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Free Sample Contents

Class XI

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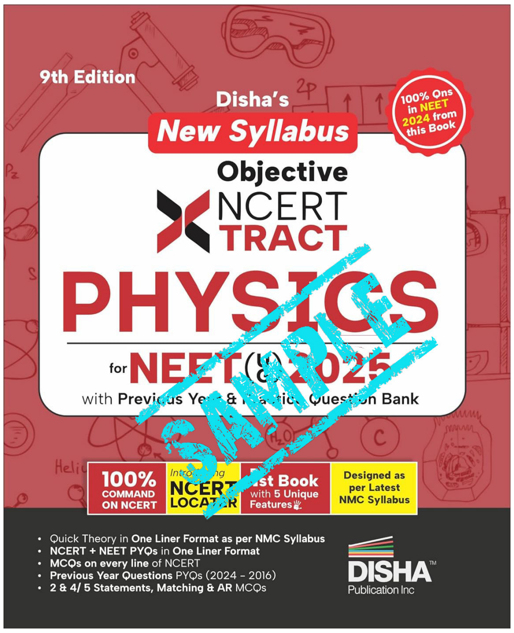

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Note : * The four Exercises in each of the chapters are :
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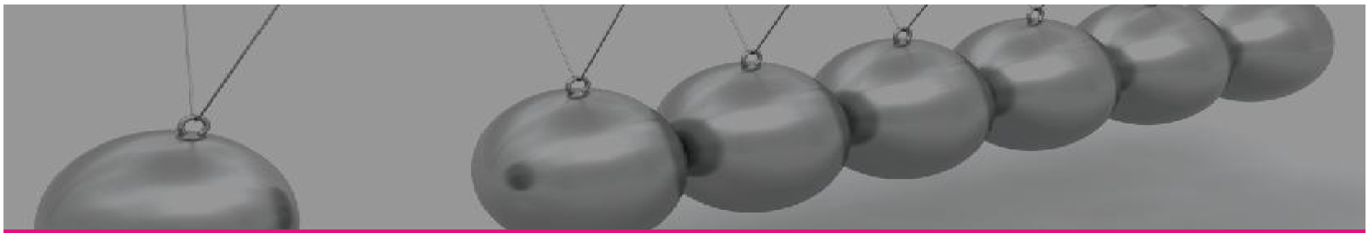
NOTE* These Topics are in new NCERT, but not in the new NEET 2024 Syllabus. These Topics have been retained in the book so as to match NCERT and any future amendments in NEET. Questions on these Topics have also been marked with a * in the respective Exercises of the Chapters.



5 Work, Energy and Power

Trend Analysis NEET

	NEET	Remarks
Number of Questions from 2024-18	12	Higher weightage chapter for NEET
Weightage	3.4%	

			NEET	
Year	**Topic Name**	**Concept Used**	**No. of Ques.**	**Difficulty Level**
2024	Power, Collisions	Instantaneous Power, Completely inelastic collisions	2	Easy (1) Average(1)
2023	The potential energy of a spring	Potential energy, $u = \frac{1}{2}kx^2$	1	Average
2022	Energy, Power, Collisions	Energy = Power (kW) × time(h) Power, P = F × V, Conservation of momentum	3	Easy(1) Average (2)
2021	Power, P.E.	Potential Energy, Kinetic Energy, Power	2	Average (2)
2020	–	–	–	–
2019	Work done by force/Elastic potential energy	Work done, $W = \int_{y_i}^{y_f} F.dy$ Elastic potential energy	2	Easy Average
2018	Conservation of mechanical energy/collisions	Conservation of mechanical energy/Coefficient of restitution	2	Average

NCERT ONE-LINERS
(Important Points to Remember)

5.1 Introduction

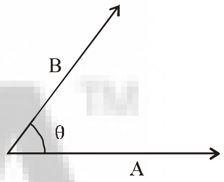
- Energy is our capacity to do work. In Physics too, the term 'energy' is related to work in this sense, but the term 'work' is defined much more precisely.
- Work is said to be done when a force applied on the body displaces the body through a certain distance in the direction of force.

The Scalar Product

- The scalar product or dot product of any two vectors **A** and **B**, denoted as **A·B** is defined as

$$\mathbf{A}\cdot\mathbf{B} = A\,B\cos\theta$$

where θ is the angle between the two vectors.



(a)

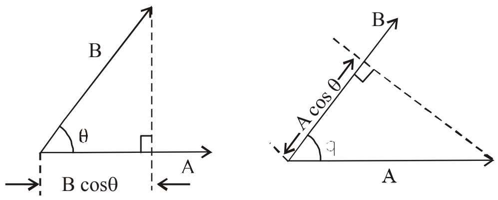
Fig.: (a) The scalar product of two vectors A and B is a scalar: A.B = AB cosθ.

- The dot product of **A** and **B** is a scalar quantity. Each vector, **A** and **B**, has a direction but their scalar product does not have a direction.

  Two vectors $\vec{A}$ and $\vec{B}$ are said to be orthogonal if $\vec{A}.\vec{B} = 0$

  NEET 2015

- **B** cos θ is the projection of **B** onto **A** and **A** cos θ is the projection of **A** onto **B.**



(b) (c)

Fig.: (b) B cosθ is the projection of B onto A. (c) A cosθ is the projection of A onto B.

- The scalar product follows the **commutative law**:

$$\mathbf{A}\cdot\mathbf{B} = \mathbf{B}\cdot\mathbf{A}$$

- Scalar product obeys the **distributive law**:

$$\mathbf{A}\cdot(\mathbf{B}+\mathbf{C}) = \mathbf{A}\cdot\mathbf{B} + \mathbf{A}\cdot\mathbf{C}$$

- For unit vectors $\hat{\mathbf{i}}, \hat{\mathbf{j}}, \hat{\mathbf{k}}$ we have

$$\hat{\mathbf{i}}\cdot\hat{\mathbf{i}} = \hat{\mathbf{j}}\cdot\hat{\mathbf{j}} = \hat{\mathbf{k}}\cdot\hat{\mathbf{k}} = 1$$

$$\hat{\mathbf{i}}\cdot\hat{\mathbf{j}} = \hat{\mathbf{j}}\cdot\hat{\mathbf{k}} = \hat{\mathbf{k}}\cdot\hat{\mathbf{i}} = 0$$

5.2 Notions of Work and Kinetic Energy: The Work-energy Theorem

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

$$K_f - K_i = w$$

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \mathbf{ma.d} = \mathbf{F}\cdot\mathbf{d}$$

This is known as **work energy theorem**. NEET 2015, 2017

5.3 Work

- The **work** done by the force is defined to be the product of component of the force in the direction of the displacement and the magnitude of this displacement. Thus $W = (F\cos\theta)d = \mathbf{F}\cdot\mathbf{d}$

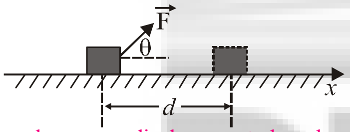


Fig.: An object undergoes a displacement d under the influence of the force F.

No work is done if :

- the displacement is zero. A weightlifter holding a 150kg mass steadily on his shoulder for 30 s does no work on the load during this time.
- the force is zero. A block moving on a smooth horizontal table is not acted upon by a horizontal force (since there is no friction), but may undergo a large displacement.
- the force and displacement are mutually perpendicular. This is so since, for $\theta = \pi/2$ rad (= 90°), $\cos(\pi/2) = 0$.

- In many examples the frictional force opposes displacement and $\theta = 180°$. Then the work done by friction is negative ($\cos 180° = -1$).

5.4 Kinetic Energy

- If an object of mass m has velocity $\mathbf{v}$, its kinetic energy K is

$$K = \frac{1}{2}m\,\mathbf{v}\cdot\mathbf{v} = \frac{1}{2}mv^2$$

Relation between kinetic energy (K) and momentum (p) is given by

$$K = \frac{1}{2}\frac{m^2v^2}{m} = \frac{1}{2}\frac{p^2}{m}$$

- Kinetic energy is a scalar quantity. The kinetic energy of an object is a measure of the work an object can do by the virtue of its motion.
- The kinetic energy of a fast flowing stream has been used to grind corn. Sailing ships employ the kinetic energy of the wind.

5.5 Work Done by a Variable Force

- For a varying force the work done can be expressed as a definite integral of force over displacement.
- The work done by a variable force is

$$W = \int_{x_i}^{x_f} F(x)\,dx$$ NEET 2019

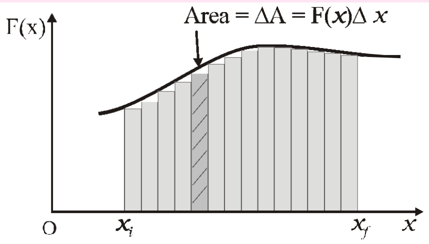


Fig.: The shaded rectangle represented the work done by the varying force $F(x)$, over the small displacement Δx, $\Delta W = F(x)\,\Delta x$.

5.6 The Work-Energy Theorem for a Variable Force

- The time rate of change of kinetic energy is

$$\frac{dK}{dt} = \frac{d}{dt}\left(\frac{1}{2}mv^2\right) = m\frac{dv}{dt}v$$

$$= F\,v \text{ (from Newton's Second Law)} = F\frac{dx}{dt}$$

Thus $dK = Fdx$

Integrating from the initial position (x_i) to final position (x_f), we have

$$\int_{K_i}^{K_f} dK = \int_{x_i}^{x_f} Fdx$$

where, K_i and K_f are the initial and final kinetic energies corresponding to x_i and x_f.

$$\text{or } K_f - K_i = \int_{x_i}^{x_f} Fdx = W$$

5.7 The Concept of Potential Energy

- Potential energy is the 'stored energy' by virtue of the position or configuration of a body.
- Gravitational potential energy of an object, as a function of the height h, is denoted by V(h) and it is the negative of work done by the gravitational force in raising the object to that height.

$$V(h) = mgh$$ NEET 2021

- If h is taken as a variable, the gravitational force F equals the negative of the derivative of $V(h)$ with respect to h.

$$F = -\frac{d}{dh}V(h) = mg$$

The negative sign indicates that the gravitational force is downward.

- Change in potential energy $(V_f - V_i) = \Delta V = V_f - V_i$

$$= \int_{x_i}^{x_f} F(x)dx = -W_{\text{conservative}}$$

- The work done by a **conservative force** such as gravity depends on the initial and final positions only.
- If the work done or the kinetic energy did depend on other factors such as the velocity or the particular path taken by the object, the force would be called **non-conservative**.
- When work is done upon a system by a conservative force then its potential energy increases. NEET 2011

5.8 The Conservation of Mechanical Energy

- Suppose that a body undergoes displacement Δx under the action of a conservative force F. Then from the *WE* theorem we have,

$$\Delta K = F(x)\,\Delta x$$

- If the force is conservative, the potential energy function $V(x)$ can be defined such that

$$\Delta V = -F(x)\,\Delta x$$

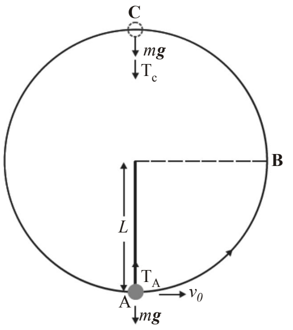
The above equations imply that

$$\Delta K + \Delta V = 0$$
$$\Delta(K + V) = 0$$

- Individually the kinetic energy (K) and potential energy V(x) may vary from point to point but the sum is a constant.
- The work done by the **conservative force** depends only on the end points. This can be seen from the relation, Work done $W = K_f - K_i = V(x_i) - V(x_f)$ which depends on the end points.
- Work done by this force in a closed path is zero.
- The total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.

Vertical Circular Motion

- At the maximum height from the ground. The energy is purely potential (E = mgH). It is partially converted to kinetic at height h ($E = mgh + ½ mv^2$) and is fully kinetic at ground level ($k = ½ mv^2$).



- The potential energy of the system to be zero at the lowest point A. Thus, at A :

$$E = \frac{1}{2}mv_0^2\ ;\ T_A - mg = \frac{mv_0^2}{L}\ \text{[Newton's Second Law]}$$

where T_A is the tension in the string at A.

- At the highest point C, the string slackens, as the tension in the string (T_C) becomes zero.
Thus, at C

$$E = \frac{1}{2}mv_c^2 + 2mgL\ ;\ mg = \frac{mv_c^2}{L}\ \text{[Newton's Second Law]}$$

where v_C is the speed at C. $E = \frac{5}{2}mgL$

Equating this to the energy at A

$$\frac{5}{2}mgL = \frac{m}{2}v_0^2 \ \text{ or, }\ v_0 = \sqrt{5gL}$$

It is clear; $v_c = \sqrt{gL}$

At B, the energy is

$$E = \frac{1}{2}mv_B^2 + mgL$$

Equating this to the energy at A and employing the result namely $v_0^2 = 5gL$

$$\frac{1}{2}mc_B^2 + mgL = \frac{1}{2}mv_0^2 = \frac{5}{2}mgL \quad \therefore\ v_B = \sqrt{3gL}$$

The ratio of the kinetic energies at B and C is :

$$\frac{K_B}{K_C} = \frac{\frac{1}{2}mv_B^2}{\frac{1}{2}mv_C^2} = \frac{3}{1}$$

At point C, the string becomes slack and the velocity of the bob is horizontal and to the left.

- When one end of a string of length l is connected to a particle of mass m and the other end to a small peg on a smooth horizontal surface. Centripetal force for circular motion will be provided by the tension in string. NEET 2017

5.9 The Potential Energy of a Spring

- Force law for the spring is called Hooke's law and is mathematically stated as

$$F_s = -kx$$

The constant k is called the spring constant.

- The spring is said to be stiff if k is large and soft if k is small.
- If the extension is x_m, then work done by the spring force is

$$W_s = \int_0^{x_m} F_s\,dx = -\int_0^{x_m} kx\,dx = -\frac{kx_m^2}{2}$$ NEET 2015

$$\Rightarrow V_f - V_i = -W = \frac{kx_m^2}{2} \Rightarrow V = \frac{kx_m^2}{2}\ \text{[putting } V_i = 0\ \&\ V_f = V]$$

$V = \frac{1}{2}kx_m^2$ is the potential energy stored in spring in extension or compression x_m.

- If the block is moved from an initial displacement x_i to a final displacement x_f, the work done by the spring force W_s is

$$W_s = -\int_{x_i}^{x_f} kx\,dx = \frac{kx_i^2}{2} - \frac{kx_f^2}{2}$$ NEET 2023

- If the block is pulled from x_i and allowed to return to x_i;

$$W_s = -\int_{x_i}^{x_f} k\,x\,\mathrm{d}x = \frac{k\,x_i^2}{2} - \frac{k\,x_i^2}{2} = 0$$

The **work done by the spring force in a cyclic process is zero**.

