



GOVERNMENT OF KARNATAKA

DEPARTMENT OF SCHOOL EDUCATION (PRE-UNIVERSITY)

18TH CROSS, MALLESHWARAM, BENGALURU – 560 012

CHAPTER-WISE MULTIPLE-CHOICE QUESTIONS FOR COMPETITIVE EXAM

SUBJECT: I PUC - PHYSICS

NAME OF THE CHAPTER: 5. WORK, ENERGY AND POWER

SYNOPSIS

5.1. Scalar Multiplication – The Dot Product:

➤ When the multiplication of two vector yields a third scalar different kind, the multiplication is called *scalar multiplication* or *scalar product* or *dot product*.

➤ Two vectors namely $\vec{a}$ and $\vec{b}$ make an angle of ϕ with each other when their tails are joined together. The scalar product or dot product of the two vectors is defined as

$$\vec{a} \cdot \vec{b} = ab \cos \phi$$

➤ The dot product between two vectors namely $\vec{a}$ and $\vec{b}$ can also be written as

$$\vec{a} \cdot \vec{b} = a(b \cos \phi) = |\vec{a}| \text{ multiplied by component of } \vec{b} \text{ in the direction of } \vec{a}$$

➤ Dot product or scalar product is always *commutative*.

That is, the order or sequence is unimportant when multiplying two vectors through scalar multiplication $\vec{a} \cdot \vec{b} = \vec{b} \cdot \vec{a}$.

➤ Scalar product is also distributive. That is

$$\vec{a} \cdot (\vec{b} + \vec{c}) = \vec{a} \cdot \vec{b} + \vec{a} \cdot \vec{c}.$$

➤ Dot product or scalar product of the three unit vectors $\hat{i}, \hat{j}$ and $\hat{k}$ is as follows:

$$\hat{i} \cdot \hat{i} = |\hat{i}||\hat{i}| \cos 0 = 1, \hat{j} \cdot \hat{j} = |\hat{j}||\hat{j}| \cos 0 = 1 \text{ and } \hat{k} \cdot \hat{k} = |\hat{k}||\hat{k}| \cos 0 = 1.$$

➤ However, $\hat{i} \cdot \hat{j} = |\hat{i}||\hat{j}| \cos 90^\circ = 0, \hat{j} \cdot \hat{k} = |\hat{j}||\hat{k}| \cos 90^\circ = 0$

$$\text{and } \hat{k} \cdot \hat{i} = |\hat{k}||\hat{i}| \cos 90^\circ = 0.$$

➤ Analytically if two vectors $\vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$ and $\vec{b} = b_x \hat{i} + b_y \hat{j} + b_z \hat{k}$ are given, their scalar product is given by

$$\vec{a} \cdot \vec{b} = (a_x \hat{i} + a_y \hat{j} + a_z \hat{k}) \cdot (b_x \hat{i} + b_y \hat{j} + b_z \hat{k}) = a_x b_x + a_y b_y + a_z b_z$$

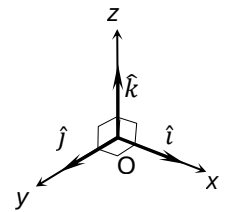
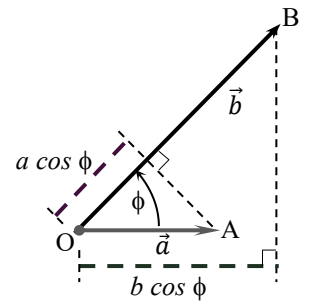
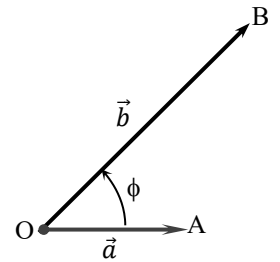
➤ The angle between two vectors when joined in common tail arrangement is given by

$$\phi = \cos^{-1} \left(\frac{\vec{a} \cdot \vec{b}}{ab} \right) \text{ or } \phi = \cos^{-1} \left(\frac{a_x b_x + a_y b_y + a_z b_z}{\sqrt{a_x^2 + a_y^2 + a_z^2} \times \sqrt{b_x^2 + b_y^2 + b_z^2}} \right).$$

➤ The dot product of two parallel vectors is $\vec{a} \cdot \vec{b} = ab \cos 0 = ab \leftarrow \text{maximum}$

➤ The dot product of two antiparallel vectors is $\vec{a} \cdot \vec{b} = ab \cos 180^\circ = -ab \leftarrow \text{minimum}$

➤ The dot product of two mutually perpendicular vectors is $\vec{a} \cdot \vec{b} = ab \cos 90^\circ = 0$.



EXAMPLE 5.1:

Which of the following statements is true about the relationship between the dot product of two vectors and the product of the magnitudes of the vectors?

- (A) $\vec{A} \cdot \vec{B}$ is larger than AB
- (B) $\vec{A} \cdot \vec{B}$ is smaller than AB
- (C) $\vec{A} \cdot \vec{B}$ is equal to AB
- (D) $\vec{A} \cdot \vec{B}$ is larger or smaller than AB depending on angle between them

Ans (4)

EXAMPLE 5.2:

A projectile is launched from a point on the ground. At one point on its path the direction of its velocity $\vec{v}_1$ is making 120° with the acceleration due to gravity. At another instant, the velocity of the projectile $\vec{v}_2$ makes an angle of 30° with the acceleration due to gravity. Then the value of $\vec{v}_1 \cdot \vec{v}_2$ equals

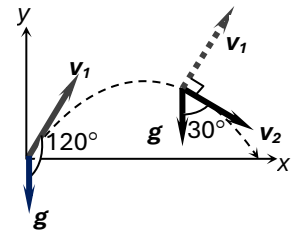
- (A) $v_1 v_2$
- (B) $-v_1 v_2$
- (C) $\frac{v_1^2 v_2^2}{v_1^2 + v_2^2}$
- (D) zero

Ans (D)

Exampe Solved:

From the Figure to the right, : the angle between $\vec{v}_1$ and $\vec{v}_2$ is 90° .

Hence the required dot product : $\vec{v}_1 \cdot \vec{v}_2 = v_1 v_2 \cos 90^\circ = 0$

**5.2. Work done by a constant force – Dot product of force and displacement:**

➤ When a force $\vec{F}$ causes a displacement of $\vec{s}$ in an object as in Fig (a) below, the work done by that force is defined as

$$W = \vec{F} \cdot \vec{s} = F s \cos \theta.$$

➤ The SI unit of work is joule (J).

