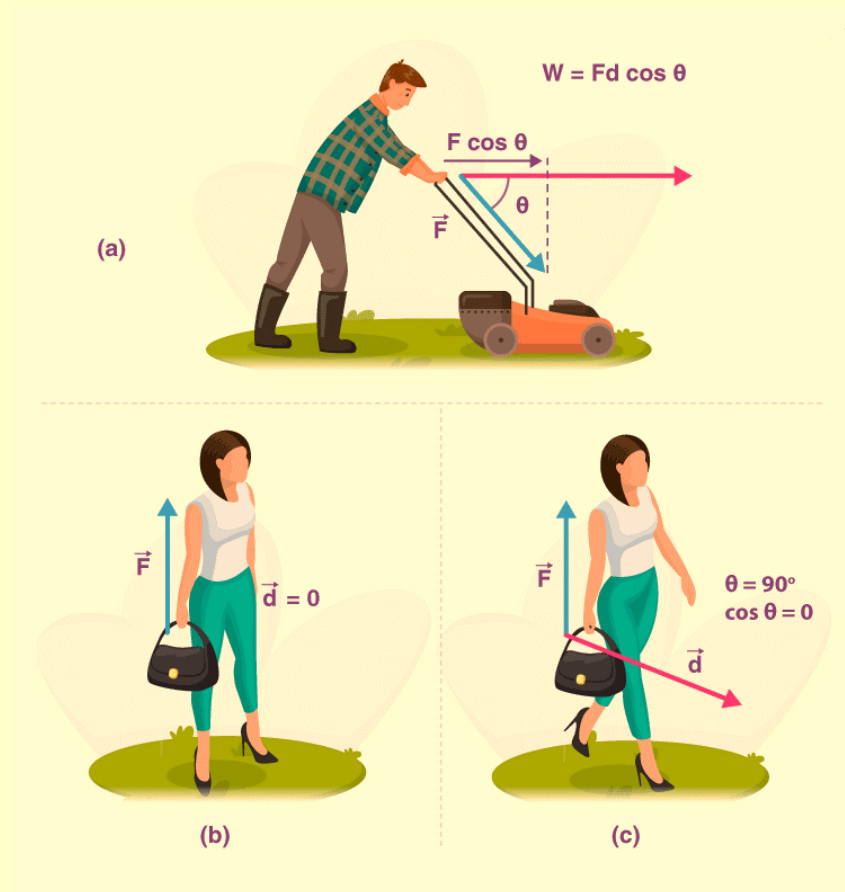
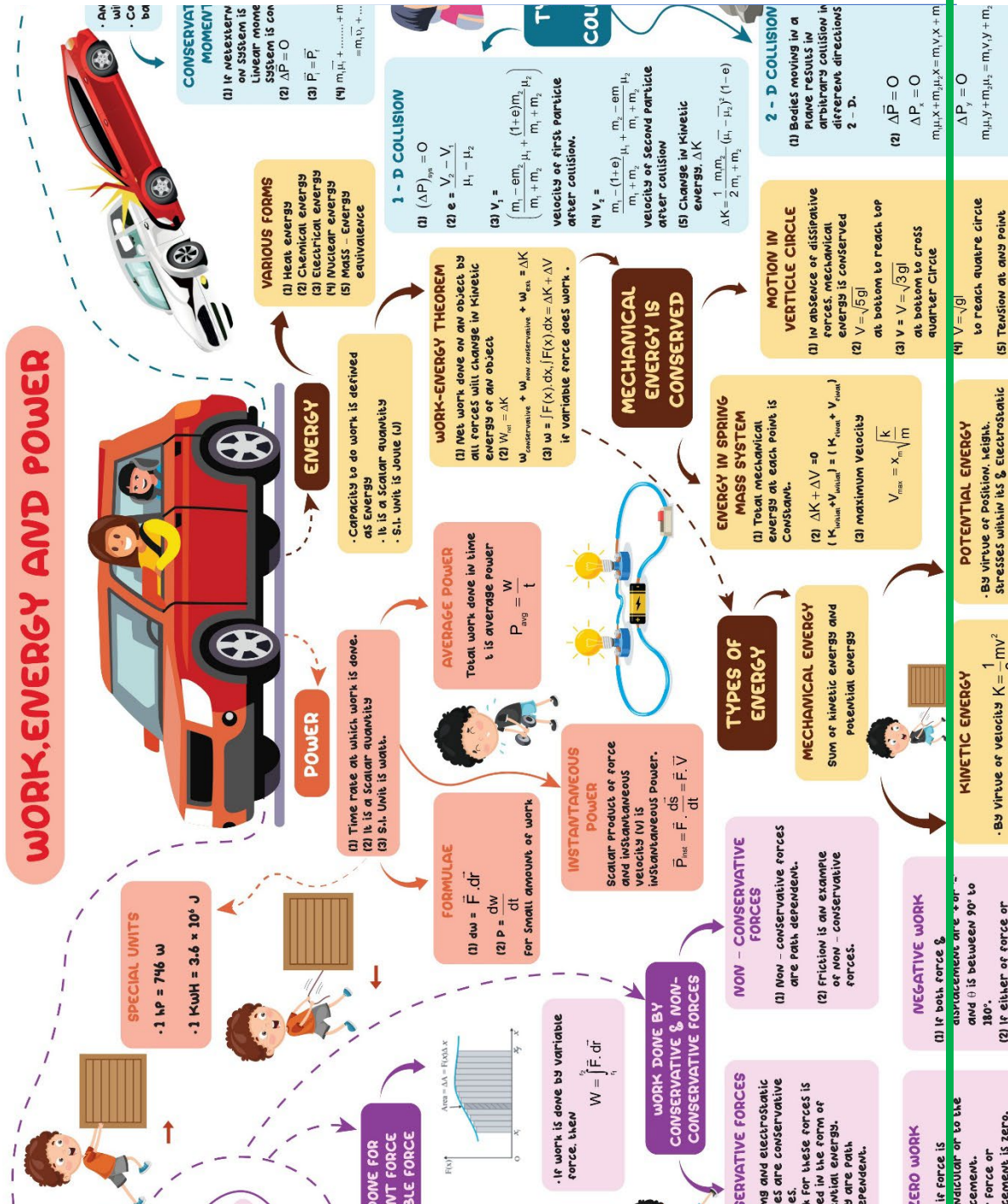


6. Work, Energy and Power



Ramanujan School of Mathematics and Physics
Theory + NCERT MCQs + Topic Wise Practice
MCQs + NEET PYQs



Work, Power and Energy

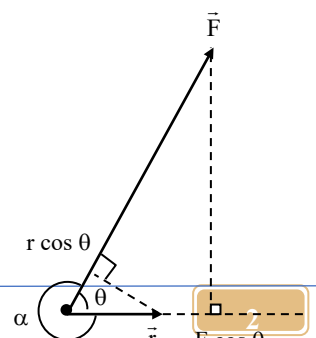
In everyday language and in ordinary sense, the term 'work' is used to denote any type of activity that requires the exertion of muscular or mental effort. In physics, the term 'work' has a precise meaning and an explicit definition. Similarly, the terms 'energy and power' are used in everyday life with different shades of meaning. The aim of this chapter is to understand these three physical quantities and to co-relate them.

Work

- Definition of work:** It is the dot product of force $\vec{F}$ and the displacement $\vec{r}$

$$W = \vec{F} \cdot \vec{r}$$

$$= F \cdot r \cdot \cos \theta = r \cdot F \cos \theta$$

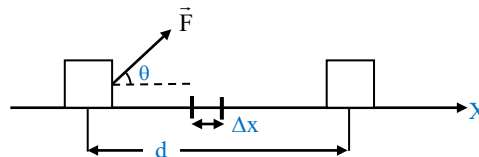


$$= r.F \cos \theta$$

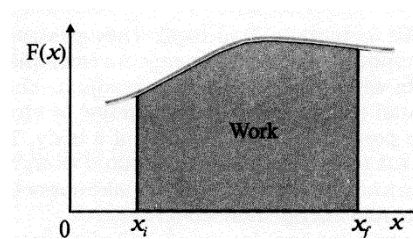
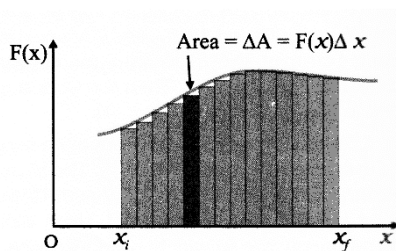
- Work depends not only on the magnitudes of the displacement and the force but also on the angle between them.
- $W = 0$ if $\vec{F} \perp \vec{r}$ i.e. $\theta = 90^\circ$
 $W = Fr$ if $\vec{F}$ is parallel to $\vec{r}$ i.e. $\theta = 0^\circ$
 $W = -Fr$ if $\vec{F}$ is antiparallel to $\vec{r}$ i.e. $\theta = 180^\circ$
- Work is a scalar
- The dimensional formula for work is $[M^1 L^2 T^{-2}]$
- The SI unit of work is the joule (J)
 $1 \text{ J} = 1 \text{ N m}$

Work done by a variable force

Rarely we come across a constant force. It is the variable force, which is more commonly encountered.



An object undergoes a displacement d under the influence of the force $F = F(x)$



$$\text{Work done is } W = \lim_{\Delta x \rightarrow 0} \sum_{x_i}^{x_f} F(x) \Delta x = \int_{x_i}^{x_f} F(x) dx$$

For a varying force the work done can be expressed as a definite integral of force over displacement.

Nature of work done in various situations

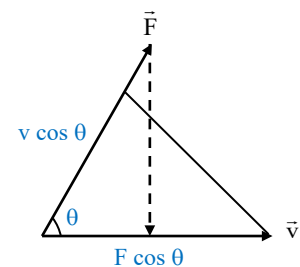
Work done is given by $W = \vec{F} \cdot \vec{s}$

Therefore, work done will be positive, negative or zero depending on whether the angle between $\vec{F}$ or $\vec{s}$ is acute, obtuse or is 90° . Also, the work done is zero, when either $\vec{F}$ or $\vec{s}$ or both $\vec{F}$ and $\vec{s}$ are zero.

Power

It is the time rate of doing work

- Average power $P_{av} = \frac{\Delta W}{\Delta t}$, where $\Delta W \rightarrow$ work done in time Δt
- Instantaneous power, $P = \lim_{\Delta t \rightarrow 0} \frac{\Delta W}{\Delta t} = \frac{dW}{dt}$
- The SI unit of power is watt. $1 \text{ W} = 1 \text{ J s}^{-1}$
- The dimensional formula for power is $[ML^2 T^{-3}]$
- $P = \vec{F} \cdot \vec{v} = Fv \cos \theta$, where $\theta \rightarrow$ angle between $\vec{F}$ and $\vec{v}$
- The FPS unit is the horse power (hp). This unit is still in use.
 The power of an engine is usually quoted in hp.



$$1 \text{ hp} = 746 \text{ W} = 0.746 \text{ kW}$$

Energy

A body capable of doing work is said to have 'energy'. Hence the term energy is defined as the capacity of a body to do work.

[When work is done on a body, it gains energy. When work is done by a body, it loses energy.]

The following points are important about energy.

- Energy is a scalar quantity.
- The unit of energy is same as that of work. In SI, the unit of energy is joule (J)
- Dimensional formula for energy is $[M L^2 T^{-2}]$
- Energy manifests in different forms like mechanical energy, electrical energy, heat energy, sound energy, light energy, etc.
- The energy associated with the motion and position/configuration of a body or a physical system is called mechanical energy.

The mechanical energy is of two types viz.,

1. Kinetic energy 2. Potential energy

Kinetic energy

The energy possessed by a body by virtue of its motion is called kinetic energy.

Example: Energy possessed by a bullet fired from a gun.

Kinetic energy is given by $\frac{1}{2}mv^2$ where m is the mass of a body and v is its velocity.

Kinetic energy – momentum relation is $K = \frac{p^2}{2m}$

Both the kinetic energy K and linear momentum $\vec{p}$ of a particle depend on its velocity $\vec{v}$ and hence related to each other.



Energy is a scalar quantity but momentum $\vec{p}$ is a vector quantity. But $\vec{p} \cdot \vec{p} = p^2$ is a scalar quantity.

Work and kinetic energy (Work energy theorem)

Statement

“The change in kinetic energy of a particle is equal to the work done on it by the net force”.

$$K_f - K_i = W$$

where K_i and K_f are initial and final kinetic energies of the object.

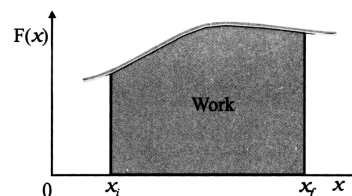
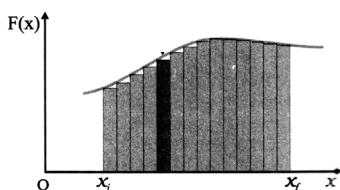


- From the work energy theorem one can note the following points.
When work done on the object is positive, its kinetic energy increases.
When work done on the object is negative, its kinetic energy decreases.

Work energy theorem for a variable force

For a variable force $\vec{F}$ acting on an object moving along x -axis and if K_i and K_f are the initial and final kinetic energies corresponding to x_i and x_f positions then, $K_f - K_i = W$.

$$W = \int_{x_i}^{x_f} F dx$$



Work energy theorem is an integral from of Newton's second law

Conservative and non-conservative force

Conservative Force		Non-Conservative Force
1.	Work done is independent of path	Work done depends on the path
2.	Work done over a closed path is zero.	Work done over a closed path is non-zero
3.	Mechanical energy of the system (KE + PE) is always conserved	Mechanical energy of the system is not conserved
4.	PE can be defined. Eg : Gravitational force, Electrostatic force	PE can not be defined. Eg : Friction, viscous force, Air drag

Potential Energy

It is the energy possessed by a body by virtue of its position or configuration (shape or size).

OR

Potential energy of a system (configuration) may be defined as the amount of work done in bringing the bodies constituting the system to their present locations after having been removed to positions infinite distance apart. Ex: The potential energy of water in dams is used to run turbines in order to produce electric energy from the generators.

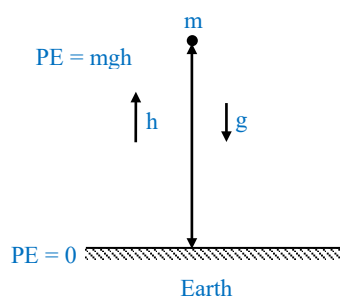
The potential energy of a body may be the **positive** or **negative**.

1. If the force between the two bodies is repulsive in nature (such as between two like charges), then work has to be done by an external agent to bring the two bodies from infinity to their respective locations. Such a system is said to possess **positive potential energy**.
2. In case if the force between the two bodies constituting the system is attractive (such as between two unlike electric charges or between two masses) the two bodies will move at the expense of their own energy. Such a system is said to possess **negative potential energy**.

- Potential energy of an object in Earth's gravitational field

$$U = mgh$$

where m = mass of an object and h = height of an object.



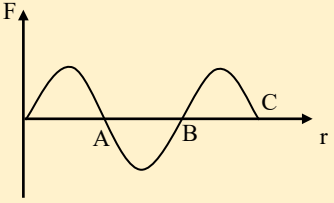
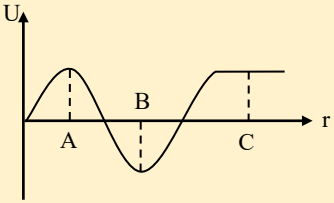
- Potential energy of an isolated object is meaningless.
- Absolute value of potential energy of a configuration cannot be calculated. Only changes in potential energy can be observed and measured.