- Spring force (i) is position dependent only as first stated by Hooke ($F_s = -kx$); (ii) does work which only depends on the initial and final positions.
- The spring force is a **conservative force**.
- The potential energy $V(x)$ of the spring is zero when block and spring system is in the equilibrium position.

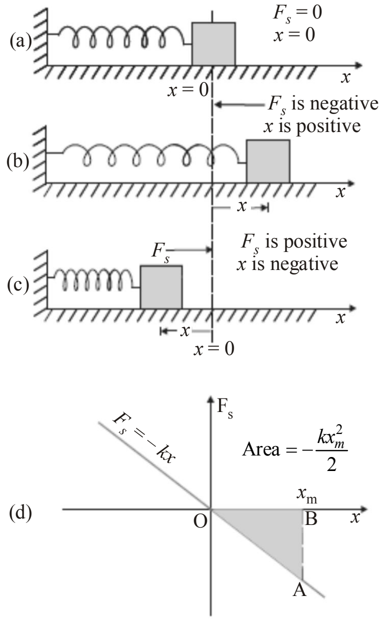
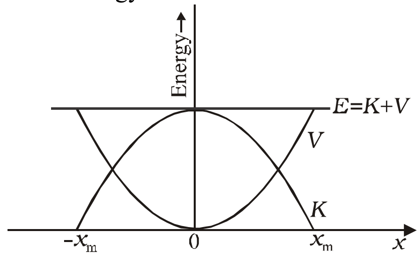


Fig.: *Illustration of the spring force with a block attached to the free end of the spring. (a) The spring force F_s is zero when the displacement x from the equilibrium position is zero. (b) For the stretched spring $x > 0$ and $F_s < 0$ (c) For the compressed spring $x < 0$ and $F_s > 0$.(d) The plot of F_s versus x. The area of the shaded triangle represents the work done by the spring force. Due to the opposing signs of F_s and x, this work done is negative, $W_s = -kx_m^2 / 2$.*

- The kinetic energy (K) of spring gets converted to potential energy (V) and vice versa, however, the total mechanical energy remains constant.



5.10 Power

- **Power** is defined as the time rate at which work is done or energy is transferred.
- The **average power** of a force is defined as the ratio of the work, W, to the total time t taken

$$P_{av} = \frac{W}{t}$$

- The **instantaneous power** is defined as the limiting value of the average power as time interval approaches zero,

$$P = \frac{\mathrm{d}W}{\mathrm{d}t}$$

- The work dW done by a force F for a displacement $\mathbf{dr}$ is $\mathrm{d}W = \mathbf{F}\cdot\mathbf{dr}$.

- The instantaneous power can also be expressed as

$$P = F \cdot \frac{\mathbf{dr}}{\mathrm{d}t} = \mathbf{F}\cdot\mathbf{v}$$ NEET 2016, 2022, 2024

where **v** is the instantaneous velocity when the force is **F**.

- There is another unit of power, namely the **horse-power** (hp)

1 hp = 746 W

This unit is still used to describe the output of automobiles, motorbikes, etc.

- 1 kilowatt hour (kWh) of energy. $= 3.6 \times 10^6$ J

Our electricity bills carry the energy consumption in units of kWh.

Power on turbine, $P = \frac{d(mgh)}{dt}$ NEET 2021

The energy radiated by 100 kW transmitter in

1 hour = 100 kW × 1hr = 100 kWh

$= 100 \times 3.6 \times 10^6 \mathrm{J} = 36 \times 10^7 \mathrm{J}$ NEET 2022

5.11 Collisions

- In **collision** a strong force acts between two or more bodies for a short time as a result of which the energy and momentum of the interacting particles change.

Elastic and Inelastic Collisions

- In all collisions the total linear momentum is conserved; the initial momentum of the system is equal to the final momentum of the system. NEET 2022
- The total kinetic energy of the system is not necessarily conserved. The impact and deformation during collision may generate heat and sound. Part of the initial kinetic energy is transformed into other forms of energy.
- A useful way to visualise the deformation during collision is in terms of a ‘compressed spring’. If the ‘spring’ connecting the two masses regains its original shape without loss in energy, then the initial kinetic energy is equal to the final kinetic energy but the kinetic energy during the collision time Δt is not constant. Such a collision is called an **elastic collision**.
- A collision in which the two particles move together after the collision is called a **completely inelastic collision.**

- The intermediate case where the deformation is partly relieved and some of the initial kinetic energy is lost is more common and is appropriately called an **inelastic collision**.

Collisions in One Dimension

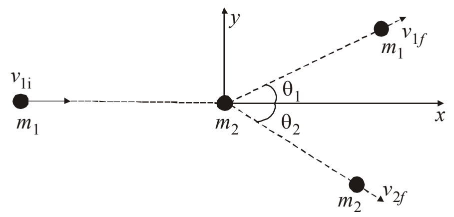


Fig.: Collision of mass m_1 with a stationary mass m_2.

- A **completely inelastic collision** in one dimension.
  $\theta_1 = \theta_2 = 0$
  $m_1v_{1i} = (m_1 + m_2)v_f$ (momentum conservation)
  $$v_f = \frac{m_1}{m_1+m_2}v_{1i}$$ NEET 2024

  The loss in kinetic energy on collision is
  $$\Delta K = \frac{1}{2}m_1v_{1i}^2 - \frac{1}{2}(m_1+m_2)v_f^2$$
  $$= \frac{1}{2}m_1v_{1i}^2 - \frac{1}{2}\frac{m_1^2}{m_1+m_2}v_{1i}^2 = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}v_{1i}^2$$
  the momentum and kinetic energy conservation equations are
  $m_1v_{1i} = m_1v_{1f} + m_2v_{2f}$ ...(i)
  $m_1v_{1i}^2 = m_1v_{1f}^2 + m_1v_{2f}^2 \therefore v_{2f} = v_{1i} + v_{1f}$
  Substituting this in Eq. (i)
  $$v_{1f} = \frac{(m_1-m_2)}{m_1+m_2}v_{1i} \text{ and } v_{2f} = \frac{2m_1v_{1i}}{m_1+m_2}$$

- Coefficient of restitution, $e = \dfrac{\text{velocity of seperation}}{\text{velacity of approach}}$ NEET 2018

Case I: If the two masses are equal

$v_{1f} = 0$

$v_{2f} = v_{1i}$

Case II: If one mass dominates, e.g. $m_2 >> m_1$

$v_{1f} \simeq -v_{1i}$ $v_{2f} \simeq 0$

The heavier mass is undisturbed while the lighter mass reverses its velocity.

- If the initial velocities and final velocities of both the bodies are along the same straight line, then it is called a **one-dimensional collision**, or **head-on collision**.

When a body of mass m, collides with a body of mass m_2 in elastic and head on collision, energy lost by body of mass m $= \dfrac{4m_1m_2}{(m_1+m_2)^2}$ NEET 2019

Collisions in Two Dimensions

- Linear momentum is conserved. The *x*- and *y*-component equations are
  $m_1v_{1i} = m_1v_{1f}\cos\theta_1 + m_2v_{2f}\cos\theta_2$
  $0 = m_1v_{1f}\sin\theta_1 - m_2v_{2f}\sin\theta_2$

  If, the collision is elastic, $\frac{1}{2}m_1v_{1i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$

- In collision particles may or may not come in real touch.

  In scattering, the velocities and directions in which the two particles go away depend on their initial velocities as well as the type of interactions between them, their masses shapes and sizes.

Tips/Tricks/Techniques ONE-LINERS
(Exam Special)

- If work is done on a body, its kinetic or potential energy increases. If work is done by the body, its potential or kinetic energy decreases.
- In the elastic collisions, the kinetic or mechanical energy is not converted into any other form of energy.
- The force involved in an inelastic collision is non-conservative in nature.
- If collision is head on the colliding bodies move along the same straight line before and after collision.
- If collision is oblique, the colliding bodies move at certain angles before and/or after the collisions.
- In static and dynamic equilibrium, work done is zero.
- Work done by a man holding the weight at fixed position is zero.
- Work done by a force depends on the frame of reference.
- Only tangential component of force is responsible for power dissipation. Power dissipated by radial component is zero. For example power dissipated by centripetal force is zero.
- In a perfectly elastic collision, in one dimension, when masses of the colliding particles are equal, their velocities get exchanged after collision.
- If a body starts rotating after collision, then both linear momentum and angular momentum are conserved.
- In the elastic collisions the forces involved are conservative.
- If the speed of water flowing through a pipe is v, then power is proportional to v^3.
- If n bullets are fired from a machine gun, each having kinetic energy k, then power of the machine gun will be nk.
- Work done by a body of mass m against friction on a rough horizontal surface of coefficient of friction μ is μmgx. Here, x is the distance moved by the body.
- Let h_1, h_2 .... h_n be the heights of the body to which the body rebounds again and again, then

$$e = \sqrt{\frac{h_1}{h}} = \sqrt{\frac{h_2}{h_1}} = \sqrt{\frac{h_3}{h_2}}$$

Clearly $h_1 = e^2h$; $h_2 = e^4h$ and similarly, after nth rebound $h_n = (e^{2n})h$

- The velocity of an object depends on the choice of reference frame. Thus, kinetic energy also depends on the choice of the reference frame.
- Potential energy depends on the reference level. In case of spring, it is advised to assume zero potential energy at the natural length of the spring. In case of gravity any convenient level can be chosen as reference frame.
- If a ball is dropped from a height h_0 on a horizontal floor, then time taken by the ball to stop bouncing is given by

$$T = \left(\frac{1+e}{1-e}\right)\sqrt{\frac{2h_0}{g}}$$ (Here, e = coefficient of restitution)

- An engine pulls a train of mass m with constant velocity. If the rails are on a plane surface and there is no friction, the power dissipated by the engine is zero.
- When the momentum of a body is made n times then its kinetic energy is increased by factor n^2.
- Slope of work time graph = power.
- Area under power time curve = work done by/on the body.
- If a chain of length L and mass M is held on a frictionless table with $(1/n)^{th}$ of its length is hanging over the edge, then work done in pulling the hanging portion on the table is given by

$$W = \frac{MgL}{2n^2}$$

- The phrase 'calculate the work done' is incomplete. We should refer to the work done by a specific force or a group of forces on a given body over a certain displacement.
- Work done is a scalar quantity. It can be positive or negative unlike mass and kinetic energy which are positive scalar quantities. The work done by the friction or viscous force on a moving body is negative.
- For two bodies, the sum of the mutual forces exerted between them is zero from Newton's Third Law,

$$\mathbf{F}_{12} + \mathbf{F}_{21} = 0$$

But the sum of the work done by the two forces need not *always cancel, i.e.*

$$W_{12} + W_{21} \neq 0$$

However, it may sometimes be true.

- The work done by a force can be calculated sometimes even if the exact nature of the force is not known.
- The WE theorem is not independent of Newton's Second Law. The WE theorem may be viewed as a scalar form of the Second Law. The principle of conservation of mechanical energy may be viewed as a consequence of the WE theorem for conservative forces.
- The WE theorem holds in all inertial frames. It can also be extended to noninertial frames provided we include the pseudoforces in the calculation of the net force acting on the body under consideration.
- The potential energy of a body subjected to a conservative force is always undetermined upto a constant. For example, the point where the potential energy is zero is a matter of choice. For the gravitational potential energy mgh, the zero of the potential energy is chosen to be the ground. For the spring potential energy $kx^2/2$, the zero of the potential energy is the equilibrium position of the oscillating mass.
- Every force encountered in mechanics does not have an associated potential energy. For example, work done by friction over a closed path is not zero and no potential energy can be associated with friction.
- During a collision : (a) the total linear momentum is conserved at each instant of the collision ; (b) the kinetic energy conservation (even if the collision is elastic) applies after the collision is over and does not hold at every instant of the collision. In fact the two colliding objects are deformed and may be momentarily at rest with respect to each other.

Exercise 1 : NCERT Based Topic-wise MCQs

5.1 Introduction

1. Let $A = \hat{i}A\cos\theta + \hat{j}A\sin\theta$ be any vector. Another vector B, which is normal to A can be expressed as

NCERT Page-115 / N-72

(a) $\hat{i}\,B\cos\theta - \hat{j}\,B\sin\theta$ (b) $\hat{i}\,B\cos\theta + \hat{j}\,B\sin\theta$
(c) $\hat{i}\,B\sin\theta - \hat{j}\,B\cos\theta$ (d) $\hat{i}\,B\sin\theta + \hat{j}\,B\cos\theta$

2. If $\vec{A} = 4\hat{i} + 3\hat{j}$ and $\vec{B} = 3\hat{i} + 4\hat{j}$ then cosine of angle between $\vec{A}$ and $\vec{A} + \vec{B}$ is NCERT Page-115 / N-72

(a) $\frac{9\sqrt{2}}{5}$ (b) $\frac{7}{5\sqrt{2}}$ (c) $\frac{5\sqrt{2}}{49}$ (d) $\frac{5\sqrt{2}}{28}$

3. A particle moves from position $3\hat{i} + 2\hat{j} - 6\hat{k}$ to $14\hat{i} + 13\hat{j} + 9\hat{k}$ due to a uniform force of $(4\hat{i} + \hat{j} + 3\hat{k})\,N$. If the displacement is in metre then work done will be

NCERT Page-115 / N-72

(a) 300 J (b) 250 J (c) 100 J (d) 0

4. If a vector $2\hat{i} + 3\hat{j} + 8\hat{k}$ is perpendicular to the vector $4\hat{j} - 4\hat{i} + \alpha\hat{k}$, then the value of α is NCERT Page-115 / N-72

(a) 1/2 (b) –1/2 (c) 1 (d) –1

5.2 Notions of Work and Kinetic Energy: The Work-energy Theorem

5. According to work-energy theorem, the work done by the net force on a particle is equal to the change in its

NCERT Page-116 / N-73

(a) kinetic energy (b) potential energy
(c) linear momentum (d) angular momentum

6. 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

NCERT Page-116 / N-73

(a) $\frac{V}{T}t$ (b) $\frac{V^2}{T}t^2$ (c) $\frac{V^2}{T^2}t$ (d) $\frac{V^2}{T^2}t^2$

5.3 Work

7. When the force retards the motion of body, the work done is

NCERT Page-117 / N-74

(a) zero
(b) negative
(c) positive
(d) Positive or negative depending upon the magnitude of force and displacement

8. A man pushes a wall and fails to displace it, he does

NCERT Page-117 / N-74

(a) negative work
(b) positive but not maximum work
(c) no work at all
(d) maximum positive work

9. A boy carrying a box on his head is walking on a level road from one place to another is doing no work. This statement is

NCERT Page-117 / N-74

(a) correct (b) incorrect
(c) partly correct (d) cannot say

10. No work is done if NCERT Page-117 / N-74

(a) displacement is zero
(b) force is zero
(c) force and displacement are mutually perpendicular
(d) All of these

