Sample Paper-05
Physics (Theory)
Class – XI

Answer

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1. (a) Low pressure
   (b) High temperature
2. This is because
   (a) The energy received is less due to large distance.
   (b) Loss of energy takes place due to radiation, absorption and convection currents.
3. For 1 mole with 'f' degrees of freedom,
   Internal energy U = 1 x C_v x T = $\frac{f}{2}RT$
   For 'n' moles,
   U = n x C_v x T = $\frac{nf}{2}RT$
4. Curved roads are generally banked so as to help in providing centripetal force needed to balance the centrifugal force arising due to the circular motion of the curved road.
5. This is because the spring loses its elastic character after long use.
6. $T_1 = 200^0$ C = 473 K and $T_2 = 100^0$ C = 373 K
   The efficiency of engine $\eta = \frac{W}{Q_1} = \left(\frac{T_1 - T_2}{T_1}\right) = \frac{473-373}{473} = \frac{100}{473} = 0.21$
   W = 0.21, Q_1= 21%
   Hence the engine will convert 21% of heat used for doing work.

   Or

   r.m.s velocity C = 8 km s^{-1} = 8 x 10^5 cm s^{-1}
   Molar gas constant R = 8.31 x 10^7 erg mol^{-1} K^{-1}
   Molecular weight of nitrogen M =28
   Let T be the required temperature
   $C = \sqrt{\frac{3RT}{M}} or C^2 = \frac{3RT}{M}$
   $T = \frac{MC^2}{3R} = \frac{28 \text{ x } (8 \text{ x} 10^5)^2}{3 \text{ x } 8.31 \text{x} 10^7} K = 71881K$
7. The value of acceleration due to gravity at a depth 'd' below the surface of earth is given by,
   $g_a = g\left(1 - \frac{d}{R}\right)$
   At the centre of earth d = R and hence
   $g_{centre} = g\left(1 - \frac{R}{R}\right) = g(1 - 1) = 0$
   Weight of a body at the centre of earth = mg_{centre} = m x 0 which means that at the centre of earth a body will be weightless.
8. A spring will be better one if a large restoring force is set up in it on being deformed, which in turn depends upon the elasticity of the material of the spring. Since the Young's modulus of elasticity of steel is more than that of copper, hence the steel is preferred in making the springs.
9. m = 20 g = 0.02 kg, u = 150 m s^{-1}, v =0 and s = 10cm = 0.1 m

According to work – K.E. theorem

k –K' = W = Fs

$\frac{1}{2}mu^2 - 0 = Fs$

$F = \frac{mu^2}{2s} = \frac{0.02 \text{ x } (150)^2}{2 \text{ x } 0.1} = 2250N$

10. When a ball is dropped from a height h, it gains velocity due to gravity pull. The body will enter the tunnel of earth with velocity $v = \sqrt{2gh}$ after a time $t = \sqrt{2h/g}$. The body will go out of the earth on the other side through the same distance before coming back towards the earth. When the body is outside the earth, the restoring force $F\alpha(-1/r^2)$ and not (-r) so the motion does not remain SHM.

11. On earth T = 3.5s, g = 9.8 m/s^2

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

$\Rightarrow 3.5 = 2\pi\sqrt{\frac{l}{9.8}}$

On Moon T' =?, g' =1.7 m/s^2

$\Rightarrow T' = 2\pi\sqrt{\frac{l}{g'}} = 2\pi\sqrt{\frac{l}{1.7}}$

$\frac{T'}{3.5} = \sqrt{\frac{9.8}{1.7}}$

T' = 240 x 3.5 = 8.4 s

12. Velocity of sound in gases depends directly on the square root of the absolute temperature. According to Newton's second law, force acting on an object is the rate of change of its momentum

$F = \frac{dp}{dt} = \frac{m(v-u)}{t} = ma$

13. In a SHM velocity is given by $v = \omega\sqrt{A^2 - x^2}$ where x is the displacement from mean position.

Velocity at $x = \frac{\sqrt{3}A}{2}$

$v_1 = \omega\sqrt{A^2 - \frac{3}{4}A^2} = \omega A\sqrt{\frac{1}{4}} = \frac{\omega A}{2}$

Velocity at central position = $\omega\sqrt{A^2 - 0^2} = \omega A$

Therefore Velocity at $\frac{\sqrt{3}A}{2} = \frac{1}{2}$

14. It is a device that helps in maintaining a constant temperature. It consists of a bi-metallic strip which comprises of two thin strips of different materials welded together along their lengths. On heating, this combination bends into an arc. It happens because brass has a higher coefficient of expansion than invar.

