}{(\gamma - 1)}$
8. Critical velocity (v_0) of the liquid are:
   (a) Directly proportional to the coefficient of viscosity of the liquid
   (b) Inversely proportional to the density of the liquid $V_c \infty \frac{1}{\rho}$
   (c) Inversely proportional to the diameter of the tube through which it flows $V_c \infty \frac{1}{D}$
9. r = 80 cm = 0.8 m

$v = \frac{14}{25}$ rev / s

$\omega = 2\pi v = 2 \times \frac{22}{7} \times \frac{14}{25}$ rad /s

$= \frac{88}{25}$ rad s^{-1}

The centripetal acceleration

$a = \omega^2 r = \left(\frac{88}{25}\right)^2 \times 0.80$

$= 9.90\ ms^{-2}$

The direction of centripetal acceleration is along the string directed towards the centre of circular path.

10. $L = I\omega$ = constant.

K.E of rotation $K = \frac{1}{2} I\omega^2$

$K = \frac{1}{2I} I\omega^2 = \frac{L^2}{2I}$

$K \propto \frac{1}{I}$

When moment of inertia (I) decreases, K.E of rotation (K) increases. Thus K.E. of rotation is not conserved.

11. Temperature T = 300 K

Volume V = 4 litres = $4 \times 10^{-3} m^3$

The pressure exerted by a gas is given by

$p = \frac{nRT}{V} = \frac{\text{mass}}{\text{molecular weight}} \times \frac{RT}{v}$

Pressure exerted by oxygen $p_1 = \frac{8}{32}\frac{RT}{V} = \frac{1}{4}\frac{RT}{V}$

Pressure exerted by nitrogen $p_2 = \frac{14}{28}\frac{RT}{V} = \frac{1}{2}\frac{RT}{V}$

Pressure exerted by carbon dioxide $p_3 = \frac{24}{44}\frac{RT}{V} = \frac{1}{2}\frac{RT}{V}$

From Dalton's law of partial pressure, the total pressure exerted by the mixture is given by

$P = P_1 + P_2 + P_3$

$P = \frac{1}{4}\frac{RT}{V} + \frac{1}{2}\frac{RT}{V} + \frac{1}{2}\frac{RT}{V}$

$P = \frac{5}{4}\frac{RT}{V} = \frac{5}{4} \times \frac{8.315 \times 300}{4 \times 10^{-3}}$

$P = 7.79 \times 10^5\ N\ m^{-2}$

12. Let mass of satellite = m, distance of apogee from the earth = r_a

Distance of perigee from earth = r_p,

Velocity of satellite at apogee = v_a

Velocity of satellite at perigee = v_p

Now angular momentum of satellite at apogee = mv_ar_a

Angular momentum of the satellite at perigee = mv_pr_p

According to the law of conservation of angular momentum $mv_ar_a = mv_pr_p$

$\frac{v_a}{v_p} = \frac{r_p}{r_a}$

13. g = $\frac{GM}{R^2}$

Let g_M and g_e be the acceleration due to gravity at Mars and earth.

$$\frac{gM}{g_e} = \left(\frac{M_M}{M_e}\right)\left(\frac{R_e}{R_M}\right)^2$$

$$= \left(\frac{1}{10}\right)\left(\frac{12742}{6760}\right)^2$$

= 0.35

$g_M = 0.35 \text{ x } g_e = 0.35 \text{ x } 9.8 = 3.48 \text{ ms}^{-2}$

14. In a closed glass cage, air inside is bound with the cage,
(i) There would be no change in weight of the cage if the bird flies with a constant velocity.
(ii) The cage becomes heavier, when bird flies upwards with acceleration.
(iii) The cage appears lighter, when bird flies downwards with acceleration.

15. Volume of the room V = 25.0 m^3, temperature T = 27^0 C = 300 k
Gas equation $PV = \mu RTB = T\mu N_A.k$
Total number of air molecules in the volume of given gas

$$N = \mu.N_A = \frac{PV}{k_B T}$$

$$N = \frac{1.01 \text{ x } 10^5 \text{ x } 25.0}{(1.38 \text{ x } 10^{-23}) \text{ x } 300} = 6.1 \text{ x } 10^{26}$$

16. The weight will become zero under the following conditions:
(i) During free fall
(ii) At the centre of the earth
(iii) In an artificial satellite
(iv) At a point where gravitational pull of earth to the gravitational pull of the moon.