11. A particle is taken round a circle by application of force. The work done by the force is NCERT Page-117 / N-74

(a) positive non–zero (b) negative non–zero
(c) Zero (d) None of these

12. A porter lifts a heavy suitcase of mass 80 kg and at the destination lowers it down by a distance of 80 cm with a constant velocity. Calculate the work done by the porter in lowering the suitcase. (take g = 9.8 ms^{-2})

NCERT Page-117 / N-74

(a) –62720.0 J (b) –627.2 J
(c) +627.2 J (d) 784.0 J

13. Consider a force $\vec{F} = -x\hat{i} + y\hat{j}$. The work done by this force in moving a particle from point A(1, 0) to B(0, 1) along the line segment is: (all quantities are in SI units)

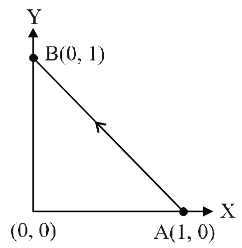
NCERT Page-117 / N-74

(a) 2J

(b) $\frac{1}{2}$J

(c) 1J

(d) $\frac{3}{2}$J



14. If W represents the work done, then match the two columns:

NCERT Page-117 / N-74

Column I	Column II
(A) Force is always along the velocity	(1) W = 0
(B) Force is always perpendicular to velocity	(2) W < 0
(C) Force is always perpendicular to acceleration	(3) W > 0
(D) The object is stationary but the point of application of the force moves on the object	

(a) (A)→(1); (B)→(2); C→(3); (D)→(2)
(b) (A)→(3); (B)→(1); C→(2,3); (D)→(1)
(c) (A)→(2); (B)→(3); C→(1); (D)→(2)
(d) (A)→(1); (B)→(2); C→(3); (D)→(1)

15. A particle moving in the xy plane undergoes a displacement of $\vec{s} = (2\hat{i} + 3\hat{j})$ while a constant force $\vec{F} = (5\hat{i} + 2\hat{j})$ N acts on the particle. The work done by the force F is

NCERT Page-117 / N-74

(a) 17 joule (b) 18 joule (c) 16 joule (d) 15 joule

16. A particle describe a horizontal circle of radius 0.5 m with uniform speed. The centripetal force acting is 10 N. The work done in describing a semicircle is NCERT Page-117 / N-74

(a) zero (b) 5 J (c) 5 π J (d) 10 π J

17. 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 metres and t is in seconds. The work done during the first 4 seconds is NCERT Page-118 / N-74

(a) 576mJ (b) 450mJ (c) 490mJ (d) 530mJ

18. A cord is used to lower vertically a block of mass M, a distance d at a constant downward acceleration of g/4. The work done by the cord on the block is

NCERT Page-117 / N-74

(a) $Mg\frac{d}{4}$ (b) $3Mg\frac{d}{4}$ (c) $-3Mg\frac{d}{4}$ (d) Mg d

19. 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 NCERT Page-117 / N-74

(a) 1500 J (b) –1500 J (c) 750J (d) Zero

20. A ball moves in a frictionless inclined table without slipping. The work done by the table surface on the ball is

NCERT Page-117 / N-74

(a) positive (b) negative
(c) zero (d) None of these

21. 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 NCERT Page-117 / N-74

(a) 6 J (b) 13 J (c) 15 J (d) 9 J

22. 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 60º to the horizontal. The work done by the boy is NCERT Page-117 / N-74

(a) 6 J (b) 8 J (c) 10 J (d) 12 J

23. 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 NCERT Page-117 / N-74

(a) 0º (b) 30º (c) 60º (d) 90º

5.4 Kinetic Energy

24. A light and a heavy body have equal momentum. Which one has greater K.E.? NCERT Page-117 / N-74

(a) The lighter body (b) The heavier body
(c) Both have equal K.E. (d) Data given is incomplete

25. A particle of mass m has momentum p. Its kinetic energy will b NCERT Page-117 / N-74

(a) mp (b) p^2m (c) $\frac{p^2}{m}$ (d) $\frac{p^2}{2m}$

26. Kinetic energy, with any reference, must be NCERT Page-117 / N-74

(a) zero (b) positive
(c) negative (d) both (b) and (c)

27. If the momentum of a body is increased by 50%, then the percentage increase in its kinetic energy is NCERT Page-117 / N-74

(a) 50% (b) 100% (c) 125% (d) 200%

28. Four particles given, have same momentum. Which has maximum kinetic energy NCERT Page-117 / N-74

(a) Proton (b) Electron (c) Deutron (d) α-particles

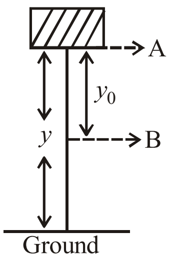
29. The K.E. acquired by a mass m in travelling a certain distance d, starting form rest, under the action of a constant force is directly proportional to NCERT Page-117 / N-74

(a) m_1 (b) $\sqrt{m}$
(c) $\frac{1}{\sqrt{m}}$ (d) independent of m

30. A running man has half the kinetic energy of that of a boy of half of his mass. The man speeds up by 1m/s so as to have same K.E. as that of the boy. The original speed of the man will be NCERT Page-117 / N-74

(a) $\sqrt{2}$ m/s (b) $(\sqrt{2}-1)$ m/s
(c) $\frac{1}{(\sqrt{2}-1)}$ m/s (d) $\frac{1}{\sqrt{2}}$ m/s

31. In the given figure, the block of mass m is dropped from the point 'A'. The expression for kinetic energy of block when it reaches point 'B' is : NCERT Page-117 / N-74



(a) $\frac{1}{2}mgy_0^2$
(b) $\frac{1}{2}mgy^2$
(c) $mg(y-y_0)$
(d) mgy_0

32. Two bodies A and B having masses in the ratio of 3 : 1 possess the same kinetic energy. The ratio of linear momentum of B to A is NCERT Page-117 / N-74

(a) 1 : 3 (b) 3 : 1 (c) $1:\sqrt{3}$ (d) $\sqrt{3}:1$

33. A small body is projected in a direction inclined at 45° to the horizontal with kinetic energy K. At the top of its flight, its kinetic energy will be NCERT Page-117 / N-74

(a) Zero (b) $K/2$ (c) $K/4$ (d) $K/\sqrt{2}$

34. 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] NCERT Page-117 / N-74

(a) 4s (b) 8s (c) 10s (d) 12s

35. A bomb of mass 9 kg explodes into the pieces of masses 3 kg and 6 kg. The velocity of mass 3 kg is 16 m/s. The kinetic energy of mass 6 kg in joule is NCERT Page-117 / N-74

(a) 96 (b) 384 (c) 192 (d) 768

36. An athlete in the olympic games covers a distance of 100 m in 10 s. His kinetic energy can be estimated to be in the range NCERT Page-117 / N-74

(a) 200 J - 500 J (b) 2×10^5 J - 3×10^5 J
(c) 20, 000 J - 50,000 J (d) 2,000 J - 5, 000 J

5.5 Work Done by a Variable Force

37. A particle moves under the effect of a force F = cx from x = 0 to x = x_1, the work done in the process is NCERT Page-118 / N-75

(a) cx_1^2 (b) $\frac{1}{2}cx_1^2$ (c) $2cx_1^2$ (d) zero

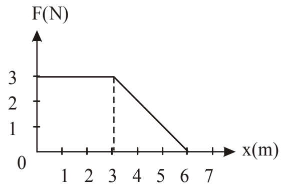
38. Calculate the work done on the tool by $\vec{F}$ if this displacement is along the straight line y = x that connects these two points. NCERT Page-118 / N-75

(a) 2.50 J (b) 500 J (c) 50.6 J (d) 2 J

39. Calculate the work done on the tool by $\vec{F}$ if the tool is first moved out along the x-axis to the point x = 3.00m, y = 0 and then moved parallel to the y-axis to x = 3.00m, y = 3.00 m. NCERT Page-118 / N-75

(a) 67.5 J (b) 85 J (c) 102 J (d) 7.5 J

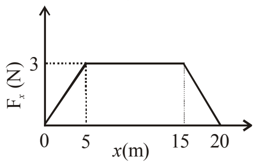
40. A force F acting on an object varies with distance x as shown here. The force is in N and x in m. The work done by the force in moving the object from x = 0 to x = 6 m is



NCERT Page-119 / N-76

(a) 18.0 J (b) 13.5 J (c) 9.0 J (d) 4.5 J

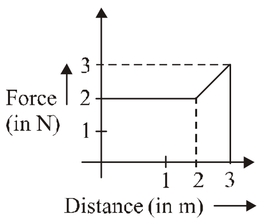
41. A force F_x acts on a particle such that its position x changes as shown in the figure. The work done by the particle as it moves from x = 0 to 20 m is



NCERT Page-119 / N-76

(a) 37.5 J (b) 10 J (c) 45 J (d) 22.5 J

42. A particle moves in one dimension from rest under the influence of a force that varies with the distance travelled by the particle as shown in the figure. The kinetic energy of the particle after it has travelled 3 m is : NCERT Page-118 / N-75



(a) 4 J (b) 2.5 J (c) 6.5 J (d) 5 J

5.6 The Work-energy Theorem for a Variable Force

43. A body of mass 0.5 kg travels on straight line path with velocity $v = (3x^2 + 4)$ m/s. The net workdone by the force during its displacement from $x = 0$ to $x = 2$ m is :

NCERT Page-119 / N-76

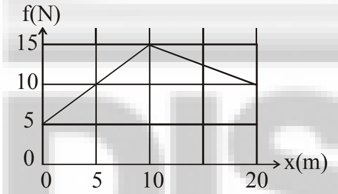
(a) 64 J (b) 60 J (c) 120 J (d) 128 J

44. A body of mass 20kg, moving in x-direction with a constant speed of 20 m/s, is subjected to a retarding force $F = 0.2x$ J/m during its travel from $x = 20$ m to 30 m. Its final kinetic energy will be NCERT Page-119 / N-76

(a) 50 J (b) 475 J
(c) 4000 J (d) 3250 J

45. Figure here shows the frictional force versus displacement for a particle in motion. The loss of kinetic energy in travelling over s = 0 to 20 m will be NCERT Page-119 / N-76

(a) 225 J
(b) 200 J
(c) 250 J
(d) 750 J



5.7 The Concept of Potential Energy

46. Work done by a conservative force is positive if

(a) P.E. of the body increases NCERT Page-121 / N-78
(b) P.E. of the body decreases
(c) K.E. of the body increases
(d) K.E. of the body decreases

47. For a conservative force in one dimension, potential energy function V(x) is related to the force F(x) as

NCERT Page-121 / N-78

(a) $F(x) = \frac{-dV(x)}{dx}$ (b) $F(x) = \frac{dV(x)}{dx}$

(c) $F(x) = V(x)\,dx$ (d) $F(x) = \int \frac{-dV(x)}{dx}$

48. 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

NCERT Page-120 / N-77

(a) two is different (b) two is same
(c) first is more (d) second is more

49. A ball dropped from a height of 2m reaches to a height of 1.5m before hitting the ground. Then the percentage of potential energy lost is NCERT Page-120 / N-77

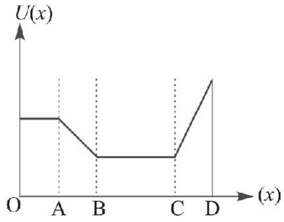
(a) 25 (b) 30 (c) 50 (d) 100

50. The potential energy of a system increases if work is done

NCERT Page-121 / N-78

(a) upon the system by a non conservative force
(b) by the system against a conservative force
(c) by the system against a non conservative force
(d) upon the system by a conservative force

51. The figure gives the potential energy function $U(x)$ for a system in which a particle is in one-dimensional motion. In which region the magnitude of the force on the particle is greatest :



NCERT Page-121 / N-78

(a) OA (b) AB (c) BC (d) CD

52. A rod of mass m and length ℓ is made to stand at an angle of 60° with the vertical. Potential energy of the rod in this position is NCERT Page-120 / N-77

(a) $mg\ell$ (b) $\frac{mg\ell}{2}$ (c) $\frac{mg\ell}{3}$ (d) $\frac{mg\ell}{4}$

53. 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? NCERT Page-121 / N-78

(a) $-ay$ (b) $-by$
(c) $2ay - b$ (d) $b - 2ay$

54. A body falls freely under gravity. Its velocity is v when it has lost potential energy equal to U. What is the mass of the body? NCERT Page-120, 121 / N-77, 78

(a) U^2/v^2 (b) $2U^2/v^2$ (c) $2U/v^2$ (d) U/v^2

5.8 The Conservation of Mechanical Energy

55. Total ....X.... energy of a system is conserved, if the forces, doing work on it, are .....Y..... . NCERT Page-121 / N-79

Here, X and Y refer to

(a) conservative, mechanical
(b) mechanical, conservative
(c) mechanical, non-conservative
(d) kinetic, conservative

56. A metallic wire of length L metre extends by ℓ metre when stretched by suspending a weight Mg from it. The mechanical energy stored in the wire is NCERT Page-121 / N-79

(a) 2 Mg ℓ (b) Mg ℓ (c) $\frac{Mg\ell}{2}$ (b) $\frac{Mg\ell}{4}$

57. A steel ball of mass 5g is thrown downward with velocity 10 m/s from height 19.5 m. It penetrates sand by 50 cm. The change in mechanical energy will be ($g = 10$ m/s^2)

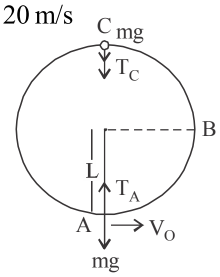
NCERT Page-121 / N-79

(a) 1J (b) 1.25 J (c) 1.5 J (d) 1.75 J

58. A ball is allowed to fall from a height of 10 m. If there is 40% loss of energy due to air friction, then velocity of the ball when it hit the ground is **NCERT** Page-121 / N-79

(a) $\sqrt{190}$ m/s (b) $\sqrt{180}$ m/s
(c) $\sqrt{150}$ m/s (d) $\sqrt{120}$ m/s

59. Figure shows a bob of mass m suspended from a string of length L. The velocity is V_0 at A, then the potential energy of the system is ________ at the lowest point A.