15. $\sigma = 0.07Nm^{-1}, R = \frac{D}{2} = 2x10^{-3}m$

= 1000

Change in surface energy $W = \sigma[N4\pi r^2 - 4\pi R^2]$ where r = RN$^{-1/3}$

$\therefore W = \sigma[N^{1-3/2}4\pi R^2 - 4\pi R^2]$

$W = \sigma 4\pi R^2[N^{1/3} - 1]$

$W = 0.07 x 4 x \frac{22}{7} x (2 x 10^{-3})^2 x [(1000)^{1/3} - 1]$

$W = 0.07 x 4 x \frac{22}{7} x 4 x 10^{-6} x 9$

W = 31.68 x 10-6 J

16. (i) When the force applied $\vec{F}$ or the displacement $\vec{s}$ or both are zero then work done $W = Fs\cos\theta$ is zero. Also when angle θ between $\vec{F}$ and $\vec{s}$ is 90^0, $\cos\theta = \cos 90^0 = 0$ therefore work done is zero.
(ii) A person carrying a load on his head and standing at a place. A body moving in a circle.

17. Let V be the volume of the ball. Weight of the ball = $V\rho g$
Upward thrust on the ball = $V\sigma g$
Effective upward thrust = $V\rho g - V\sigma g$
Upward acceleration $a = \frac{V\rho g - V\sigma g}{V\rho} = \left(\frac{\sigma - \rho}{\rho}\right)g$
Let v be the velocity of ball while reaching the surface of the water, after being released at depth h in water.
$v^2 = 2as = 2x\left(\frac{\sigma - \rho}{\rho}\right)gh$
For the motion of ball outside the water,
Kinetic Energy at the surface of water = Potential Energy at height H
$\frac{1}{2}mv^2 = mgH$
$H = \frac{v^2}{2g} = \left(\frac{\sigma - \rho}{\rho}\right)h = \left(\frac{\sigma}{\rho} - 1\right)h$

18. (a) We cannot associate a vector with the length of a wire bent into a loop. This is because the length of the loop does not have a definite direction.
(b) We can associate a vector with a plane area. Such vector is called area vector and its direction is represented by a normal drawn outward to the area.
(c) The area of a sphere does not point in any definite direction. However we can associate a null vector with the area of the sphere. We cannot associate a vector with the volume of a sphere.

19. (i) False, the net acceleration of a particle in circular motion is along the radius of the circle towards the centre only in uniform circular motion.
(ii) True, because while leaving the circular path, the particle moves tangentially to the circular path
(iii) True, the direction of acceleration vector in a uniform circular motion is directed towards the centre of circular path. It is constantly changing with time. The resultant of all these vectors will be a zero vector.

20. (a) $T_2 = 0^0$ C = 273 K
$T_1 = 30^0$ C = 273 + 30 = 303 K
$\beta = \frac{T_2}{T_1 - T_2}$
$= \frac{273}{303-273} = \frac{273}{30} = 9.1$
(b) Mass of Nitrogen M = 28
Temperature T = 77 + 273 – 350 K
Gas constant R = 8.31 J mol^{-1} K^{-1}

K.E. of 1g of nitrogen = $\frac{3}{2}\frac{RT}{M}$

= $\frac{3x8.31x350}{2x28}$=155.8J

21. (i) Force constant $k = \frac{F}{l} = \frac{mg}{l}$

M = 3.0 kg and elongation in length of spring l=0.2 m

Force constant $k = \frac{3.0x9.8}{0.2} = 174Nm^{-1}$

(ii) Period of oscillation $T = 2\pi\sqrt{\frac{m}{k}} = 2 \text{ x } 3.14 = \sqrt{\frac{3}{147}} = 0.9s$

22. The wire has length *l*, area of the corss-section A made of material constant Y. let force F be applied and at any instance, x be the extension associated (x < L) where L is the maximum extension. At this incident $F = \frac{AY.x}{l}$.