17. Let M = mass of nucleus at rest
Momentum of the nucleus before disintegration = M x 0 = 0
Let m_1 and m_2 be the mass of the two smaller nuclei and v_1 and v_2 be their velocities
Momentum of the nucleus after disintegration = $m_1v_1 + m_2v_2$
According to the law of conservation of linear momentum $m_1v_1 + m_2v_2 = 0$
$m_1v_1 = - m_2v_2$
The negative sign shows that the velocities v_1 and v_2 must be opposite sign; the two products must be emitted in opposite direction. Thus the angle between two nuclei is 180^0

18. Initial velocity u = 78.4 ms^{-1}
The body reaches to the maximum height 'h
The velocity at maximum height v =0
From the equation $v^2 - u^2 = 2gh$
$v^2 = (78.4)^2 = 2(-9.8) \text{ x } h$

$$h = \frac{78.4 \text{ x } 78.4}{2 \text{ x } 9.8} \text{ m}$$

= 313.6 m
Using the equation v =u + gt
0 = 78.4 + (-9.8) t

$$t = \frac{78.4}{9.8} s$$

= 8 s

Total time taken to return to the point of projection = Time taken in ascent + time taken in descent.

= 2 x 8 = 16 s

19. Initially 1000g of water is at 5^0C

Let m gram of it be cooled to ice at 0^0C

Heat released due to this = (m x 1 x 5) + (m x 80)

= 5m + 80 m = 85 m cal.

The heat required by (1000 – m)g of water at 5^0C to become steam at 100^0C

= [(1000 – m) (100 – 5) + (1000 – m) 540]

= (1000 – m) (95 + 540) cal

= (1000 – m) (635) cal

85 m= (1000 – m) (635)

720 m = 635 x 1000

m = 881.9 g

Hence 881.9 g water by turning into at 0^0C will supply heat to evaporate 118.1 g of water.

20. T_1 = 500 K

T_2 = 375 K

Q_1 = heat absorbed per cycle = 600 Kcal

Using the relation

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\eta = \frac{T_1 - T_2}{T_1} = \frac{500 - 375}{375} = \frac{125}{500} = 0.25$$

η = 0.25 x 100 = 25%

(i) Let W = work done per cycle

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

W = ηQ_1 = 0.25 x 600 Kcal = 150 Kcal

=150 x 10^3 x 4.2 J = 6.3 x 10^5 J

(ii) Let Q_2 = heat rejected to the sink

W = $Q_1 - Q_2$

$Q_2 = Q_1 - W$ = 600 – 150 = 450 Kcal

21. For second pendulum, frequency $v = \frac{1}{2} s^{-1}$

When elevator is moving upwards with acceleration a, the effective acceleration due to gravity is

g_1 = g + a = $g + \frac{g}{2} = \frac{3g}{2}$

$$v = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

$$\frac{v_1^2}{v^2} = \frac{g_1}{g} = \frac{\frac{3g}{2}}{g} = \frac{3}{2}$$

$\frac{v_1}{v} = \sqrt{\frac{3}{2}} = 1.225$

$v_1 = 1.225$ v

= 1.225 x $\frac{1}{2}$ = 0.612 s^{-1}

Or

(a) v = $v_0\left(1 - \frac{v_s}{v}\right)^{-1}$

= 1000 x (1-200/300) = 2540 Hz

(b) $v' = v\left(\frac{v + v_0}{v}\right)$

= 2540 x (200 + 330/330) = 4080 Hz

22. The total energy of a satellite of a mass m in a circular orbit of radius r is

½ mv^2 – GMm/r

Where r is measured from the centre of the earth, then the total mechanical energy in the orbit,

$E = g\frac{mM}{2r} - G\frac{Mm}{r} = -G\frac{mM}{2r}$

r = 2R + R = 2R

$E = -G\frac{mM}{6R}$

The potential energy on the surface of the earth = $-G\frac{mM}{R}$

Minimum energy required $= \frac{1}{6}G\frac{mM}{R} - \left(-G\frac{Mm}{R}\right)$

$= \frac{5}{6}G\frac{mM}{R} = \frac{5}{6}mgR$

$= \frac{5}{6}$ x 250 x 9.8 x 6.4 x 10^6J

=1.3 x 10^{10} J

23. (a) She has presence of mind and is helpful in nature.