NCERT Page-122 / N-79

(a) $\frac{1}{2}mv_0^2$ (b) mgh (c) $\frac{-1}{2}mv_0^2$ (d) zero

60. Calculate the K.E and P.E. of the ball half way up, when a ball of mass 0.1 kg is thrown vertically upwards with an initial speed of 20 ms^{-1}. **NCERT** Page-121, 122 / N-79

(a) 10 J, 20 J (b) 10 J, 10 J
(c) 15 J, 8 J (d) 8 J, 16 J

61. A spherical ball of mass 20 kg is stationary at the top of a hill of height 100 m. It rolls down a smooth surface to the ground, then climbs up another hill of height 30 m and finally rolls down to a horizontal base at a height of 20 m above the ground. The velocity attained by the ball is **NCERT** Page-121 / N-79

(a) 20 m/s (b) 40 m/s (c) $10\sqrt{30}$ m/s (d) 10 m/s

62. A particle is moving in a circle of radius r under the action of a force F = αr^2 which is directed towards centre of the circle. Total mechanical energy (kinetic energy + potential energy) of the particle is (take potential energy = 0 for r = 0) **NCERT** Page-121 / N-79

(a) $\frac{1}{2}\alpha r^3$ (b) $\frac{5}{6}\alpha r^3$ (c) $\frac{4}{3}\alpha r^3$ (d) αr^3

63. When a body is projected vertically up from the ground with certain velocity, its potential energy and kinetic energy at a point A are in the ratio 2 : 3. If the same body is projected with double the previous velocity, then at the same point A the ratio of its potential energy to kinetic energy is **NCERT** Page-121 / N-79

(a) 9 : 1 (b) 2 : 9 (c) 1 : 9 (d) 9 : 2

64. A mass m is revolving in a vertical circle at the end of a string of length 20 cm. By how much does the tension of the string at the lowest point exceed the tension at the topmost point? **NCERT** Page-122 / N-79

(a) 2 m g (b) 4 m g (c) 6 m g (d) 8 m g

65. A particle tied to a string describes a vertical circular motion of radius r continually. If it has a velocity $\sqrt{3\,gr}$ at the highest point, then the ratio of the respective tensions in the string holding it at the highest and lowest points is **NCERT** Page-122 / N-79

(a) 4 : 3 (b) 5 : 4 (c) 1 : 4 (d) 3 : 2

66. A particle of mass 'm' tied to a string of length 'ℓ' and whirled in a horizontal circle. If the particles moves in circle with speed 'v' then the net force on the particle will be (T = tensaion in the string) **NCERT** Page-122 / N-79

(a) $T+\frac{mv^2}{l}$ (b) $T-\frac{mv^2}{r}$

(c) T (d) zero

67. A body of mass 0.4 kg is whirled in a vertical circle making 2 rev/sec. If the radius of the circle is 1.2 m, then tension in the string when the body is at the top of the circle, is **NCERT** Page-122 / N-79

(a) 41.56 N (b) 89.86 N (c) 109.86 N (d) 115.86 N

68. A bucket tied at the end of a 1.6 m long string is whirled in a vertical circle with constant speed. What should be the minimum speed so that the water from the bucket does not spill when the bucket is at the highest position? **NCERT** Page-122 / N-79

(a) 4 m/sec (b) 6.25 m/sec
(c) 16 m/sec (d) None of these

5.9 The Potential Energy of a Spring

69. The work done in stretching a spring of force constant k from length ℓ_1 and ℓ_2 is **NCERT** Page-124 / N-81

(a) $k(\ell_2^2-\ell_1^2)$ (b) $\frac{1}{2}k(\ell_2^2-\ell_1^2)$

(c) $k(\ell_2-\ell_1)$ (d) $\frac{k}{2}(\ell_2+\ell_1)$

70. 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 **NCERT** Page-124 / N-81

(a) 18.75 J (b) 25.00 J (c) 6.25 J (d) 12.50 J

71. A spring whose unstretched length is l has a force constant k. The spring is cut into two pieces of unstretched lengths l_1 and l_2 where, $l_1 = nl_2$ and n is an integer. The ratio k_1/k_2 of the corresponding force constants, k_1 and k_2 will be: **NCERT** Page-123 / N-80

(a) n (b) $\frac{1}{n^2}$ (c) $\frac{1}{n}$ (d) n^2

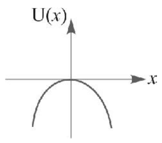
72. The ...X... energy $V(x)$ of the spring is said to be zero when block and spring system is in the ...Y... position.
Here, X and Y refer to **NCERT** Page-124 / N-81

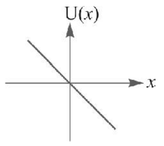
(a) potential, equilibrium (b) kinetic, equilibrium
(c) mechanical, equilibrium (d) vibrational, left

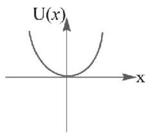
73. If stretch in a spring of force constant k is tripled then the ratio of elastic potential energy in the two cases will be **NCERT** Page-124 / N-81

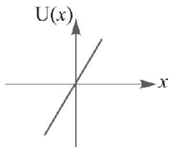
(a) 9 : 1 (b) 1 : 6 (c) 3 : 1 (d) 1 : 3

74. 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) : **NCERT** Page-124 / N-81

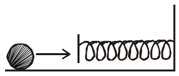
(a) 

(b) 

(c) 

(d) 

75. A mass of m kg moving with a speed of 1.5 m/s on a horizontal smooth surface, collides with a nearly weightless spring of force constant k = 50 N/m. If the maximum compression of the spring is 0.15 m, the value of mass m is



NCERT Page-124 / N-81

(a) 0.5 kg (b) 0.15 kg (c) 0.12 kg (d) 1.5 kg

76. Two spring P and Q of force constant k_p and $k_q \left(k_q = \dfrac{k_p}{2}\right)$ are stretched by applying forces of equal magnitude. If the energy stored in Q is E, then the energy stored in P is **NCERT** Page-123 / N-80

(a) E (b) 2 E (c) E / 8 (d) E / 2

77. Two springs have their force constant as k_1 and k_2 ($k_1 > k_2$). When they are stretched by the same force **NCERT** Page-123 / N-80

(a) no work is done in case of both the springs.
(b) equal work is done in case of both the springs
(c) more work is done in case of second spring
(d) more work is done in case of first spring.

78. One end of a light spring of spring constant k is fixed to a wall and the other end is tied to a block placed on a smooth horizontal surface. In a displacement, the work done by the spring is 1/2 k x^2. The possible cases are **NCERT** Page-123 / N-80

(a) the spring was initially compressed by a distance x, was finally in its natural length
(b) it was initially stretched by a distance x and was finally in its natural length
(c) it was initially in its natural length and finally in a compressed position
(d) it was initially in its natural length and finally in the stretched position

79. If the extension in a spring is increased to 4 times then the potential energy **NCERT** Page-124 / N-81

(a) remains the same (b) becomes 4 times
(c) becomes one fourth (d) becomes 16 times

80. A long string is stretched by 2 cm and the potential energy is V. If the spring is stretched by 10 cm, its potential energy will be **NCERT** Page-124 / N-81

(a) V / 25 (b) V/5 (c) 5 V (d) 25 V

5.10 Power

81. At time t = 0s particle starts moving along the x-axis. If its kinetic energy increases uniformly with time t, the net force acting on it must be proportional to

NCERT Page-128 / N-83

(a) $\sqrt{t}$ (b) constant (c) t (d) $\dfrac{1}{\sqrt{t}}$

82. If a force F is applied on a body and it moves with a velocity V, the power will be **NCERT** Page-128 / N-83

(a) F × v (b) F/v
(c) F/v^2 (d) F × v^2

83. Sand is being dropped from a stationary dropper at a rate of 0.5 kgs^{-1} on a conveyor belt moving with a velocity of 5 ms^{-1}. The power needed to keep belt moving with the same velocity will be : **NCERT** Page-128 / N-83

(a) 1.25 W (b) 2.5 W (c) 6.25 W (d) 12.5 W

84. A body of mass m is accelerated uniformly from rest to a speed v in a time T. The instantaneous power delivered to the body as a function of time is given by **NCERT** Page-128 / N-83

(a) $\dfrac{mv^2}{T^2}\cdot t^2$ (b) $\dfrac{mv^2}{T^2}\cdot t$ (c) $\dfrac{1}{2}\dfrac{mv^2}{T^2}\cdot t^2$ (d) $\dfrac{1}{2}\dfrac{mv^2}{T^2}\cdot t$

85. A car of mass m starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude p_o. The instantaneous velocity of this car is proportiourl to: **NCERT** Page-128 / N-83

(a) $t^2 p_o$ (b) $t^{1/2}$ (c) $t^{-1/2}$ (d) $\dfrac{t}{\sqrt{m}}$

86. A vehicle is moving with a uniform velocity on a smooth horizontal road, then power delivered by its engine must be **NCERT** Page-128 / N-83

(a) uniform (b) increasing
(c) decreasing (d) zero

87. How much water, a pump of 2 kW can raise in one minute to a height of 10 m, take g = 10 m/s^2? **NCERT** Page-128 / N-83

(a) 1000 (b) 1200 (c) 100 (d) 2000

88. The engine of a vehicle delivers constant power. If the vehicle is moving up the inclined plane then, its velocity, **NCERT** Page-128 / N-83

(a) must remain constant
(b) must increase
(c) must decrease
(d) may increase, decrease or remain same.

89. A body is moved along a straight line by a machine delivering a constant power. The distance moved by the body in time 't' is proportional to **NCERT** Page-128 / N-83

(a) $t^{3/4}$ (b) $t^{3/2}$ (c) $t^{1/4}$ (d) $t^{1/2}$

90. 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 **NCERT** Page-128 / N-83

(a) at the highest position of the body
(b) at the instant just before the body hits the earth
(c) it remains constant all through
(d) at the instant just after the body is projected

91. 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 **NCERT** Page-128 / N-83

(a) 10 J/s (b) 98 J/s (c) 49 J/s (d) zero

92. 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 **NCERT** Page-128 / N-83

(a) Johnny did more work and delivered more power.
(b) Johnny did more work and delivered the same amount of power.
(c) Johnny did more work and delivered less power
(d) Johnny did less work and johnny delivered less power.

93. A constant power P is applied to a car starting from rest. If v is the velocity of the car at time t, then NCERT Page-128 / N-83

(a) $v \propto t$ (b) $v \propto \frac{1}{t}$
(c) $v \propto \sqrt{t}$ (d) $v \propto \frac{1}{\sqrt{t}}$

94. 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 NCERT Page-128 / N-83
(a) 1 : 2 (b) 1 : 1
(c) 2 : 1 (d) 1 : 3

95. A 10 H.P. motor pumps out water from a well of depth 20 m and fills a water tank of volume 22380 litres at a height of 10 m from the ground. The running time of the motor to fill the empty water tank is (g = 10ms^{-2}) NCERT Page-128 / N-83
(a) 5 minutes (b) 10 minutes
(c) 15 minutes (d) 20 minutes

96. If a machine gun fires n bullets per second each with kinetic energy K, then the power of the machine gun is NCERT Page-128 / N-83
(a) nK^2 (b) $\frac{K}{n}$ (c) n^2K (d) nK

97. A particle of mass 1 kg begins to move under the action of a time dependent force $\vec{F} = (4 + \hat{i} + 6\hat{j})N$ 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? NCERT Page-128 / N-83
(a) $(4t^2 + 6 + 4)W$ (b) $(4t^3 + 6 + 5)W$
(c) $(4t + 6t^2)W$ (d) $(4t^3 + 6t^4)W$

98. A force applied by an engine of a train of mass 2.05 × 10^6 kg changes its velocity from 5m/s to 25 m/s in 5 minutes. The power of the engine is NCERT Page-128 / N-83
(a) 1.025 MW (b) 2.05 MW (c) 5 MW (d) 6 MW

99. 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 ms^{-2}, then the power required to left the chain upto the point of support in 10 second NCERT Page-128 / N-83
(a) 10 W (b) 20W (c) 30 W (d) 40 W

5.11 Collisions

100. Which one of the following statements is true? NCERT Page-129 / N-84
(a) Momentum is conserved in elastic collisions but not in inelastic collisions
(b) Total kinetic energy is conserved in elastic collisions but momentum is not conserved in elastic collisions
(c) Total kinetic energy is not conserved but momentum is conserved in inelastic collisions
(d) Kinetic energy and momentum both are conserved in all types of collisions

101. When after collision the deformation is not relived and the two bodies move together after the collision, it is called
(a) elastic collision NCERT Page-129 / N-84
(b) inelastic collision
(c) perfectly inelastic collision
(d) perfectly elastic collision

102. In an inelastic collision, which of the following does not remain conserved? NCERT Page-129 / N-84
(a) Momentum
(b) kinetic energy
(c) Total energy
(d) Neither momentum nor kinetic energy

103. In case of elastic collision, at the time of impact. NCERT Page-129 / N-84
(a) total K.E. of colliding bodies is conserved.
(b) total K.E. of colliding bodies increases
(c) total K.E. of colliding bodies decreases
(d) total momentum of colliding bodies decreases.

104. In elastic collision, 100% energy transfer takes place when NCERT Page-130 / N-84
(a) $m_1 = m_2$ (b) $m_1 > m_2$ (c) $m_1 < m_2$ (d) $m_1 = 2m_2$

105. If two equal masses ($m_1 = m_2$) collide elastically in one dimension, where m_2 is at rest and m_1 moves with a velocity u_1, then the final velocities of two masses are NCERT Page-130 / N-84
(a) $V_1 = 0; V_2 = u_1$ (b) $V_1 = V_2 = 0$
(c) $V_1 = 0$ and $V_2 = -u_1$ (d) $V_1 = -u_1; V_2 = 0$

106. A particle A suffers an oblique elastic collision with a particle B that is at rest initially. If their masses are the same, then after collision NCERT Page-130, 131 / N-84, 85
(a) they will move in opposite directions
(b) A continues to move in the original direction while B remains at rest
(c) they will move in mutually perpendicular directions
(d) A comes to rest and B starts moving in the direction of the original motion of A

107. A metal ball of mass 2 kg moving with a velocity of 36 km/h has a head on collision with a stationary ball of mass 3 kg. If after the collision, the two balls move together, the loss in kinetic energy due to collision is NCERT Page-129, 130 / N-84, 85
(a) 140 J (b) 100 J (c) 60 J (d) 40 J

108. Two particles having the position $\vec{r}_1 = (3\hat{i} + 5\hat{j})$ m and $\vec{r}_2 = (-5\hat{i} - 3\hat{j})$ m move with velocities $\vec{V}_1 = (4\hat{i} + 3\hat{j})$ m/s and $\vec{V}_2 = (a\hat{i} + 7\hat{j})$ m/s. If the particles collide, then value of a must be
(a) 8 (b) 6
(c) 4 (d) 2

109. A mass of 20 kg moving with a speed of 10m/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 NCERT Page-129 / N-84
(a) 600 (b) 800
(c) 1000 (d) 1200

110. 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 NCERT Page-131 / N-85

(a) $\frac{1}{4}v\hat{i}+\frac{3}{2}v\hat{j}$ (b) $\frac{1}{3}v\hat{i}+\frac{2}{3}v\hat{j}$

(c) $\frac{2}{3}v\hat{i}+\frac{1}{3}v\hat{j}$ (d) $\frac{3}{2}v\hat{i}+\frac{1}{4}v\hat{j}$

111. 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 K. E. of colliding body before and after collision will be **NCERT** Page-130 / N-85

(a) 1 : 1 (b) 2 : 1
(c) 4 : 1 (d) 9 : 1

112. 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? **NCERT** Page-131 / N-86

(a) 0.75 kg (b) 1.0 kg
(c) 1.2 kg (d) None of these

113. A bullet of mass 20g 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? **NCERT** Page-129, 130 / N-84, 85

(a) 200 m/s (b) 150 m/s
(c) 400 m/s (d) 300 m/s

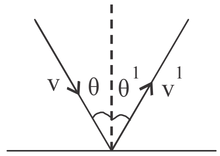
114. A block of mass 0.50 kg is moving with a speed of 2.00 ms^{-1} on a smooth surface. It strikes another mass of 1.00 kg and then they move together as a single body. The energy loss during the collision is **NCERT** Page-129 / N-84

(a) 0.16 J (b) 1.00 J (c) 0.67 J (d) 0.34 J

115. If a shell fired from a cannon, explodes in mid air, then **NCERT** Page-129 / N-84

(a) its total kinetic energy increases
(b) its total momentum increases
(c) its total momentum decreases
(d) None of these

116. A ball of mass *m* hits the floor making an angle θ as shown in the figure. If e is the coefficient of restitution, then which relation is true, for the velocity component before and after collision?