Since force is a variable with x, work done to stretch wire is

$$W = \int_o^L F dx$$

$$W = \frac{1}{2}\frac{AY}{l}.L^2$$

$$W = \frac{1}{2}(Al)\left(\frac{YL}{l}\right)\left(\frac{L}{l}\right)$$

$W = \frac{1}{2}$x Volume x Stress x Strain

Therefore Work done per unit volume = $\frac{1}{2}$ x Stress x Strain

Or

(i) Reading on balance = 10 +1.5 = 1.5 Kg

Volume of Iron = $\frac{M}{P} = \frac{7.8}{7.8x10^3} = 10^{-3}m^3$

Mass of water displaced = $\frac{10^{-3}}{2}x10^3 = \frac{1}{2}kg$

Reading of balance = 10 +0.5 = 10.5 kg

23. (i) Hema is very understanding and helpful.

(ii) $\theta = 30^0$

Horizontal component

A_x = 250 km/h

Actual velocity A =?

Vertical component A_y =?

$A_x = A\cos\theta$

$A = A_x / \cos\theta = 250 / \cos 30^0$

$A = 250x2\sqrt{3}$

A = 288.7 km/h

$A_y = A\sin\theta$

A_y = 288.7 x sin 30^0

$A_y = 288.7x\frac{1}{2}$

A_y =144.35 km/h

Here v = 600 revolution/ minute

$= \frac{600}{60}$ revolution / minute

$\omega = 2\pi v$

$\omega = 2\pi x 600/60$

$\omega = 20\pi$ rad.s^{-1}

24. (a) In SHM the velocity V at a displacement x is given by

$V = \omega(A^2 - x^2)^{1/2}$

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

V = 3 cm s^{-1} when x = 4 cm.

$9 = \omega^2 (A^2 - 16)$ ---------------------- (i)

V = 4 cm s^{-1} when x = 3 cm

$16 = \omega^2 (A^2 - 9)$ ---------------------- (ii)

Simultaneous solution of equations (i) and (ii)

Amplitude A =5m and Angular frequency ω = 1 rad s^{-1}

Hence time period $T = \frac{2\pi}{\omega}$ = 2π seconds = 6.25 s

(a) m = 50 g = 50 x 10^{-3} kg, A = 5 cm = 5 x 10^{-2} m, ω = 1 d s^{-1}

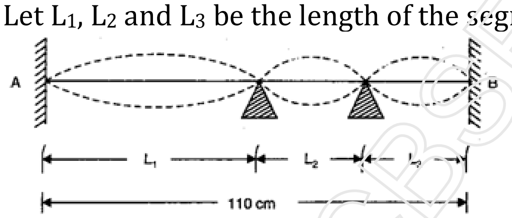
Total energy = ½ $mA^2\omega^2$

= ½ x (50 x 10^{-3}) x (5 x $10^{-2})^2(1)^2$

= 6.25 x 10^{-5} J

Or

Let L_1, L_2 and L_3 be the length of the segments of wire AB.



$L_1 + L_2 + L_3 = 110$ cm ………………………….. (i)

Let n_1, n_2 and n_3 be their respective fundamental frequencies

$n_1 = \frac{1}{2L_1}\sqrt{\frac{T}{m}}$

$n_2 = \frac{1}{2L_2}\sqrt{\frac{T}{m}}$

$n_3 = \frac{1}{2L_3}\sqrt{\frac{T}{m}}$

Hence $n_1L_1 = n_2L_2 = n_3L_3$ ………………………………. (ii)

$n_1 : n_2 : n_3$ = 1 : 2 : 3

$n_2 = 2n_1$ and $n_3 = 3n_1$ ………………………………. (iii)

From (ii) and (iii) we get

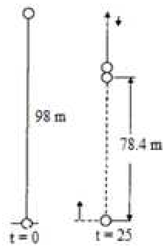
$L_1 = 2L_2 = 3L_3$ …………………………………. (iv)

Substituting (4) in (1) we get

$L_1 + \frac{1}{2}L_1 + \frac{1}{3}L_1 = 110$

$L_1 = 60$ cm
$L_2 = 30$ cm and $L_3 = 20$ cm
Thus the bridges should be placed at distance of 60 cm and 90 cm from A.