- Potential energy stored in a spring is $U = \frac{1}{2}kx^2$ where k is the spring constant. x is the displacement

Relation between potential energy (U) and conservative force

- (i) If U is a function of only one variable, then $F = -\frac{dU}{dr} = -\text{slope of } U - r \text{ graph}$

(ii) If U is a function of three coordinate variables x , y and z , then $\vec{F} = -\left[\frac{\partial U}{\partial x}\hat{i} + \frac{\partial U}{\partial y}\hat{j} + \frac{\partial U}{\partial z}\hat{k}\right]$

	Physical situation	Stable equilibrium	Unstable equilibrium	Neutral equilibrium
1.	Net force	Zero	Zero	Zero
2.	Potential energy	Minimum	Maximum	Constant
3.	When displaced from mean (equilibrium) position	A restoring nature of force will act on the body, which brings the body back towards mean position	A force will act which moves the body a way from mean position	Force is again zero
4.	In U - r graph 	At point B	At point A	At point C
5.	In F - r graph 	At point A	At point B	At point C

Conservation of mechanical energy

- “The total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.”
- If some of the forces involved are non-conservative part of the mechanical energy may get transferred to other forms such as heat light, sound etc. However total energy of an isolated system remains same.
- For a freely falling object of mass ‘ m ’ at a height ‘ H ’ above the ground.

Total mechanical energy at A is

$$E_H = mgH + 0$$

at B is

$$E_h = mgh + \frac{1}{2}mv_h^2$$

and at C it is

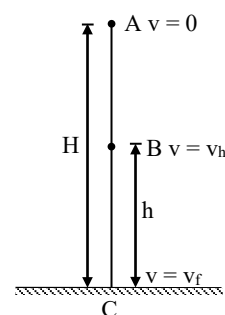
$$E_0 = 0 + \frac{1}{2}mv_f^2$$

Thus at H, energy is purely potential.

It is partially converted to kinetic at h and

It is fully kinetic at ground level.

This illustrates conservation of mechanical energy.



- $v_0 = \sqrt{5gL}$ is the minimum horizontal velocity required at the lowest point, for a particle undergoing circular motion in a vertical plane, to complete the circular motion.

Mass energy equivalence

In 1905, Einstein proved the equivalence of mass and energy. He showed that mass m can be converted into energy E , which is given by

$$E = mc^2 \quad \dots (1)$$

c = velocity of light in air/vacuum = $2.99 \times 10^8 \text{ ms}^{-1}$

This equation is known as Einstein's formula of mass energy equivalence.

Collisions

- A process in which transfer of momentum and kinetic energy happens between bodies.

OR

- A collision is a process in which the motion of the interacting particles changes abruptly.

The collision between two bodies are of following three types:

1. **Elastic collision:** Collisions in which both momentum and kinetic energy of the system are conserved, are called *elastic collisions*.

The collision between two bodies and subatomic particles are elastic in nature. In daily life, the collisions between two glass or preferably ivory balls may be taken as elastic collisions.

Characteristics of elastic collisions:

- (i) The momentum, total energy and kinetic energy are conserved.
 - (ii) The mechanical energy is not converted into any other form (sound, heat, light) of energy.
 - (iii) Forces involved during the interaction are of conservative nature.
2. **Inelastic collision:** Collisions in which the momentum of the system is conserved but the kinetic energy is not conserved are called *inelastic collisions*.
Most of the collisions in every day life are inelastic collisions. The kinetic energy lost in an inelastic collision appears in some other form of energy, such as heat, sound, etc.
 3. **Perfectly inelastic collision:** Collisions in which the colliding bodies stick together after the collision and then move with a common velocity are called *perfectly inelastic collision*.

Mud thrown on the wall and sticking to it, a bullet fired into wooden block and remaining embedded in it, are the examples of perfectly inelastic collision. In such collisions, the momentum of the system is conserved, but the loss of kinetic energy is maximum.

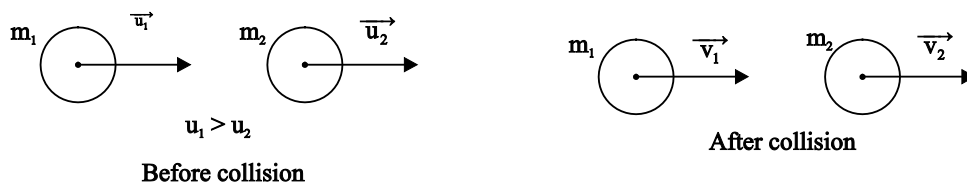
Characteristics of inelastic collisions:

- (i) Momentum and total energy are conserved.
- (ii) The kinetic energy is not conserved.
- (iii) A part or whole of the mechanical energy may be converted into other forms (heat, light sound) of energy.
- (iv) Some or all of the forces involved are non-conservative in nature.

Elastic one dimensional (head – on) collision

If the initial and final velocities of two colliding particles lie along the same straight line, the collision is said to be a one dimensional or head – on collision. If the total kinetic energy of these particles remain same before and after collision, it is said to be elastic head-on collision.

Consider two particles of masses m_1 and m_2 moving with velocities $\vec{u}_1$ and $\vec{u}_2$ ($u_1 > u_2$) along the same direction respectively. When they collide elastically with each other, let them move with velocity $\vec{v}_1$ and $\vec{v}_2$ and along the same direction, after collision as shown in the figure.



It can be shown that $v_1 = \frac{m_1 - m_2}{m_1 + m_2} u_1 + \frac{2m_2 u_2}{m_1 + m_2} \dots(1)$

$$v_2 = \frac{m_2 - m_1}{m_2 + m_1} u_2 + \frac{2m_1 u_1}{m_2 + m_1} \dots(2)$$

Equations (1) and (2) give velocities of m_1 and m_2 after collision. In some special cases, we get the following interesting results.

Case (i): If the two masses are equal, from equation (1) and (2) we get, $v_1 = u_2$ and $v_2 = u_1$

That is, initial velocity of one becomes the final velocity of the other. The objects interchange their velocities. If the second object is initially at rest ($u_2 = 0$), after collision $v_1 = 0$, the first object comes to rest. Also the second object starts moving with the initial velocity of first one.

Case (ii): If a light object m_1 collides with a big object m_2 initially at rest, ($m_1 \ll m_2$, $u_2 = 0$), then

We get from equations (1) and (2) $v_1 = -u_1$, $v_2 = 0$

The lighter object rebounds with almost same speed. The heavier object gets negligible velocity.

Case (iii): If a heavier object in motion collides with a lighter object at rest, ($m_1 \gg m_2$, $u_2 = 0$), then

$$v_1 = u_1, \quad v_2 = 2u_1.$$

That is, the colliding heavier object moves without change in its velocity, whereas the lighter object (which is initially at rest) starts moving with double the initial velocity of the bigger object.



When a lighter object collides with a heavier object at rest, or a heavier object collides with a lighter object at rest, the motion of the heavier object does not alter much. It is the lighter object that experiences a larger change in its motion.

- Loss of energy in a completely inelastic collision in one dimension and is given by $\Delta K = \frac{m_1 m_2}{2(m_1 + m_2)} (u_1 - u_2)^2$, always positive, $\therefore (u_1 - u_2)^2$ where m_1 and m_2 masses are moving with velocities v_1 and v_2 along a straight line.
- In perfect inelastic collision, loss of kinetic energy is maximum when one of the colliding objects is initially at rest. $u_1 \sim u_2$ is maximum.

Coefficient of restitution (e)

The ratio of the velocity of separation to the velocity of approach of the two colliding bodies is defined as the coefficient of restitution $e = \frac{\text{velocity of separation}}{\text{velocity of approach}}$



For inelastic collision, e lies between 0 and 1, i.e., $0 < e < 1$.

Distinction between elastic and inelastic collisions

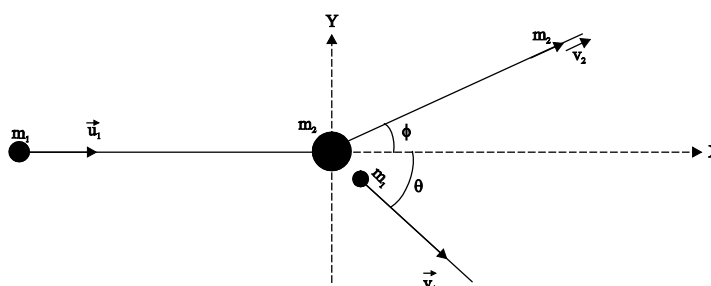
	Elastic collision	Inelastic collision
1.	Linear momentum, kinetic energy and mechanical energy are conserved.	Linear momentum alone is conserved. Kinetic energy and mechanical energy are not conserved.

	P = constant, K = constant, E = constant	However total energy is conserved in both cases. P = constant, K $\neq$ constant, E $\neq$ constant
2.	Colliding particles have different velocities after collision	Particles have same velocity in the case of perfectly inelastic collision. (Particles stick together and move with same velocity)
3.	e = 1 for perfect elastic collision	e = 0 for perfect inelastic collision

Oblique collision (collision in two dimensions)

When two small spherical objects collide, only when their centres of mass lie along a straight line, the collision will be head-on or one dimensional. In all other cases, the velocities before and after collision will not lie in a straight line. However, the velocity vectors lie in a plane. Such collisions are called oblique collisions or two dimensional collisions.

As an example, consider a small object of mass m_1 and moving with velocity u_1 . Let it collide with another object of mass m_2 at rest. After collision, let the velocities of m_1 and m_2 be v_1 and v_2 respectively as shown in the figure.



To find the velocities of the particles after collision, we have to resolve the velocities after collision along two perpendicular directions x and y. Then the law of conservation of momentum is applied separately for x and y directions. If it is an elastic collision, law of conservation of kinetic energy is also used.



Since we have four unknowns v_1 , v_2 , θ and ϕ , we require four independent equations. But here, we get only three equations (two for momenta along x and y directions and one energy equation). If one of the angles or velocity of one of the particles after collision is known, we can find other quantities.

Illustrations

- Three constant forces $\vec{F}_1 = \hat{i} + \hat{j} - 2\hat{k}$, $\vec{F}_2 = 2\hat{i} - 2\hat{j} - 3\hat{k}$ and $\vec{F}_3 = \hat{i} + 2\hat{j} + 4\hat{k}$ in newton displace a particle from $(1, -1, 2)$ to $(-1, -1, 3)$ and then to $(2, 2, 0)$ in metre. The total work done by the forces is
(A) 10 J (B) 9 J (C) 8J (D) 6J

Ans (B)

$$\vec{F}_{\text{net}} = (1 + 2 + 1)\hat{i} + (1 - 2 + 2)\hat{j} + (-2 - 3 + 4)\hat{k} = 4\hat{i} + \hat{j} - \hat{k} \text{ N}$$

$$\text{Resultant displacement, } \vec{S} = \vec{S}_1 + \vec{S}_2 = (2 - 1)\hat{i} + (2 + 1)\hat{j} + (0 - 2)\hat{k}$$

$$\vec{S} = \hat{i} + 3\hat{j} - 2\hat{k}$$

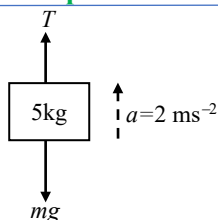
$$\text{Now, work done, } W = \vec{F} \cdot \vec{S} = (4\hat{i} + \hat{j} - \hat{k}) \cdot (\hat{i} + 3\hat{j} - 2\hat{k})$$

$$= 4 + 3 + 2 = 9\text{J}$$

- A block of mass 5 kg is being raised vertically upwards by the help of a string attached to it. It raises with an acceleration of 2 ms^{-2} . The work done by the tension in the string if the block rises by 2.5 m is
(A) 147.5 J (B) 152.7 J (C) 125.5 J (D) 135.5 J

Ans (A)

$$T - mg = ma$$



$$T - 5(9.8) = 5(2) \Rightarrow T = 59 \text{ N}$$

$$S = 2.5 \text{ m}$$

Angle between T and S is $\theta = 0^\circ$

$$\therefore \text{Work done by tension, } W_T = TS \cos 0^\circ = 59 \times 2.5 \times 1 = 147.5 \text{ J}$$

3. A body is thrown on a rough surface such that friction force acting on it is linearly varying with distance travelled by it as $f = ax + b$. The magnitude of work done by the friction on the box if before coming to rest the box travels a distance s is

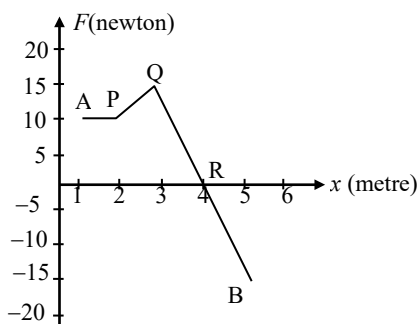
- (A) $as + b$ (B) $\frac{1}{2}as^2 + bs$ (C) $a^2s + b$ (D) none of these

Ans (B)

As the force is acting in the direction opposite to the box motion, work done by this force must be negative. As force is not constant, we use

$$W = -\int_0^s f \cdot dx = -\int_0^s (ax + b) dx = -\left[\frac{ax^2}{2} + bx\right]_0^s = -\left[\frac{1}{2}as^2 + bs\right]$$

4. A body moves on x -axis under the action of a force varying in magnitude as shown in the graph. The work done on the body in moving from A to B is



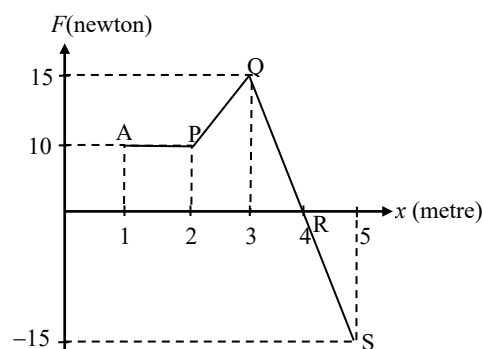
- (A) 27.5 J
(B) 22.5 J
(C) 25 J
(D) 30 J

Ans (B)

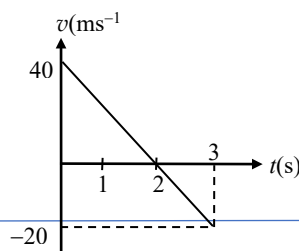
$W = \text{Area under curve}$

$$= 10 \times 1 + \left[1 \times 10 + \frac{1}{2} \times 1 \times 5\right] + \frac{1}{2} \times 1 \times 15 - \frac{1}{2} \times 1 \times 15$$

$$= 10 + 10 + 2.5 + 7.5 - 7.5 = 22.5 \text{ J}$$



5. Velocity-time graph of a particle of mass 3 kg moving in a straight line is shown in the figure. The work done by all the forces acting on the particle in a time $t = 3$ s is



- (A) -1800 J
(B) +1800 J

- (C) +3200 J
(D) -3200 J

Ans (A)

Initial speed, $v_i = 40 \text{ ms}^{-1}$

Final speed, $v_f = 20 \text{ ms}^{-1} \therefore KE_i = \frac{1}{2} \times 3 \times 40^2 = 2400 \text{ J}$

$$KE_f = \frac{1}{2} \times 3 \times 20^2 = 600 \text{ J}$$

$$\Delta KE = 600 - 2400 = -1800 \text{ J}$$

$\therefore$ From work – energy theorem, work done by all forces is $W_{\text{net}} = \Delta KE = -1800 \text{ J}$

6. Two equal masses are attached to the two ends of a spring of spring constant k . The masses are pulled apart symmetrically to stretch the spring by a length x over its natural length. The work done by the spring on each mass is

- (A) $\frac{1}{2}kx^2$ (B) $-\frac{1}{2}kx^2$ (C) $\frac{1}{4}kx^2$ (D) $-\frac{1}{4}kx^2$

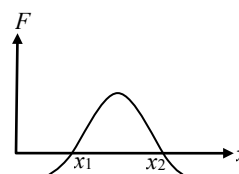
Ans (D)

Work done on both the blocks is same and total work done by spring is $-\frac{1}{2}kx^2$.

Hence work done on each block is $-\frac{1}{4}kx^2$.

7. The force acting on a body moving along x -axis varies with the position of the particle, as shown in the figure. The body is instable equilibrium at

- (A) $x = x_1$
(B) $x = x_2$
(C) both x_1 and x_2
(D) neither x_1 nor x_2



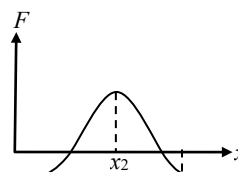
Ans (B)

At x_1 and x_2 , $F = 0$. $\therefore$ Both correspond to equilibrium positions.