NCERT Page-129, 130 / N-84, 85

(a) $V^1 \sin\theta = V\sin\theta$ (b) $V^1 \sin\theta' = -\sin\theta$
(c) $V^1 \cos\theta' = V\cos\theta$ (d) $V^1 \cos\theta' = -V\cos\theta$

117. Before a rubber ball bounces off from the floor, the ball is in contact with the floor for a fraction of second. Which of the following statements is correct? **NCERT** Page-129, 131 / N-84, 85

(a) Conservation of energy is not valid during this period
(b) Conservation of energy is valid during this period
(c) As ball is compressed, kinetic energy is converted to compressed potential energy
(d) None of these

118. A bag of sand of mass 9.8 kg is suspended by a rope. A bullet of 200 g travelling with speed 10 ms^{-1} gets embedded in it, then loss of kinetic energy will be **NCERT** Page-129, 130 / N-84, 85

(a) 4.9 J (b) 9.8 J (c) 14.7 (d) 19.6 J

119. A object of mass m_1 collides with another object of mass m_2, which is at rest. After the collision the objects move with equal speeds in opposite direction. The ratio of the masses $m_2 : m_1$ is: **NCERT** Page-129, 130 / N-84, 85

(a) 2 : 1 (b) 3 : 1 (c) 1 : 2 (d) 1 : 1

120. Two billiard balls of mass 0.05 kg each moving in opposite directions with 10 ms^{-1} collide and rebound with the same speed. If the time duration of contact is t = 0.005 s, then what is the force exerted on the ball due to each other? **NCERT** Page-129, 130 / N-84, 85

(a) 100 N (b) 200 N (c) 300 N (d) 4000 N

Exercise 2 : NCERT Exemplar & Past Years NEET

NCERT Exemplar Questions

1. An electron and a proton are moving under the influence of mutual forces. In calculating the change in the kinetic energy of the system during motion, one ignores the magnetic force of one on another. This is, because **NCERT** Page-117 / N-74

(a) the two magnetic forces are equal and opposite, so they produce no net effect
(b) the magnetic forces do not work on each particle
(c) the magnetic forces do equal and opposite (but non-zero) work on each particle
(d) the magnetic forces are necessarily negligible

2. A proton is kept at rest. A positively charged particle is released from rest at a distance *d* in its field. Consider two experiments; one in which the charged particle is also a proton and in another, a positron. In the same time *t*, the work done on the two moving charged particles is **NCERT** Page-117 / N-74

(a) same as the same force law is involved in the two experiments
(b) less for the case of a positron, as the positron moves away more rapidly and the force on it weakens
(c) more for the case of a positron, as the positron moves away a larger distance
(d) same as the work done by charged particle on the stationary proton

3. A man squatting on the ground gets straight up and stand. The force of reaction of ground on the man during the process is **NCERT** Page-117 / N-74

(a) constant and equal to *mg* in magnitude
(b) constant and greater than *mg* in magnitude
(c) variable but always greater than *mg*
(d) at first greater than *mg* and later becomes equal to *mg*

4. A bicyclist comes to a skidding stop in 10 m. During this process, the force on the bicycle due to the road is 200N and is directly opposed to the motion. The work done by the cycle on the road is **NCERT** Page-117 / N-74

(a) +2000 J (b) – 200 J (c) zero (d) – 20,000 J

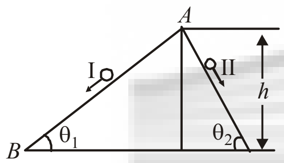
5. A body is falling freely under the action of gravity alone in vaccum. Which of the following quantities remain constant during the fall? **NCERT** Page-121 / N-78

(a) Kinetic energy
(b) Potential energy
(c) Total mechanical energy
(d) Total linear momentum

6. During inelastic collision between two bodies, which of the following quantities always remain conserved? **NCERT** Page-129 / N-84

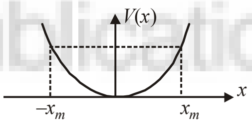
(a) Total kinetic energy (b) Total mechanical energy
(c) Total linear momentum (d) Speed of each body

7. Two inclined frictionless tracks, one gradual and the other steep meet at A from where two stones are allowed to slide down from rest, one on each track as shown in figure. Which of the following statement is correct? **NCERT** Page-121 / N-78



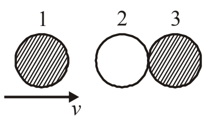
(a) Both the stones reach the bottom at the same time but not with the same speed
(b) Both the stones reach the bottom with the same speed and stone I reaches the bottom earlier than stone II
(c) Both the stones reach the bottom with the same speed and stone II reaches the bottom earlier than stone I
(d) Both the stones reach the bottom at different times and with different speeds

8. The potential energy function for a particle executing linear SHM is given by $V(x) = \frac{1}{2}kx^2$ where k is the force constant of the oscillator (Fig.). For k = 0.5 N/m, the graph of $V(x)$ versus x is shown in the figure. A particle of total energy E turns back when it reaches $x = \pm x_m$. If V and K indicate the PE and KE, respectively of the particle at $x = +x_m$, then which of the following is correct? **NCERT** Page-124 / N-81

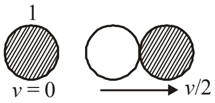


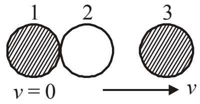
(a) $V = O,\ K = E$ (b) $V = E,\ K = O$
(c) $V < E,\ K = O$ (d) $V = O,\ K < E$

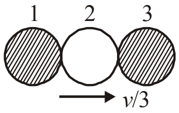
9. Two identical ball bearings in contact with each other and resting on a frictionless table are hit head-on by another ball bearing of the same mass moving initially with a speed v as shown in figure.

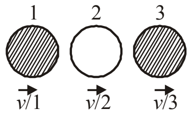


If the collision is elastic, which of the following (figure) is a possible result after collision? **NCERT** Page-129, 130 / N-84, 85

(a)


(b)


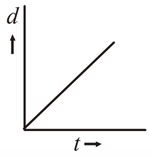
(c)


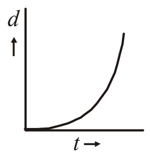
(d)


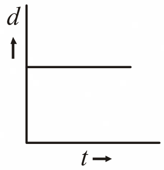
10. A body of mass 0.5 kg travels in a straight line with velocity $v = a\,x^{3/2}$ where $a = 5\ m^{-1/2}s^{-1}$. The work done by the net force during its displacement from $x = 0$ to $x = 2$ m is **NCERT** Page-118 / N-75

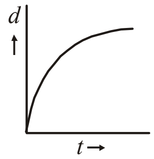
(a) 15 J (b) 50 J (c) 10 J (d) 100 J

11. A body is moving unidirectionally under the influence of a source of constant power supplying energy. Which of the diagrams shown in figure correctly shown the displacement-time curve for its motion? **NCERT** Page-128 / N-83

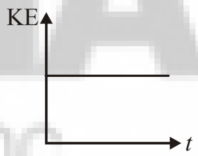
(a)


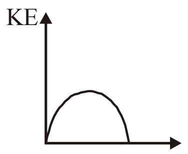
(b)


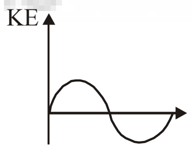
(c)


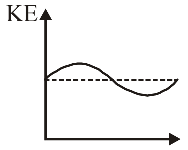
(d)


12. Which of the diagrams shown in figure most closely shows the variation in kinetic energy of the earth as it moves once around the sun in its elliptical orbit? **NCERT** Page-117 / N-74

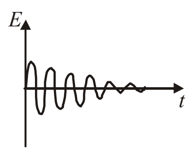
(a)


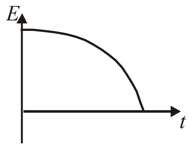
(b)


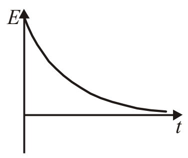
(c)


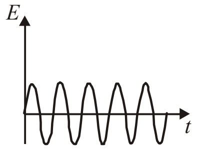
(d)


13. Which of the diagrams shown in figure represents variation of total mechanical energy of a pendulum oscillating in air as function of time? **NCERT** Page-121 / N-78

(a)


(b)


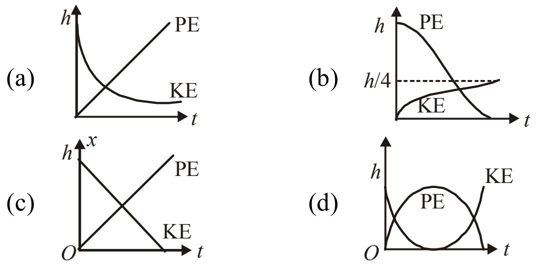
(c)


(d)


14. A mass of 5 kg is moving along a circular path of radius 1 m. If the mass moves with 300 rev/min, its kinetic energy would be **NCERT** Page-117 / N-74

(a) $250\,\pi^2$ (b) $100\,\pi^2$
(c) $5\,\pi^2$ (d) 0

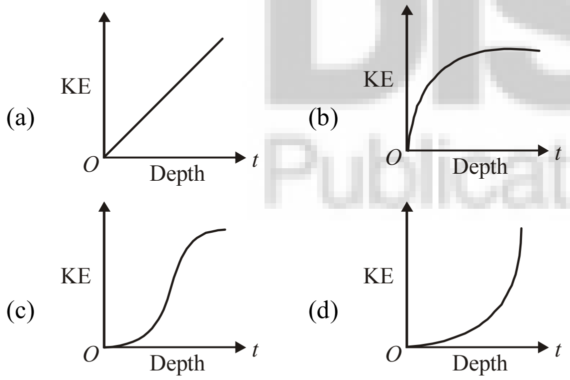
15. A raindrop falling from a height h above ground, attains a near terminal velocity when it has fallen through a height $(3/4)h$. Which of the diagrams shown in figure correctly shows the change in kinetic and potential energy of the drop during its fall up to the ground? **NCERT** Page-121 / N-78



16. In a shotput event an athlete throws the shotput of mass 10 kg with an initial speed of 1 m s^{-1} at 45° from a height 1.5 m above ground. Assuming air resistance to be negligible and acceleration due to gravity to be 10 m s^{-2}, the kinetic energy of the shotput when it just reaches the ground will be **NCERT** Page-121 / N-78

(a) 2.5 J (b) 5.0 J (c) 52.5 J (d) 155.0 J

17. Which of the diagrams in figure correctly shows the change in kinetic energy of an iron sphere falling freely in a lake having sufficient depth to impart it a terminal velocity? **NCERT** Page-117 / N-74



18. A cricket ball of mass 150 g moving with a speed of 126 km/h hits at the middle of the bat, held firmly at its position by the batsman. The ball moves straight back to the bowler after hitting the bat. Assuming that collision between ball and bat is completely elastic and the two remain in contact for 0.001s, the force that the batsman had to apply to hold the bat firmly at its place would be **NCERT** Page-129 / N-84

(a) 10.5 N (b) 21 N
(c) 1.05×10^4 N (d) 2.1×10^4 N

Past Years NEET

19. 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 13.6×10^3 kg/m^3 and g = 10m/s^2 then the power of heart in watt is : **NCERT** Page-128 / N-83 | **AIPMT** 2015 RS, A

(a) 2.35 (b) 3.0 (c) 1.50 (d) 1.70

20. 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 ms^{-2}) **NCERT** Page-117 / N-74 | **AIPMT** 2015 RS, A

(a) 20 ms^{-1} (b) 28 ms^{-1} (c) 10 ms^{-1} (d) 14 ms^{-1}

21. A particle of mass m is driven by a machine that delivers a constant power of k watts. If the particle starts from rest the force on the particle at time t is **NCERT** Page-128 / N-83 | **AIPMT** 2015, C

(a) $\sqrt{mk}\ t^{-1/2}$ (b) $\sqrt{2mk}\ t^{-1/2}$

(c) $\frac{1}{2}\sqrt{mk}\ t^{-1/2}$ (d) $\sqrt{\frac{mk}{2}}\,t^{-1/2}$

22. Two similar springs P and Q have spring constants K_P and K_Q, such that $K_P > K_Q$. They are stretched, first by the same amount (case a,) then by the same force (case b). The work done by the springs W_P and W_Q are related as, in case (a) and case (b), respectively **NCERT** Page-123 / N-80 | **AIPMT** 2015, C

(a) $W_P = W_Q$; $W_P = W_Q$ (b) $W_P > W_Q$; $W_Q > W_P$
(c) $W_P < W_Q$; $W_Q < W_P$ (d) $W_P = W_Q$; $W_P > W_Q$

23. 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 = 0.1x J/m during its travel from x = 20 m to 30 m. Its final KE will be: **NCERT** Page-117 / N-74 | **AIPMT** 2015, S

(a) 450 J (b) 275 J (c) 250 J (d) 475 J

24. A body of mass 1 kg begins to move under the action of a time dependent force $\vec{F}=(2t\hat{i}+3t^2\hat{j})$ N, where $\hat{i}$ and $\hat{j}$ are unit vectors alogn x and y axis. What power will be developed by the force at the time t? **NCERT** Page-128 / N-83 | **NEET** 2016, A

(a) $(2t^2 + 3t^3)$W (b) $(2t^2 + 4t^4)$W
(c) $(2t^3 + 3t^4)$ W (d) $(2t^3 + 3t^5)$W

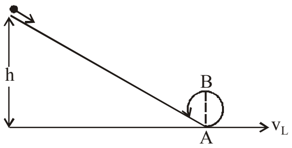
25. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion? **NCERT** Page-117 / N-74 | **NEET** 2016, S

