S1. Ans. (d)

$x = 2t - 1$

$v = \frac{dx}{dt} = 2m\,s^{-1}$

$P = F.v$

$= 2 \times 5 = 10\,W.$

S2. Ans. (a)

Before collision ⇒ (A) → v_1 (B) rest

It undergoes completely inelastic collision Using conservation of linear momentum Initial momentum = Final momentum.

$\Rightarrow mv_1 = mv_2 + mv_2$

$\Rightarrow mv_1 = 2mv_2$

$\Rightarrow \frac{V_1}{V_2} = \frac{2}{1}.$

S3. Ans. (a)

Potential energy stored in the spring

$= \frac{1}{2}kx^2$

Now $\frac{1}{2}k(2)^2 = U$

$\&\frac{1}{2}k(8)^2 = U'$ (say)

$\Rightarrow U' = \frac{64}{4}U = 16\,U$

S4. Ans. (b)

$\frac{1}{2}m\left(\frac{u}{3}\right)^2 - \frac{1}{2}mu^2 = -F_R \times 24$

$0 - \frac{1}{2}mu^2 = -F_R \times d$

$\frac{\frac{1}{2}mu^2}{\frac{1}{2}mu^2 \times \frac{8}{9}} = \frac{d}{24}$

$d = 24 \times \frac{9}{8} = 27\,cm$

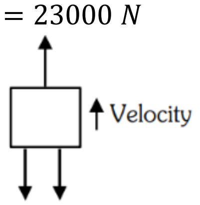
S5. Ans. (b)

Constant velocity ⇒ $a = 0$

$\Rightarrow T = W + f$

$= 20000 + 3000$

$= 23000\,N$



⇒ Power $= Tv$

$= 23000 \times 1.5$

$= 34500$ watts

S6. Ans. (a)

Hint: E = mgh

$P_{input} = \frac{mgh}{t}$

$= \frac{15 \times 10 \times 60}{1} = 9000 = 9kW$

10% loss = 0.9×10^3

$P_{input} = 9 \times 10^3 - 0.9 \times 10^3 = 8.1$ kW

S7. Ans. (b)

Hint: According to the given question

$T - mg = m\frac{(\sqrt{7gr})^2}{r}$

$\Rightarrow T = 8$ mg

S8. Ans. (b)

Hint: From law of conservation of momentum, we have

$4mu_1 = 4mv_1 + 2mv_2$

$\Rightarrow 2(u_1 - v_1) = v_2 \ldots\ldots\ldots..(1)$

From the law of conservation of K.E. we have

$\frac{1}{2}4mu_1^2 = \frac{1}{2}4mv_1^2 + \frac{1}{2}2mv_2^2$

$\Rightarrow 2(u_1^2 - v_1^2) = v_2^2$ ....(2)

From (1) and (2),

$2(u_1^2 - v_1^2) = 4(u_1 - v_1)^2$

$3v_1 = u_1$

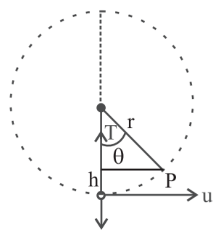
Now, fraction of loss in kinetic energy for mass $4m$,

$\frac{\Delta K}{K_i} = \frac{K_i - K_f}{K_i} = \frac{\left(\frac{1}{2}(4m)u_1^2 - \frac{1}{2}(4m)v_1^2\right)}{\frac{1}{2}(4m)u_1^2}$

$\therefore \frac{\Delta K}{\Delta K_i} = \frac{8}{9}$

S9. Ans. (c)

Hint: Now, at point P from figure



$T - mg\cos\theta = \frac{mv^2}{r}$

$\therefore T = mg\cos\theta + \frac{mv^2}{r}$

From figure, $\cos\theta = \frac{r-h}{r}$

So T will be maximum when cos θ will be 1

$\therefore \frac{r-h}{r} = 1$

$\Rightarrow h = 0$

The tension is maximum when the mass is at the lowest position of the verticle circle, so the chance of breaking is maximum.