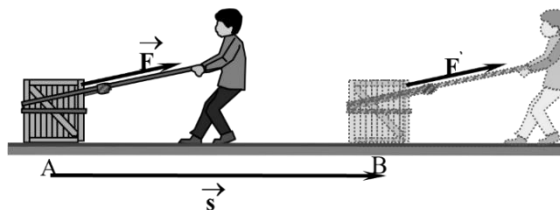


Fig (a)

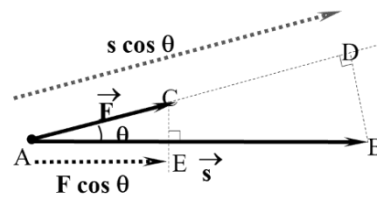


Fig (b)

➤ When a force $\vec{F}$ is parallel to the displacement $\vec{d}$, the work done by the force is maximum. That is

$$W_{max} = F s \cos 0^\circ = F s.$$

➤ When a force $\vec{F}$ is anti parallel to the displacement $\vec{d}$, the work done by the force is minimum and negative. That is,

$$W_{min} = F s \cos 180^\circ = -F s.$$

➤ When a force $\vec{F}$ is perpendicular to the displacement $\vec{d}$, the work done by the force is zero. That is,

$$W = F s \cos 90^\circ = \text{zero}.$$

EXAMPLE 5.3:

In stuntman lifts a 300 kg object through a distance of 20 cm using only his teeth. The work done on the object by the stuntman in this lift, assuming the object was lifted at constant speed is (take $g = 10 \text{ m/s}^2$)

- (A) 60 J
- (B) 200 J
- (C) 600 J
- (D) 3000 J

Ans (C)

Example Solved:

Since the speed of the object is constant : force of his teeth F = weight of the object W

The angle between the force F and displacement s : $\theta = 0^\circ$

Hence the work done on the object : $W_F = Fs = \underbrace{300 \times 10}_F \times \underbrace{0.2}_s = 600J$

5.3. Work done by a variable force:

➤ When a variable force $\vec{F}$ causes a displacement of $\delta\vec{s}$ in an object, the work done by that force is defined as $\delta W = \vec{F} \cdot \delta\vec{s} = F_{\parallel} \delta s$. (where $F_{\parallel} = F \cos \theta$)

➤ The total work done by this force is calculated using $W = \sum \delta W = \sum F_{\parallel} \delta s$.

➤ If the force is varying continuously, we may replace the summation by the integral sign as in

$$W = \int dW = \int F_{\parallel} ds$$

➤ For example, the spring force acting on an ideal spring is a variable force according to

$$F = -kx.$$

➤ Hence the work done by the spring force when extended or compressed by x is

$$W = - \int_0^x -kx dx = -\frac{1}{2} kx^2$$

➤ We can also evaluate the work done by a variable force by graphical method. If force is drawn along vertical and displacement is drawn along the horizontal axes, the area under the $F - x$ curve gives the work done by that force. Refer to Fig (a).

$$W = \text{area under } F - x \text{ curve}$$

➤ For example, the work done by the spring force either during compression or expansion is given by the area under the $F - x$ curve. See Fig (b).

EXAMPLE 5.4:

A force of $F = 3x^2 - 2x$ (where x is in m and F is in N) acts on an object from $x = 1$ m to $x = 3$ m. The net work done by this force on the object is

- (A) 9 J (B) 18 J (C) 27 J (D) 36 J

Ans (B)

Example Solved:

Work done by the force is : $W = \int_1^3 (3x^2 - 2x) dx = 3 \left| \frac{x^3}{3} \right|_1^3 - 2 \left| \frac{x^2}{2} \right|_1^3 = 18J$

5.4. Kinetic energy and Work Energy Principle/Theorem (W – E theorem):

➤ The measure of a body to do work is called energy. If that energy is associated with a moving body, it is called **kinetic energy**.

➤ For a body of mass m moving with speed v , the kinetic energy of that body is given by

$$K = \frac{1}{2} mv^2$$

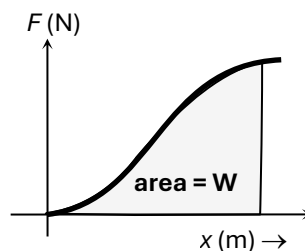
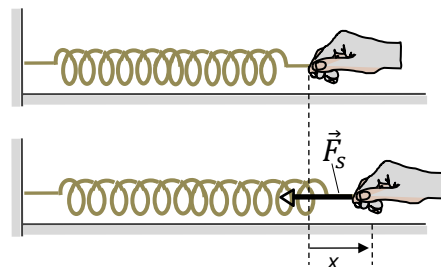


Fig (a)

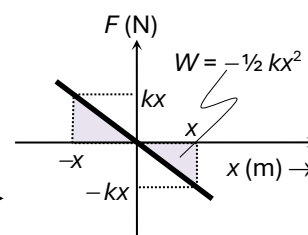


Fig (b)

➤ The **kinetic energy** is a scalar and has a SI unit of joule (J).

➤ In terms of the momentum **p** of the object and its mass **m**, the kinetic energy of the object may be written as

$$K = \frac{p^2}{2m}$$

➤ When a number of forces act on an object, they change its kinetic energy. If **W_{tot}** is the total work done on the object and **K_i** is the initial kinetic energy of the object and **K_f** is its final kinetic energy, by the **work energy theorem**,

$$W_{tot} = K_f - K_i \Leftrightarrow W_{tot} = \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2$$

➤ In the case of uniform circular motion, the initial and final speeds of the object are same. Hence by the **W – E theorem**, the total work done by the centripetal force on the object is **zero**.

EXAMPLE 5.4:

The positions of a particle moving along the *x* axis change with time according to the equation $x = 4t^3 - t^2$ (where *x* is in m and *t* is in s). If the mass of the particle is 2 kg, the total work done on it between *t* = 0 s and *t* = 1 s is

(A) 4 J

(B) 117 J

(C) 121 J

(D) 125 J

Ans (B)

Example Solved:

The velocity of the particle is : $v = \frac{dx}{dt} = \frac{d}{dt}(4t^3 - t^2) = 12t^2 - 2t$

The velocities of the particle at *t* = 0 and *t* = 1 s are : $v_0 = v(0) = 13(0)^2 - 2 = -2 \text{ m/s}$
and : $v = v(1) = 13(1)^2 - 2 = 11 \text{ m/s}$

By the work energy theorem, the total work : $W_{tot} = \frac{1}{2}m(v^2 - v_0^2) = \frac{1}{2} \times 2[11^2 - (-2)^2] = 117 \text{ J}$

5.5. Conservative and Non-conservative forces:

➤ When the work done on an object by forces such as **gravity**, **electrostatic force** and **spring force** does not depend on the path of the object, these forces are said to be **path independent**. Hence such forces are called **conservative forces**.

➤ When the work done on an object by forces such as **friction**, **air drag** and **tension** depends on the path of the object, these forces are said to be **path dependent**. Hence such forces are called **non-conservative forces**.

EXAMPLE 6.5:

When a man climbs a mountain from the bottom to its top, a certain force does a work of + 200 J. When he climbs down the same mountain from the top to its bottom, the work done by the same force is – 220 J. The force may be

(A) air drag

(B) gravity

(C) normal reaction

(D) tension

Ans (B)

Example Solved:

Since the work done by the force : depends on the path followed by the man
the force is : necessarily a **non conservative force**.

However : normal force does zero work, gravity is conservative force

and : air drag force is always opposite to the displacement

the work of : air drag is always negative.

Thus the only choice is : tension force!