(a) 0.1 m/s^2 (b) 0.15 m/s^2
(c) 0.18 m/s^2 (d) 0.2 m/s^2

26. Consider a drop of rain water having mass 1 g 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 **NCERT** Page-116, 117 / N-73, 74 | **NEET** 2017, A

(a) (i) 1.25 J (ii) –8.25 J
(b) (i) 100 J (ii) 8.75 J
(c) (i) 10 J (ii) – 8.75 J
(d) (i) – 10 J (ii) –8.25 J

27. 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



NCERT Page-121 / N-78 | NEET 2018, A

(a) $\frac{3}{2}D$ (b) D (c) $\frac{5}{4}D$ (d) $\frac{7}{5}D$

28. 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 NCERT Page-129 / N-84 | NEET 2018, S

(a) 0.5 (b) 0.25 (c) 0.4 (d) 0.8

29. When a block of mass M is suspended by a long wire of length L, the length of the wire becomes (L + *l*). The elastic potential energy stored in the extended wire is :

NCERT Page-123 / N-80 | NEET 2019, S

(a) Mgl (b) MgL (c) $\frac{1}{2}Mgl$ (d) $\frac{1}{2}$MgL

30. A force F = 20 + 10*y* 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 :

NCERT Page-118 / N-75 | NEET 2019, S

(a) 30 J (b) 5 J (c) 25 J (d) 20 J

31. 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

NCERT Page-117, 120 / N-74, 77 | NEET 2021, A

(a) $\frac{S}{4}, \sqrt{\frac{3gS}{2}}$ (b) $\frac{S}{4}, \frac{3gS}{2}$

(c) $\frac{S}{4}, \frac{\sqrt{3gS}}{2}$ (d) $\frac{S}{2}, \frac{\sqrt{3gS}}{2}$

32. 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 m/s^2)

NCERT Page-128 / N-83 | NEET 2021, A

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

33. The energy that will be ideally rediated by a 100 kW transmitter in 1 hour is: NCERT Page-128 / N-83 | NEET 2022, C

(a) 36×10^4 J (b) 36×10^5 J

(c) 1×10^5 J (d) 36×10^7 J

34. An electric lift with a maximum load of 2000 kg (lift + passengers) is moving up with a constant speed of 1.5 ms^{-1}. The frictional force opposing the motion is 3000 N. The minimum power delivered by the motor to the lift in watts is: (g = 10 ms^{-2}) NCERT Page-128, 129 / N-83, 84 | NEET 2022, A

(a) 20000 (b) 34500 (c) 23500 (d) 23000

35. A shell of mass m is at rest initially. It explodes into three fragments having mass in the ratio 2 : 2 : 1. If the fragments having equal mass fly off along mutually perpendicular directions with speed v, the speed of the third (lighter) fragment is NCERT Page-129 / N-84 | NEET 2022, A

(a) $\sqrt{2}$ v (b) $2\sqrt{2}$ v (c) $3\sqrt{2}$ v (d) v

36. The potential energy of a long spring when stretched by 2 cm is U. If the spring is stretched by 8 cm, potential energy stored in it will be

NCERT Page-124 / N-82 | NEET 2023,A

(a) 2 U (b) 4 U (c) 8 U (d) 16 U

37. At any instant of time t, the displacement of any particle is given by 2t – 1 (SI unit) under the influence of force of 5N. The value of instantaneous power is (in SI unit):

NCERT Page-128 / N-83 | NEET 2024

(a) 10 (b) 5 (c) 7 (d) 6

38. Two bodies A and B of same mass undergo completely inelastic one dimensional collision. The body A moves with velocity v_1 while body B is at rest before collision. The velocity of the system after collision is v_2. The ratio $v_1 : v_2$ is NCERT Page-129 / N-84 | NEET 2024

(a) 1 : 2 (b) 2 : 1 (c) 4 : 1 (d) 1 : 4

Exercise 3 : Matching, Statement & Assertion-Reason Type

Match the Following

1. A small block of mass 200*g* is kept at the top of a an incline which is 10 *m* long and 3.2 *m* high. Match the columns

Column I	Column II
(A) Work done, to lift the block from the ground and put it at the top	(1) 6.4 J
(B) Work done to slide the block up the incline	(2) 7.2 J
(C) the speed of the block at the ground when left from the top of the incline to fall vertically	(3) 4 m/s
(D) The speed of the block at the ground when side along the incline	(4) 8 m/s

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(2)
(d) (A)→(1); (B)→(3); C→(1); (D)→(2)

2. If W represents the work done, then match the two columns:

Column I	Column II
(A) Force is always along the velocity	(1) W = 0
(B) Force is always perpendicular to velocity	(2) W < 0
(C) Force is always opposite to velocity	(3) W > 0
(D) The object is stationary but the point of application of the force moves on the object	

(a) (A)→(1); (B)→(2); C→(3); (D)→(2)
(b) (A)→(3); (B)→(1); C→(2); (D)→(1)
(c) (A)→(2); (B)→(3); C→(1); (D)→(2)
(d) (A)→(1); (B)→(2); C→(3); (D)→(1)

3.

Column I	Column II
(A) Kinetic Energy	(1) Stretched spring
(B) Potential Energy	(2) Watt
(C) Collision	(3) Elastic or inelastic
(D) Power	(4) A boy running on the roof

(a) (A)→(2); (B)→(3); C→(1); (D)→(4)
(b) (A)→(1); (B)→(1); C→(3); (D)→(3)
(c) (A)→(4); (B)→(3); C→(2); (D)→(2)
(d) (A)→(4); (B)→(1); C→(3); (D)→(2)

Two-Statement Type Questions

Directions: *Read the statements carefully and answer the question on the basis of following options.*

(a) Both statement I and II are correct.
(b) Both statement I and II are incorrect.
(c) Statement I is correct but statement II is incorrect.
(d) Statement II is correct but statement I is incorrect.

4. **Statement I:** The work done in moving a body over a closed loop is zero for every force in nature.
Statement II : Work done depends on nature of force.

5. **Statement I :** If collision occurs between two elastic bodies their kinetic energy decreases during the time of collision.
Statement II : During collision intermolecular space decreases and hence elastic potential energy increases.

6. **Statement I :** In an elastic collision of two billiard balls, the total kinetic energy is conserved during the short time of collision of the balls (*i.e.*, when they are in contact).
Statement II : Energy spent against friction follow the law of conservation of energy.

Four/Five Statement Type Questions

7. Which of the following statements are incorrect?
I. If there were no friction, work need to be done to move a body up an inclined plane is zero.
II. Kinetic energy. $Ek = \frac{1}{2}mv^2$
III. As the angle of inclination is increased, the normal reaction on the body placed on it increases.
IV. A duster weighing 0.5 kg is pressed against a vertical board with a force of 11 N. If the coefficient of friction is 0.5, the work done in rubbing it upward through a distance of 10 cm is 0.55J.
(a) I and II (b) I, II and IV
(c) I, III and IV (d) I, II, III and IV

8. Which of the following statements are incorrect ?
I. If there were no friction, work need to be done to move a body up an inclined plane is zero.
II. If there were no friction, moving vehicles could not be stopped even by locking the brakes.
III. As the angle of inclination is increased, the normal reaction on the body placed on it increases.
IV. A duster weighing 0.5 kg is pressed against a vertical board with a force of 11 N. If the coefficient of friction is 0.5, the work done in rubbing it upward through a distance of 10 cm is 0.55J.
(a) I and II (b) I, II and IV
(c) I, III and IV (d) I, II, III and IV

9. A force $F(x)$ is conservative, if
I. there is change in kinetic energy over a round trip.
II. it depends only on the end points.
III. work done by $F(x)$ in a closed path is zero.
IV. it depends on the path taken.
Which of the following option is correct ?
(a) Only I (b) I and III
(c) II and IV (d) II and III

10. Consider the following statements and select the correct statements.
I. Area under force- displacement curve with proper algebraic sign represents work done by the force.
II. Conservation of mechanical energy is a consequence of work energy theorem for conservative forces
III. Work energy theorem holds in all inertial frames
IV. Area under force-displacement gives kinetic energy.
(a) I and II (b) II and III
(c) I and IV (d) I, II and III

11. In elastic collision,
I. initial kinetic energy is equal to the final kinetic energy.
II. kinetic energy during the collision time Δt is constant.
III. total momentum is conserved.
IV. kinetic energy during the collision time Δt is not constant.
Which of the above statements is/are correct ?
(a) Only I (b) I, III and IV
(c) Only III (d) Only II

Assertion & Reason Questions

Directions : *These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following four responses.*

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If the Assertion is incorrect and Reason is correct.

12. **Assertion :** A force applied on the body always does work on the body.
Reason : If a force applied on a body displaces the body along the direction of force work done will be minimum.

13. **Assertion :** The change in kinetic energy of a particle is equal to the work done on it by the net force.
Reason : Change in kinetic energy of particle is equal to the work done only in case of a system of one particle.

14. **Assertion:** A light body and heavy body have same momentum. Then they have same kinetic energy.
Reason: Kinetic energy does not depend on mass of the body.

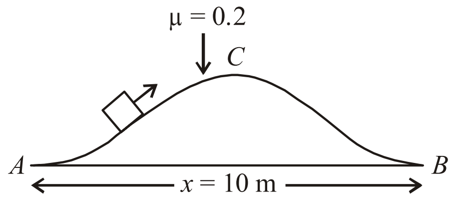
15. **Assertion :** When a machine gun fires n bullets per second each with kinetic energy K, the power of a gun is $P = nK$
Reason : Power P = work done / time also work done = change in kinetic energy.

16. **Assertion :** A point particle of mass m moving with speed V collides with stationary point particle of mass M. If the maximum energy loss possible is given as $f\left(\frac{1}{2}mv^2\right)$ then $f = \left(\frac{M}{M+m}\right)$.

Reason : Maximum energy loss occurs when the particles get stuck together as a result of the collision.

Exercise 4 : Skill Enhancer MCQs

1. A block of mass 1 kg is pulled along the curve path *ACB* by a tangential force as shown in figure. The work done by the frictional force when the block moves from *A* to *B* is



(a) 5 J (b) 10 J
(c) 20 J (d) None of these

2. A bullet looses $\left(\frac{1}{n}\right)^{th}$ of its velocity passing through one plank. The number of such planks that are required to stop the bullet can be:
(a) $\frac{n^2}{2n-1}$ (b) $\frac{2n^2}{n-1}$ (c) infinite (d) n

3. A mass of *M* kg is suspended by a weightless string. The horizontal force that is required to displace it untill the string makes an angle of 45° with the initial vertical direction is :
(a) $Mg(\sqrt{2}-1)$ (b) $Mg(\sqrt{2}+1)$
(c) $Mg\sqrt{2}$ (d) $\frac{Mg}{\sqrt{2}}$

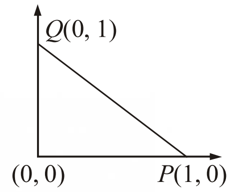
4. A particle of mass m is moving in a circular path of constant radius *r* such that its centripetal acceleration a_c is varying with time *t* as $a_c = k^2rt^2$ where *k* is a constant. The power delivered to the particles by the force acting on it is
(a) $2\pi mk^2r^2t$ (b) mk^2r^2t
(c) $\frac{(mk^4r^2t^5)}{3}$ (d) zero

5. A man of mass *m* on an initially stationary boat gets off the boat by jumping to the left in an exactly horizontal direction. Immediately after the jump, the boat of mass *M*, is observed to be moving to the right at speed *v*. How much work did the man do during the jump (both on his own body and on the boat)
(a) $\frac{1}{2}(M+m)v^2$ (b) $\frac{1}{2}\left(M+\frac{M^2}{m}\right)v^2$
(c) $\frac{1}{2}\left(\frac{Mm}{M+m}\right)v^2$ (d) None of these

6. The potential energy of particle in a force field is $U = \frac{A}{r^2} - \frac{B}{r}$, where *A* and *B* are positive constants and *r* is the distance of particle from the centre of the field. For stable equilibrium, the distance of the particle is
(a) $B/2A$ (b) $2A/B$ (c) A/B (d) B/A

7. An electric pump is used to fill an overhead tank of capacity $9m^3$ kept at a height of 10m above the ground. If the pump takes 5 minutes to fill the tank by consuming 10 *kW* power the efficiency of the pump should be (g = 10 ms^{-2})
(a) 60% (b) 40% (c) 20% (d) 30%

8. Consider a force $F = -x\hat{i} + y\hat{j}$. The workdone by this force in moving a particle from point *P*(1, 0) to *Q*(0, 1) along the line segment is (all quantities are in SI units).



(a) $\frac{1}{2}$J (b) 1J (c) $\frac{3}{2}$J (d) zero

9. A car of mass *m* starts from rest and accelerates so that the instantaneous power delivered to the car has a constant magnitude P_0. The instantaneous velocity of this car is proportional to :
(a) t^2P_0 (b) $t^{1/2}$ (c) $t^{-1/2}$ (d) $\frac{t}{\sqrt{m}}$

10. A body of mass 5 kg explodes at rest into three fragments with masses in the ratio 1 : 1 : 3. The fragments with equal masses fly in mutually perpendicular directions with speeds of 21 m/s. The velocity of heaviest fragment in m/s will be
(a) $7\sqrt{2}$ (b) $5\sqrt{2}$ (c) $3\sqrt{2}$ (d) $\sqrt{2}$

11. A stationary particle explodes into two particles of masses m_1 and m_2 which move in opposite directions with velocities v_1 and v_2. The ratio of their kinetic energies E_1/E_2 is
(a) m_1v_2/m_2v_1 (b) m_2/m_1
(c) m_1/m_2 (d) 1

12. A bullet is fired and gets embedded in block kept on table. If table is frictionless, then
(a) kinetic energy gets conserved
(b) potential energy gets conserved
(c) momentum gets conserved
(d) both (a) and (c)

13. The speed of an object of mass *m* dropped from an inclined plane (frictionless), at the bottom of the plane, depends on:
(a) height of the plane above the ground
(b) angle of inclination of the plane
(c) mass of the object
(d) All of these

14. If two particles are brought near one another, the potential energy of the system will
(a) increase (b) decrease
(c) remains the same (d) equal to the K.E

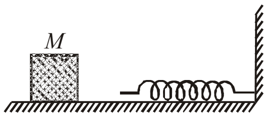
15. A crate is pushed horizontally with 100 N across a 5 m floor. If the frictional force between the crate and the floor is 40 N, then the kinetic energy gained by the crate is
(a) 200 J (b) 240 J (c) 250 J (d) 300 J

16. A 2 kg block slides on a horizontal floor with a speed of 4m/s. It strikes a uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15N and spring constant is 10,000 N/m. The spring compresses by
(a) 8.5 cm (b) 5.5 cm (c) 2.5 cm (d) 11.0 cm

17. 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
(a) $\frac{aS}{R}$ (b) $\frac{2(aS)^2}{R}$ (c) $\frac{aS^2}{R^2}$ (d) $\frac{2aS}{R}$

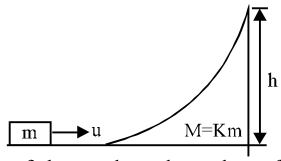
18. A uniform chain of length 2 m and mass 0.1 kg overhangs a smooth table with its two third part lying on the table. Find the kinetic energy of the chain as it completely slips-off the table.
(a) $\frac{8}{9}$ J (b) $\frac{12}{5}$ J (c) $\frac{3}{7}$ J (d) $\frac{11}{3}$ J

19. 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



(a) $\frac{kL^2}{2M}$ (b) $\sqrt{Mk}\ L$
(c) $\frac{ML^2}{k}$ (d) zero

20. A block of mass m is moved towards a movable wedge of mass M = km and height h with velocity u (All the surface are smooth).