S10. Ans. (c)

Hint: Work done by variable force is

$W = \int_{y_i}^{y_f} F dy$

Here, $y_i = 0, y_f = 1$ m

$\therefore W = \int_0^1 (20 + 10y)dy = [20 + 5y^2]_0^1 = 25$ J

S11. Ans. (d)

Hint: To complete vertical circle minimum velocity required at lowest point of circle is $\sqrt{5gr}$ so by

$mgh = \frac{1}{2}mv^2 \qquad r = \frac{D}{2}$

$mgh = \frac{1}{2} m \times 5g\frac{D}{2}$

$h = \frac{5D}{4}$

S12. Ans. (b)

Hint: Spring constant $K \propto \frac{1}{\ell}$

Where ℓ = natural length of spring

$K = \frac{c}{\ell}$ = constant

It is cut into lengths of ratio 1 : 2 : 3 then ratio of spring constant,

$\frac{c}{1} : \frac{c}{2} : \frac{c}{3} \Rightarrow \frac{1}{1} : \frac{1}{2} : \frac{1}{3}$

$K_1 : K_2 : K_3 \Rightarrow 6 : 3 : 2$

Now,

parallel combination

K = 6K + 3K +2K ⇒ K = 11 K

$\frac{1}{K'} = \frac{1}{6K} + \frac{1}{2K} + \frac{1}{3K}$

$\frac{1}{K'} = \frac{1}{6K} + \frac{(3+2)}{6K} = \Rightarrow \frac{1}{K'} = \frac{1}{K}$

$K' = K$

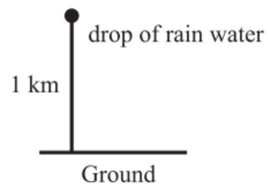
$\frac{K'}{K''} = \frac{K}{11K} \Rightarrow \frac{K'}{K''} = \frac{1}{11}$

S13. Ans. (c)

Hint: Apply work energy theorem

$W_{all\ force} = K_f - K_i$

$W_{(conservative)} + W_{(non\ conservative)} = K_f - K_i$



$W_g = mgh$

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

$= 10$ J

$(U_1 - U_2) + W_{fr} = \frac{1}{2}mv^2 - 0 \quad [K_i = 0, u = 0]$

$mgh + W_{fr} = \frac{1}{2}mv^2 \qquad [U_2 = 0]$

$10^{-30} \times 10 \times 1000 + W_{fr} = \frac{1}{2} \times 10^{-3} \times (50)^2$

$10 + W_{fr} = 1.25$

↓

Work done by resistive force

$W_{fr} = -8.25$ J

S14. Ans. (d)

Hint:

$F_{ext} = 0$

$\vec{P}$ = constant

$K.E. = \frac{P^2}{2m} \Rightarrow K.E. \propto \frac{1}{m}$

$\therefore K.E_{2M} = \frac{3E}{5}$

S15. Ans. (d)

Hint: Power $= \frac{K.E}{t} = \frac{\frac{1}{2}mv^2}{t}$

$v = \sqrt{t}$

$\frac{ds}{dt} = t^{\frac{1}{2}}$

$ds = t^{\frac{1}{2}}dt$

$s = \frac{2t^{\frac{3}{2}}}{3} \Rightarrow s \propto t^{\frac{3}{2}}$

Slope of x -t graph is +ve.

S16. Ans. (a)

Hint: $\vec{s} = \vec{r}_f - \vec{r}_i = 2\hat{i} - \hat{j} + 3\hat{k}$

$W = \vec{F}.\vec{s} = (4\hat{i} + 3\hat{j}).[2\hat{i} - j + 3\hat{k}]$

$= 8 - 3 = 5J$

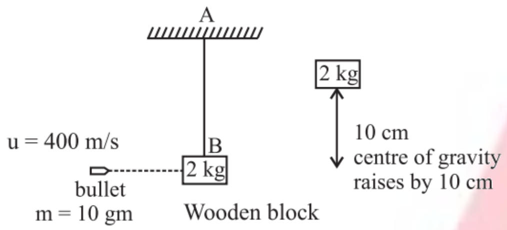
S17. Ans. (d)

Hint: Since both bodies are identical and collision is elastic. Therefore, velocities will be interchanged after collision.

$v_A = -0.3$ m/s and $v_B = 0.5$ m/s

S18. Ans. (a)

Hint: AB = 5 m



Apply conservation of linear momentum

$mu + 0 = mv + Mv$

$\frac{10}{100} \times 400 + 0 = \frac{10}{100}v + 2V$

$0.01v + 2V = 4 \ldots\ldots\ldots.(1)$

PE = KE

$MgH = \frac{1}{2} \times MV^2$

$2 \times 10 \times \frac{10}{100} = \frac{1}{2} \times 2 \times v^2$

$\Rightarrow V^2 = 2$

$v = \sqrt{2}\ ms^{-1}$

Substituting the value of V in Eq. (1), we get

$\frac{v}{100} + 2\sqrt{2} = \Rightarrow v = (4 - 2\sqrt{2})100$

$\simeq 120\ ms^{-1}$

S19. Ans. (d)