(b) She has used linear expansion of solids.

(c) Here,

L_1 = 6.231 m, L_2 = 6.243 m, T_1 = 27^0C

Using the formula, $\alpha = \frac{L_2 - L_1}{L_1(T_2 - T_1)}$

We get $T_2 = \frac{6.243 - 6.231}{6.243 \text{ x } 1.2 \text{ x } 10^{-5}} + 27$ = 187^0C

24. Y = 12.5 x 10^{11} dyne cm^{-2}

= 12.5 x 10^{10} Nm^{-2}.

Diameter D = 2.5 mm = 2.5 x 10^{-3}m

F = 100 kg f = 100 x 9.8 N = 980 N

$\frac{\Delta L}{L}$ x $100 = x$

A = $\pi r^2 = \pi(1.25 \text{ x } 10^{-3})^2 m^2$.

Using the relation,

$Y = \frac{FL}{A\Delta L}$ we get,

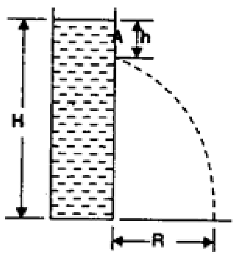
Percentage increase in length = $\frac{\Delta L}{L}$ x 100

$= \frac{F}{AY} \text{ x } 100 = \frac{F}{\pi r^2 Y} \text{ x } 100$

$= \frac{980}{3.142x(1.25x10^{-3})^2 x12.5x10^{10}} x100$

= 15.96×10^{-2} = 0.16%

Or



$v_A = \sqrt{2gh}$ ……………………….. (i)

$(H-h) = \frac{1}{2}gt^2$ …………………………….. (ii)

The distance R,

R = v_A x t ……………………… (iii)

From equation (ii) $t = \sqrt{\left(\frac{2(H-h)}{g}\right)}$ ………………………….. (iv)

Substituting the value of v_A from equation (i) and the value of t from equation (iv) in equation (iii) we get,

$R = \sqrt{(2gh)}x\sqrt{\{2(H-h)/g\}}$

$R = 2\sqrt{\{h(\text{H}-\text{h})\}}$

The range R will be at maximum when

dR/ dh =0

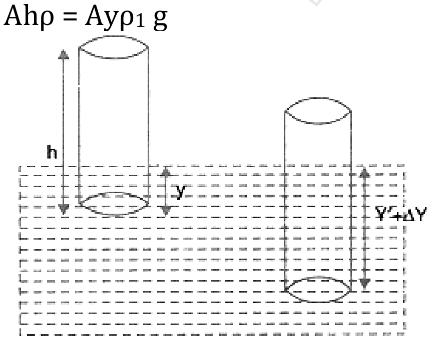
$22.\frac{1}{2}h^{-1/2}(H-h)^{-1/2} - 2h^{1/2}.\frac{1}{2}(H-h)^{i/2} = 0$

h= H/2

25. In equilibrium y height of cylinder is inside the liquid.

Weight of the cylinder = up thrust due to liquid displaced.

Ahρ = Ayρ$_1$ g



When the cork cylinder is depressed slightly by Δy and released a restoring force equal to additional up thrust acts on it. The restoring force is

$F = A(y + \Delta y)\rho 1g - Ay\rho_1 g = A\rho_1 g\Delta y$

Acceleration $a = F/m = A\rho_1 g\Delta y / Ah\rho = \rho_1 g / h\rho.\Delta y$ and the acceleration is directed in a direction opposite to Δy. As a $a = -\Delta y$, the motion of cork cylinder is SHM

$$T = 2\pi\sqrt{\frac{\text{displacement}}{\text{acceleration}}}$$

$$T = 2\pi\sqrt{\frac{\Delta y}{a}}$$

$$T = 2\pi\sqrt{\frac{h\rho}{\rho_1 g}}$$

Or

(i) Stationary waves are produced in a bounded medium. A medium whose boundaries are separated from other media by distinct surface is called bounded medium. The boundaries of a bounded medium may be rigid or free.