6.6. Concept of Potential Energy – Gravitational and Elastic Potential Energy :

➤ When an object of mass m is raised to a height h on the surface of Earth, (where h is very small compared with the radius of the Earth) the **gravitational potential energy** increases by

$$U_g = U_f - U_i$$

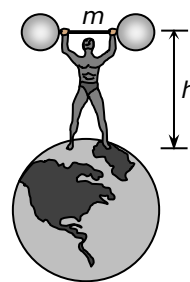
Or

$$U_g = mgh - 0 \Rightarrow U_g = mgh$$

➤ When a spring of force constant k is expanded or compressed by x from its mean position, the **elastic potential energy** increases by $U_{el} = U_f - U_i$

Or

$$U_g = \frac{1}{2}kx^2 - 0 \Rightarrow U_{el} = \frac{1}{2}kx^2$$



EXAMPLE 5.6:

An object is connected to the free end of a spring whose another end is connected to a fixed support as shown in the figure. When the block moves down and comes to rest at a new equilibrium position, the gravitational potential energy and the elastic potential energy of the spring.....

(A) increases, increases

(B) increases, decreases

(C) decreases, decreases

(D) decreases, increases

Ans (D)

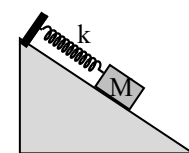
Example Solved:

Since the object descends,

: height h decreases and hence $U_g = mgh$ decreases as well.

However, as the

: spring undergoes extension, $U_{el} = \frac{1}{2}kx^2$ increases



5.7. Total Mechanical Energy - and its Conservation:

➤ The sum of kinetic energy, potential energies of all types is called **total mechanical energy** of the system.

That is

$$E = K + U_{el} + U_g \text{ OR } E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 + mgh$$

➤ When **no non conservative forces** act on a system of particles, the **total mechanical energy** of the system is a **constant**.

$$E = K + U_{el} + U_g = \text{Constant}$$

Or

$$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 + mgh = \text{Constant}$$

➤ If E_i is the initial total mechanical energy, E_f is the final total mechanical energy, then according to the **conservation of mechanical energy (COME)**, we can write

$$E_i = E_f \quad \text{Or} \quad \frac{1}{2}mu^2 + \frac{1}{2}kx_i^2 + mgh_i = \frac{1}{2}mv^2 + \frac{1}{2}kx_f^2 + mgh_f$$

➤ In still another, way, we may express the **COME** as

$$E_i - E_f = 0 \Leftrightarrow \Delta E = 0 \quad \text{Or} \quad \Delta K + \Delta U_{el} + \Delta U_g = 0$$

$$\Leftrightarrow \frac{1}{2}m(v^2 - u^2) + \frac{1}{2}k(x_f^2 - x_i^2) + mg(h_f - h_i) = 0$$

EXAMPLE 5.7:

A block of mass $M = 1 \text{ kg}$ is released from rest at the top of a smooth incline making an angle of 37° with the horizontal. A light spring of force constant 100 N/m is attached to the incline as shown. if $g = 10 \text{ m/s}^2$, $\sin 37^\circ = 0.6$ and $\cos 37^\circ = 0.8$, the greatest compression in the spring is approximately (take $\sqrt{7} = 2.6$)

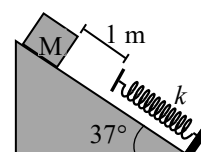
(A) 25 cm

(B) 36 cm

(C) 40 cm

(D) 56 cm

Ans (D)



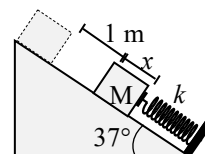
Example Solved:

Since the incline is smooth, : the total mechanical energy is conserved.

$$\text{Hence} \quad \frac{1}{2}m(v^2 - u^2) + \frac{1}{2}k(x_f^2 - x_i^2) + mg(h_f - h_i) = 0$$

$$\text{Or} \quad \frac{1}{2} \times 1(0^2 - 0^2) + \frac{1}{2} \times 100 \times (x^2 - 0^2) - 1 \times 10 \times (1 + x) = 0 (\because h_f < h_i)$$

$$\text{Solving the above expression : } 50x^2 - 10(x + 1) = 0 \Rightarrow 5x^2 - x - 1 = 0 \Rightarrow x \approx 0.56\text{m} = 56\text{ cm}$$



5.8. Mechanical Power - Rate of doing Work :

➤ If the total work done by a force is W in total time t, the **average power** delivered by the force is

$$P_{av} = \frac{W}{t} \quad [\text{measured in watt (W)}].$$

➤ The rate at which a force does work on a system is called **instantaneous power**.

$$P_{in} = \frac{dW}{dt} \quad [\text{measured in watt (W)}].$$

➤ The rate at which an agent transfers energy to a system is also called its **instantaneous power**.

$$P_{in} = \frac{dE}{dt} \quad [\text{measured in watt (W)}].$$

➤ OR the rate at which the kinetic energy is changing in a system is also called its **instantaneous power**.

$$P_{in} = \frac{dK}{dt} \quad [\text{measured in watt (W)}].$$

➤ In terms of the force acting on the object and its velocity, the instantaneous power of the force is given by

$$P_{in} = \vec{F} \cdot \vec{v} = Fv \cos \theta$$

➤ The power of the force is maximum, when the force is parallel to the velocity of the object. That is, $\theta = 0$

$$P_{max} = Fv \cos 0 = Fv$$

EXAMPLE 5.8:

An escalator is used to move 20 people (60 kg each) per minute from the first floor of a mall to the second floor, 5 m above. Neglecting friction, the power required is approximately

(A) 100 W

(B) 200 W

(C) 1000 W

(D) 2000 W

Ans (C)

Illustration Solved:

$$\text{Total work done} \quad : W = Mgh = 20 \times 60 \times 10 \times 5 = 60 \times 1000 \text{ J.}$$

$$\text{Power required} \quad : P = \frac{\text{workdone}}{\text{timetaken}} = \frac{W}{t} = \frac{60 \times 1000 \text{ J}}{60 \text{ s}} = 1000 \text{ W}$$

5.9. Impulsive Forces and Impulse of a Force

➤ Very large forces acting for a short time intervals are called **impulsive forces**.