If the block just reaches the top of the wedge, the value of u is
(a) $\sqrt{2gh}$ (b) $\sqrt{\frac{2ghK}{1+K}}$
(c) $\sqrt{\frac{2gh(1+K)}{K}}$ (d) $\sqrt{2gh\left(1-\frac{1}{K}\right)}$

Answer Keys

Exercise 1 : (NCERT Based Topic-wise MCQs)																			
1	(c)	**13**	(c)	**25**	(d)	**37**	(b)	**49**	(a)	**61**	(b)	**73**	(a)	**85**	(b)	**97**	(b)	**109**	(b)
2	(b)	**14**	(b)	**26**	(b)	**38**	(c)	**50**	(d)	**62**	(b)	**74**	(a)	**86**	(d)	**98**	(b)	**110**	(a)
3	(c)	**15**	(c)	**27**	(c)	**39**	(a)	**51**	(d)	**63**	(c)	**75**	(a)	**87**	(b)	**99**	(d)	**111**	(d)
4	(b)	**16**	(a)	**28**	(b)	**40**	(b)	**52**	(d)	**64**	(c)	**76**	(d)	**88**	(a)	**100**	(c)	**112**	(d)
5	(a)	**17**	(a)	**29**	(d)	**41**	(c)	**53**	(d)	**65**	(c)	**77**	(c)	**89**	(b)	**101**	(c)	**113**	(a)
6	(d)	**18**	(c)	**30**	(c)	**42**	(c)	**54**	(c)	**66**	(c)	**78**	(a)	**90**	(b)	**102**	(b)	**114**	(c)
7	(b)	**19**	(d)	**31**	(d)	**43**	(b)	**55**	(b)	**67**	(a)	**79**	(d)	**91**	(d)	**103**	(c)	**115**	(a)
8	(c)	**20**	(c)	**32**	(c)	**44**	(d)	**56**	(c)	**68**	(a)	**80**	(d)	**92**	(b)	**104**	(a)	**116**	(a)
9	(a)	**21**	(d)	**33**	(b)	**45**	(a)	**57**	(b)	**69**	(b)	**81**	(d)	**93**	(a)	**105**	(a)	**117**	(b)
10	(d)	**22**	(c)	**34**	(c)	**46**	(b)	**58**	(d)	**70**	(a)	**82**	(a)	**94**	(c)	**106**	(c)	**118**	(b)
11	(c)	**23**	(c)	**35**	(c)	**47**	(a)	**59**	(d)	**71**	(c)	**83**	(d)	**95**	(c)	**107**	(c)	**119**	(b)
12	(b)	**24**	(a)	**36**	(d)	**48**	(b)	**60**	(b)	**72**	(a)	**84**	(b)	**96**	(d)	**108**	(a)	**120**	(b)
Exercise 2 : (NCERT Exemplar & Past Years NEET)																			
1	(b)	**5**	(c)	**9**	(b)	**13**	(c)	**17**	(b)	**21**	(d)	**25**	(a)	**29**	(c)	**33**	(d)	**37**	(a)
2	(c)	**6**	(c)	**10**	(b)	**14**	(a)	**18**	(c)	**22**	(b)	**26**	(c)	**30**	(c)	**34**	(b)	**38**	(b)
3	(d)	**7**	(c)	**11**	(b)	**15**	(b)	**19**	(d)	**23**	(d)	**27**	(c)	**31**	(a)	**35**	(b)		
4	(c)	**8**	(b)	**12**	(d)	**16**	(d)	**20**	(a)	**24**	(d)	**28**	(b)	**32**	(c)	**36**	(d)		
Exercise 3 : (Matching, Statement & Assertion-Reason Type)																			
1	(b)	**3**	(d)	**5**	(b)	**7**	(c)	**9**	(d)	**11**	(b)	**13**	(c)	**15**	(a)				
2	(b)	**4**	(b)	**6**	(d)	**8**	(c)	**10**	(d)	**12**	(d)	**14**	(d)	**16**	(a)				
Exercise 4 : (Skill Enhancer MCQs)																			
1	(c)	**3**	(a)	**5**	(b)	**7**	(d)	**9**	(b)	**11**	(b)	**13**	(a)	**15**	(d)	**17**	(d)	**19**	(b)
2	(a)	**4**	(b)	**6**	(b)	**8**	(b)	**10**	(a)	**12**	(c)	**14**	(a)	**16**	(b)	**18**	(a)	**20**	(c)

5 Work, Energy and Power

EXERCISE - 1

1. **(c)** The dot product should be zero.
2. **(b)**
3. **(c)** $S = \vec{r}_2 - \vec{r}_1 = (14\hat{i} + 13\hat{j} + 9\hat{k}) - (3\hat{i} + 2\hat{j} - 6\hat{k})$

   $W = \vec{F} \cdot \vec{S} = (4\hat{i} + \hat{j} + 3\hat{k}) \cdot (11\hat{i} + 11\hat{j} + 15\hat{k})$

   $= 4 \times 11 + 1 \times 11 + 3 \times 15 = 100\text{J}$
4. **(b)** For two vectors to be perpendicular to each other

   $\vec{A} \cdot \vec{B} = 0$

   $(2\hat{i} + 3\hat{j} + 8\hat{k}) \cdot (4\hat{j} + 4\hat{i} + \alpha\hat{k}) = 0$

   $-8 + 12 + 8\alpha = 0$ or $\alpha = -\frac{4}{8} = -\frac{1}{2}$
5. **(a)** Work done by the net force = change in kinetic energy of the particle.
   This is according to work energy theorem.
6. **(d)** Work done on the body is gain in the kinetic energy. Acceleration of the body is a = V/T.

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

   K.E. acquired $\propto v^2$. That is work done $\propto \frac{V^2t^2}{T^2}$
7. **(b)** When force retards motion *i.e.*, F –(ve) so, work done –(ve)
8. **(c)** When a man pushes a wall and fails to displace it, then displacement of wall = 0
   ∴ Work done by man = $F \times 0 = 0$
   Therefore, man does no work at all.
9. **(a)** When a person carrying load on his head moves over a horizontal road, work done against gravitational force is zero.
10. **(d)** $W = FS\cos\theta$
    ∴ If F = 0; W = 0
    If S = 0; W = 0
    & if $\theta = 90°$; $\cos 90° = 0$ ∴ W = 0.
11. **(c)** Displacement of the particle when it takes a complete round the circular path is zero.
    ∴ Work done = force × displacement
    $W = F \times 0 = 0$
    Therefore, work done by the force is zero.
12. **(b)** From work-energy theorem,

    $W_{Porter} + W_{mg} = \Delta K.E. = 0$ (∵ velocity constant)

    or, $W_{Porter} = -W_{mg} = -mgh$

    ∴ $W_{Porter} = -80 \times 9.8 \times \frac{80}{100} = -627.2\text{J}$
13. **(c)** Work done, $W = \int \vec{F} \cdot \vec{ds} = \left(-x\hat{i} + y\hat{j}\right) \cdot \left(d \times \hat{i} + dy\hat{j}\right)$

    $\Rightarrow W = -\int_1^0 x\,dx + \int_0^1 y\,dy = \left(0 + \frac{1}{2}\right) + \frac{1}{2} = 1J$
14. **(b)** (A)→(3); (B)→(1); C→(2,3); (D)→(1)
15. **(c)** $W = \vec{F}.\vec{s} = (5\hat{i} + 2\hat{j}).(2\hat{i} + 3\hat{j}) = 10 + 6 = 16$ J.
16. **(a)** W = F s cos 90º = zero
17. **(a)** $x = 3t - 4t^2 + t^3$ $\quad \frac{dx}{dt} = 3 - 8t + 3t^2$

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

    Acceleration after 4 sec = –8 + 6 × 4 = 16
    Displacement in 4 sec = $3 \times 4 - 4 \times 4^2 + 4^3 = 12$ m
    ∴ Work = Force × displacement
    = Mass × acc. × disp. = $3 \times 10^{-3} \times 16 \times 12 = 576$ mJ
18. **(c)** As the cord is trying to hold the motion of the block, work done by the cord is negative.

    $W = -M(g - a)\,d = -M\left(g - \frac{g}{4}\right)d = \frac{-3Mgd}{4}$
19. **(d)** 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.
20. **(c)** Motion without slipping implies pure rolling. During pure rolling work done by friction force is zero.
21. **(d)** Given : $\vec{F} = 3\hat{i} + \hat{j}$

    $\vec{r_1} = \left(2\hat{i} + \hat{k}\right)$, $\vec{r_2} = \left(4\hat{i} + 3\hat{j} - \hat{k}\right)$

    $\vec{r} = \vec{r_2} - \vec{r_1} = \left(4\hat{i} + 3\hat{j} - \hat{k}\right) - \left(2\hat{i} + \hat{k}\right)$

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

    So work done by the given force $w = \vec{f}.\vec{r}$

    $= \left(3\hat{i} + \hat{j}\right).\left(2\hat{i} + 3\hat{j} - 2\hat{k}\right) = 6 + 3 = 9J$
22. **(c)** W = F s cos θ = 10 × 2 cos 60º = 10 J.
23. **(c)** $W = Fs\cos\theta$, $\cos\theta = \frac{W}{Fs} = \frac{25}{5 \times 10} = \frac{1}{2}$, $\theta = 60º$.
24. **(a)** Since momentum of both bodies are equal

    So $p_1 = p_2 \Rightarrow \frac{M_1}{M_2} = \frac{u_2}{u_1} \Rightarrow u_2 > u_1$ (let $M_1 > M_2$)

    so $\frac{E_{k_1}}{E_{k_2}} = \frac{P_1^2/2M_1}{P_2^2/2M_2} = \frac{M_2}{M_1} \Rightarrow E_{k_1} < E_{k_2}$

    It means that light body has greater kinetic energy, if they have equal momentum.
25. **(d)** Let the velocity of the particle be *v m/s*.
    Momentum of the particle (*p*) = mv
    Kinetic energy of the particle

    $(E) = \frac{1}{2}mv^2 = \frac{1}{2}.\frac{(mv)^2}{m} \Rightarrow E = \frac{p^2}{2m}$

26. **(b)** K. E = $\frac{1}{2}mv^2$ It is always positive

27. **(c)** Initial momentum (p_1) = p; Final momentum (p_2) = 1.5 p and initial kinetic energy (K_1) = K.

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

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

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

28. **(b)** $E = \frac{P^2}{2m} \therefore E \propto \frac{1}{m}$ [If P = constant]

i.e., the lightest particle will possess maximum kinetic energy and in the given option mass of electron is minimum.

29. **(d)** $\text{K.E.} = \frac{1}{2}mv^2$

Further, $v^2 = u^2 + 2as = 0 + 2ad = 2ad = 2(F/m)d$

Hence, K.E. = $\frac{1}{2}m \times 2(F/m)d = Fd$

or, K.E. acquired = Work done = F × d = constant.

i.e., it is independent of mass m.

30. **(c)** Let m = mass of boy, M = mass of man

v = velocity of boy, V = velocity of man

$$\frac{1}{2}MV^2 = \frac{1}{2}\left[\frac{1}{2}mv^2\right] \qquad ...(i)$$

$$\frac{1}{2}M(V+1)^2 = 1\left[\frac{1}{2}mv^2\right] \qquad ...(ii)$$

Putting $m = \frac{M}{2}$ and solving $V = \frac{1}{\sqrt{2}-1}$

31. **(d)** By law of conservation of mechanical energy

$\Delta k = -\Delta U$

$\Rightarrow k_f - k_i = U_i - U_f$

$\Rightarrow k_f = mgy - mg[y - y_0]$

[$\because k_i = 0, U_i = mgy$ and $U_f = mg(y - y_0)$]

$\Rightarrow k_f = mgy_0$

32. **(c)** As $\frac{1}{2}m_A v_A^2 = \frac{1}{2}m_B v_B^2$

$\frac{v_A}{v_B} = \sqrt{\frac{m_B}{m_A}}$;

$$\frac{P_B}{P_A} = \frac{m_B v_B}{m_A v_A} = \frac{m_B}{m_A}\sqrt{\frac{m_A}{m_B}} = \sqrt{\frac{m_B}{m_A}} = \frac{1}{\sqrt{3}}$$

33. **(b)** At the top of flight, horizontal component of velocity = $u \cos 45° = u/\sqrt{2}$

$$\therefore \text{K.E.} = \frac{1}{2}m\left(\frac{u}{\sqrt{2}}\right)^2 = \frac{1}{2}\left(\frac{mu^2}{2}\right) = \frac{1}{2}K.$$

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

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

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

Using v = u + at

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

35. **(c)** $v_2 = \frac{-m_1 v_1}{m_2} = \frac{-3}{6} \times 16 = -8\ m/s$

$E_2 = \frac{1}{2}m_2 v_2^2 = \frac{1}{2} \times 6(-8)^2 = 192\ J$

36. **(d)** The average speed of the athelete

$v = \frac{100}{10} = 10\ m/s$

$\therefore \text{K.E.} = \frac{1}{2}mv^2$

If mass is 40 kg then, $\text{K.E.} = \frac{1}{2} \times 40 \times (10)^2 = 2000\ J$

If mass is 100 kg then,

$\text{K.E.} = \frac{1}{2} \times 100 \times (10)^2 = 5000\ J$

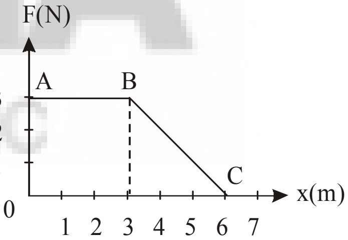
37. **(b)** $W = \int_0^{x_1} F\,dx = \int_0^{x_1} c\,x\,dx = \left[\frac{1}{2}cx^2\right]_0^{x_1}$

$= \frac{1}{2}c(x_1^2 - 0) = \frac{1}{2}cx_1^2$

38. **(c)**

39. **(a)**

40. **(b)**



Work done = area under F-x graph

= area of trapezium OABC = $\frac{1}{2}(3+6)(3) = 13.5\ J$

41. **(c)** W = area of $F - x$ graph

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

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

42. **(c)** We know area under F-x graph gives the work done by the body

$\therefore W = \frac{1}{2} \times (3+2) \times (3-2) + 2 \times 2 = 2.5 + 4 = 6.5\ J$

Using work energy theorem,

Δ K.E = work done

∴ ΔK.E = 6.5 J

43. **(b)** By work-energy thorem

$W = \Delta K$

$$\Rightarrow W = \frac{1}{2}m\,(v_f^2 - v_i^2) \Rightarrow W = \frac{1}{2}\times 0.5\times(16^2 - 4^2)$$

$$\Rightarrow W = \frac{1}{4}\times 240 \Rightarrow W = 60\text{ J}$$

44. **(d)**

45. **(a)** Loss in K.E = Area under the curve $F - x$ = work done

46. **(b)**

47. **(a)** Conservative force is negative gradient of potential

$$F(x) = \frac{-dV(x)}{dx}$$

48. **(b)** Energy required = mgh

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

49. **(a)** $U_1 = mgh_1$ and $U_2 = mgh_2$

$$\%\text{ energy lost} = \frac{U_1 - U_2}{U_1}\times 100$$

$$= \frac{mgh_1 - mgh_2}{mgh_1}\times 100 = \left(\frac{h_1 - h_2}{h_1}\right)\times 100$$

$$= \frac{2 - 1.5}{2}\times 100 = 25\%$$

50. **(d)** When work is done upon a system by a conservative force then its potential energy increases.

