1. A body of mass $40kg$ having velocity $4m/s$ collides with another body of mass $60kg$ having velocity $2m/s$. If the collision is inelastic, then loss in kinetic energy will be
(a) 440 J (b) 392 J (c) 48 J (d) 144 J

2. A bullet of mass a is fired with velocity b in a large block of mass c. The final velocity of the system will be
(a) $\frac{c}{a+c}$ (b) $\frac{ab}{a+c}$ (c) $\frac{(a+b)}{c}$ (d) $\frac{(a+c)}{a}b$

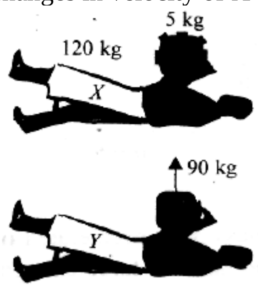
3. A 10 kg object is acted on by a conservative force given by F = - 2x – 6x^2, with F in newtons and x in metres. Take the potential energy associated with the force to be zero when the object is at x = 0. The potential energy of the system at x = 2 m is:
(a) 16 J (b) 20 J (c) 24 J (d) 32 J

4. Consider a system of three particles, each of mass 0.1 kg, which remains always in the same xy – plane. The particles interact among themselves, always in a manner consistant with Newton's third law. The particles A, B and C have positions at various times having equal intervals as given in the table.
(a) Net external force acting on the system is zero.
(b) Net external force acting on the system is 2.0 N.
(c) Net external force acting on the system is 4.6 N.
(d) Information provided is not sufficient to draw the conclusion.

5. A brick of mass 1.8 kg is kept on a spring of spring constant K = 490 N m^{-1}. The spring is compressed so that after the release brick rises to 3.6 m. Find the compression in the spring.
(a) 0.21 m (b) 0.322 m (c) 0.414 m (d) 0.514 m

6. A particle of mass m is moving in a circular path of constant radius r such that radial acceleration $a_r = k^2t^2r$. Find the power delivered to the particle by the forces acting on it.
(a) $2\pi mk^2r^2t$ (b) mk^2r^2t (c) 1/3 $mk^4r^2t^3$ (d) 0

7. A astronauts Mr. X and Mr. Y float in gravity zero space with no relative velocity to one another. Mr. Y throws a mass of 5 kg towards X with speed 2 ms^{-1}. If Mr. X catches it the changes in velocity of X and Y are

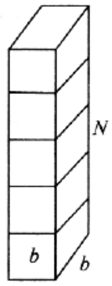


(a) 0.21 ms^{-1}, 0.80 ms^{-1} (b) 0.80 ms^{-1}, 0.21 ms^{-1}
(c) 0.12 ms^{-1}, 0.08 ms^{-1} (d) 0.08 ms^{-1}, 0.12 ms^{-1}

8. A coconut of mass m falls from the tree through a vertical distance of s and could reach ground with a velocity of v ms^{-1} due to air resistance. Work done by air resistance is

(a) - $\frac{m}{2}\left(2gs - v^2\right)$ (b) – $\frac{1}{2}$ mv^2
(c) mgs (d) mv^2 + 2mgs

9. Similar of cubical shape of edge b are lying on ground. Density of material of slab is δ. Work done to arrange then one over the other is



(a) $(N^2 - 1)b^2\rho g$ (b) $(N - 1)b^4\rho g$

(c) $\frac{1}{2}(N^2 - N)b^4\rho g$ (d) $(N^2 - N)b^4\rho g$

10. a 5 kg block is kept on a horizontal platform at rest. at time t = 0, the platform starts moving with a constant acceleration of 1 m/s^2. the coefficient of friction μ between the block and the platform is 0.2. the work done by the force of friction on the block in the fixed reference frame in 10 s is

(a) +250 J (b) -250 J (c) +500 J (d) -500 J

11. A particle of mass $m = 9 \times 10^{-31}$ kg moving towards the wall of a vessel at a velocity of $v = 600\ ms^{-1}$ strikes it at an angle of 60° to the normal and rebounds at the same angle at the same speed. The impulse of the force experienced by the wall during the impact is -

(a) 3×10^{21} N s (b) 9×10^{-28} N s

(c) 5.4×10^{-28} N s (d) 5.4×10^{-27} N s

12. A balloon of mass M is descending at a constant acceleration α. When a mass m is released from the balloon it starts rising with the same acceleration α. Assuming that its volume does not change, what is the value of m?