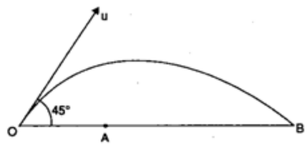
25.



Let the balls collide at an instant t seconds after they start their respective motion. Clearly the two balls are at the same height above the ground at that instant.
The height of the first ball after t seconds = $49\,t - \frac{1}{2} \times 9.8t^2 = 4.9\,t\,(10 - t)$
The height of the second ball after t seconds = 98- downward moved in t seconds
$= 98 - \frac{1}{2} \times 9.8t^2$
$= 4.9(20 - t^2)$
$4.9\,t(100- t)$
$= 4.9(20 - t^2)$
$10t - t^2 = 20 - t^2$
t = 2s
The balls are colliding two seconds after the start of their motion. Their velocities at that instant are
First ball: $v_1 = (49 - 9.8 \times 2)$ m/s
= 29.4 m/s directed upwards
Second ball: $v_2 = (0 + 9.8 \times 2)$ m/s
= 19.6 m/s directed downwards
If v is the velocity of the combined mass of the two balls after they stick together following their collision, we have by principle of conservation of momentum
$200 \times v = 100 \times 29.4 - 100 \times 19.6$
v = 4.9 m/s
The combined mass moves forward after collision with the velocity of 439 m/s. its height above the ground at this instant
$(98 - \frac{1}{2} \times 9.8 \times 2^2)$m = (98 - 19.6) m = 78.4 m
Now, to find the time 't' taken by the combined mass of the two balls to fall to ground,
Combined mass u = 4.9 m/s
s = -78.4 m
$a = -g = - 9.8\ ms^{-2}$
$-78.4 = 4.9\,t' + \frac{1}{2}(-9.8)\,t^2$
$t'^2 - t' - 16 = 0$
$$t' = \frac{1 \pm \sqrt{1+64}}{2} = \frac{1 \pm 8.06}{2}$$
t' = 4.532 s
The combined mass thus takes 4.53 s to fall to the ground. Since the balls collided 2s after they started their motion, their total time of flight is (2 + 4.53) s = 6.53 s

Or

The gun and the card are at O and A at t=0



Let at t=t, the shell and the car reach B simultaneously so that the shell hits the car when it is at a distance OB from the gun.

Let u be the speed of projection of the shell from the gun. Then the initial horizontal component of the velocity of the shell = u cos 45^0 = $\frac{u}{\sqrt{2}}$ and the initial vertical component of the velocity of the shell = u sin 45^0 = $\frac{u}{\sqrt{2}}$

Time of flight of the shell = $\frac{2(u/\sqrt{2}}{g} = \sqrt{2}(u/g)$

The car takes this time to cover the distance AB while the shell covers the distance OB in this time

OB = OA + AB = 500 + AB

OB = $\frac{u}{\sqrt{2}}.\frac{\sqrt{2}u}{g} = \frac{u^2}{g}$

AB = $20\text{x}\sqrt{2}\left(\frac{u}{g}\right) = 20\sqrt{2}\frac{u}{g}$

$$\frac{u^2}{g} = 500 + 20\sqrt{2}\frac{u}{g}$$

$$u^2 - 20\sqrt{2}u - 4900 = 0$$

$$u = \frac{20\sqrt{2} \pm \sqrt{400 \text{ x } 4 + 4 \text{ x } 4900}}{2} ms^{-1}$$

$$u = (10\sqrt{2} \pm \sqrt{5300})ms^{-1}$$

$$u = 10\left[\sqrt{2} \pm \sqrt{53}\right]ms^{-1}$$

$$u = 10[1.414 + 7.280]ms^{-1} = 86.94ms^{-1}$$

This is the speed of projection of the shell from the gun. The distance of the car from the gun when the shell hits it is OB where

$$OB = \frac{u^2}{g} = \frac{(86.94)^2}{9.8}m = 771.3m$$

26. Let x_1 be the distance travelled by the object in t_1 second then v, the speed acquired after travelling distance x_1. $v = a_1t_1$ …………………………… (i)

$2a_1t_1 = v^2 - 0^2 = v^2$

$x_1 = v^2/2a_1$ ………………………………… (ii)

letx_2 and x_3 are distance travelled in the second and third leg of the journey of the particle extending over the time t_2 and t_3.