➤ If $\vec{F}_{av}$ is the average impulsive force acting for a short time interval δt , the impulse of the force is given by

$$\vec{I} = \vec{F}_{av} \delta t$$

➤ The area under the impulsive force vs time graph gives the impulse of that force.

$$\text{Hence} \quad \vec{I} = \int \vec{F} dt = \text{AREA UNDER } F - t \text{ GRAPH}$$

➤ If $\delta \vec{p}$ is the change in momentum of an object, $\vec{I}$ is the impulse of the force on it, then according to the **impulse - momentum theorem**,

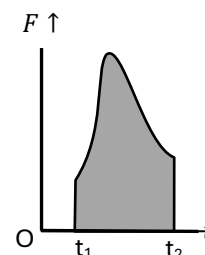
$$\text{we may write} \quad \vec{I} = \vec{F}_{av} \delta t = \delta \vec{p} = m\vec{v} - m\vec{u}$$

In terms of components :

$$I_x = F_{av,x} \delta t = mv_x - mu_x, \quad I_y = F_{av,y} \delta t = mv_y - mu_y$$

and

$$I_z = F_{av,z} \delta t = mv_z - mu_z$$



EXAMPLE 5.9:

A rifle of mass M is initially at rest but free to recoil. It fires a bullet of mass m and velocity u (relative to the rifle). After firing, the impulse on the rifle (relative to the ground) is

(A) $-\frac{m^2 u}{M}$

(B) $-\frac{mMu}{M+m}$

(C) $-\frac{M^2 u}{M+m}$

(D) $-\frac{M^2 u}{m}$

Ans (B)

Example Solved:

The velocity of the bullet relative to ground is

$$: v_{bg} = v_{br} + v_{rg} = u - V$$

By the conservation of momentum

$$: mv_{bg} + Mv_{rg} = 0$$

Solving for recoil velocity V

$$: m(u - V) - MV = 0 \Rightarrow V = -\frac{mu}{M+m}$$

By impulse momentum theorem

$$: I_{rif} = M(V - 0) = MV \Rightarrow I_{rif} = -\frac{Mmu}{M+m}$$

5.10. Collisions in One and Two Dimensions – Elastic, Inelastic and Perfectly Inelastic collisions :

➤ There are basically two types of collisions: (i) **elastic collisions** and (ii) **inelastic collisions**.

➤ In **perfectly elastic collisions**, the momentum and kinetic energy are both conserved, while in the **inelastic collisions**, only momentum is conserved.

➤ If m_1 and m_2 are the masses of two objects having initial velocities v_{1i} and v_{2i} respectively, their common velocity after the **perfectly inelastic collision** [See Fig (b)] given by

$$V = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$$

➤ The loss of KE in the perfectly inelastic collision between m_1 and m_2 is given by

$$\Delta K_{loss} = \frac{1}{2} \frac{m_1 m_2}{m_1 + m_2} (u_1 - u_2)^2$$

➤ If a moving object m_1 having initial velocity u collides **elastically** with a stationary object of mass m_2 their velocities after the perfectly elastic collision [See Fig (a)] are given by

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2} \right) u \text{ and } v_2 = \frac{2m_1 u}{m_1 + m_2}$$

➤ Or when the masses m_1 and m_2 move with initial velocities u_1 and u_2 before collision, their velocities after a perfectly elastic collision [see fig (d)] are

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

and

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

➤ In a **two dimensional perfectly elastic collision** as in Fig (c), the momentum and kinetic energy both are conserved.

➤ By **momentum conservation** along the horizontal, we may write

$$m_1 u_1 = m_1 v_1 \cos \theta + m_2 v_2 \cos \phi$$

and along the vertical, we may write

$$0 = m_1 v_1 \sin \theta - m_2 v_2 \sin \phi$$

➤ By **kinetic energy conservation**, we may write $\frac{1}{2} m_1 u_1^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$

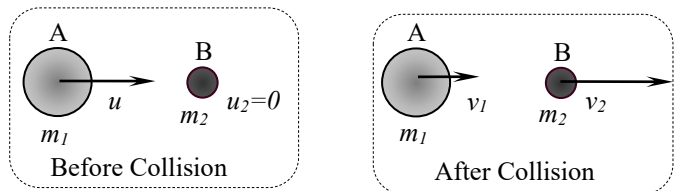


Fig (a) : Perfectly Elastic Collision

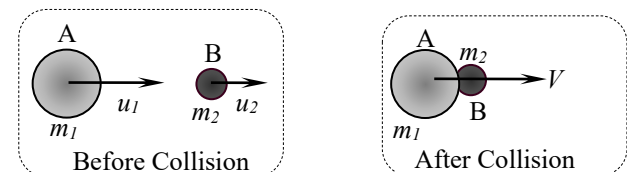


Fig (b) : Perfectly Inelastic Collision

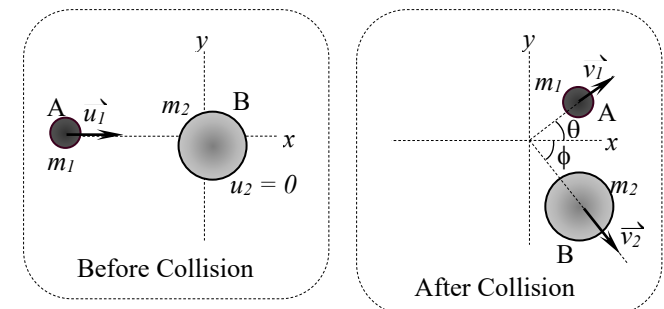


Fig (c) : Perfectly elastic Collision in two dimensions

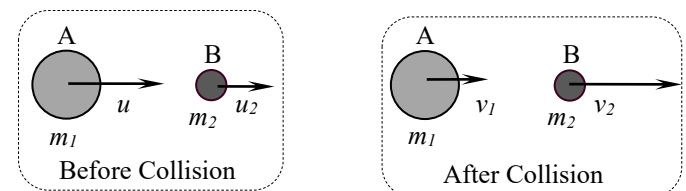


Fig (d) : Perfectly elastic Collision

Steel ball A has mass M and is moving with velocity u . It makes a head-on elastic collision with a stationary brass ball B of mass $4M$. After the collision their speeds of A and B respectively are

- Ans (C)

Velocities after the collision: the velocity of A : $v_A = \left(\frac{m_A - m_B}{m_B + m_B}\right) u_A \Rightarrow v_A = \left(\frac{M - 4M}{M + 4M}\right) u = -0.6u$
 and the velocity of B : $v_B = \left(\frac{2m_A}{m_A + m_B}\right) u_A \Rightarrow v_B = \left(\frac{2 \times M}{M + 4M}\right) v = 0.4u$