Hint: $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$

$m\frac{d\bar{v}}{dt} = 2t\hat{i} + 3t^2\hat{j}$

$\int_0^{\bar{v}} d\bar{v} = \int_0^t (2t\hat{i} + 3t^2\hat{j})dt = t^2\hat{i} + t^3\hat{j}$

Power $= \bar{F}.\bar{V} = (2t^3 + 3t^5)W$

S20. Ans. (c)

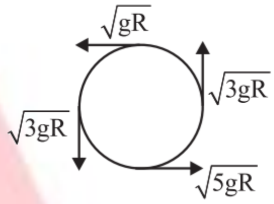
Hint: The potential energy gets converted into heat and only one quarter of it is absorbed by ice.

$\frac{mgh}{4} = mL$

$h = \frac{4L}{g} = \frac{4 \times 3.4 \times 10^5}{10} = 136$ km

S21. Ans. (d)

Hint: Minimum velocity required at different points to complete full vertical circle



S22. Ans. (a)

Hint: $\frac{1}{2}mv^2 = E \rightarrow \frac{1}{2}\left(\frac{10}{1000}\right)v^2 = 8 \times 10^{-4}$

$v^2 = (8 \times 10^{-4})200 = \frac{16}{100}\ ms^{-1}$

$v = \frac{4}{10}\ ms^{-1}$

Now applying $v^2 - u^2 = 2as$

$\left(\frac{4}{10}\right)^2 = 2a(4\pi R); [s = 4\pi R = 2\ (2\pi R)]$

$\frac{16}{100} = 2a\left(4\pi\frac{6.4}{100}\right)$

$a = \frac{16}{100} \times \left[\frac{7 \times 100}{8 \times 22 \times 6.4}\right] = 0.1\ m/s^2$

S23. Ans. (d)

Hint: P = Fv = mav

$\Rightarrow k = m\frac{dv}{dt}$

By integrating the equation

$\Rightarrow \int vdv = \int \frac{k}{m}dt$

$\Rightarrow \frac{v^2}{2} = \frac{k}{m}t \Rightarrow v = \sqrt{\frac{2kt}{m}}$

$a = \frac{dv}{dt} = \sqrt{\frac{2k}{m}}\left(\frac{1}{2}t^{\frac{-1}{2}}\right)$

$F = ma = m\left(\frac{1}{2}\right)\sqrt{\frac{2k}{m}} \Rightarrow F = \sqrt{\frac{mk}{2t}} = \sqrt{\frac{mk}{2}}t^{\frac{-1}{2}}$

S24. Ans. (b)

Hint: Given $K_P > K_Q$

Case (a) : $x_1 = x_2 = x$

$\frac{W_P}{W_Q} = \frac{\frac{1}{2}K_P x^2}{\frac{1}{2}K_Q x^2} = \frac{K_P}{K_Q} \Rightarrow W_P > W_Q$

Case (b): $F_1 = F_2 = F$

For constant force

$W = \frac{F^2}{2K} \Rightarrow W \propto \frac{1}{K}$

So, $\frac{W_P}{W_Q} = \frac{K_Q}{K_P} \Rightarrow W_Q > W_P$

S25. Ans. (d)

F = -0.1 x J/m

According to Work Energy theorem Work done by all force = $K_f - K_i$

$\int F.dx = K_f - K_i$

$\int_{20}^{30} -0.1x\,dx = K_f - \frac{1}{2} \times mu^2$

$(-)0.1\left[\frac{x^2}{2}\right]_{20}^{30} = K_f - \frac{1}{2} \times 10 \times 10^2$

$\frac{1}{10\times 2}[x^2]_{30}^{20} = K_f - 500$

Limit inverse to make –ve to positive

$\frac{1}{20} \times [400 - 900] = K_f - 500$

$-\frac{500}{20} = K_f - 500$

$K_f = 500 - 25 = 475J$

S26. Ans. (b)

Hint: Energy will always be conserved so

$K.E._{initial} = K.E._{final}$ + Excitation energy

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \varepsilon$

S27. Ans. (b)

Hint: Pressure = 150 mm Hg

Pumping rate = $\frac{dV}{dt} = \frac{5\times10^{-3}}{60} m^3/s$

Power of heart = $P.\frac{dV}{dt} = \rho gh \times \frac{dV}{dt}$

$= (13.6 \times 10^3 kg/m^3)\ (10) \times (0.15) \times \frac{5\times10^{-3}}{60}$

$= \frac{13.6\times5\times0.15}{6} = = 1.72$ watt

S28. Ans. (b)