(ii) There are certain points in the bounded medium which are always in the state of rest. These points are called nodes. If the stationary waves are longitudinal, then the change in pressure and density is maximum at nodes as compared to the other points.

(iii) There are points between the nodes whose displacement is maximum as compared to other points. These points are called anti-nodes. In the longitudinal stationary waves, there is no-charge in pressure and density of the medium at anti-nodes.

(iv) The distance between any two successive nodes or antinodes is $\lambda/2$. The distance between a node and the neighbouring anti-node is $\lambda/4$

(v) All the particles between two successive nodes vibrate in the same phase. They pass simultaneously through their mean positions and also pass simultaneously through their positions of maximum displacement.

(vi) Stationary waves do not advance in the medium, but remains steady at its place.

(vii) All the particles except those at nodes, execute simple harmonic motion about their mean positions with the same time period.

(viii) In a stationary wave, the medium splits up into a number of segments. Each segment vibrates up and down as a whole.

26. For steel wire A $l_1 = l$; $A_1 = 1$ mm^2 ; $Y_1 = 2 \times 10^{11}$ Nm^{-2}

For aluminium wire B, $l_2 = l$; $A_2 = 2$mm^2 ; $Y_2 = 7 \times 10^{10}$ Nm^{-2}

a) Let mass m be suspended from the rod at distance x from the end where wire A is connected. Let F_1 and F_2 be the tensions in two wires and there e is equal stress in two wires

$$\frac{F_1}{A_1}=\frac{F_2}{A_2}\Rightarrow\frac{F_1}{F_2}=\frac{A_1}{A_2}=\frac{1}{2} \text{ -------------------------- (i)}$$

Taking moment of forces about the point of suspension of mass from the rod,

$F_1x = F_2(1.05 - x)$

$2.10 - 2x = x = 0.70\text{m} = 70 \text{ cm}$

(a) Let mass m be suspended from the rod at distance x from the end where wire A is connected. Let F_1 and F_2 be the tension in the wires and there is equal strain in the two wires.

$$\frac{F_1}{A_1Y_1}=\frac{F_2}{A_2Y_2}\Rightarrow\frac{F_1}{F_2}=\frac{A_1Y_1}{A_2Y_2}=\frac{1}{2}\text{X}\frac{2\text{ x }10^{11}}{7\text{ x }10^{10}}=\frac{10}{7}$$

As the rod is stationary $F_1x = F_2(1.05 - x)$

$10x = 7.35 - 7x$

$x = 0.4324 \text{ m} = 43.2 \text{ cm}$

Or

According to Bernoulli's theorem,

$$\frac{P_1}{\rho}+gh_1+\frac{1}{2}2v_1^2=\frac{P_2}{\rho}+gh_2+\frac{1}{2}v_2^2$$

For the horizontal flow $h_1=h_2$

$$\frac{P_1}{\rho}+\frac{1}{2}v_1^2=\frac{P_2}{\rho}+\frac{1}{2}v_2^2$$

$v_1 = 90 \text{ ms}^{-1}$;$v_2 = 120 \text{ ms}^{-1}$

$\rho = 1.3 \text{ kg m}^{-3}$

$$\frac{P_1-P_2}{\rho}=\frac{1}{2}1\left(v_2^2-v_1^2\right)$$

$$\left(P_1-P_2\right)=\frac{\rho\left(v_2^2-v_2^2\right)}{2}$$

$$(P_1 - P_2) = \frac{1.3(14400 - 8100)}{2}$$

$$(P_1 - P_2) = \frac{1.3x6300}{2}$$

$$(P_1 - P_2) = 4.095x10^3\,Nm^{-2}$$

This is the pressure difference between the top and the bottom of the wing.

Gross lift of the wing

= $(P_1$-$P_2)$ x area of the wing

= 4.095 x 10^3 x 10 x 2

= 8.190 x 10^4 N