At x_2 : If we imagine a slight positive displacement (i.e., towards right), negative force (i.e., restoring) starts acting. Similarly, if we imagine a slight negative displacement (i.e. towards left) positive force (i.e., restoring) comes into picture.

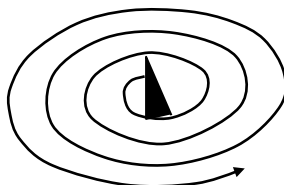
So x_2 corresponds to stable equilibrium.

If we examine at x_1 , restoring force does not act.



8. A cable in the form of a spiral roll (shown in the figure) has a linear density 0.25 kg m^{-1} . It is uncoiled at a uniform speed of 2 ms^{-1} . If the total length of the cable is 15 m , the work done in uncoiling is (neglect friction).

- (A) 15 J
(B) 7.5 J
(C) 30 J
(D) 3.75 J



Ans (B)

v_i , initial speed (i.e., at the start of uncoiling) = 0 ms^{-1}

v_f , final speed (i.e., at the end of uncoiling) = 2 ms^{-1}

$$\text{mass of coil} = 0.25 \times 15 = 3.75 \text{ kg}$$

$$\text{Work done, } W = KE_f - KE_i = \frac{1}{2} \times 3.75 \times 2^2 - 0 = 7.5 \text{ J}$$

9. A smooth sphere of mass 0.5 kg moving with horizontal speed 3 ms^{-1} strikes, at right angles, a vertical wall and bounces off the wall with horizontal speed 2 ms^{-1} . The coefficient of restitution between the sphere and the wall and the impulse exerted on the wall at impact.

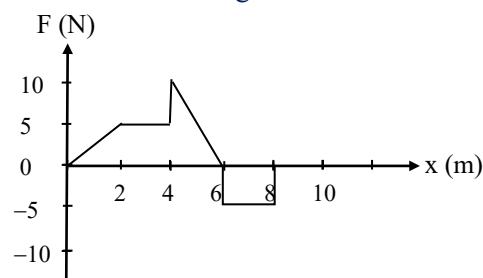
- (A) $\frac{2}{3}, 2.5 \text{ NS}$ (B) $\frac{3}{2}, 1.5 \text{ NS}$ (C) $\frac{2}{3}, 1.5 \text{ NS}$ (D) $\frac{3}{2}, 2.5 \text{ NS}$

Ans (A)

$$e = \frac{v_2 - v_1}{u_1 - u_2} = \frac{0 - (-2)}{3 - 0} = \frac{2}{3}; \quad J = \Delta p = mv - mu = m(v - u) = 0.5(2 + 3) = 2.5 \text{ N}$$

10. Force-position graph for a particle moving along X axis is shown in the figure. The work done by the force in displacing the body from $x = 1 \text{ m}$ to $x = 5 \text{ m}$ is

- (A) 5 J
(B) 10 J
(C) 15 J
(D) 20 J



Ans(B)

Work done = Area under force-displacement curve = 10 J.

Note that, the area above the position axis is positive and that below the position axis is negative.

11. A particle is displaced by a force $\vec{F} = \hat{i} + 2\hat{j} + 3\hat{k}$, from origin to a point P(0, 0, 4). The work done by the force is

- (A) 2 J (B) 7 J (C) 12 J (D) 17 J

Ans (C)

$$W = \vec{F} \cdot \vec{r} = (\hat{i} + 2\hat{j} + 3\hat{k}) \cdot (0\hat{i} + 0\hat{j} + 4\hat{k}) = 12 \text{ J.}$$

12. Work is always done on a body, when

- (A) a force acts on it
(B) it moves through a distance
(C) its momentum changes
(D) it experiences an increase in energy through a mechanical influence

Ans (D)

13. Engine of a car is moving on a straight horizontal road is switched off when its speed is v_0 . If the coefficient of friction between the tyres and the road is μ , the distance travelled by the car before it comes to rest is

- (A) $\frac{v_0^2}{2\mu g}$ (B) $\left(\frac{v_0}{\mu g}\right)^2$ (C) $\frac{v_0}{\mu g}$ (D) $\frac{v_0^2}{\mu g}$

Ans (A)

Work done by friction = change in kinetic energy

$$\mu mgd = \frac{1}{2} mv_0^2 \Rightarrow d = \frac{v_0^2}{2\mu g}$$

14. A plank of thickness x can just stop a bullet, moving with a speed of $\sqrt{3} \text{ m s}^{-1}$. The speed of the bullet that can be just stopped by a plank of thickness $3x$ is

- (A) 3 m s^{-1} (B) 6 m s^{-1} (C) $\sqrt{3} \text{ m s}^{-1}$ (D) 9 m s^{-1}

Ans(A)

Let average resistance offered by plank be F .

$$\therefore Fx = \frac{1}{2}mv^2 = \frac{1}{2}m(C) \quad \dots (1)$$

The speed of the bullet stopped by a plank of thickness $3x$ is given by

$$F(3x) = \frac{1}{2}mv_1^2 \quad \dots (2)$$

From equations (1) and (2), we get $3 \times \frac{3m}{2} = \frac{1}{2}mv_1^2$

$$v_1 = 3 \text{ m s}^{-1}$$

15. A body of mass m accelerates uniformly from rest to gain a velocity v_1 in time t_1 . The instantaneous power developed as a function of time is

(A) $\frac{mv_1 t}{t_1^2}$ (B) $\frac{mv_1^2 t}{t_1}$ (C) $\frac{mv_1 t^2}{t_1}$ (D) $\frac{mv_1^2 t}{t_1^2}$

Ans(D)

From $v = u + at$, $a = (v_1/t_1)$. Instantaneous velocity, $v = at$

$$\text{Instantaneous power, } P = Fv = ma \cdot at = \frac{mv_1^2 t}{t_1^2}.$$

16. If v , P and E denote the velocity, momentum and kinetic energy of the particle, then

(A) $P = \frac{dE}{dv}$ (B) $P = \frac{dE}{dt}$ (C) $P = \frac{dv}{dt}$ (D) $P = \left(\frac{dE}{dv}\right) \times \left(\frac{dv}{dt}\right)$

Ans(A)

$$E = \frac{1}{2}mv^2; \frac{dE}{dv} = mv = P.$$

17. A body is moved along a straight line by a machine delivering constant power. The distance traversed by the body in time t is proportional to

(A) $t^{1/2}$ (B) $t^{3/4}$ (C) $t^{3/2}$ (D) t^2

Ans (C)

$$P = Fv = \frac{m dv}{dt} v \Rightarrow mv \, dv = P \, dt$$

$$\Rightarrow \frac{mv^2}{2} = Pt \Rightarrow v = \frac{dx}{dt} = \sqrt{\frac{2Pt}{m}} \Rightarrow dx = \sqrt{\frac{2P}{m}} \cdot t^{1/2} dt \Rightarrow x = \frac{2}{3} \sqrt{\frac{2P}{m}} t^{3/2}$$

18. A block of mass m slides down a smooth vertical circular track. During the motion the block is

(A) in vertical equilibrium (B) in horizontal equilibrium
(C) in radial equilibrium (D) not in equilibrium

Ans (D)

19. A car covers a distance of 10 km along an inclined plane under the action of a horizontal force of 5N. The work done on car is 25 kJ. The inclination of the plane to horizontal is

(A) 0° (B) 30° (C) 60° (D) 90°

Ans (C)

$$W = FS \cos \theta$$

$$W = (F \cos \theta) \times S$$

$$\cos \theta = \frac{W}{F \times S} = \frac{25 \times 10^3}{5 \times 10^4} = 0.5 \quad \theta = 60^\circ$$

20. A ball of mass 5 kg experiences a force $F = 2x^2 + x$. Work done in displacing the ball by 2 m is

- (A) $\frac{22}{3}$ J (B) $\frac{44}{3}$ J (C) $\frac{32}{3}$ J (D) $\frac{16}{3}$ J

Ans (A)

$$W = \int_0^x F dx = \int_0^x (2x^2 + x) dx = \left[\frac{2x^3}{3} + \frac{x^2}{2} \right]_0^x = \left(\frac{16}{3} + \frac{4}{2} \right) = \frac{22}{3} \text{ J}$$

21. In an elastic collision

- (A) K.E remains constant
 (B) Linear momentum does not remain constant
 (C) Final K.E. = Initial K.E
 (D) Initial linear momentum does not remain constant.

Ans (C)

In a elastic collision, linear momentum remains constant, K.E does not. However, total KE before and after collision is equal.

22. A spring of force constant 800 N/m has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is

- (A) 16 J (B) 8 J (C) 32 J (D) 24 J

Ans (B)

$$W = \frac{1}{2} K (x_2^2 - x_1^2) = \frac{1}{2} \times 800 \times [(15 \times 10^{-2})^2 - (5 \times 10^{-2})^2]$$

$$= 400 \times 200 \times 10^{-4} = 8 \text{ J}$$

23. Energy associated with a kilogram of matter is

- (A) 9×10^3 J (B) 3×10^{16} J (C) 9×10^{16} J (D) 8×10^{15} J

Ans (C)

$$E = mc^2 = 1 \times (3 \times 10^8)^2 = 9 \times 10^{16} \text{ J}$$

24. A mass of 2 kg rests on an incline of 1 : 8. Work done in moving it from bottom to top when coefficient of friction is 0.2 can be

- (A) 52 J (B) 25 J (C) zero (D) 141.5 J

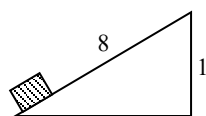
Ans (A)

Here $\cos \theta = 1$

$$\sin \theta = \frac{1}{8}$$

$$W = mg (\sin \theta + \mu \cos \theta) s$$

$$= 2 \times 10 \left(\frac{1}{8} + 0.2 \times 1 \right) 8 = 52 \text{ J}$$



25. A disc of mass M is free to rotate in vertical plane around pivot P. A bullet of mass m fired with velocity v hits the disc and gets sunk in it. Change in momentum is

- (A) $\frac{mv}{2}$ (B) $-\frac{mv}{3}$ (C) $\frac{2}{3}mv$ (D) $\frac{3}{2}mv$

Ans (B)

$$\text{Change in momentum } \Delta P = \frac{2mv}{3} - mv = -\frac{mv}{3}$$

Note: Negative sign shows that direction of impulse is opposite to direction of bullet.

26. A stone tied to a string of length L is whirled in a vertical circle with the other end of string at the centre. At a certain instant of time the stone is at its lowest position and has a speed u . The magnitude of change in velocity as it reaches a position where string is horizontal is

(A) $\sqrt{u^2 - 2gL}$ (B) $\sqrt{2gL}$ (C) $\sqrt{u^2 - gL}$ (D) $\sqrt{2(u^2 - gL)}$

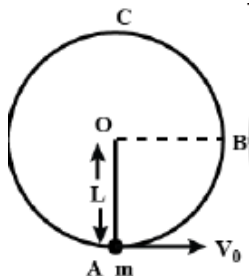
Ans (A)

By the principle of conservation of energy $\frac{1}{2}mv^2 + mgL = \frac{1}{2}mu^2$ or $v = \sqrt{u^2 - 2gL}$

NCERT LINE BY LINE QUESTIONS

- What is the angle between force $\vec{F} = 3\hat{i} + 4\hat{j} - 5\hat{k}$ unit and displacement $\vec{S} = 4\hat{j} + 3\hat{k}$ unit?
[NCERT Pg. 115]
1) $\cos^{-1}\left(\frac{1}{5\sqrt{2}}\right)$ 2) $\cos^{-1}\left(\frac{1}{25\sqrt{2}}\right)$ 3) $\cos^{-1}\left(\frac{1}{5}\right)$ 4) $\cos^{-1}\left(\frac{1}{25}\right)$
- A force $F = 20$ N acts on an object and displaces it from rest to speed of 10 m/s in its direction. What is displacement, if mass of object is 2 kg?
[NCERT Pg. 119]
(1) 6m (2) 5m (3) 12m (4) 10m
- Raindrop is falling downwards under influence of gravity and opposing resistive force. Consider a drop of mass 5.00 g falling from height of 500 m and hits ground with speed of 70 m s⁻¹. What is work done by resistive force?
[NCERT Pg. 136]

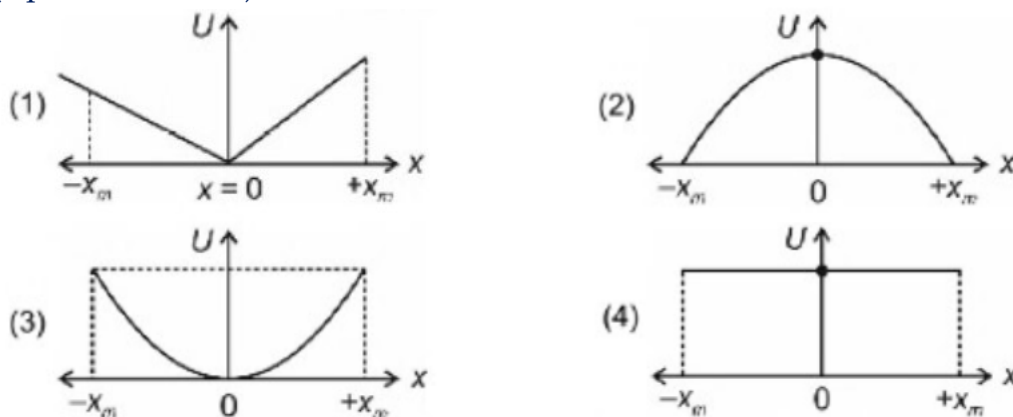
- (1) -7.85 J (2) -9.50 J (3) -12.75 J (4) -13.50 J
4. A cyclist comes to skidding stop in 6 m. During this process the force on cycle due to road is 120 N and is opposing the motion. How much work does road do on cycle?
[NCERT Pg. 117]
- (1) -720 J (2) -420 J (3) 20 J (4) Zero
5. A shooter fires a bullet of mass 50 g with speed of 200 m s^{-1} on softwood of thickness 2 cm. If bullet loses 80% of its kinetic energy and emerges out. What is emergent bullet speed?
[NCERT Pg. 118]
- (1) 89.4 ms^{-1} (2) 69.5 ms^{-1} (3) 100 ms^{-1} (4) 20.0 ms^{-1}
6. A woman pushes a box on railway platform which has rough surface. She applies a force of 20 N over a distance of 5 m thereafter gets tired and applied force which reduces linearly to 10 N with distance. The total distance which box has been moved is 10 m. Work done during second displacement is
- (1) 175 J (2) 19.5 J (3) 75 J (4) 14.65 J
7. A block of mass $m = 1 \text{ kg}$ is moving on horizontal surface with speed of 4 m s^{-1} enters a rough patch ranging from $x = 0.1 \text{ m}$ to $x = 1.6 \text{ m}$. The retarding force in this range is inversely proportional to x
- $$F = -\frac{1}{x} \quad (0.1 < x < 1.6 \text{ m})$$
- What is final kinetic energy of the body?
[NCERT Pg. 120]
- (1) 9.2 J (2) 7.3 J (3) 6.84 J (4) 5.23 J
8. A bob of mass m is suspended by light string of length l . At lowest position it is imparted a horizontal velocity $\sqrt{5gl}$ such that it just completes circular trajectory in vertical circle. What is ratio of its KE at B and C?
[NCERT Pg. 122]