(a) $\frac{\alpha}{\alpha + g}M$ (b) $\frac{2\alpha}{\alpha + g}M$ (c) $\frac{\alpha + g}{\alpha}M$ (d) $\frac{\alpha + g}{2\alpha}M$

13. A body of mass 3 kg acted upon by a constant force is displaced by S meter, given by relation $S = \frac{1}{3}t^2$, where t is in second. Work done by the force in 2 second is :

(a) $\frac{8}{3}$ J (b) $\frac{19}{5}$ J (c) $\frac{5}{19}$ J (d) $\frac{3}{8}$ J

14. Water falls from a height of 60 m at the ratio of 15 kg/s to operate a turbine. The losses due to frictional forces are 10% of energy. How much power is generated by the turbine ? ($g = 10\ m/s^2$)

(a) 12.3 kW (b) 7.0 kW (c) 8.1 kW (d) 10.2 kW

15. A ball is dropped from a height h on a floor of coefficient of restitution e. The total distance covered by the ball just before second hit is :

(a) $h(1 – 2e^2)$ (b) $h(1 + 2e^2)$ (c) $h(1 + e^2)$ (d) he^2

16. A block is hanged from spring in a cage. Elongation in spring is 'x_1' and 'x_2' when cage moves up and down respectively with same acceleration. The expansion in spring when the cage move horizontally with same acceleration -

(a) $\frac{x_1 + x_2}{2}$ (b) $\sqrt{\frac{x_1^2 - x_2^2}{2}}$ (c) $\sqrt{\frac{x_1^2 + x_2^2}{2}}$ (d) $\sqrt{x_1 x_2}$

17. A hydrogen atom moving at a speed v absorbs a photon of wavelength 122 nm and stops. The value of v is –

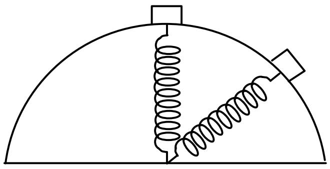
(a) 2.75 m/s (b) 3.25 m/s (c) 4.85 m/s (d) 5.65 m/s

18. The potential energy U for a force field $\vec{F}$ is such that U = – Kxy, where K is a constant -

(a) $\vec{F} = Ky\hat{i} + Kx\hat{j}$ (b) $\vec{F} = Kx\hat{i} + Ky\hat{j}$

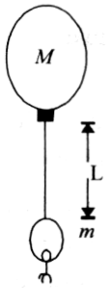
(c) $\vec{F} = Ky\hat{i} - Kx\hat{j}$ (d) $\vec{F} = Kx\hat{i} - Ky\hat{j}$

19. A 10 N block is released from rest at A and slides down along the smooth cylindrical surface. The attached spring has a stiffness, k = 30 Nm^{-1}. If it does not allow the block to leave the surface until θ = 60°, its unstretched length is -



(a) 0.166 m (b) 0.5 m (c) 0.333 m (d) 0.666 m

20. A monkey of mass m and a balloon of mass M are in equilibrium as shown in Fig. If the monkey reaches the top of balloon, by what distance balloon should descend.