PRACTICE QUESTIONS - WORK, ENERGY and POWER

1. A force $\vec{F} = (5\hat{i} + 3\hat{j})$ N is applied over a particle which displaces it from its origin to the point $\vec{r} = (3\hat{i} - 2\hat{j} + 5\hat{k})$ m. The work done on the particle is
(A) -9 J (B) 9 J (C) 13 J (D) 11 J
2. A body moves through a distance of 10 m along a straight line under the action of a force of 5 N. If the work done is 25 J, the angle which the force makes with the direction of motion of the body is
(A) 0° (B) 30° (C) 60° (D) 90°
3. A body of mass 5 kg is placed at the origin, and can move only on the x-axis. A force of 10 N is acting on it in a direction making an angle of 30° with the x-axis and displaces it along the x axis by 4 metres. The work done by the force is
(A) 40 J (B) 17.3 J (C) 20 J (D) 34.6 J
4. A force acts on a 30 g 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 metre and t is in second. The work done during the first 4 seconds is
(A) 5.28 J (B) 528 mJ (C) 52.8 J (D) 528 J
5. A box of mass 1 kg is pulled on a horizontal plane of length 1 m by a force of 8 N then it is slowly raised vertically to a height of 2 m, the net work done is
(A) 8 J (B) 20 J (C) 24 J (D) 28 J
6. 500 kg satellite completes one revolution around the earth at a height of 100 km in 108 minutes. The work done by the gravitational force of earth will be (Take $g = 10 \text{ m/s}^2$)
(A) 50000 J (B) $2\pi \times 6500 \times 5000 \text{ J}$ (C) $500 \times 100 \times 10^8 \text{ J}$ (D) 0
7. A position dependent force $F = (10 - 2x + 4x^3)$ N acts on a small body of mass 3 kg and displaces it from $x = 0$ m to $x = 3$ m. The work done is
(A) 20 J (B) 81 J (C) 102 J (D) 120 J
8. A bullet moving with a speed of $\sqrt{3}$ m/s, pierces a plank and comes to rest. The speed of the bullet that would be just stopped by triple the thickness of the same plank must be
(A) 3 m/s (B) 6 m/s (C) $3\sqrt{3}$ m/s (D) 9 m/s
9. A body falls on the surface of the Earth from a height of 2 m. If after colliding with the Earth, its mechanical energy is lost by 75%, then the body would reach up to a height of
(A) 50 cm (B) 1 m (C) 1.5 m (D) 5 m
10. A 500 g body has a velocity $\vec{v} = 3\hat{i} + 4\hat{j}$ m/s at a certain instant. Its kinetic energy at that instant is
(A) 6.25 J (B) 62.5 J (C) $6.25 \times 10^3 \text{ J}$ (D) $62.5 \times 10^3 \text{ J}$
11. A spherical ball of mass 30 kg is stationary at the top of a hill of height 150 m. It rolls down a smooth surface to the ground then climbs up another hill of height 100 m and finally rolls down a horizontal base at a height of 50 m above the ground. The velocity attained by the ball is (Take $g = 10 \text{ m/s}^2$)
(A) 15 m s^{-1} (B) 20 m s^{-1} (C) 25 m s^{-1} (D) 45 m s^{-1}
12. If the momentum of a body increases by 0.01%, its kinetic energy will increase by
(A) 0.01% (B) 0.02 % (C) 0.04 % (D) 0.08 %

13. A body of mass 10 kg at rest is acted upon simultaneously by two forces 4 N and 3 N at right angles to each other. The kinetic energy of the body at the end of 10 second is

(A) 50 J (B) 100 J (C) 125 J (D) 150 J

14. An ice cream has a marked value of 700 kcal. How many kilowatt-hour of energy will it deliver to the body as it is digested?

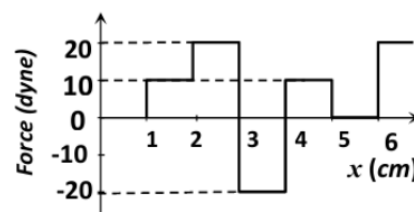
(A) 0.81 kWh (B) 0.90 kWh (C) 1.11 kWh (D) 0.71 kWh

15. A running man has half the kinetic energy of that of a boy of half his mass. When the man speeds up by 1 m/s he has the same kinetic energy as that of the boy. The original speed of the man is

(A) $\sqrt{2}$ m/s (B) $(\sqrt{2}-1)$ m/s (C) $\frac{1}{\sqrt{2}}$ m/s (D) $\left(\frac{1}{\sqrt{2}-1}\right)$ m/s

16. The relationship between force and position is shown in the figure given. The work done by the force in displacing a body from $x = 1$ cm to $x = 5$ cm is

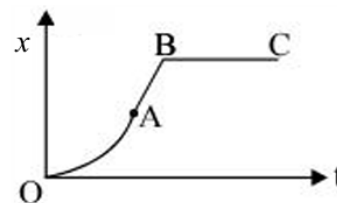
(A) 20 ergs (B) 60 ergs
(C) 70 ergs (D) 700 ergs



17. The position-time ($x - t$) graph of a body acted upon by some forces is shown in the figure. Select the correct alternatives.

- (a) Work done by the forces during BC is zero
(b) Work done by the forces during AB is zero.
(c) Work done by the forces during AB is positive
(d) Work done by the forces during OA is positive.

(A) a, b and c. (B) a, b, and d. (C) a, c, and d. (D) b, c, and d.

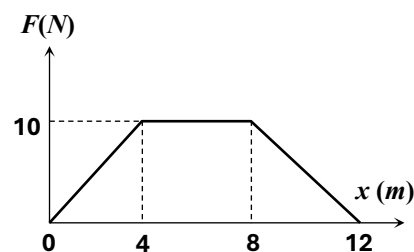


18. A uniform chain of length 3 m is kept on a table such that a length of 1 m hangs freely from the edge of the table. The total mass of the chain is 6 kg. The work done in pulling the entire chain on the table is

(A) 4.9 J (B) 9.8 J (C) 14.7 J (D) 19.6 J

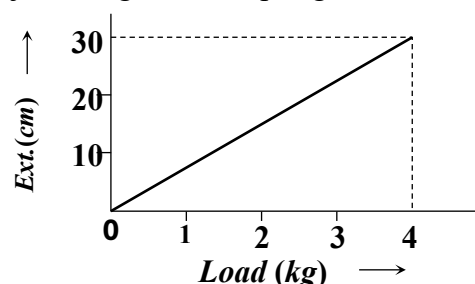
19. The force (F) on a particle of mass 100 g varies with its position (x) as shown in adjacent figure. It starts its journey from rest at $x = 0$, then its velocity at $x = 12$ m is

(A) 0 (B) $20\sqrt{2}$ m/s
(C) $20\sqrt{3}$ m/s (D) 40 m/s



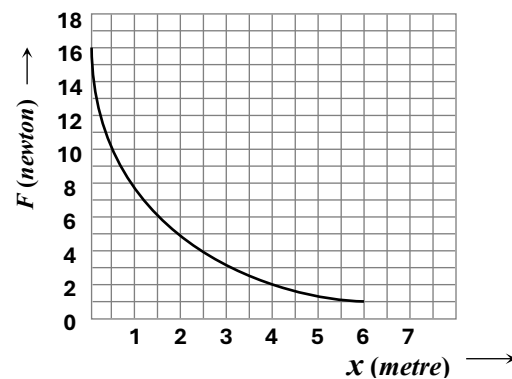
20. Extension Vs Load graph for a spring balance is as given in the adjacent figure. The spring constant of the spring is

(A) 7.5 N/m
(B) 130 N/m
(C) 0.75 N/m
(D) 1.33 N/m



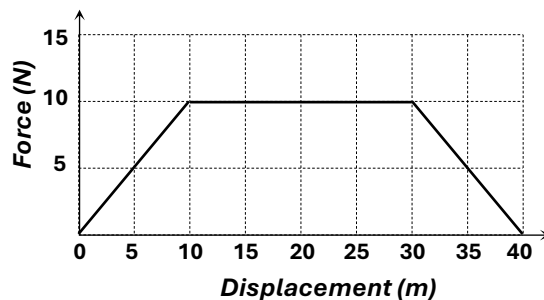
21. The relation between the displacement x of an object produced by the application of the variable force F is represented by a graph shown in the figure. If the object undergoes a displacement from $x = 0.5$ m to $x = 2.5$ m, the work done will be approximately equal to