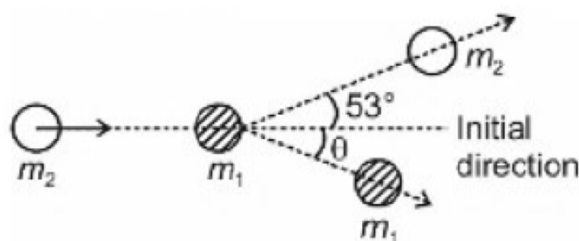
- (1) 2:1 (2) 3:1 (3) 5:3 (4) 3:2
9. The potential energy of a body as a function of distance is given as $U(x) = (-6x^2 + 2x) \text{ J}$. The conservative force acting on body at $x = 1 \text{ m}$ will be
[NCERT Pg. 124]
- (1) 6 N (2) 8 N (3) 10 N (4) 12 N
10. Consider the following statements.
A; Spring force is deformation dependent.
B: Work done by Spring force depends on initial and final deformation.
[NCERT Pg. 124]
- (1) Both statements are true (2) Both statements are false
(3) Only first statement is true (4) Only second statement is true
11. A spring is executing motion about equilibrium position $x = 0$ where we take potential energy of spring to be zero. The spring is oscillating between $-x_m$ and $+x_m$ position with a mass m attached. During motion, maximum speed of spring will be
[NCERT Pg. 124]

1) $2\sqrt{\frac{k}{m}}x_m$ 2) $\sqrt{\frac{k}{m}}x_m$ 3) $\sqrt{\frac{k}{2m}}x_m$ 4) $\sqrt{\frac{k}{m}}\left(\frac{x_m}{2}\right)$

12. The graph between potential energy (U) of a spring versus its position (x) is best shown by graph (equilibrium $x = 0$)



13. Consider a situation in which a car of mass 2000 kg moving with speed of 54 km/h on a smooth road and colliding with a horizontal mounted spring of spring constant $12.5 \times 10^3 \text{ Nm}^{-1}$. What is maximum compression of spring? [NCERT Pg. 124]
 (1) 4m (2) 6 m (3) 8 m (4) 1 m
14. An elevator can carry a maximum load of 900 kg (elevator + passengers) is moving up with constant speed of 2 m s^{-1} . A constant frictional force of 5000 N opposes the motion. What minimum power is delivered by motor (in HP)? [NCERT Pg. 128]
 (1) 37.5 HP (2) 32.5 HP (3) 42.5 HP (4) 50.2 HP
15. Two objects with mass $m_1 = 2 \text{ kg}$ and $m_2 = 3 \text{ kg}$ collides perfect inelastically. The particles were moving with speed of 10 m s^{-1} and zero respectively before collision. The loss of KE on collision is [NCERT Pg. 131]
 (1) 60 J (2) 40 J (3) 100 J (4) 90 J
16. Consider a collision between two identical billiard balls with equal masses $m_1 = m_2 = m$. First ball was at rest and second hits it on edge. Second ball after hitting moves through an angle of 53° to initial direction. Assuming elastic collision, the angle through which first ball moves with initial line after collision is [NCERT Pg. 131]



- (1) 53° (2) 47° (3) 37° (4) 90°
17. In a nuclear reactor, a neutron of high speed 10^4 m s^{-1} collides elastically with a light nuclei of deuterium (at rest). The collision results in loss of KE of neutron. What fraction of KE is lost by neutron? [NCERT Pg. 130]
 1) $\frac{1}{4}$ 2) $\frac{2}{5}$ 3) $\frac{1}{9}$ 4) $\frac{2}{9}$

18. A bullet of mass 12 g and moving with horizontal speed of 100 m s^{-1} strikes a block of wood of mass 348 g and instantly comes to rest with respect to block. The block is suspended from ceiling by means of a thin wire. The height through which block rises is [NCERT Pg. 137]
 (1) 0.55 m (2) 0.88 m (3) 0.77 m (4) 1.22 m
19. The blades of wind mill sweep out a circle of area $A = 2 \text{ m}^2$. The wind is flowing at velocity $v = 6 \text{ m s}^{-1}$ perpendicular to circle, the density of air is 1.2 kg m^{-3} . What is power generated? [NCERT Pg. 137]
 (1) 160.8 W (2) 259.2 W (3) 302.5 W (4) 239.2 W
20. An electron and a proton are detected in cosmic ray experiment. The electron has kinetic energy of 20 keV and proton has 50 keV. The ratio of speed of electron to proton is ($m_e = 9.1 \times 10^{-31} \text{ kg}$, $m_p = 1.67 \times 10^{-27} \text{ kg}$) [NCERT Pg. 136]
 (1) 157 (2) 17.5 (3) 26.6 (4) 4.9

NCERT BASED PRACTICE QUESTIONS

- Which of the following relation show work energy theorem
 (a) $\Delta K = W$ (b) $\Delta U = W$ (c) $\Delta U = -W_c$ (d) None of these
- Which of the following correctly represent work done by a constant force
 (a) $W = \vec{F} \cdot \vec{d}$ (b) $W = \vec{F} \times \vec{d}$ (c) $W = \vec{F} + \vec{d}$ (d) $W = \vec{F} - \vec{d}$
- A stone is whirled in a circle by tiding it at one end of a string. Then work done by the tension in the string is
 (a) Negative (b) Positive (c) zero (d) cannot be said
- Work done by the spring force is
 (a) Positive (b) Negative (c) zero (d) none of these
- A particle have mass m moving with momentum P then kinetic energy of the particle is.
 (a) $P/2m$ (b) $\frac{P^2}{m}$ (c) Pm (d) $\frac{P^2}{2m}$
- Work done by a force is work done under graph
 (a) $F - t$ (b) $F - x$ (c) $F - v$ (d) $a - x$
- A block of mass $m = 1 \text{ kg}$ moving on a horizontal surface with speed $u_i = 2 \text{ m/s}$ enters a rough patch ranging from $x = 0.10 \text{ m}$ to $x = 2.01 \text{ m}$. The retarding force F_r from the block in this range is inversely proportional to x over this region $F_r = \frac{-k}{x}$. $k = 0.5 \text{ J}$ The final kinetic energy of the block? $\log(20.1) = 0.5$
 (a) 1J (b) 0.5 J (c) 1.5 J (d) 2J
- Conservation of mechanical energy is applicable when
 (a) No external force is acting (b) external force is acting
 (c) Friction force is present (d) Always applicable
- Which of the following is correct?
 $W_{\text{external}} + W_{\text{gravitation}} + W_{\text{internal}} =$
 (a) $U_f - U_i$ (b) $K_f - K_i$
 (c) $T \cdot E_f - T \cdot E_i$ (d) all of above

10. Minimum speed required by the particle to complete a vertical circle at the lowest point is
 (a) $\sqrt{3gl}$ (b) $\sqrt{2gl}$ (c) $\sqrt{5gl}$ (d) $\sqrt{gl}$
11. Minimum speed of the particle moving in a vertical circle when string is horizontal to complete the circle is
 (a) $\sqrt{3gl}$ (b) $\sqrt{2gl}$ (c) $\sqrt{5gl}$ (d) $\sqrt{gl}$
12. Total energy of a particle moving in a vertical circle to just complete the circle is
 (a) $\frac{3}{2}mgl$ (b) $\frac{5}{2}mgl$ (c) $\frac{7}{2}mgl$ (d) $\frac{1}{2}mgl$
13. Which of the following is not a conservative force?
 (a) Gravitational force (b) Electrostatic force
 (c) Spring force (d) Frictional force
14. Instantaneous power delivered by the body is
 (a) $P = \vec{F} \cdot \vec{u}$ (b) $P = \frac{w}{t}$ (c) $P = \frac{W_{total}}{t_{total}}$ (d) None of these
15. 1 kwh =
 (a) $3.6 \times 10^5 J$ (b) $3.6 \times 10^4 J$
 (c) $3.6 \times 10^6 J$ (d) $3.6 \times 10^3 J$
16. For completely inelastic collision final velocity of the particles initially moving with velocity V_1 and V_2 is
 (a) $\frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$ (b) $\frac{m_1 v_1}{m_1 + m_2}$
 (c) $\frac{m_2 v_2}{m_1 + m_2}$ (d) $\frac{m_1 v_1 - m_2 v_2}{m_1 + m_2}$
17. Which of the following is correct for perfectly elastic collision?
 (a) $P_i = P_f$ $k_i > k_f$ (b) $P_i > P_f$, $K_i = k_f$
 (c) $P_i = P_f$, $k_i = k_f$ (d) $P_i = P_f$ $k_i < k_f$
18. Which of the following relation is true for perfectly elastic collision?
 (a) Velocity of separation = velocity of approach
 (b) Velocity of separation > velocity of approach
 (c) Velocity of separation < velocity of approach (d) None of these
19. A body of mass 2kg initially at rest moves under the action of an applied horizontal force of 7N on a table with coefficient of kinetic friction = 0.1 work done by the applied force in 10s is
 (a) - 247 J (b) 882 J (c) 605 J (d) 1129J
20. The potential energy function for a particle executing simple harmonic motion is $v(x) = \frac{kx^2}{2}$, $k = 0.5 N/m$. The particle turn back when it reaches $x = \pm 2m$ then total energy of the particle is
 (a) 2J (b) 4 J (c) 1J (d) $\frac{1}{2} J$
21. When a conservative force does positive work on a – The potential energy of the body

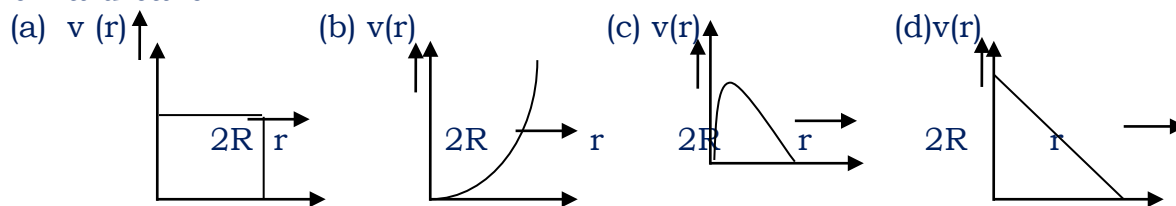
- (a) increases (b) decreases
(c) remain unchanged (d) become zero
22. Work done by a body against frictional always results in a loss of its
(a) kinetic energy (b) potential energy
(c) total energy (d) there is no loss of energy
23. The rate of change of total momentum of a many – particle system is proportional to
(a) internal force (b) external force
(c) gravitation force (d) none of these
24. In an inelastic collision of two bodies, the quantities which do not change after the collision is
(a) Kinetic energy (b) total linear momentum
(c) total energy of the system (d) none of these
25. Which of the following statement is correct?
(a) In an elastic collision of two bodies the total momentum and energy of bodies is conserved
(b) Total energy of the system is always conserved no matter what internal and external forces on the body are present
(c) Work done in the motion of a body over a closed loop is zero for very very force in nature.
(d) In an inelastic collision, the final kinetic energy is always less than the initial kinetic energy of the system
26. A body is initially at rest. It undergoes one – dimensional motion with constant acceleration. The power delivered to it at time t is proportional to
(a) $t^{1/2}$ (b) t (c) $t^{3/2}$ (d) t^2
27. A body is moving unidirectionally under the influence of a source of constant power. Its displacement in time t is proportional to
(a) $t^{1/2}$ (b) t (c) $t^{3/2}$ (d) t^2
28. An electron and a proton are detected in a cosmic ray experiment the first with kinetic energy 10 KeV and the second with 100 KeV. Ratio of their speeds is
(a) 1 (b) 12.5 (c) 13.5 (d) 18.5
29. A pump on the ground floor of a building can pump up water to fill a tank of volume 30m^3 in 15min. If the tank is 40m above the ground and the efficiency of the pump is 30% how much electric power is consumed by the pump?
(a) 40 kw (b) 43.6 w (c) 54 w (d) 43.6 kw
30. A body constrained to move along the z – axis of a coordinate system is subjected to a constant force $\vec{F} = -\hat{i} + 2\hat{j} + 3\hat{k}$. Then work done by this force in moving the body a distance 4m along the y – axis is
(a) - 4J (b) 8 J (c) 12 J (d) 16 J
31. A body of mass 0.5kg travels in a straight line with velocity $v = ax^{3/2}$ where $a = 5 \text{ m}^{-1/2} \text{ s}^{-1}$. Then work done by the net force during its displacement from $x = 0$ to $x = 2\text{m}$ is
(a) 30J (b) 40 J (c) 60J (d) 50J
32. A molecule in a gas container hits a horizontal wall with speed 200m/s and angle 30° with the normal and rebounds with the same speed. Then collision of the particle is
(a) Perfectly elastic (b) Perfectly inelastic
(c) partially inelastic (d) can not be said
33. Two identical ball bearings in contact with each other and resting on a frictionless table are hit head on by another ball bearing of the same mass moving initially with a

speed V . If the collision is elastic which of the following is a possible result after collision

- (a) $\begin{matrix} 1 & 2 & 3 \\ O & O & O \\ v=0 & \frac{v}{2} & \end{matrix} \rightarrow$ (b) $\begin{matrix} 1 & 2 & 3 \\ O & O & O \\ v=0 & v & \end{matrix} \rightarrow$ (c) $\begin{matrix} 1 & 2 & 3 \\ O & O & O \\ \frac{v}{3} & & \end{matrix} \rightarrow$ (d) $\begin{matrix} & 2 & 3 \\ & O & O \\ & \frac{v}{3} & \end{matrix} \rightarrow$

34. A family uses 8kw of power. Direct solar energy is incident on the horizontal surface at an average rate of 200w/m². If 20% of this energy can be converted to useful electrical energy how large an area is needed to supply 8kw
 (a) 100m² (b) 400 m² (c) 200 m² (d) 600m²

35. Which of the following potential energy curve represent the elastic collision of two billiard balls



36. A bolt of mass 0.3kg falls from the ceiling of an elevator moving down with an uniform speed of 7m/s. It hits the floor of the elevator (length of elevator = 3m) and does not rebound. Heat produced in this impact is
 (a) 6.42J (b) 4.41 J (c) 8.82J (d) None of these

37. Coefficient of restitution is

- (a) $\frac{\text{velocity of separation}}{\text{Velocity of approach}}$
 (b) velocity of separation x velocity of approach

- (c) $\frac{\text{Velocity of approach}}{\text{Velocity of separation}}$

(d) none of these

38. If a ball is released from a height n . Hits a surface and rebound if coefficient of restitution between ball and surface is 'e' then height attained by the ball after first rebound is

- (a) $\frac{h}{e}$ (b) e^2h (c) $e h$ (d) none of these

39. If a ball hit a surface with velocity v . If coefficient between ball and surface is e then velocity of rebound is

- (a) $e^2 v$ (b) $\frac{v}{e}$ (c) $e v$ (d) none of these

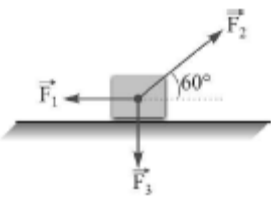
40. If a ball of mass m elastically collide with a ball of same mass resting on the surface the velocity of the ball after collision are v_1 and v_2 then

- (a) $V_1 = V, V_2 = 0$ (b) $V_1 = 0, V_2 = V$
 (c) $V_1 = V, V_2 = V$ (d) None of these

TOPIC WISE PRACTICE QUESTIONS

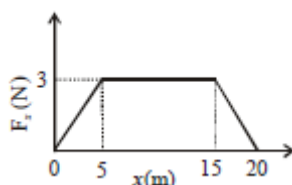
Topic 1: Work

1. A force $\vec{F} = (5\vec{i} + 3\vec{j} + 2\vec{k})$ N is applied over a particle which displaces it from its origin to the point $\vec{r} = (2\vec{i} - \vec{j})$ m. The work done on the particle in joule is
 (1) +10 (2) +7 (3) -7 (4) +13
2. Figure shows three forces applied to a trunk that moves leftward by 3 m over a smooth floor. The force magnitudes are $F_1 = 5$ N, $F_2 = 9$ N, and $F_3 = 3$ N. The net work done on the trunk by the three forces