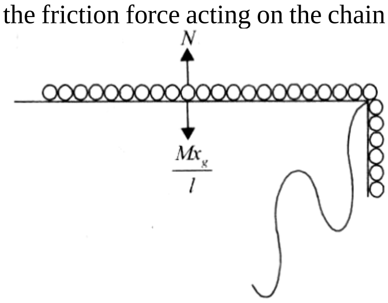


(a) $-\frac{mL}{M}$ (b) $+\frac{mL}{M}$ (c) $-\frac{mL}{M+m}$ (d) $+\frac{mL}{M+m}$

21. A particle of mass m = 5 units is moving with a uniform speed v = $3\sqrt{2}$ m/s in the XOY plane along the line Y = X + 4. The magnitude of the angular momentum about origin is :

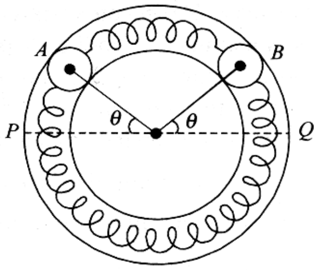
(a) Zero (b) 60 unit (c) 7.5 unit (d) $40\sqrt{2}$ unit

22. A chain of mass m and length l rests on a rough table with part overhanging. The chain starts sliding down by itself if overhanging part is l/3. What will be the work performed by the friction force acting on the chain by the moment it slides completely off the table.



(a) $\frac{Mgl}{3}$ (b) $\frac{2Mgl}{3}$ (c) $\frac{2Mgl}{9}$ (d) $\frac{Mgl}{9}$

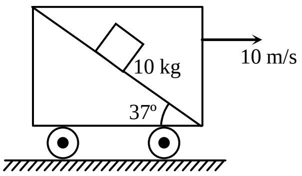
23. Two identical balls A and B of mass m kg are attached to two identical massless springs. The spring mass system is constrained to move inside a rigid pipe bent in the form of a circle as shown in figure. The pipe is fixed in a horizontal plane. The centres of the balls can move in a circle of radius r metre. Each spring has a natural length of rπmetre and spring constant K. Initially, both the balls are displaced by an angle 8 radian with respect to diameter PQ of the circles and released from rest. The speed of ball A when A and B are at the two ends of dia PQ is



(a) $R\theta\sqrt{\frac{m}{K}}$ (b) $2R\theta\sqrt{\frac{K}{m}}$ (c) $2R\theta\sqrt{\frac{m}{K}}$ (d) $R\theta\sqrt{\frac{K}{m}}$

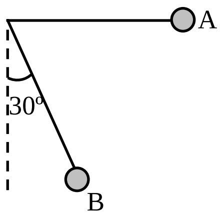
24. A pump motor is used to deliver water at a certain rate from a given pipe. To obtain 'n' times water from the same pipe in the same time the amount by which the power of the motor should be increased –
(a) $n^{1/2}$ (b) n^2 (c) n^3 (d) n

25. A block of mass 10 kg is released on a fixed wedge inside a cart which is moved with constant velocity 10 m/s towards right. Take initial velocity of block with respect to cart, zero. Then work done by normal reaction on block in 2 s from ground frame will be : ($g = 10\ m/s^2$)



(a) 1320 J (b) 960 J (c) 1200 J (d) 240 J

26. A simple pendulum is released from A as shown. If m and ℓ represent the mass of the bob and length of the pendulum, the gain in kinetic energy at B is :



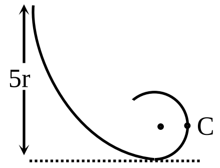
(a) $\frac{mg\ell}{2}$ (b) $\frac{mg\ell}{\sqrt{2}}$ (c) $\frac{\sqrt{3}}{2}mg\ell$ (d) $\frac{2}{\sqrt{3}}mg\ell$

27. Two particles A and B start moving due to their mutual interaction only. If at any time 't', $\vec{a}_A$ and $\vec{a}_B$ are their respective accelerations, $\vec{v}_A$ and $\vec{v}_B$ are their respective velocities and upto that time W_A and W_B are the work done on A and B respectively by the mutual force, m_A and m_B are their masses respectively, then which of the following is always correct -
(a) $\vec{v}_A + \vec{v}_B = 0$ (b) $m_A\vec{v}_A + m_B\vec{v}_B = 0$
(c) $W_A + W_B = 0$ (d) $\vec{a}_A + \vec{a}_B = 0$