Hint: In elastic collision energy of system remains same

$(K.E)_{before\ collision} = (K.E)_{after\ collision}$

Let speed of second body after collision is V

$\frac{1}{2}mv^2 + 0 = \frac{1}{2}m\left(\frac{v}{3}\right)^2 + \frac{1}{2}m(v')^2 \Rightarrow v' = \frac{2\sqrt{2}}{3}v$

S29. Ans. (c)

Hint: Let ball rebounds with speed v so

$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20\ m/s$

Energy just after rebound

$E = \frac{1}{2} \times m \times v^2 = 200\ m$

50% energy loses in collision means just before collision energy is 400 m By using energy conservation

$\frac{1}{2}mv_0^2 + mgh = 400\ m$

$\Rightarrow \frac{1}{2}mv_0^2 + m \times 10 \times 20 = 400\ m$

$\Rightarrow v_0 = 20\ ms^{-1}$

S30. Ans. (b)

Hint:) For two particles to collide, the direction of the relative velocity of one with respect to other should be directed towards the relative position of the other particle

i.e. $\frac{\vec{r}_1 - \vec{r}_2}{|\vec{r}_1 - \vec{r}_2|} \rightarrow$ direction of relative position of 1 w.r.t 2

And $\frac{\vec{v}_2 - \vec{v}_1}{|\vec{v}_2 - \vec{v}_1|} \rightarrow$direction velocity of 2 w.r.t. 1

So for collision of A and B

$\frac{\vec{r}_1 - \vec{r}_2}{|\vec{r}_1 - \vec{r}_2|} = \frac{\vec{v}_2 - \vec{v}_1}{|\vec{v}_2 - \vec{v}_1|}$

S31. Ans. (d)

Hint: $\vec{A}.\vec{B} = 0$

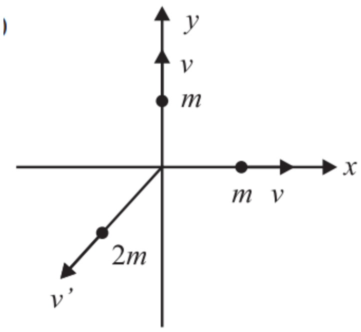
$\cos\omega t \cos\frac{\omega t}{2} + \sin\omega t \sin\frac{\omega t}{2} = 0$

$\cos\left(\omega t - \frac{\omega t}{2}\right) = 0 \Rightarrow \cos\frac{\omega t}{2} = 0$

$\Rightarrow \frac{\omega t}{2} = \frac{\pi}{2} \Rightarrow t = \frac{\pi}{\omega}$

S32. Ans. (b)

Hint:



Let

$\vec{v}'$ be velocity of third piece of mass 2m.

Initial momentum, $\vec{p}_1 = 0$ (As the body is rest)

Final momentum, $\vec{p}_f = mv\hat{i} + mv\hat{j} + 2m\vec{v}'$

According to law of conservation of momentum

$\vec{p}_i = \vec{p}_f$

$= mv\hat{i} + mv\hat{j} + 2m\vec{v}$

$\vec{v}' = -\frac{v}{2}\hat{i} - \frac{v}{2}\hat{j}$

The magnitude of $\vec{v}'$is

$v' = \sqrt{\left(-\frac{v}{2}\right)^2 + \left(-\frac{v}{2}\right)^2} = \frac{v}{\sqrt{2}}$

Total kinetic energy generated due to explosion

$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v^2$

$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)\left(\frac{v}{\sqrt{2}}\right)^2$

$= mv^2 + \frac{mv^2}{2} = \frac{3}{2}mv^2$

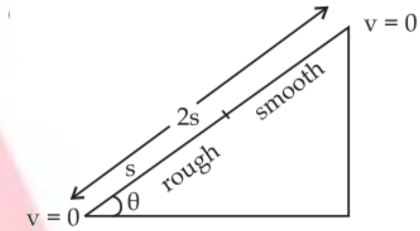
S33. Ans. (b)

Hint: $W = \vec{F}.\vec{S} = (3\hat{i} + \hat{j}).[(4-2)\hat{i} + (3-0)\hat{j} + (-1-1)k]$

$= (3\hat{i} + \hat{j}).(2\hat{i} + 3\hat{j} - 2\hat{k}) \Rightarrow 3(2) + 1(3) + 0(-2) = 9J$

S34. Ans. (d)

Hint:



From Work Energy theorem (W = ΔK.E)

(mg sin θ) (2s) – (μmg cos θ) (s) = 0 – 0

⇒ μ = 2tan θ