 (1) 1.50 J (2) 2.40 J (3) 3.00 J (4) 6.00 J
3. A man pushes a wall and fails to displace it. He does
 (1) negative work (2) positive but not maximum work
 (3) no work at all (4) Maximum work
4. Given that a force $\hat{F}$ acts on a body for time t , and displaces the body by $\hat{d}$. In which of the following cases, the speed of the body must not increase?
 (1) $F > d$ (2) $F < d$ (3) $\hat{F} = \hat{d}$ (4) $\hat{F} \perp \hat{d}$
5. A force acts on a 30 gm particle in such a way that the position of the particle as a function of time is given by $x = 3t - 4t^2 + t^3$, where x is in metres and t is in seconds. The work done during the first 4 seconds is
 (1) 576 mJ (2) 450 mJ (3) 490 mJ (4) 530 mJ
6. A particle moving in the xy plane undergoes a displacement of $\vec{s} = (2\hat{i} + 3\hat{j})$ while a constant force $\vec{F} = (5\hat{i} + 2\hat{j})$ acts on the particle. The work done by the force F is
 (1) 17 joule (2) 18 joule (3) 16 joule (4) 15 joule
7. A boy pushes a toy box 2.0 m along the floor by means of a force of 10 N directed downward at an angle of 60° to the horizontal. The work done by the boy is
 (1) 6 J (2) 8 J (3) 10 J (4) 12 J
8. A body moves a distance of 10 m along a straight line under the action of a force of 5 newtons. If the work done is 25 joules, the angle which the force makes with the direction of motion of body is
 (1) 0° (2) 30° (3) 60° (4) 90°
9. If a motorcyclist skids and stops after covering a distance of 15 m. The stopping force acting on the motorcycle by the road is 100 N, then the work done by the motorcycle on the road is
 (1) 1500 J (2) -1500 J (3) 750J (4) Zero
10. A uniform force of $(3\hat{i} + \hat{j})$ newton acts on a particle of mass 2 kg. The particle is displaced from position $(2\hat{i} + \hat{k})$ meter to position $(4\hat{i} + 3\hat{j} - \hat{k})$ meter. The work done by the force on the particle is
 (1) 6 J (2) 13 J (3) 15 J (4) 9 J
11. The position of a particle of mass 4 g, acted upon by a constant force is given by $x = 4t^2 + t$, where x is in metre and t in second. The work done during the first 2 seconds is
 (1) 128 mJ (2) 512 mJ (3) 576 mJ (4) 144 mJ
12. If work done on a system, depends upon initial and final positions only then, it can be due to
 (1) a conservative or non conservative force (2) a conservative force

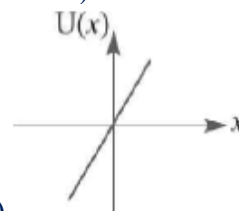
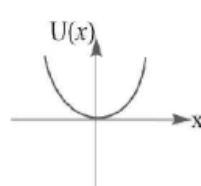
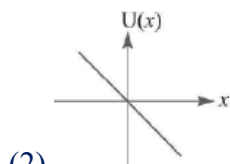
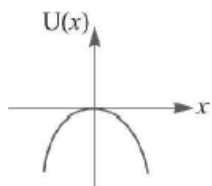
- (3) a non-conservative force (4) None of these
13. A force F_x acts on a particle such that its position x changes as shown in the figure. The work done by the particle as it moves from $x = 0$ to 20 m is



- (1) 37.5 J (2) 10 J (3) 45 J (4) 22.5 J
14. A particle moves from position $\vec{r}_1 = 3\hat{i} + 2\hat{j} - 6\hat{k}$ to position $\vec{r}_2 = 14\hat{i} + 13\hat{j} + 9\hat{k}$ under the action of force $4\hat{i} + \hat{j} + 3\hat{k}$ N. The work done will be
- (1) 100 J (2) 50 J (3) 200 J (4) 75 J
15. A man drags a block through 10 m on rough surface ($\mu = 0.5$). A force of $\sqrt{3}$ kN acting at 30° to the horizontal. The work done by applied force is
- (1) zero (2) 15 kJ (3) 5 kJ (4) 10 kJ
16. A spring of spring constant 5×10^3 N/m is stretched initially by 5 cm from the unstretched position. Then the work required to stretch it further by another 5 cm is
- (1) 18.75 J (2) 25.00 J (3) 6.25 J (4) 12.50 J

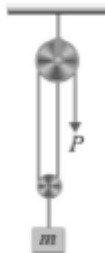
Topic 2: Energy

17. One man takes 1 min. to raise a box to a height of 1 metre and another man takes 1/2 min. to do so. The energy of the
- (1) two is different (2) two is same (3) first is more (4) second is more
18. A metallic wire of length L metre extends by 1 metre when stretched by suspending a weight Mg from it. The mechanical energy stored in the wire is
- (1) $2Mg\ell$ (2) $Mg\ell$ (3) $\frac{Mg\ell}{2}$ (4) $\frac{Mg\ell}{4}$
19. If the momentum of a body is increased by 50%, then the percentage increase in its kinetic energy is
- (1) 50% (2) 100% (3) 125% (4) 200%
20. A particle is placed at the origin and a force $F = kx$ is acting on it (where k is positive constant). If $U(0) = 0$, the graph of $U(x)$ versus x will be (where U is the potential energy function) :



- (1) (2) (3) (4)
21. A ball is allowed to fall from a height of 10 m. If there is 40% loss of energy due to impact, then after one impact ball will go up to
- (1) 10 m (2) 8 m (3) 4 m (4) 6 m
22. A body accelerates uniformly from rest to a velocity of 1 ms^{-1} in 15 seconds. The kinetic energy of the body will be $\frac{2}{9}$ J when 't' is equal to [Take mass of body as 1 kg]
- (1) 4s (2) 8s (3) 10s (4) 12s
23. The potential energy of a conservative system is given by $U = ay^2 - by$, where y represents the position of the particle and a as well as b are constants. What is the force acting on the system ?
- (1) $-ay$ (2) $-by$ (3) $2ay - b$ (4) $b - 2ay$
24. The kinetic energy of particle moving along a circle of radius R depends upon the distance covered S and is given by $K = aS$ where a is a constant. Then the force acting on the particle is

- (1) $\frac{aS}{R}$ (2) $\frac{2(aS)^2}{R}$ (3) $\frac{aS^2}{R^2}$ (4) $\frac{2aS}{R}$
25. A body starts from rest and acquires a velocity V in time T . The work done on the body in time t will be proportional to
- (1) $\frac{V}{T}t$ (2) $\frac{V^2}{T}t^2$ (3) $\frac{V^2}{T^2}t$ (4) $\frac{V^2}{T^2}t^2$
26. A spring of unstretched length l has a mass m with one end fixed to a rigid support. Assuming spring to be made of a uniform wire, the kinetic energy possessed by it if its free end is pulled with uniform velocity v is:
- (1) $\frac{1}{2}mv^2$ (2) mv^2 (3) $\frac{1}{3}mv^2$ (4) $\frac{1}{6}mv^2$
27. Two springs of force constants 300 N/m (Spring A) and 400 N/m (Spring B) are joined together in series. The combination is compressed by 8.75 cm. The ratio of energy stored in A and B is
- (1) $\frac{4}{3}$ (2) $\frac{16}{9}$ (3) $\frac{3}{4}$ (4) $\frac{9}{16}$
28. A rubber ball is dropped from a height of 5m on a plane, where the acceleration due to gravity is not yet calculated. On bouncing it rises to 1.8 m. The ball loses its velocity on bouncing by a factor of
- (1) $\frac{16}{25}$ (2) $\frac{2}{5}$ (3) $\frac{3}{5}$ (4) $\frac{9}{25}$
29. A mass of M kg is suspended by a weightless string. The horizontal force that is required to displace it until the string makes an angle of 45° with the initial vertical direction is
- (1) $Mg(\sqrt{2}+1)$ (2) $Mg\sqrt{2}$ (3) $\frac{Mg}{\sqrt{2}}$ (4) $Mg(\sqrt{2}-1)$
30. A body is allowed to fall freely under gravity from a height of 10m. If it loses 25% of its energy due to impact with the ground, then the maximum height it rises after one impact is
- (1) 2.5m (2) 5.0m (3) 7.5m (4) 8.2m
31. The block of mass m is pulling, vertically up with constant speed, by applying force P . The free end of the string is pulled by l meter, the increase in potential energy of the block is :



- (1) $\frac{mgl}{2}$ (2) mgl (3) $2mgl$ (4) $\frac{mgl}{4}$

Topic 3: Power

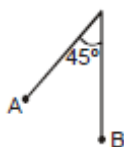
32. Ten litre of water per second is lifted from a well through 10 m and delivered with a velocity of 10 ms^{-1} . If $g = 10 \text{ ms}^{-2}$, then the power of the motor is
- (1) 1 kW (2) 1.5 kW (3) 2 kW (4) 2.5 kW
33. How much water, a pump of 2 kW can raise in one minute to a height of 10 m, take $g = 10 \text{ m/s}^2$?
- (1) 1000 (2) 1200 (3) 100 (4) 2000
34. A body of mass m accelerates uniformly from rest to v_1 in time t_1 . As a function of t , the instantaneous power delivered to the body is

- (1) $\frac{mv_1 t}{t_1^2}$ (2) $\frac{mv_1^2 t}{t_1}$ (3) $\frac{mv_1 t^2}{t_1}$ (4) $\frac{mv_1^2 t}{t_1^2}$
35. Johnny and his sister Jane race up a hill. Johnny weighs twice as much as Jane and takes twice as long as Jane to reach the top. Compared to Jane
 (1) Johnny did more work and delivered more power.
 (2) Johnny did more work and delivered the same amount of power.
 (3) Johnny did more work and delivered less power
 (4) Johnny did less work and delivered less power.
36. If a force F is applied on a body and it moves with a velocity v , the power will be
 (1) $F \times v$ (2) F/v (3) F/v^2 (4) $F \times v^2$
37. An electric motor exerts a force of 40 N on a cable and pulls it by a distance of 30 m in one minute. The power supplied by the motor (in watt) is
 (1) 20 (2) 200 (3) 2 (4) 10
38. An engine pumps water continuously through a hose. Water leaves the hose with a velocity v and m is the mass per unit length of the water jet. What is the rate at which kinetic energy is imparted to water?
 (1) mv^2 (2) $\frac{1}{2} mv^2$ (3) $\frac{1}{2} m^2 v^2$ (4) $\frac{1}{2} mv^3$
39. If two persons A and B take 2 seconds and 4 seconds respectively to lift an object to the same height h , then the ratio of their powers is
 (1) 1 : 2 (2) 1 : 1 (3) 2 : 1 (4) 1 : 3
40. A body of mass 10 kg moves with a velocity v of 2 m/s along a circular path of radius 8 m. The power produced by the body will be
 (1) 10 J/s (2) 98 J/s (3) 49 J/s (4) zero
41. An engineer claims to have made an engine delivering 10kW power with fuel consumption of 1 g/s. The calorific value of fuel is 2 kcal/g. This claim is
 (1) valid (2) invalid (3) depends on engine design (4) dependent on load
42. A body projected vertically from the earth reaches a height equal to earth's radius before returning to the earth. The power exerted by the gravitational force is greatest
 (1) at the highest position of the body (2) at the instant just before the body hits the earth
 (3) it remains constant all through (4) at the instant just after the body is projected
43. A 10 m long iron chain of linear mass density 0.8 kg m^{-1} is hanging freely from a rigid support. If $g = 10 \text{ ms}^{-2}$, then the power required to lift the chain upto the point of support in 10 second
 (1) 10 W (2) 20W (3) 30 W (4) 40 W
44. A force of $2\hat{i} + 3\hat{j} + 4\hat{k}$ N acts on a body for 4 second, produces a displacement of $(3\hat{i} + 4\hat{j} + 5\hat{k})$ m. The power used is
 (1) 9.5 W (2) 7.5 W (3) 6.5 W (4) 4.5 W
45. An elevator of total mass (elevator + passenger) 1800 kg is moving up with a constant speed of 2 m/s. A friction of 4000 N opposes its motion. Determine the approximate power delivered by the motor to the elevator ($g = 10 \text{ m/s}^2$)
 (1) 59 hp (2) 22 hp (3) 34 hp (4) 44 hp
46. A car of mass m is driven with acceleration a along a straight level road against a constant external resistive force R . When the velocity of the car is v , the rate at which the engine of the car is doing work will be
 (1) Rv (2) $ma v$ (3) $(R + ma)v$ (4) $(ma - R)v$
47. An engine is hauling a train of mass M kg on a level track at a constant speed v m/s. The resistance due to friction is f N/kg. What extra power must the engine develop to maintain the speed up a gradient of h in s
 (1) $\frac{Mghv}{s}$ (2) $\frac{Mghs}{v}$ (3) $Mghvs$ (4) zero
48. An automobile moves under the action of a constant power supplied by its engine, it follows that
 (1) The driving force and velocity, both are constant

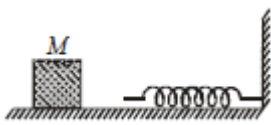
- (2) The driving force is constant but not the velocity
 (3) The velocity is constant but not the driving force
 (4) Both driving force as well as velocity vary
49. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of energy. How much power is generated by the turbine? ($g = 10 \text{ m/s}^2$)
 (1) 0.9 kW (2) 0.4 kW (3) 0.3 kW (4) 0.6 kW
50. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude r_0 . The instantaneous velocity of this car is proportional of
 (1) t^2 (2) $t^{1/2}$ (3) $t^{-1/2}$ (4) $\frac{t}{\sqrt{m}}$
51. If a machine gun fires n bullets per second each with kinetic energy K , then the power of the machine gun is
 (1) nK^2 (2) $\frac{K}{n}$ (3) $n^2 K$ (4) nK

Topic 4: Collisions

52. A body of mass m moving with velocity v makes a head on elastic collision with another body of mass $2m$ which is initially at rest. The loss of kinetic energy of the colliding body (mass m) is
 (1) $\frac{1}{2}$ of its initial kinetic energy (2) $\frac{1}{9}$ of its initial kinetic energy
 (3) $\frac{8}{9}$ of its initial kinetic energy (4) $\frac{1}{4}$ of its initial kinetic energy
53. Two solid rubber balls A and B having masses 200 & 400 gm respectively are moving in opposite direction with velocity of A equal to 0.3 m/sec. After collision the two balls come to rest when the velocity of B is
 (1) 0.15 m/sec (2) 1.5 m/sec (3) -0.15 m/sec (4) None of these
54. A body of mass m moving with velocity 3 km/h collides with a body of mass 2 m at rest. Now the coalesced mass starts to move with a velocity
 (1) 1 km/h (2) 2 km/h (3) 3 km/h (4) 4 km/h
55. The bob A of a simple pendulum is released when the string makes an angle of 45° with the vertical. It hits another bob B of the same material and same mass kept at rest on the table. If the collision is elastic

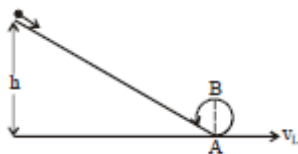


- (1) both A and B rise to the same height (2) both A and B come to rest at B
 (3) both A and B move with the velocity of A (4) A comes to rest and B moves with the velocity of A
56. A sphere of mass $8m$ collides elastically (in one dimension) with a block of mass $2m$. If the initial energy of sphere is E . What is the final energy of sphere?
 (1) 0.8 E (2) 0.36 E (3) 0.08 E (4) 0.64 E
57. Hail storms are observed to strike the surface of the frozen lake at 300 with the vertical and rebound at 600 with the vertical. Assume contact to be smooth, the coefficient of restitution is
 (1) $e = \frac{1}{\sqrt{3}}$ (2) $e = \frac{1}{3}$ (3) $e = \sqrt{3}$ (4) $e = 3$
58. A mass m moving horizontally (along the x-axis) with velocity v collides and sticks to mass of $3m$ moving vertically upward (along the y-axis) with velocity $2v$. The final velocity of the combination is
 (1) $\frac{1}{4} v\hat{i} + \frac{3}{2} v\hat{j}$ (2) $\frac{1}{3} v\hat{i} + \frac{2}{3} v\hat{j}$ (3) $\frac{2}{3} v\hat{i} + \frac{1}{3} v\hat{j}$ (4) $\frac{3}{4} v\hat{i} + \frac{1}{4} v\hat{j}$
59. A body of mass m moving with a constant velocity v hits another body of the same mass moving with the same velocity v but in the opposite direction and sticks to it. Velocity of the compound body after collision is