28. Assuming that potential energy of spring is zero when it is stretched by 'x_0', its potential energy when it is compressed by '$x_0/2$' is -
(a) $\frac{3}{8}kx_0^2$ (b) $-\frac{3}{4}kx_0^2$ (c) $-\frac{3}{8}kx_0^2$ (d) $\frac{1}{8}kx_0^2$

29. A particle of mass 'm' is subjected to a force $\vec{F} = F_0(\cos t\,\hat{i} + \sin t\,\hat{j})$. If initially (t = 0) the particle is at rest, then K.E. of particle as a function of time is given by -
(a) $\frac{F_0^2}{m}(1 - \cos 2t)$ (b) $\frac{F_0^2}{m}(1 - \cos t)$
(c) $\frac{F_0^2}{m}\sin t$ (d) $\frac{F_0^2}{m}.t$

30. An inclined plane ends into a vertical loop of radius r as shown in figure. If a particle of mass m is released from topmost point. The point C on the track as shown in the figure and centre of circular tack are at same horizontal level. The normal force at point C is -



(a) 8 mg (b) 7 mg (c) 1 mg (d) 3 mg

1. **(c)**

Loss of K.E. in inelastic collision

$$\Delta K = \frac{1}{2}\frac{m_1 m_2}{(m_1 + m_2)}(u_1 - u_2)^2 = \frac{1}{2}\frac{40\times 60}{(40+60)}(4-2)^2$$ J.

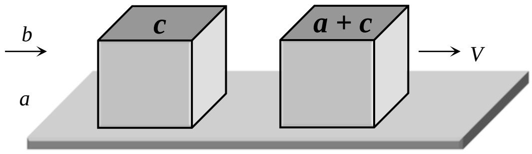
$$= \frac{1}{2}\frac{2400}{100}4 = 48$$

2. **(b)**

Initially bullet moves with velocity b and after collision bullet get embedded in block and both move together with common velocity.

By the conservation of momentum $a \times b + 0 = (a + c) V$

$$\therefore \; V = \frac{ab}{a+c}$$



3. **(b)**

$$U_x = -\int_0^x F.dx = \int_0^x (2x + 6x^2)dx$$

$U_x = x^2 + 2x^3$

at x = 2

U = 4 + 16 = 20 J

4. **(a)**

$$X_{cm} \text{at } t = 0 = \frac{1.1 + 2.1 + 3.1}{1+1+1} = 2\text{m} \;\; Y_{cm} \text{ at } t = 0 = \frac{1.1 + 2.1 + 3.1}{1+1+1} = 2\text{m}$$

Similarly

$$X_{cm} \text{ at } t = 1 = \frac{4}{3}\text{m}$$

$$Y_{cm} \text{ at } t = 1 = \frac{4}{3}\text{m}$$

And X_{cm} at $t = 2 = \frac{2}{3}$m

$$Y_{cm} \text{ at } t = 2 = \frac{2}{3}\text{m}$$

Thus it is obvious that COM is moving along line X = Y and distances between t = 0 to t = 1 to t = 2 are equal.

i.e COM is moving with constant velocity.

Net external force on the system is zero.

5. **(d)**

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

$$x = \sqrt{\frac{2\times 1.8 \times 10 \times 3.6}{490}} = \frac{3.6}{7} = 0.514\text{m}$$

6. **(b)**

$\frac{v^2}{r} = k^2 t^2 r$ or

$v = ktr$ $F = \frac{mdv}{dt} = mkr$ and

Power $P = \vec{F}.\vec{v}$

$P = mkr\,(t\,k\,r) = mk^2r^2t$

7. (d)

Using conservation of momentum,

$(120 + 5)v_x = 5 \times 2$

or $v_x = \frac{10}{125} = 0.08 ms^{-1}$

Also $(90 - 5)v_y = 5 \times 2$

or $v_y = \frac{10}{85} = 0.12\ ms^{-1}$

8. (a)

Work done = Change in K.E.

i.e. $W_g + W_a = \frac{1}{2} mv^2$

where $W_g = mgs$ and W_a is the work done by air resistance

$\therefore W_a = -mgs + \frac{1}{2} mv^2$

$= -\frac{m}{2}(-v^2 + 2gs)$

$= -\frac{m}{2}(2gs - v^2)$

9. (c)