(A) 1.3 J (B) 2.6 J
(C) 13 J (D) 26 J



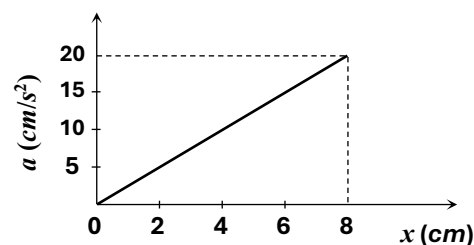
22. Adjacent figure shows the force-displacement graph of a moving body, the work done in displacing body from $x = 0$ to $x = 35$ m is equal to

(A) 50 J (B) 25 J
(C) 287.5 J (D) 200 J



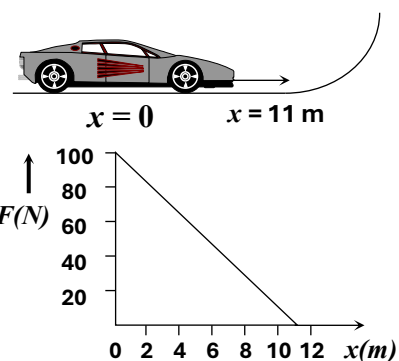
23. A 10 kg mass moves along x -axis. Its acceleration (a) as a function of its position (x) is shown in the figure. What is the total work done on the mass by the force as the mass moves from $x = 0$ to $x = 8$ cm?

(A) 0.08 J (B) 0.16 J
(C) 0.4 mJ (D) 1.6 mJ



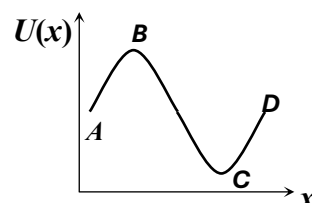
24. A toy car of mass 5 kg moves up a ramp under the influence of force F plotted against displacement x . The maximum height attained by the car is

(A) $y_{\max} = 5$ m
(B) $y_{\max} = 8$ m
(C) $y_{\max} = 11$ m
(D) $y_{\max} = 14$ m

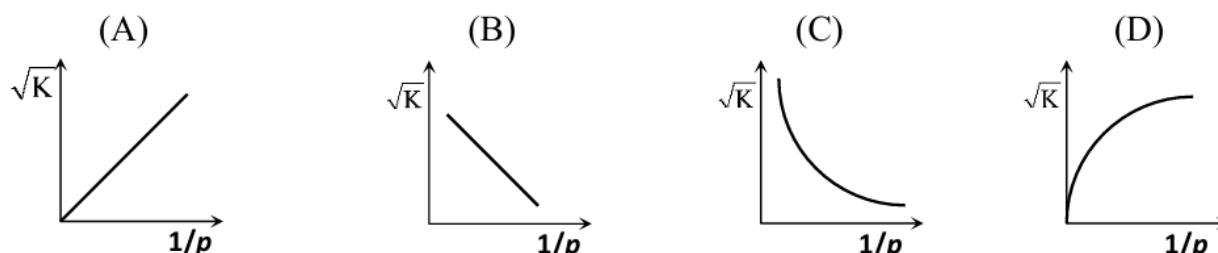


25. The potential energy (U) of a particle varies with distance x as shown in the adjacent graph. The force acting on the particle is zero at

(A) only at C (B) only at B
(C) both B and C (D) both A and D



26. The graph between $\sqrt{K}$ and $\frac{1}{p}$ is (K =kinetic energy and p = momentum)



27. Match the following:

- (A) i-a, ii-d, iii-b, iv-c
- (B) i-d, ii-a, iii-b, iv-c
- (C) i-d, ii-a, iii-c, iv-b
- (D) i-a, ii-d, iii-c, iv-b

Column-I	Column-II
(i) erg	(a) 1.6×10^{-19} J
(ii) electron volt (eV)	(b) 3.6×10^6 J
(iii) kilo watt hour (kWh)	(c) 746 W
(iv) horse-power (hp)	(d) 10^{-7} J

28. Assertion: A person walking on a horizontal road with a load on his head does no work.

Reason: No work is said to be done, if the directions of force and displacement of load are perpendicular to each other.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is true but Reason is false.
- (D) Assertion is false but the Reason is true.

29. Assertion: The work done during a round trip is always zero.

Reason: No force is required to move a body in its round trip.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is true but Reason is false.
- (D) Both Assertion and Reason are false.

30. Assertion: A light body and heavy body have same momentum. Then they should have same kinetic energy.

Reason: Kinetic energy does not depend on mass of the body.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is false but Reason is true.
- (D) Both Assertion and Reason are false.

31. Assertion: Water at the foot of the water-fall is always at different temperature from that at the top.

Reason: The potential energy of water at the top is converted into heat energy during its fall.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is true but Reason is false.
- (D) Both Assertion and Reason are false.

32. Assertion: A spring has potential energy, both when it is compressed or stretched.

Reason: In compressing or stretching, work is done on the spring against the restoring force.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is true but Reason is false.
- (D) Both Assertion and Reason are false.

33. Assertion: The graph between potential energy of a spring versus the extension or compression of the spring is a straight line.

Reason: Potential energy of a stretched or compressed spring, proportional to square of extension or compression.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is false but Reason is true.
- (D) Both Assertion and Reason are false.

34. Assertion: In case of bullet fired from gun, the ratio of kinetic energy of gun and bullet is equal to ratio of mass of bullet and gun.

Reason: In firing, momentum is conserved.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is false but Reason is true.
- (D) Both Assertion and Reason are false.

35. Assertion: Power of machine gun is determined by both, the number of bullets fired per second and kinetic energy of bullets.

Reason: Power of any machine is defined as work done (by it) per unit time.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is false but Reason is true.
- (D) Both Assertion and Reason are false.

36. Assertion: Power developed in circular motion is always zero.

Reason: Work done in case of circular motion is zero.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is false but Reason is true.
- (D) Both Assertion and Reason are false.

37. Two springs P and Q having spring constant k_P and k_Q respectively ($k_P = 2k_Q$) are stretched by applying force of equal magnitude. If energy stored in spring P is U_P , then the energy stored in spring Q will be

- (A) $U_P/2$
- (B) $U_P/4$
- (C) $2 U_P$
- (D) $4 U_P$

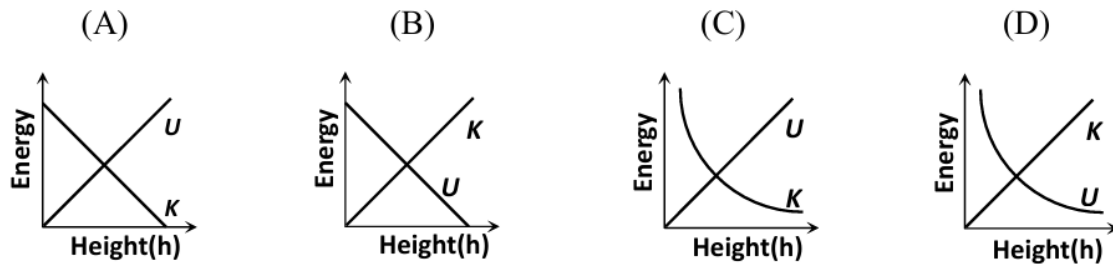
38. A car of mass 1250 kg is moving at 30 m/s. Its engine delivers 30 kW while resistive force due to surface is 750 N. What maximum acceleration can be given in the car?