- (1) v (2) $2v$ (3) zero (4) $v/2$
60. The block of mass M moving on the frictionless horizontal surface collides with the spring of spring constant k and compresses it by length L . The maximum momentum of the block after collision is
- 
- (1) $\frac{kL^2}{2M}$ (2) $\sqrt{Mk} L$ (3) $\frac{ML^2}{k}$ (4) zero
61. Two particles having the position $\vec{r}_1 = (3\hat{i} + 5\hat{j})\text{ m}$ and $\vec{r}_2 = (-5\hat{i} - 3\hat{j})\text{ m}$ move with velocities $\vec{V}_1 = (4\hat{i} + 3\hat{j})\text{ m/s}$ and $\vec{V}_2 = (a\hat{i} + 7\hat{j})\text{ m/s}$. If the particles collide, then value of a must be
- (1) 8 (2) 6 (3) 4 (4) 2
62. A mass of 20 kg moving with a speed of 10 m/s collides with another stationary mass of 5 kg. As a result of the collision, the two masses stick together. The kinetic energy of the composite mass will be
- (1) 600 (2) 800 (3) 1000 (4) 1200
63. An object of mass 2.0 kg makes an elastic collision with another object of mass M at rest and continues to move in the original direction but with one-fourth of its original speed. What is the value of M ?
- (1) 0.75 kg (2) 1.0 kg (3) 1.2 kg (4) None of these
64. A bullet of mass 20 g and moving with 600 m/s collides with a block of mass 4 kg hanging with the string. What is velocity of bullet when it comes out of block, if block rises to height 0.2 m after collision?
- (1) 200 m/s (2) 150 m/s (3) 400 m/s (4) 300 m/s
65. In case of elastic collision, at the time of impact
- (1) total K.E. of colliding bodies is conserved (2) total K.E. of colliding bodies increases
(3) total K.E. of colliding bodies decreases (4) total momentum of colliding bodies decreases
66. A molecule of mass m of an ideal gas collides with the wall of a vessel with a velocity v and returns back with the same velocity. The change in linear momentum of molecule is
- (1) $2mv$ (2) $4mv$ (3) $8mv$ (4) $10mv$
67. A ball moving with velocity 2 m/s collides head on with another stationary ball of double the mass. If the coefficient of restitution is 0.5, then their velocities (in m/s) after collision will be:
- (1) 0, 1 (2) 1, 1 (3) 1, 0.5 (4) 0, 2
68. Consider the elastic collision of two bodies A and B of equal mass. Initially B is at rest and A moves with velocity v . After the collision
- (1) the body A traces its path back with the same speed
(2) the body A comes to rest and B moves away in the direction of A's approach with the velocity v
(3) both the bodies stick together and are at rest
(4) B moves along with velocity $v/2$ and A retraces its path with velocity $v/2$.
69. A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 ms^{-1} . The kinetic energy of the other mass is
- (1) 324 J (2) 486 J (3) 256 J (4) 524 J
70. A tennis ball is released from height h above ground level. If the ball makes inelastic collision with the ground, to what height will it rise after third collision?
- (1) he^6 (2) e^2h (3) e^3h (4) e^4h

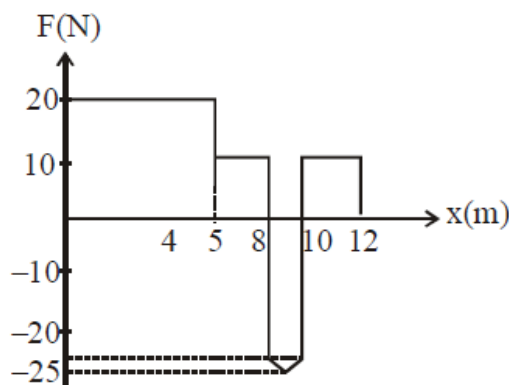
NEET PREVIOUS YEARS QUESTIONS

1. A body initially at rest and sliding along a frictionless track from a height h (as shown in the figure) just completes a vertical circle of diameter $AB = D$. The height h is equal to [2018]



- (1) $\frac{3}{2}D$ (2) D (3) $\frac{5}{4}D$ (4) $\frac{7}{5}D$
2. A moving block having mass m , collides with another stationary block having mass $4m$. The lighter block comes to rest after collision. When the initial velocity of the lighter block is v , then the value of coefficient of restitution (e) will be
[2018]
(1) 0.5 (2) 0.25 (3) 0.4 (4) 0.8
3. Consider a drop of rain water having mass $1g$ falling from a height of 1 km . It hits the ground with a speed of 50 m/s . Take ' g ' constant with a value 10 m/s^2 . The work done by the (i) gravitational force and the (ii) resistive force of air is
[2017]
(1) (i) 1.25 J (ii) -8.25 J (2) (i) 100 J (ii) 8.75 J
(3) (i) 10 J (ii) -8.75 J (4) (i) -10 J (ii) -8.25 J
4. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to $8 \times 10^{-4}\text{ J}$ by the end of the second revolution after the beginning of the motion ?
[2016]
(1) 0.1 m/s^2 (2) 0.15 m/s^2 (3) 0.18 m/s^2 (4) 0.2 m/s^2
5. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F} = (2t\hat{i} + 2t^2\hat{j})\text{ N}$, where $\hat{i}$ and $\hat{j}$ are unit vectors along x and y axis. What power will be developed by the force at the time t ?
[2016]
(1) $(2t^2 + 3t^3)W$ (2) $(2t^2 + 4t^4)W$ (3) $(2t^3 + 3t^4)W$ (4) $(2t^3 + 3t^5)W$
6. A block of mass 10 kg , moving in x direction with a constant speed of 10 ms^{-1} , is subject to a retarding force $F = 0.1 \times J/m$ during its travel from $x = 20\text{ m}$ to 30 m . Its final KE will be:
[2015]
(1) 450 J (2) 275 J (3) 250 J (4) 475 J
7. A ball is thrown vertically downwards from a height of 20 m with an initial velocity v_0 . It collides with the ground loses 50 percent of its energy in collision and rebounds to the same height. The initial velocity v_0 is : (Take $g = 10\text{ ms}^{-2}$)
[2015 RS]
(1) 20 ms^{-1} (2) 28 ms^{-1} (3) 10 ms^{-1} (4) 14 ms^{-1}
8. The heart of man pumps 5 litres of blood through the arteries per minute at a pressure of 150 mm of mercury. If the density of mercury be $13.6 \times 10^3\text{ kg/m}^3$ and $g = 10\text{ m/s}^2$ then the power of heart in watt is:
[2015 RS]
(1) 2.35 (2) 3.0 (3) 1.50 (4) 1.70
9. A body of mass $(4m)$ is lying in x - y plane at rest. It suddenly explodes into three pieces. Two pieces, each of mass (m) move perpendicular to each other with equal speeds (v) . The total kinetic energy generated due to explosion is :
[2014]
(1) mv^2 (2) $\frac{3}{2}mv^2$ (3) $2mv^2$ (4) $4mv^2$
10. Body A of mass $4m$ moving with speed u collides with another body B of mass $2m$, at rest. The collision is head on and elastic in nature. After the collision the fraction of energy lost by the colliding body A is :
[NEET-2019]
(1) $\frac{1}{9}$ (2) $\frac{8}{9}$ (3) $\frac{4}{9}$ (4) $\frac{5}{9}$
11. A mass m is attached to a thin wire and whirled in a vertical circle. The wire is most likely to break when

- (1) the mass is at the highest point (2) the wire is horizontal
 (3) the mass is at the lowest point (4) inclined at an angle of 60° from vertical
12. A force $F = 20 + 10y$ acts on a particle in y-direction where F is in newton and y in meter. Work done by this force to move the particle from $y = 0$ to $y = 1$ m is : [NEET-2019]
 (1) 30 J (2) 5 J (3) 25 J (4) 20 J
13. An object flying in air with velocity $(20\hat{i} + 25\hat{j} - 12\hat{k})$ suddenly breaks in two pieces whose masses are in the ratio 1 : 5. The smaller mass flies off with a velocity $(100\hat{i} + 35\hat{j} + 8\hat{k})$. The velocity of the larger piece will be :- [NEET – 2019 (ODISSA)]
 1) $4\hat{i} + 23\hat{j} - 16\hat{k}$ 2) $-100\hat{i} - 35\hat{j} - 8\hat{k}$ 3) $20\hat{i} + 15\hat{j} - 80\hat{k}$ 4) $-20\hat{i} - 15\hat{j} - 80\hat{k}$
14. A particle of mass 5 m at rest suddenly breaks on its own into three fragments. Two fragments of mass m each move along mutually perpendicular direction with speed v each. The energy released during the process is : [NEET – 2019 (ODISSA)]
 (1) $\frac{3}{5}mv^2$ (2) $\frac{5}{3}mv^2$ (3) $\frac{3}{2}mv^2$ (4) $\frac{4}{3}mv^3$
15. An object of mass 500g, initially at rest acted upon by a variable force, whose X component varies with x in the manner shown. The velocities of the object at point $X = 8$ m and $X = 12$ m, would be the respective values of (nearly) [NEET – 2019 (ODISSA)]



- (1) 18 m/s and 24.4 m/s (2) 23 m/s and 24.4 m/s
 (3) 23 m/s and 20.6 m/s (4) 18 m/s and 20.6 m/s
16. A point mass 'm' is moved in a vertical circle of radius 'r' with the help of a string. The velocity of the mass is $\sqrt{7gr}$ at the lowest point. The tension in the string at the lowest point is NEET-2020(COVID-19)
 (1) 6 mg (2) 7 mg (3) 8 mg (4) 1 mg
17. The energy required to break one bond in DNA is 10^{-20} J. This value in eV is nearly: [NEET-2020]
 1) 0.006 2) 6 3) 0.6 4) 0.06
18. Water falls from a height of 60 m at the rate of 15 kg/s to operate a turbine. The losses due to frictional force are 10% of the input energy. How much power is generated by the turbine? ($g = 10 \text{ m/s}^2$) [NEET-2021]
 1) 8.1 kW 2) 12.3 kW 3) 7.0 kW 4) 10.2 kW
19. A particle is released from height S from the surface of the Earth. At a certain height its kinetic energy is three times its potential energy. The height from the surface of earth and the speed of the particle at that instant are respectively: [NEET-2021]
 1) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$ 2) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$ 3) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$ 4) $\frac{S}{4}, \frac{3gS}{2}$

NCERT LINE BY LINE QUESTIONS – ANSWERS

1) 2	2) 2	3) 3	4) 1	5) 1	6) 3	7) 4	8) 2	9) 3	10) 1
11) 2	12) 3	13) 2	14) 21	15) 1	16) 3	17) 3	18) 1	19) 2	20) 3

NCERT BASED PRACTICE QUESTIONS – ANSWERS

1) a	2) a	3) c	4) b	5) d	6) b	7) b	8) a	9) b	10) c
11) a	12) b	13) d	14) a	15) c	16) a	17) c	18) a	19) b	20) c
21) b	22) a	23) b	24) b	25) a	26) b	27) c	28) c	29) d	30) b
31) d	32) a	33) b	34) c	35) d	36) c	37) a	38) b	39) c	40) b

b

TOPIC WISE PRACTICE QUESTIONS - ANSWERS

1) 2	2) 1	3) 3	4) 4	5) 1	6) 3	7) 3	8) 3	9) 4	10) 4
11) 3	12) 2	13) 3	14) 1	15) 2	16) 1	17) 2	18) 3	19) 3	20) 1
21) 4	22) 3	23) 4	24) 4	25) 4	26) 4	27) 1	28) 2	29) 4	30) 3
31) 1	32) 2	33) 2	34) 4	35) 2	36) 1	37) 1	38) 4	39) 3	40) 4
41) 2	42) 2	43) 4	44) 1	45) 4	46) 3	47) 3	48) 4	49) 1	50) 2
51) 4	52) 3	53) 1	54) 1	55) 4	56) 2	57) 2	58) 1	59) 3	60) 2
61) 1	62) 2	63) 4	64) 1	65) 3	66) 1	67) 1	68) 2	69) 2	70) 1

NEET PREVIOUS YEARS QUESTIONS-ANSWERS

1) 3	2) 2	3) 3	4) 1	5) 4	6) 4	7) 1	8) 4	9) 2	10) 2
11) 3	12) 3	13) 1	14) 4	15) 3	16) 3	17) 4	18) 1	19) 3	

TOPIC WISE PRACTICE QUESTIONS - SOLUTIONS

- (2) $W = \vec{F} \cdot \vec{x} = (5\hat{i} + 3\hat{j} + 2\hat{k}) \cdot (2\hat{i} - \hat{j}) = 10 - 3 = 7 \text{ joules}$
- (1) $\vec{F} = -5\hat{i} + 9 \cos 60^\circ \hat{i} + 9 \sin 60^\circ \hat{j} - 3\hat{j}$
 $= -5\hat{i} + \frac{9}{2}\hat{i} + \frac{9\sqrt{3}}{2}\hat{j} - 3\hat{j} = -\frac{\hat{i}}{2} + \left(\frac{9\sqrt{3}}{2} - 3\right)\hat{j}$
 $\vec{s} = -3\hat{i}$
 $W = \vec{F} \cdot \vec{s} = \left[-\frac{\hat{i}}{2} + \left(\frac{9\sqrt{3}}{2} - 3\right)\hat{j}\right] \cdot (-3\hat{i}) = 1.5J$
- (3) We know work done in displacing the object is equal to the product of the force applied on the object and the distance travelled by it in the direction of force applied. Let us apply this concept to solve the problem.
- (4) Speed will not increase when force is perpendicular to displacement i.e., $\hat{F} \perp \hat{d}$
- (1) $x = 3t - 4t^2 + t^3$
 $\frac{dx}{dt} = 3 - 8t + 3t^2$

$$\text{Acceleration} = \frac{d^2x}{dt^2} = -8 + 6t$$

$$\text{Acceleration after 4 sec} = -8 + 6 \times 4 = 16 \text{ ms}^{-2}$$

$$\text{Displacement in 4 sec} = 3 \times 4 - 4 \times 4^2 + 4^3 = 12 \text{ m}$$

$$\therefore \text{Work} = \text{Force} \times \text{displacement} = \text{Mass} \times \text{acc.} \times \text{disp.}$$

$$= 3 \times 10^{-3} \times 16 \times 12 = 576 \text{ mJ}$$

6. (3) $W = \vec{F} \cdot \vec{s} = (5\hat{i} + 2\hat{j}) \cdot (2\hat{i} + 3\hat{j}) = 10 + 6 = 16 \text{ J}$

7. (3) $W = Fs \cos \theta = 10 \times 2 \cos 60^\circ = 10 \text{ J}$

8. (3) $W = Fs \cos \theta, \cos \theta = \frac{W}{Fs} = \frac{25}{5 \times 10} = \frac{1}{2}, \theta = 60^\circ$

9. (4) Though an equal and opposite force acts on the road but since road does not undergo any displacement, hence no work is done on the road

10. (4) Given : $\vec{F} = 3\hat{i} + \hat{j}$

$$\vec{r}_1 = (2\hat{i} + \hat{k}), \vec{r}_2 = (4\hat{i} + 3\hat{j} - \hat{k})$$

$$\vec{r} = \vec{r}_2 - \vec{r}_1 = (4\hat{i} + 3\hat{j} - \hat{k}) - (2\hat{i} + \hat{k})$$

$$\text{or } \vec{r} = 2\hat{i} + 3\hat{j} - 2\hat{k}$$

$$\text{So work done by the given force } W = \vec{F} \cdot \vec{r}$$

$$= (3\hat{i} + \hat{j}) \cdot (2\hat{i} + 3\hat{j} - 2\hat{k}) = 6 + 3 = 9 \text{ J}$$

11. (3) Here, $m = 4 \times 10^{-3} \text{ kg}$

$$x = 4t^2 + t$$

$$\therefore \frac{dx}{dt} = 8t + 1, \frac{d^2x}{dt^2} = 8$$

$$\text{Work done, } W = \int f dx = \int m \frac{d^2x}{dt^2} \left(\frac{dx}{dt} \right) dt$$

$$= \int_0^2 (4 \times 10^{-3})(8)(8t + 1) dt$$

$$= 32 \times 10^{-3} \int_0^2 (8t + 1) dt = 32 \times 10^{-3} \left[\frac{8t^2}{2} + t \right]_0^2$$

$$= 32 \times 10^{-3} [4(2)^2 + 2 - 0] = 576 \text{ mJ}$$

12. (2) conservative force path independent

13. (3) $W = \text{area of } F - x \text{ graph}$

= area of Δ + area of rectangle + area of Δ

$$= \frac{5 \times 3}{2} + 10 \times 3 + \frac{5 \times 3}{2} = 45 \text{ J}$$

14. (1) $W = \vec{F} \cdot (\vec{r}_2 - \vec{r}_1) = (4\hat{i} + \hat{j} + 3\hat{k}) \cdot (11\hat{i} + 11\hat{j} + 15\hat{k})$

15. (2) Horizontal component of applied force = $(\sqrt{3} \times 10^3) \times \cos 30^\circ$

$$= \sqrt{3} \times 10^3 \times \frac{\sqrt{3}}{2} = \frac{3}{2} \times 10^3 \text{ N}$$

$$\text{Work done} = F \cdot s$$

$$= \frac{3}{2} \times 10^3 \times 10 = 15 \times 10^3 \text{ J} = 15 \text{ kJ}$$

16. (1) $W_1 = \frac{1}{2} \times 5 \times 10^3 (0.05)^2 \Rightarrow W_2 = \frac{1}{2} \times 5 \times 10^3 (0.10)^2$

$$\therefore \Delta W = \frac{1}{2} \times 5 \times 10^3 \times 0.15 \times 0.05 = 18.75 \text{ J}$$

17. (2) Energy required = mgh

In both cases, h is the same. Hence energy both is the same.