C.G. of first slab = $\frac{b}{2}$

Weight of each stab = volume × density × g = $b^2\rho g$

C.G. of column of slabs

$= \frac{\text{Total height of N slabs}}{2} = \frac{Nb}{2}$

Height of displacement of force

$= \left(\frac{Nb}{2} - \frac{b}{2}\right) = (N-1)\frac{b}{2}$

Work done = $N \times b^2\rho G \times (N - 1)\ \frac{b}{2}$

$= \frac{1}{2}(N^2 - N)b^4\rho g$

10. (a)

Assuming that the block does not slide on the platform

$F_F = MA = 5(1) = 5N$; $N - MG = 0$

$\Rightarrow N = mg = 50\ N$, As $\mu N = 10\ N$, $F_f < \mu N$

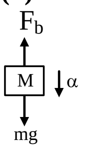
The block will remain at rest relative to the platform. Displacement D relative to the ground = $\frac{1}{2}(1)(10)^2 = 50$ m

$\therefore$ Work of friction $= F_fD \cos 0 = +250$ J, Hence, the correct choice is (A).

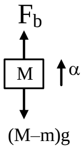
11. (c)

Impulse = change in momentum = 2 mv cosθ

12. (b)



$Mg - F_b = M\alpha$ .....(1)



$F_b - (M-m)\,g = (M-m)\,\alpha$ ....(2)

Solving equation (1) and (2), we get $m = \dfrac{2\alpha}{\alpha + g}M$

13. (a)

$\therefore\ S = t^2/3 \quad \therefore\ v = \dfrac{ds}{dt} = \dfrac{2}{3}t$

at $t = 0$; $v_1 = 0$; $t = 2s$; $v_2 = \dfrac{4}{3}$ m/s

$\therefore\ W = \dfrac{1}{2}m\,(v_2^2 - v_1^2) = \dfrac{1}{2}(3)\left(\dfrac{16}{9} - 0\right) = \dfrac{8}{3}J$

14. (c)

P = dW/dt = d/dt(0.9 mgh)

[∵ 10% loss of energy]

= (0.9)hg dm/dt

= (0.9) (60) (10)·15 = 8100 watt

= 8.1 kw

15. (b)

Distance = $h + e^2h + e^2h = h(1+2e^2)$

16. (c)

$x_1 = \dfrac{m}{k}(g + a)$

$x_2 = \dfrac{m}{k}(g - a)$

$x_3 = \dfrac{m}{k}\sqrt{g^2 + a^2}$

[m = mass of pendulum

k = spring constant]

$\therefore\ x_1^2 + x_2^2 = \dfrac{m^2}{k^2}.2(g^2 + a^2)$

$= 2x_3^2$

$\Rightarrow x_3 = \sqrt{\dfrac{x_1^2 + x_2^2}{2}}$

17. (b)

Linear momenta of photon and electron are equal and opposite.

$p = mv = \frac{h}{\lambda}$

$v = \frac{h}{m\lambda} = \frac{6.62\times10^{-34}}{1.67\times10^{-27}\times122\times10^{-9}}$

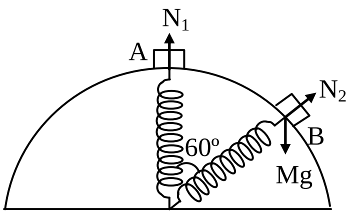
v = 3.25 m/s

18. (a)

$\vec{F} = -\vec{\nabla}U =$

$K(y\hat{i} + x\hat{j})$

19. (c)



$N_1 = mg + kx_1$ ...(1)

$mg\cos 60^0 - N_2 + kx_2 = \frac{mv^2}{R}$

Block will leave surface if $N_2 = 0$

$\frac{mg}{2} + kx_2 = mg\,\frac{v^2}{R}$ ...(2)