$x_2 = vt_2$ ……………………………… (iii)

$-2a_2x_3 = 0^2 - v^2 = -v^2$ …………………………………… (iv)

$0 = v - a_2t_3$

$V = a_2t_3$ ………………………………. (v)

The total time t of the journey,

$t = t_1 + t_2 + t_3 = \frac{v}{a_1} + \frac{x_2}{v} + \frac{v}{a_2}$ .... (vi)

$X = x_1 + x_2 + x_3 = \frac{v^2}{2a_1} + x_2 + \frac{v^2}{2a_2}$

$x_2 = X - \frac{v^2}{2}\left(\frac{1}{a_1} + \frac{1}{a_2}\right)$ .... (vii)

From the equation (vi) and (vii)

$t = \frac{v}{a_1} + \frac{X}{v} - \frac{v}{2}\left(\frac{1}{a_1} + \frac{1}{a_2}\right) + \frac{v}{a_2}$

$t = \frac{X}{v} + \frac{v}{2}\left(\frac{1}{a_1} + \frac{1}{a_2}\right)$ .... (viii)

Using equation (viii) and (i)

$t = \frac{X}{a_1 t_1} + \frac{a_1 t_1}{2}\left(\frac{1}{a_1} + \frac{1}{a_2}\right)$ .... (ix)

For a particular value of X, t is least

$\frac{dt}{dt_1} = 0$ .... (x)

Differentiating equation (ix) we get

$\frac{dt}{dt_1} = -\frac{X}{a_1 t_1^2} + \frac{a_1}{2}\left(\frac{1}{a_1} + \frac{1}{a_2}\right) = 0$

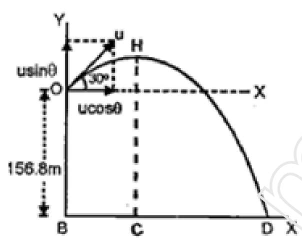
$\frac{X}{a_1 t_1^2} = \frac{a_1(a_1 + a_2)}{2a_1 a_2}$

$t_1 = \left[\frac{X.2a_2}{a_1(a_1 + a_2)}\right]^{\frac{1}{2}}$

Corresponding to these values of t_1 we get

$t = \left[2X\left(\frac{1}{a_1} + \frac{1}{a_2}\right)\right]^{\frac{1}{2}}$

Or



The height of the tower OB = 156.8 m; u =39.2 m/s ;ϴ =30^0

Component of the velocity along OX = u cosϴ = 39.2 cos 30^0 = 33.947 ms^{-1}

Component of the velocity along OY = u sinϴ = 39.2 sin 30^0 = 19.6 ms^{-1}

Let 't' be the total time of flight. Since the vertical downward direction OB is the positive direction of y axis. Taking motion of a projectile from O to D along Y axis

$y_0 = 0$, y =156.8 m

$u_y = -u \sin 30^0 = -19.6$ m/s

$a_y = 9.8$ m/s^2 , t = t

$y = y_0 + u_y t + ½ a_y t^2$

156.8 = 0 + (-19.6) t + ½ x 9.8 x t^2

$156.8 = -19.6t + 4.9\ t^2$

$4.9t^2 - 19.6t - 156.8 = 0$

$t^2 - 4t - 32 = 0$

$t^2 - 8t + 4t - 32 = 0$

$t\ (t-8) + 4(t-8) = 0$

$(t+4)(t-8) = 0$

$t = -4$ or 8

$t = -4$ s is not possible

$t = 8s$

Distance from the foot of tower where it strikes the ground,

$BD = u \cos 30^0 \times t = 30.947 \times 8$

$= 271.57$ m