- (A) 0.2 m s^{-2}
- (B) 0.4 m s^{-2}
- (C) 0.5 m s^{-2}
- (D) 0.8 m s^{-2}

39. An engine pump is used to pump a liquid of density ρ continuously through a pipe of cross-sectional area A. If the speed of flow of the liquid in the pipe is v, then the rate at which kinetic energy is being imparted to the liquid is

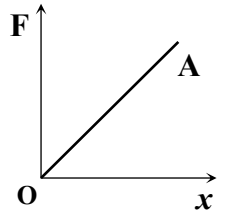
- (A) $\frac{1}{2} A \rho v^3$
- (B) $\frac{1}{2} A \rho v^2$
- (C) $\frac{1}{2} A \rho v$
- (D) $A \rho v$

40. For an object thrown vertically upwards, which of the following graphs correctly shows the variations of kinetic energy (K), change in potential energy (U) with respect to ground with height(h)?



41. The force required to stretch a spring varies with the distance as shown in the figure. If the experiment is performed with the above spring of half length, the line OA will

- (A) Shift towards F-axis (B) Shift towards X-axis
(C) Remain as it is (D) Become double in length



42. 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

- (A) 4.5 W (B) 6.5 W (C) 7.5 W (D) 9.5 W

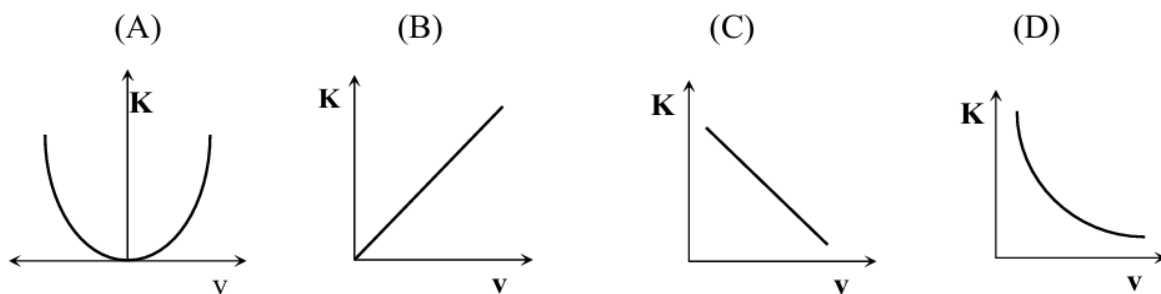
43. The power of pump, which can pump 152 kg of water to a height of 60 m in 2 minutes is nearly

- (A) 1 hp (B) 2 hp
(C) 1 kW (D) 2 kW

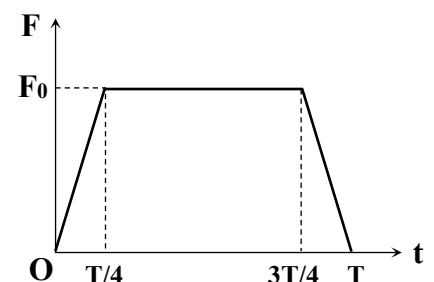
44. A 10 hp motor pumps out water from a well of depth 20 m and fills a water tank of volume 22850 litres at a height of 10 m from the ground. the running time of the motor to fill the empty water tank is

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

45. The graph between kinetic energy (K) and velocity of the particle (v) is



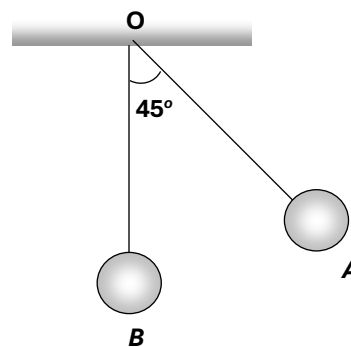
46. A particle of mass m moving with a velocity u makes an elastic one dimensional collision with a stationary particle of mass m establishing a contact with it for extremely small time T . Their force of contact increases from zero to F_0 linearly in time $\frac{T}{4}$, remains constant for a further time $\frac{T}{2}$ and decreases linearly from F_0 to zero in further time $\frac{T}{4}$ as shown. The magnitude of F_0 is



- (A) $\frac{mu}{T}$ (B) $\frac{2mu}{T}$ (C) $\frac{4mu}{3T}$ (D) $\frac{3mu}{4T}$

- 47.** An engine of a train of mass 2×10^6 kg changes its velocity from 5 m/s to 25 m/s in 5 minutes. The power of the engine is
(A) 1 MW (B) 2 MW (C) 5 MW (D) 6 MW
- 48.** A truck of mass 30,000 kg moves up an inclined plane of slope 1 in 100 at a speed of 30 kmph. The power of the truck is
(A) 2.5 kW (B) 5 kW (C) 10 kW (D) 25 kW
- 49.** A man fires 120 bullets per minute with a speed of 360 km/hour from an automatic gun. If each bullet weighs 10 g, the power of the gun is
(A) 100 W (B) 200 W (C) 600 W (D) 800 W
- 50.** From a waterfall, water is falling down at the rate of 600 kg/minute on the blades of turbine. If the height of the fall is 50 m, then the power delivered to the turbine is
(A) 1 kW (B) 2.45 kW (C) 4.9 kW (D) 9.8 kW
- 51.** An engine pumps up 100 kg of water through a height of 10 m in 5 s. Given that the efficiency of the engine is 60% . If $g=10 \text{ m/s}^2$, the power of the engine is
(A) 33 W (B) 330 W (C) 3.3 kW (D) 33 kW
- 52.** A quarter horse-power motor runs at a speed of 600 rpm. Assuming efficiency of motor to be 40%, the work done by the motor in one rotation will be
(A) 7.46 erg (B) 7.46 J (C) 74.6 J (D) 746 J
- 53.** An Uranium nucleus ${}_{92}\text{U}^{238}$ decays by emitting an alpha particle of velocity v . The recoil velocity of the residual nucleus is
(A) $-4v/234$ (B) $v/4$ (C) $-4v/238$ (D) $4v/238$
- 54.** A neutron makes a head-on elastic collision with a stationary deuteron. The fractional energy loss of the neutron in the collision is
(A) 16/81 (B) 8/9 (C) 8/27 (D) 2/3
- 55.** A body of mass 50 kg is projected vertically upwards with velocity of 100 m/s. After 5 seconds of projection, this body breaks into 20 kg and 30 kg. If 20 kg piece travels upwards with 150 m/s, then the velocity of the other piece will be
(A) 15 m/s downwards (B) 15 m/s upwards
(C) 51 m/s downwards (D) 51 m/s upwards
- 56.** A shell initially at rest explodes into two pieces of equal mass, then the two pieces will
(A) Be at rest
(B) Move with different velocities in different directions
(C) Move with the same speed in opposite directions
(D) Move with the same velocity in same direction

57. 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. If the collision is elastic,



- (A) Both A and B rise to the same height
- (B) Both A and B come to rest at B
- (C) Both A and B move with the same velocity of A
- (D) A comes to rest and B moves with the velocity of A

58. **Assertion:** In an elastic collision of two bodies, the momentum and energy of each body is conserved.