18. (3) Weight Mg moves the centre of gravity of the spring through a distance

$$\frac{(0 + \ell)}{2} = \ell / 2$$

$$\therefore \text{Mechanical energy stored} = \text{Work done} = Mg \ell / 2.$$

19. (3) Initial momentum (p_1) = p; Final momentum (p_2) = 1.5 p and initial kinetic energy (K_1) = K.

$$\text{Kinetic energy (K)} = \frac{p^2}{2m} \propto p^2$$

$$\text{or } \frac{K_1}{K_2} = \left(\frac{p_1}{p_2} \right)^2 = \left(\frac{p}{1.5p} \right)^2 = \frac{1}{2.25} \text{ or } K_2 = 2.25K$$

Therefore, increase in kinetic energy is $2.25 K - K = 1.25 K$ or 125%.

20. (1) From $F = -\frac{dU}{dx}$

$$dU = -Fdx$$

$$U = \int_0^{u(x)} dU = -\int_0^x Fdx$$

$$= -\int_0^c kx dx ; U = -\frac{kx^2}{2}$$

As, $U(0) = 0, \alpha x^2$ (where α is a constant) and U are negative.

21. (4) Kinetic energy of ball when reaching the ground = mgh = mg × 10

Kinetic energy after the impact

$$= \frac{60}{100} \times mg \times 10 = 6mg$$

If the ball rises to a height h, then mgh = 6 mg.

Hence, h = 6 m.

22. (3) The uniform acceleration is $a = \frac{1-0}{15} = \frac{1}{15} \text{ ms}^{-2}$

Let v be the velocity at kinetic energy $\frac{2}{9} \text{ J}$

$$\text{therefore } \frac{1}{2} \times 1 \times v^2 = \frac{2}{9} \text{ or } v = \frac{2}{3} \text{ ms}^{-1}$$

Using $v = u + at$

$$\frac{2}{3} = 0 + \frac{1}{15} \times t \Rightarrow t = 10 \text{ s}$$

23. (4) $F = -\frac{dU}{dy} = b - 2ay$

24. (4) Centripetal force = $\frac{mv^2}{R} = \left(\frac{1}{2} mv^2 \right) \frac{2}{R} = \frac{2K}{R} = \frac{2aS}{R}$

25. (4) Work done on the body is gain in the kinetic energy.

Acceleration of the body is $a = V/T$.

$$\text{Velocity acquired in time } t \text{ is } v = at = \frac{V}{T} t$$

K.E. acquired $\propto v^2$. That is work done $\propto \frac{V^2 t^2}{T^2}$

26. (4) Let $= \frac{m}{\ell}$ (linear mass density)

Velocity of dx element and a distance x from rigid support is $v = \frac{vx}{\ell}$

Now mass of thickness (dx) = $\omega dx = dm$

KE of particle of thickness (dx) = $\frac{1}{2} dm v^2$

$$\text{K.E.} = \int_0^L \frac{1}{2} \omega dx \left(\frac{vx}{L} \right)^2 = \frac{1}{2} \frac{m}{L} \frac{v^2}{L^2} \int_0^L x^2 dx = \frac{mv^2}{2L^3} \times \left[\frac{x^3}{3} \right]_0^L = \frac{mv^2}{6}$$

27. (1) Given : $k_A = 300 \text{ N/m}$, $k_B = 400 \text{ N/m}$

Let when the combination of springs is compressed by force F. Spring A is compressed by x. Therefore compression in spring B

$$x_B = (8.75 - x) \text{ cm}$$

$$F = 300 \times x = 400(8.75 - x)$$

Solving we get, $x = 5 \text{ cm}$ $x_B = 8.75 - 5 = 3.75 \text{ cm}$

$$\frac{E_A}{E_B} = \frac{\frac{1}{2} k_A (x_A)^2}{\frac{1}{2} k_B (x_B)^2} = \frac{300 \times (5)^2}{400 \times (3.75)^2} = \frac{4}{3}$$

28. (2) According to principle of conservation of energy

Loss in potential energy = Gain in kinetic energy

$$\Rightarrow mgh = \frac{1}{2} mv^2 \Rightarrow v = \sqrt{2gh}$$

If h_1 and h_2 are initial and final heights, then

$$v_1 = \sqrt{2gh_1}, v_2 = \sqrt{2gh_2}$$

Loss in velocity

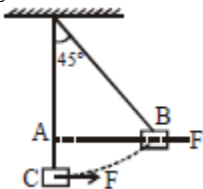
$$\Delta v = v_1 - v_2 = \sqrt{2gh_1} - \sqrt{2gh_2}$$

$\therefore$ Fractional loss in velocity

$$\frac{\Delta v}{v_1} = \frac{\sqrt{2gh_1} - \sqrt{2gh_2}}{\sqrt{2gh_1}} = 1 - \sqrt{\frac{h_2}{h_1}}$$

$$= 1 - \sqrt{\frac{1.8}{5}} = 1 - \sqrt{0.36} = 1 - 0.6 = 0.4 = \frac{2}{5}$$

29. (4) Work done by force (applied) + Work done by gravitational force = change in kinetic energy



$$\Rightarrow F \times AB - Mg AC = 0$$

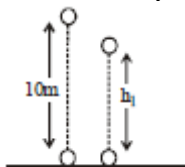
$$\Rightarrow F = Mg \left(\frac{AC}{AB} \right) = MG \left[\frac{1 - \frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{2}}} \right]$$

$$= Mg(\sqrt{2} - 1)$$

30. (3) Just before impact, energy

$$E = mgh = 10mg \text{ .. (1)}$$

Just after impact



$$E_1 = mgh - \frac{25}{100} mgh = 0.75mgh$$

Hence, $mgh_1 = E_1$ (from given figure)

$$mgh_1 = 0.75 mg (10) ; h_1 = 7.5m$$

31. (1) In the device when free end of the string is pulled by ℓ , the block will rise by $\ell/2$. So increase in potential energy $U = mg \ell/2$.

32. (2) In this case, $P = \frac{mgh + \frac{1}{2}mv^2}{t}$

$$\Rightarrow P = \frac{m}{t} \left[gh + \frac{v^2}{2} \right]$$

$$\Rightarrow P = \frac{10}{1} \left[10 \times 10 + \frac{10 \times 10}{2} \right] W = 1500W$$

33. (2) $P = \frac{W}{t}$

$$W = Mgh = M \times 10 \times 10 = 100 M \text{ and } t = 60 \text{ s.}$$

This gives, $M = 1200 \text{ kg}$

Its volume = 1200 litre as 1 litre of water contains 1 kg of its mass.

34. (4) From $v = u + at$, $v_1 = 0 + at_1$

$$\therefore a = \frac{v_1}{t_1} \quad F = ma = mv_1 / t_1$$

$$\text{Velocity acquired in } t \text{ sec} = at = \frac{v_1}{t_1} t$$

$$\text{Power} = F \times v = \frac{mv_1}{t_1} \times \frac{v_1 t}{t_1} = \frac{mv_1^2 t}{t_1^2}$$

35. (2) The work is done against gravity so it is equal to the change in potential energy. $W = E_p = mgh$
For a fixed height, work is proportional to weight lifted.

Since Johnny weighs twice as much as Jane he works twice as hard to get up the hill.

Power is work done per unit time. For Johnny this is $W/\Delta t$. Jane did half the work in half the time, $(1/2 W)/(1/2 \Delta t) = W/\Delta t$ which is the same power delivered by Johnny.

36. (1) Given, Velocity = v_1 force = F

We know that work done is equal to the product of force and displacement

$$W = f \times x$$

Divided by t in both sides then we get,

$$\frac{w}{t} = \frac{fx}{t} \Rightarrow \frac{x}{t} = v \text{ \& } \frac{w}{t} = p$$

Therefore $p = fv$

37. (1) $P = Fv = F \times \frac{s}{t} = 40 \times \frac{30}{60} = 20W$

38. (4) m : mass per unit length

$$\therefore \text{rate of mass leaving the hose per sec} = \frac{mx}{t} = mv$$

$$\text{Rate of K.E.} = \frac{1}{2}(mv)v^2 = \frac{1}{2}mv^3$$

39. (3) Given $t_1 = 2s, t_2 = 4s$ and $h_1 = h_2 = h$

$$\text{As } P_A = \frac{mgh_1}{t_1} \text{-----(i)}$$

$$\text{and } P_B = \frac{mgh_2}{t_2}$$

$$\Rightarrow P_A : P_B = \frac{mgh_1 / t_1}{mgh_2 / t_2} = \left(\frac{h_1}{h_2} \right) \left(\frac{t_2}{t_1} \right) = \frac{t_2}{t_1} = \frac{4}{2} = \frac{2}{1}$$

$$\Rightarrow P_A : P_B = 2 : 1$$

40. (4) The power of body is given by $= \vec{F} \cdot \vec{v}$ as the body is moving in circular path, centripetal force and velocity are at 90° , or power = 0.

41. (2) $P = 10 \text{ kW} = 10000 \text{ W}$

Fuel consumption = 1 g/s

Calorific value = 2 kcal/g

$\therefore$ Energy produced = 2 kcal/s

Input power

$$= 2 \text{ kcal/s} = 2000 \text{ cal/s} = 2000 \times 4.18 \text{ J/s} = 8.4 \text{ k W}$$

$\therefore$ This claim is invalid.

42. (2) the expression for acceleration due to gravity is

$$g = \frac{GMr}{R^2}, \text{ if } r < R, \text{ increasing as } r \text{ increases.}$$

$$g = \frac{GMr}{r^2}, \text{ if } r > R, \text{ decreases as } r \text{ increases.}$$

$$g = \frac{GMr}{R^2}, \text{ if } r = R$$

so the expression will have highest value at surface. i.e. $r=R$.

43. (4) $m = 10 \times 0.8 \text{ kg} = 8 \text{ kg}$

height of iron chain = 5 m

$$P = \frac{mgh}{t} = \frac{8 \times 10 \times 5}{10} \text{ W} = 40 \text{ W}$$

44. (1) $W = \vec{F} \cdot \vec{s} = (2\hat{i} + 3\hat{j} + 4\hat{k}) \cdot (3\hat{i} + 4\hat{j} + 5\hat{k})$

$$= 2 \times 3 + 3 \times 4 + 4 \times 5 = 38 \text{ J}$$

$$P = \frac{W}{t} = \frac{38}{4} = 9.5 \text{ W}$$

45. (4) $P = Fv = (1800 \text{ g} + 4000) \times 2 = 44000 \text{ W}$.

46. (3) If F is the force exerted by the engine of the car, then

$$F - R = ma ; \therefore F = (R + ma)$$

$$\text{The power } P = Fv = (R + ma)v$$

47. (3) Power = force $\times$ speed
 additional resistive force due to friction = $f \times M$
 Hence additional power is $f \times M \times v$

48. (4) For a straight line motion, $P = \vec{F} \cdot \vec{ds}$ reduces to

$$P = Fv \quad \left[\because \vec{F} \uparrow \uparrow \vec{v} \right]$$

Now since $P = \text{constant} \neq 0$

$$\therefore F \neq 0 \text{ and } v \neq 0$$

$$\text{From } F \neq 0 \Rightarrow m \frac{dv}{dt} \neq 0$$

$\therefore v$ is variable

$$\text{Further as, } F = \frac{P}{v}; \text{ so } F \propto \frac{1}{v}$$

Therefore, F also changes

49. (1) Given, $h = 60\text{m}$, $g = 10 \text{ ms}^{-2}$,
 Rate of flow of water = 15 kg/s
 $\therefore$ Power of the falling water
 $= 15 \text{ kgs}^{-1} \times 10 \text{ ms}^{-2} \times 60 \text{ m} = 9000 \text{ watt}$.
 Loss in energy due to friction
 $= 9000 \times \frac{10}{100} = 900 \text{ watt}$

50. (2) Constant power of car $P_0 = F.V = ma.v$

51. (4) The power of the machine gun

$$= \frac{\text{total work done}}{\text{time}} = \frac{n \cdot \frac{1}{2}mv^2}{t}$$

$$= n \cdot \frac{1}{2} \frac{mv^2}{t} \left(\because K = \frac{1}{2}mv^2, t = 1\text{s} \right)$$

$$\therefore \text{The power of the machine gun} = nK$$

52. (3) Fraction of energy transferred $= \frac{4 \times 2}{(1+2)^2} = \frac{8}{9}$

53. (1) $m_1 = 0.2 \text{ kg}$, $m_2 = 0.4 \text{ kg}$, $v_1 = 0.3 \text{ m/s}$, $v_2 = ?$

Applying law of conservation of momentum

$$m_1 v_1 - m_2 v_2 = \frac{0.2 \times 0.3}{0.4} = 0.15 \text{ m/s}$$

54. (1) Applying law of conservation of momentum,

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v \text{ or } m_1 u_1 = (m_1 + m_2) v \quad (\because u_2 = 0)$$

$$\Rightarrow m \frac{(3 \times 1000)}{3600} = 3m(v) \Rightarrow v = \frac{1000}{3600} \text{ m/s} = 1 \text{ km/hr}$$

55. (4) As bob B is of same material and same mass as the bob A, therefore, on elastic collision, their velocities are exchanged.

Bob A comes to rest and B moves with the velocity of A.