Conserving energy at A & B

$\frac{1}{2}mv^2 = mgR(1 - \cos 60^0) = \frac{mgR}{2}$

$v = \sqrt{gR}$

from (2) $x_2 = \frac{mg}{2k} = 0.166$ m

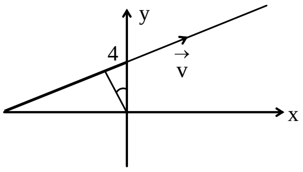
Unstretched length $x_0 = R - x_2$

= 0.5 – 0.166 = 0.333 m

20. (a)

mL + My = 0 or y = - mL/M

21. (b)



$\cos 45^0 = \frac{R}{4}$

$R = 4\,\frac{1}{\sqrt{2}} = 2\sqrt{2}$ m; L = mvR

$= 5 \times 3\sqrt{2} \times 2\sqrt{2} = 60$ unit

22. (d)

$\mu\frac{2}{3}mg = \frac{m}{3}g \text{ or } \mu = \frac{1}{2}$

Assume at any instant the length of the chain on the table is x then force friction = $\mu N = \frac{\mu M}{l} xg$

Work done against friction $\int_0^{2l/3} \mu \frac{M}{l} xg.\, dx$

$= \mu \frac{Mg}{l} \frac{x^2}{2}\Big|_0^{2l/3} = \frac{1}{2}\frac{M}{l}\frac{g}{2}\left(\frac{4l^2}{9}\right) = \frac{Mgl}{9}$

23. (b)

In stretched position of spring.

system P.E. = $2 \times \frac{1}{2} k \times 2x^2 = 4kx^2$

In mean position, both balls have kinetic energy only;

K.E. = $2\left[\frac{1}{2}mv^2\right] = mv^2$

but P.E. = K.E.

$\therefore\ 4Kx^2 = mv^2$

or $v = 2x\sqrt{\frac{K}{m}} = 2R\theta\sqrt{\frac{K}{m}}$

24. (c)

Volume delivered per sec. = Av

mass delivered per sec = Avd

momentum delivered per sec = Av^2d = force

power = force × velocity= Av^3d

i.e. power $\propto v^3$

25. (b)

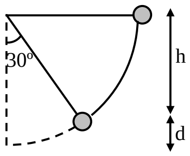
Work done depends upon frame of reference.

26. (c)

$\Delta K + \Delta U = 0$; $(K - 0) + (-mgh) = 0$

$K = mgh = mg(\ell - d)$, and

$d = \ell(1 - \cos 30^0)$



$\therefore\quad K = mg\,\ell \cos 30^0 = \sqrt{3}/2\, mg\ell$

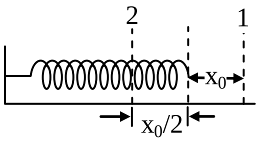
27. (b)

Since $\sum \vec{F}_{ext} = \vec{0}$

$\therefore$ Moment of system will remain conserved, equal to zero.

28. (c)

Change in potential energy is independent of reference



$$\therefore\ U_2 - U_1 = \frac{1}{2}k\left(\frac{x_0}{2}\right)^2 - \frac{1}{2}kx_0^2$$

$$= -\frac{3}{8}kx_0^2$$

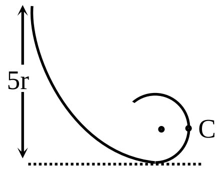
29. (b)

$\vec{a} = \frac{\vec{F}}{m} = \frac{F_0}{m}$ (cos t$\hat{i}$ + sin t$\hat{j}$)

$$\therefore\ \vec{v} = \int_0^t \vec{a}\,dt = \frac{F_0}{m}\{\sin t\,\hat{i} + (1 - \cos t)\hat{j}\}$$

$$\therefore\ K.E. = \frac{1}{2}m\,\vec{v}.\vec{v} = \frac{F_0^2}{m}(1 - \cos t)$$

30. (a)



Apply energy conservation b/w highest point & pt C,

$mg \times 4r = \frac{1}{2}mv^2$

$v = \sqrt{8gr}$

$N = \frac{mv^2}{R}$ at point C

N = 8mg