Reason: If two bodies stick to each other, after colliding, the collision is said to be perfectly elastic.

- (A) Both Assertion and Reason are true and the Reason is correct explanation of the Assertion.
- (B) Both Assertion and Reason are true but Reason is not correct explanation of the Assertion.
- (C) Assertion is true but Reason is false.
- (D) Both Assertion and Reason are false.

59. A body of mass m_1 moving with a velocity 3 ms^{-1} collides with another body at rest of mass m_2 . After collision the velocities of the two bodies are 2 ms^{-1} and 5 ms^{-1} respectively along the direction of motion of m_1 . The ratio m_1/m_2 is

- (A) 5
- (B) 10
- (C) 3
- (D) 2

60. A body of mass 4 kg moving with velocity 12 m/s collides with another body of mass 6 kg at rest. If two bodies stick together after collision, then the loss of kinetic energy of system is

- (A) 0
- (B) 288 J
- (C) 172.8 J
- (D) 144 J

61. A body of mass m moving with velocity v collides head on with another body of mass $2m$ which is initially at rest. The ratio of kinetic energy of colliding body before and after collision will be

- (A) 1 : 1
- (B) 2 : 1
- (C) 4 : 1
- (D) 9 : 1

62. A block of mass 1 kg is moving with speed 3 m/s on a smooth surface. It strikes another mass of 2 kg and they move together as a single body. The kinetic energy loss during the collision is

- (A) 1.5 J
- (B) 2.5 J
- (C) 3.0 J
- (D) 4.5 J

63. In an elastic collision of two particles, which of the following is conserved?

- (A) Momentum of each particle.
- (B) Speed of each particle.
- (C) Kinetic energy of each particle.
- (D) Total kinetic energy of both the particles.

64. Match the following Column-I with Column-II.

- (A) i-a, ii-d, iii-b, iv-c
- (B) i-d, ii-a, iii-b, iv-c
- (C) i-d, ii-a, iii-c, iv-b
- (D) i-a, ii-d, iii-c, iv-b

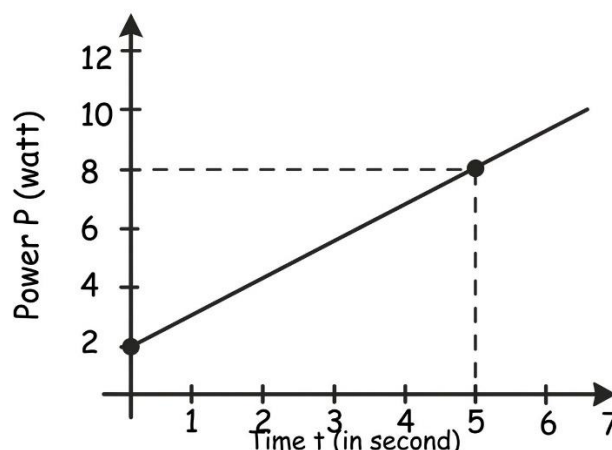
Column-I	Column-II
(i) Impulse of force	(a) $[\text{ML}^2 \text{T}^{-2}]$
(ii) Work	(b) $[\text{ML}^2 \text{T}^{-3}]$
(iii) Power	(c) $[\text{ML} \text{T}^{-2}]$
(iv) Force	(d) $[\text{ML} \text{T}^{-1}]$

KEY ANSWERS

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

PREVIOUS YEAR QUESTIONS (2020 ONWARDS)

1. A body is initially at rest. It under goes one dimensional motion with constant acceleration. The power delivered to it at time t is proportional to: (2020)
(A) $t^{3/2}$ (B) t^2 (C) $t^{1/2}$ (D) t
2. A 1 kg ball moving at 12 ms^{-1} collides with a 2 kg ball moving in opposite direction at 24 ms^{-1} . If the coefficient of restitution is $2/3$, then their velocities after the collision are: (2021)
(A) $-4\text{ ms}^{-1}, -28\text{ ms}^{-1}$ (B) $-28\text{ ms}^{-1}, -4\text{ ms}^{-1}$
(C) $4\text{ ms}^{-1}, 28\text{ ms}^{-1}$ (D) $28\text{ ms}^{-1}, 4\text{ ms}^{-1}$
3. A ball hits the floor and rebounds after an inelastic collision. In this case: (2021)
(A) the momentum of the ball is conserved.
(B) the mechanical energy of the ball is conserved.
(C) the total momentum of the ball and the earth is conserved.
(D) the total mechanical energy of the ball and the earth is conserved.
4. A smooth chain of length 2 m is kept on a table such that its length of 60 cm hangs freely from the edge of the table. The total mass of the chain is 4 kg . The work done in pulling the entire chain on the table is (taking $g = 10\text{ ms}^{-2}$): (2022)
(A) 3.6 J (B) 12.9 J (C) 2.0 J (D) 6.3 J
5. A ball of mass 0.2 kg is thrown vertically down from a height of 10 m . It collides with the floor and loses 50% of its energy and then rises back to the same height. The value of its initial velocity is: (2023)
(A) 14 ms^{-1} (B) 196 ms^{-1} (C) 20 ms^{-1} (D) Zero
6. A particle of mass 500 g is at rest. It is free to move along a straight line. The power delivered to the particle varies with time according to the following graph: (2024)



The momentum of the particle at $t = 5\text{ s}$ is:

- (A) $2\sqrt{5}$ (B) $5\sqrt{2}\text{ Ns}$ (C) 5 Ns (D) 5.5 Ns
7. A body of mass 0.25 kg travels along a straight line from $x = 0$ to $x = 2\text{ m}$ with a speed $v = kx^{3/2}$ where $k = 2\text{ SI Units}$. The work done by the net force during this displacement is: (2025)
(A) 4 J (B) 8 J (C) 16 J (D) 32 J

8. During an elastic collision between two bodies, which of the following statements are correct?
- I. The initial kinetic energy is equal to the final kinetic energy of the system.
 - II. The linear momentum is conserved.
 - III. The kinetic energy during Δt (the collision time) is not conserved.
- (A) I and II only (B) II and III only (C) I and III only (D) I, II and III
9. A horizontal force of 5 N is applied on a stationary body of mass 5 kg, which is initially at rest on a frictionless table. The change in kinetic energy of the body in 10 s is (2026)
- (A) 25 J (B) zero (C) 125 J (D) 250 J

KEY ANSWERS

1	2	3	4	5	6	7	8	9
D	B	C	A	A	C	A	D	D