We can prove this by momentum conservation and $e=1$.

$$e = \frac{\text{Speed of separation}}{\text{Speed of approach}} = \frac{v_2 - v_1}{u_1} = 1$$

$$\Rightarrow v_2 - v_1 = u_1 \text{ -----(1)}$$

$$mu_1 = mv_1 + mv_2$$

$$\Rightarrow v_2 + v_1 = u_1 \text{ -----(2)}$$

Using (1) and (2), we get,

$$v_1 = 0, v_2 = u_1$$

56. (2) For elastic collision in one dimension

$$v_1 = \frac{2m_2 u_2 + (m_1 - m_2) u_1}{m_1 + m_2}$$

As mass $2m$, is at rest, So $u_2 = 0$

$$\Rightarrow v_1 = \frac{(8m - 2m)}{8m + 2m} = \frac{3}{5}u$$

Final energy of sphere = (K.E.)_f

$$= \frac{1}{2}(8m) \left(\frac{3u}{5} \right)^2 = \frac{1}{2}(8m) u^2 \times \left(\frac{3}{5} \right)^2 = \frac{9}{25}E = 0.36E$$

57. (2) Components of velocity before and after collision parallel to the plane are equal, So

$$v \sin 60^\circ = u \sin 30^\circ \text{(1)}$$

Components of velocity normal to the plane are related to each other

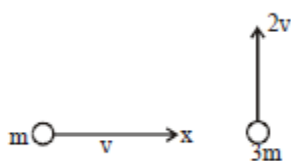
$$v \cos 60^\circ = e u (\cos 30^\circ) \text{(2)}$$

$$\Rightarrow \cot 60^\circ = e \cot 30^\circ \Rightarrow e = \frac{\cot 60^\circ}{\cot 30^\circ} \Rightarrow e = \frac{1}{\sqrt{3}} \Rightarrow e = \frac{1}{3}$$

58. (1) As the two masses stick together after collision, hence it is inelastic collision. Therefore, only momentum is conserved.

$$\therefore m\vec{v}_1 + 3m(2\vec{v})\hat{j} = (4m)\vec{v}$$

$$\vec{v} = \frac{v}{4}\hat{i} + \frac{6}{4}\vec{v}\hat{j} = \frac{v}{4}\hat{i} + \frac{3}{2}\vec{v}\hat{j}$$

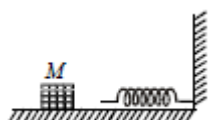


59. (3) Initial momentum of the system = $mv - mv = 0$

As body sticks together \ final momentum = $2mv$

By conservation of momentum $2mv = 0 \Rightarrow v = 0$

60. (2) $\frac{1}{2}Mv^2 = \frac{1}{2}kL^2$



$$\Rightarrow v = \sqrt{\frac{k}{M}} \cdot L$$

$$\text{Momentum} = M \times v = M \times \sqrt{\frac{k}{M}} \cdot L = \sqrt{kM} \cdot L$$

61. (1) For collision, their position vectors at $t=2$ should be same. Hence

$$(3\hat{i} + 5\hat{j}) + 2(4\hat{i} + 3\hat{j}) = (-5\hat{i} - 3\hat{j}) + 2(\alpha\hat{i} + 7\hat{j})$$

$$\Rightarrow (11\hat{i} + 11\hat{j}) = [(-5 + 2\alpha)\hat{i} + 11\hat{j}] \Rightarrow \alpha = 8$$

62. (2) $m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_{\text{sys}}$

$$20 \times 10 + 5 \times 0 = (20 + 5) v_{\text{sys}} \Rightarrow v_{\text{sys}} = 8 \text{ m/s}$$

$$\text{K. E. of composite mass} = \frac{1}{2} (20 + 5) \times (8)^2 = 800 \text{ J}$$

63. (4) For the object of mass 2.0 kg.

$$\frac{\Delta k}{k} = \frac{k - k/4}{k} = \frac{3}{4}$$

Kinetic energy transferred

$$\frac{\Delta k}{k} = \frac{4m_1 m_2}{(m_1 + m_2)^2}$$

Here, $m_1 = 2.0 \text{ kg}$, $m_2 = M$

$$\therefore \frac{3}{4} = \frac{4 \times 2M}{(2 + M)^2} \Rightarrow M = \frac{2}{3} \text{ kg or } 6 \text{ kg}$$

64. (1) Initial, K.E. = $\frac{1}{2} m v^2 = \frac{1}{2} \times \frac{20}{1000} \times 600 \times 600 = 3600 \text{ J}$

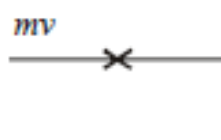
Change in K.E. = P.E.

$$\frac{1}{2} m (v^2 - v_1^2) = mgh$$

$$\Rightarrow 3600 - \frac{1}{2} \times \frac{20}{1000} \times v_1^2 = 4 \times 10 \times 80 \Rightarrow v_1 = 200 \text{ m/s}$$

65. (3) total K.E. of colliding bodies decreases

66. (1)

mv 	Initial momentum = mv Final momentum = $m(-v)$ change in momentum $= mv - m(-v) = 2mv$
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67. (1) Let mass of first ball be m i.e. $m_1 = m$

Mass of second ball $m_2 = 2m$

Velocity of first ball before collision $u_1 = 2 \text{ m/s}$

Velocity of second ball before collision $u_2 = 0 \text{ m/s}$

Given : $e = 0.5$

$$v_1 = \frac{(m_1 - e m_2) u_1 + (1 + e) m_2 u_2}{m_1 + m_2}$$

So, velocity of first ball after collision

$$\therefore v_1 = \frac{[m - 0.5(2m)](2) + (1 + 0.5)(2m)(0)}{m + 2m} = 0 \text{ m/s}$$

$$v_2 = \frac{(m_2 - e m_1) u_2 + (1 + e) m_1 u_1}{m_1 + m_2}$$

Velocity of second ball after collision

$$\therefore v_2 = \frac{[2m - 0.5m](0) + (1 + 0.5)(m)(2)}{m + 2m} = 1 \text{ m/s}$$

68. (2) When two equal mass collide elastically then velocities get interchange

69. (2) From conservation of linear momentum $m_1 v_1 + m_2 v_2 = 0$

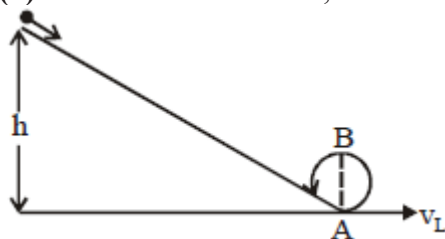
$$v_2 = \left(\frac{-m_1}{m_2} \right) v_1 = \left(\frac{-18}{12} \right) 6 = -9 \text{ ms}^{-1}$$

$$\text{K.E} = \frac{1}{2} m_2 v_2^2 = \frac{1}{2} \times 12 \times 9^2 = 486 \text{ J}$$

70. (1) $h_n = h e^{2n}$, after third collision $h_3 = h e^6$ [as $n = 3$]

NEET PREVIOUS YEARS QUESTIONS-EXPLANATIONS

1. (3) As track is frictionless, so total mechanical energy will remain constant



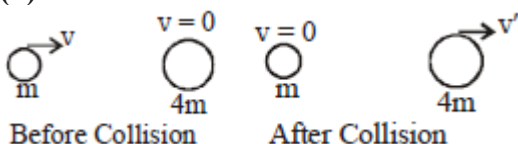
$$\text{i.e., } 0 + mgh = \frac{1}{2} m v_L^2 + 0$$

$$\text{Using } v^2 - u^2 = 2gh, h = \frac{v_L^2}{2g} (\because u = 0)$$

For completing the vertical circle $v_L \geq \sqrt{5gR}$

$$\text{or } h = \frac{5gR}{2g} = \frac{5}{2} R = \frac{5}{4} D$$

2. (2)



According to law of conservation of linear momentum,

$$mv + 4m \times 0 = 4mv' + 0 \Rightarrow v' = \frac{v}{4}$$

Coefficient of restitution,

$$e = \frac{\text{Relative velocity of separation}}{\text{Relative velocity of approach}}$$

$$= \frac{v}{4} \text{ or } e = \frac{1}{4} = 0.25$$

3. (1)

4. (1) Given: Mass of particle, $M = 10 \text{ g} = \frac{10}{1000} \text{ kg}$

radius of circle $R = 6.4 \text{ cm}$

Kinetic energy E of particle $= 8 \times 10^{-4} \text{ J}$

acceleration $a_t = ?$

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

$$\Rightarrow v^2 = 16 \times 10^{-2}$$

$$\Rightarrow v = 4 \times 10^{-1} = 0.4 \text{ m/s}$$

Now, using

$$v^2 = u^2 + 2a_t s \quad (s = 4\pi R)$$

$$(0.4)^2 = 0^2 + 2a_t \left(4 \times \frac{22}{7} \times \frac{6.4}{100}\right)$$

$$\Rightarrow a_t = (0.4)^2 \times \frac{7 \times 100}{8 \times 22 \times 6.4} = 0.1 \text{ m/s}^2$$

5. (4) Given force $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$

According to Newton's second law of motion,

$$m \frac{d\vec{v}}{dt} = 2t\hat{i} + 3t^2\hat{j} \quad (m = 1 \text{ kg})$$

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

$$\Rightarrow \vec{v} = t^2\hat{i} + t^3\hat{j}$$

$$\text{Power } P = \vec{F} \cdot \vec{v} = (2t\hat{i} + 3t^2\hat{j}) \cdot (t^2\hat{i} + t^3\hat{j})$$

$$= (2t^3 + 3t^5) \text{ W}$$

6. (4) From, $F = ma$

$$a = \frac{F}{m} = \frac{0.1x}{10} = 0.01x = V \frac{dV}{dx}$$

$$\text{So, } \int_{V_1}^{V_2} V dV = \int_{20}^{30} \frac{x}{100} dx$$

$$-\frac{V^2}{2} \Big|_{V_1}^{V_2} = \frac{x^2}{200} \Big|_{20}^{30} = \frac{30 \times 30}{200} - \frac{20 \times 20}{200}$$

$$= 4.5 - 2 = 2.5$$

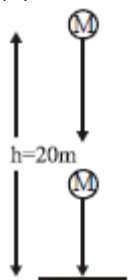
$$\frac{1}{2}m(V_2^2 - V_1^2) = 10 \times 2.5 \text{ J} = -25 \text{ J}$$

Final K.E.

$$= \frac{1}{2}mv_2^2 = \frac{1}{2}mv_1^2 - 25 = \frac{1}{2} \times 10 \times 10 \times 10 - 25$$

$$= 500 - 25 = 475 \text{ J}$$

7. (1) When ball collides with the ground it loses its 50% of energy



$$\therefore \frac{KE_f}{KE_i} = \frac{1}{2} \Rightarrow \frac{\frac{1}{2}mV_f^2}{\frac{1}{2}mV_i^2} = \frac{1}{2} \text{ or } \frac{V_f}{V_i} = \frac{1}{\sqrt{2}}$$

$$\text{or } \frac{\sqrt{2gh}}{\sqrt{V_0^2 + 2gh}} = \frac{1}{\sqrt{2}} \text{ or } 4gh = V_0^2 + 2gh$$

$$\therefore V_0 = 20\text{ms}^{-1}$$

8. (4) Power $\vec{F} \cdot \vec{V} = PA\vec{V} = \rho ghAV$

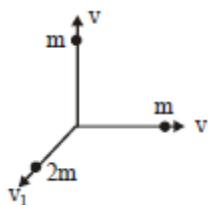
$$\left[\because P = \frac{F}{A} \text{ and } P = \rho gh \right]$$

$$= 13.6 \times 10^3 \times 10 \times 150 \times 10^{-3} \times 0.5 \times 10^{-3} / 60$$

$$= \frac{102}{60} = 1.70 \text{ watt}$$

9. (2) By conservation of linear momentum

$$2mv_1 = \sqrt{2}mv \Rightarrow v_1 = \frac{v}{\sqrt{2}}$$

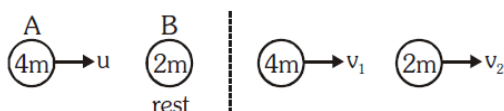


As two masses of each of mass m move perpendicular to each other.

Total KE generated

$$= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}(2m)v_1^2$$

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



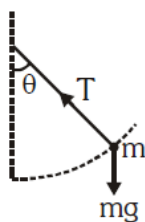
10.

$$v_1 = \frac{4m - 2m}{4m + 2m}u = \frac{2mu}{6m} = \frac{u}{3}$$

$$\text{Fraction of energy lost} = \frac{\frac{1}{2}(4m)u^2 - \frac{1}{2}(4m)\left(\frac{u}{3}\right)^2}{\frac{1}{2}(4m)u^2}$$

$$= 1 - \frac{1}{9} = \frac{8}{9}$$

11. $T \cdot mg \cos \theta = mv^2/R$



T will be maximum when $\theta = 0^\circ$,
When mass is at lowest point.

12.

$$W = \int_{y_1}^{y_2} F dy$$

$$\Rightarrow W = \int_0^1 (20 + 10y) dy$$

$$\Rightarrow W = 20[y]_0^1 + 10\left[\frac{y^2}{2}\right]_0^1$$

$$\Rightarrow W = 25 \text{ J}$$

13. $\frac{m_1}{m_2} = \frac{1}{5}; m_1 + m_2 = m$

$$m_1 = \frac{m}{6}; m_2 = \frac{5m}{6}$$

$$m_1 v_1 + m_2 v_2 = mv$$

$$\frac{m}{6}(100\hat{i} + 35\hat{j} + 8\hat{k}) + \frac{5m}{6}v_2 = m(20\hat{i} + 25\hat{j} - 12\hat{k})$$

$$5v_2 = (6 \times 20\hat{i} - 100\hat{i} + (25 \times 6)\hat{j} - 35\hat{j} - 12 \times 6\hat{k} - 8\hat{k})$$

$$v_2 = 4\hat{i} + 23\hat{j} - 16\hat{k}$$

14. Energy released $= \frac{1}{2}mv^2 + \frac{1}{2}mv^2 + \frac{1}{2}3m\left(\sqrt{2}\frac{v}{3}\right)^2$

$$= mv^2 + \frac{2}{2} \frac{3mv^2}{9} = \frac{4mv^2}{3}$$

15. From work energy theorem

$\Delta K.E. = \text{work} = \text{area under } F-x \text{ graph}$

From $x = 0$ to $x = 8\text{m}$

$$\frac{1}{2}mv^2 = (5 \times 20) + (3 \times 10)$$

$$\therefore \frac{1}{2}mv^2 = 100 + 30$$

$$\therefore v^2 = 520$$

$$\therefore v = \sqrt{520} = 22.8 \approx 23 \text{ m/s}$$

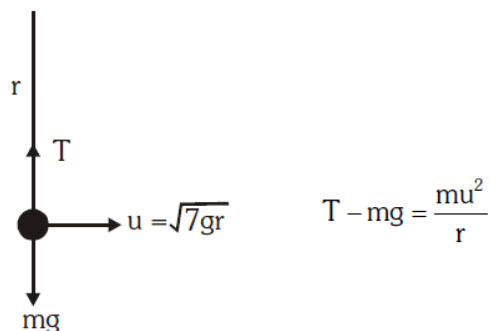
Similarly, from $x = 0$ to $x = 12\text{m}$

$$\frac{1}{2}mv^2 = 100 + 30 - 47.5 + 20$$

$$\therefore \frac{1}{2}mv^2 = 102.5; \quad \therefore v^2 = \frac{2 \times 102.5}{0.5}$$

$$\therefore v = \sqrt{410} \approx 20.6 \text{ m/s}$$

16.



$$T - mg = \frac{m(\sqrt{7gr})^2}{r} \Rightarrow T = 8mg$$

17.

$$\text{Energy} = 10^{-20} \text{ J} = \frac{10^{-20}}{1.6 \times 10^{-19}} = 0.625 \times 10^{-1} = 0.06 \text{ eV}$$

18.

$$h = 60 \text{ m}; \quad \frac{dm}{dt} = 15 \text{ kg/s}$$

$$\frac{90}{100} \frac{mgh}{t} = P$$

$$\Rightarrow P = \frac{9}{10} \times 15 \times 10 \times 60 = 9 \times 900 = 8.1 \text{ kW}$$

19.

$$K.E = 3(P.E)$$

$$\frac{1}{2}m[2g(S-h)] = 3 \times mgh$$

$$\Rightarrow S - h = 3h$$

$$S = 4h$$

$$\Rightarrow h = \frac{S}{4}$$

$$\text{And speed } V = \sqrt{2g(S-h)}$$

$$= \sqrt{2g(S - \frac{S}{4})}$$

$$= \sqrt{2g \times \frac{3S}{4}} = \sqrt{\frac{3gS}{2}}$$