51. **(d)** $|F| = \frac{dU}{dx}$, which is greatest in the reagion CD.

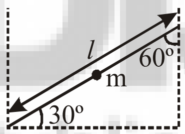
52. **(d)** For any uniform rod, the mass is supposed to be concentrated at its centre.

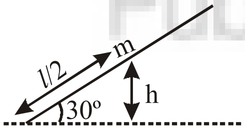
∴ height of the mass from ground is, $h = (l/2)\sin 30°$

∴ Potential energy of the rod

$$= m\times g\times\frac{\ell}{2}\sin 30°$$

$$= m\times g\times\frac{\ell}{2}\times\frac{1}{2} = \frac{mg\ell}{4}$$





53. **(d)** $F = -\frac{dU}{dy} = b - 2ay$

54. **(c)** $U = (1/2)Mv^2$

55. **(b)** The principle of conservation of total mechanical energy can be stated as, the total mechanical energy of a system is conserved if the forces, doing work on it, are conservative.

56. **(c)** Weight Mg moves the centre of gravity of the spring through a distance $\frac{(0+\ell)}{2} = \ell/2$

∴ Mechanical energy stored = Work done = Mg $\ell/2$.

57. **(b)** $v^2 = u^2 + 2gh = (10)^2 + 2\times 10\times 19.5 = 490$

K.E. at the ground

$$= \frac{1}{2}mv^2 = \frac{1}{2}\times\frac{5}{1000}\times 490 = \frac{49}{40}\text{ J}$$

$$\text{P.E.} = mgh = \frac{5}{1000}\times 10\times\left(\frac{-50}{100}\right) = -\frac{1}{40}\text{ J}$$

$$\therefore \text{ Change in energy} = \frac{49}{40} - \left(-\frac{1}{40}\right) = \frac{50}{40} = 1.25\text{J}$$

58. **(d)**

59. **(d)** At the lowest point, h = 0 ∴ P.E. = 0 (gravitational P.E.). There is no work done on the **bob** by the tension as it is perpendicular to the displacement.

∴ Potential energy is associated only to the gravitational force.

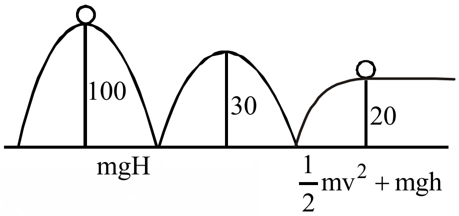
60. **(b)** Total energy at the time of projection

$$= \frac{1}{2}mv^2 = \frac{1}{2}\times 0.1(20)^2 = 20\text{J}$$

Half way up, P.E. becomes half the P.E. at the top i.e.

$$\text{P.E.} = \frac{20}{2} = 10\text{J} \qquad \therefore \text{ K.E.} = 20 - 10 = 10\text{J.}$$

61. **(b)**



Using conservation of energy,

$$m(10\times 100) = m\left(\frac{1}{2}v^2 + 10\times 20\right)$$

or $\frac{1}{2}v^2 = 800$ or $v = \sqrt{1600} = 40$ m/s

62. **(b)** As we know, $dU = F\cdot dr$

$$U = \int_0^r \alpha r^2\,dr = \frac{ar^3}{3} \qquad \text{...(i)}$$

As, $\frac{mv^2}{r} = \alpha r^2 = m^2v^2 = m\alpha r^3$

or, $2m(KE) = \frac{1}{2}\alpha r^3$ ...(ii)

Total energy = Potential energy + kinetic energy

Now, from eqn (i) and (ii)

$$\text{Total energy} = \text{K.E.} + \text{P.E.} = \frac{\alpha r^3}{3} + \frac{\alpha r^3}{2} = \frac{5}{6}\alpha r^3$$

63. **(c)** Let E be the total energy then

$$\frac{P.E}{K.E} = \frac{mgh}{E - mgh} = \frac{2}{3} \Rightarrow E = \frac{5}{2}\,mgh$$

When velocity is double then inital energy becomes $4E$.

So, $\frac{mgh}{4E - mgh} = NL = \frac{mgh}{10mgh - mgh}$

On solving we get $\frac{P.E}{K.E} = \frac{1}{9}$.

64. **(c)** The tension T_1 at the topmost point is given by

$$T_1 = \frac{mv_1^2}{20} - mg$$

Centrifugal force acting outward while weight acting downward.

The tension T_2 at the lowest point $T_2 = \frac{mv_2^2}{20} + mg$

Centrifugal force and weight (both) acting downward

$T_2 - T_1 = \frac{mv_2^2 - mv_1^2}{20} + 2mg$

$v_1^2 = v_2^2 - 2gh$ or $v_2^2 - v_1^2 = 2g(40) = 80g$

$\therefore T_2 - T_1 = \frac{80mg}{20} + 2mg = 6mg$

65. **(c)** Tension at the highest point

$T_{top} = \frac{mv^2}{r} - mg = 2mg \quad (\because v_{top} = \sqrt{3gr})$

Tension at the lowest point

$T_{bottom} = 2mg + 6mg = 8mg$

$\therefore \frac{T_{top}}{T_{bottom}} = \frac{2mg}{8mg} = \frac{1}{4}.$

66. **(c)** Tension in the string, $T = \frac{mv^2}{\ell}$

67. **(a)** Given : Mass (m) = 0.4 kg

Its frequency (n) = 2 rev/sec

Radius (r) =1.2 m. We know that linear velocity of the body (v) = ωr = (2πn)r

= 2 × 3.14 × 1.2 × 2 = 15.08 m/s.

Therefore, tension in the string when the body is at the top of the circle (T)

$= \frac{mv^2}{r} - mg = \frac{0.4 \times (15.08)^2}{2} - (0.4 \times 9.8)$

$= 45.78 - 3.92 = 41.56N$

68. **(a)** Since water does not fall down, therefore the velocity of revolution should be just sufficient to provide centripetal acceleration at the top of vertical circle. So,

$v = \sqrt{(gr)} = \sqrt{\{10 \times (1.6)\}} = \sqrt{(16)} = 4$ m/sec.

69. **(b)** $W = \frac{1}{2}k\ell_2^2 - \frac{1}{2}k\ell_1^2 = \frac{1}{2}k(\ell_2^2 - \ell_1^2)$

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

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

71. **(c)** $l_1 + l_2 = l$ and $l_1 = nl_2$

$\therefore \quad l_1 = \frac{nl}{n+1}$ and $l_2 = \frac{l}{n+1}$

As $k \propto \frac{1}{l}$, $\therefore \quad \frac{k_1}{k_2} = \frac{l/(n+1)}{(nl)/(n+1)} = \frac{1}{n}$

72. **(a)** We define the potential energy V(x) of the spring to be zero when block and spring system is in the equilibrium position.

73. **(a)** For a given spring, $u = \frac{1}{2}kx^2$

$\therefore \frac{u_2}{u_1} = \frac{\frac{1}{2}Kx_2^2}{\frac{1}{2}Kx_1^2} = \frac{(3x)^2}{x^2} = 9:1$

74. **(a)** $U = -\int_0^x F dx = -\int_0^x kx dx = -\frac{1}{2}kx^2.$

It is correctly drawn in (a)

75. **(a)** $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \Rightarrow mv^2 = kx^2$ or $m \times (1.5)^2 = 50 \times (0.15)^2$

$\therefore m = 0.5$ kg

76. **(d)**

77. **(c)** From Hooke's law

$F \propto x \Rightarrow F = kx.$, where k is spring constant

Since force is same in stretching for both spring so $F = k_1x_1 = k_2x_2 \Rightarrow x_1 < x_2$ because $k_1 > k_2$

so work done in case of first spring is $W_1 = \frac{1}{2}k_1x_1^2$ and work done in case of second spring is

$W_2 = \frac{1}{2}k_2x_2^2$ so $\frac{W_1}{W_2} = \frac{x_1}{x_2} \Rightarrow W_1 < W_2$

It means that more work is done in case of second spring (work done on spring is equal to stored elastic potential energy of the spring)

78. **(a)** Stored elastic potential energy of spring =½kx^2 where x is compression or elongation of spring from its natural length. In this position the spring can do work on the block tied to it, which is equal to ½kx^2, so both option (a) & b are correct.

79. **(d)** P.E. = $\frac{1}{2}kx^2$

$\therefore$ If x = 4x, then P.E = $\frac{1}{2}k(16x^2) = 16\left(\frac{1}{2}kx^2\right)$

80. **(d)** $V = \frac{1}{2}k(x)^2 = \frac{1}{2}k(2)^2$ or $k = \frac{2V}{4} = \frac{V}{2}$

$V' = \frac{1}{2}k(10)^2 = \frac{1}{2} \times \left(\frac{V}{2}\right)(10)^2 = 25V$

81. **(d)** Given, $\frac{dk}{dt}$ = constant

$\Rightarrow \quad k \propto t \Rightarrow v \propto \sqrt{t}$

Also, $P = Fv = \frac{dk}{dt}$ = constant

$\Rightarrow \quad F \propto \frac{1}{v} \Rightarrow F \propto \frac{1}{\sqrt{t}}$

82. **(a)**

83. **(d)** $F_{thrust} = V_{rel}\frac{dm}{dt}$

$= 5 \times 0.5 = 2.5$ N

So, Power = Force × Velocity

$= 2.5 \times 5 = 12.5$ watt.

84. **(b)** u = 0; v = u + aT; v = aT

Instantaneous power = F × v = m. a. at = $m.a^2.t$

$\therefore$ Instantaneous power = $m\frac{v^2}{T^2}t$

85. **(b)** Constant power of car $P_0 = F.V = ma.v$

$P_0 = m\frac{dv}{dt}.v$

$P_0 dt = mvdv$ Integrating

$P_0.t = \frac{mv^2}{2}$ $v = \sqrt{\frac{2P_0 t}{m}}$

$\because$ P_0, m and 2 are constant $\therefore$ $v \propto \sqrt{t}$

86. **(d)**

87. **(b)** $P = \frac{W}{t}$. Here, P = 2kW = 2000 W.

W = Mgh = M × 10 × 10 = 100 M and t = 60 s.

This gives, M = 1200 kg

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

88. **(a)**

89. **(b)** We know that F × v = Power

$\therefore F \times v = c$ where c = constant

$\therefore m\frac{dv}{dt} \times v = c$ $\left(\therefore F = ma = \frac{mdv}{dt}\right)$

$\therefore m\int_0^v vdv = c\int_0^t dt$ $\therefore \frac{1}{2}mv^2 = ct$

$\therefore v = \sqrt{\frac{2c}{m}} \times t^{1/2}$

$\therefore \frac{dx}{dt} = \sqrt{\frac{2c}{m}} \times t^{1/2}$ where $v = \frac{dx}{dt}$

$\therefore \int_0^x dx = \sqrt{\frac{2c}{m}} \times \int_0^t t^{1/2} dt$

$x = \sqrt{\frac{2c}{m}} \times \frac{2t^{3/2}}{3}$ $\Rightarrow$ $x \propto t^{3/2}$

90. **(b)** Power exerted by a force is given by

P = F.v

When the body is just above the earth's surface, its velocity is greatest. At this instant, gravitational force is also maximum. Hence, the power exerted by the gravitational force is greatest at the instant just before the body hits the earth.

91. **(d)** 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.

92. **(b)** 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/Δt. Jane did half the work in half the time, (1/2 W)/(1/2 Δt) = W/Δt which is the same power delivered by Johnny.

93. **(a)** Power, P = F.v = $m\frac{dv}{dt}.v$

As P is constant, $\frac{v}{dt}$ = constant

$\Rightarrow v \propto dt \Rightarrow v \propto t$

94. **(c)** Power = $\frac{\text{work done}}{\text{time}}$

Therefore power of A, $P_A = \frac{mgh}{t_A}$

and power of B, $P_B = \frac{mgh}{t_B}$

$\therefore$ $\frac{P_A}{P_B} = \frac{t_B}{t_A} = \frac{4}{2} = 2:1$

95. **(c)** Volume of water to raise = 22380 l = $22380 \times 10^{-3} m^3$

$P = \frac{mgh}{t} = \frac{V\rho gh}{t} \Rightarrow t = \frac{V\rho gh}{P}$

$t = \frac{22380 \times 10^{-3} \times 10^3 \times 10 \times 10}{10 \times 746} = 15$ min

96. **(d)** Power = $\frac{\text{total work done}}{\text{time}}$

$= \frac{\frac{1}{2}Mv^2}{t} = \frac{1}{2}(mv^2)n \left(\because \frac{M}{t} = mn\right)$

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

97. **(b)** $\vec{F} = \frac{md\vec{v}}{dt} = 4t\hat{i} + 6t^2\hat{j}$ $(\because m = 1 \text{ kg})$

$\int_0^v dv = \int_0^t (4t\hat{i} + 6t^2\hat{j})dt \Rightarrow \vec{v} = t^2\hat{i} + t^3\hat{j}$

Power, $P = \vec{F}\cdot\vec{v}$

$= (4t\hat{i} + 6t^2\hat{j})\cdot(t^2\hat{i} + t^3\hat{j})$

$= (4t^3 + 6t^5)$W

98. **(b)** Power = $\frac{\text{Work done}}{\text{Time}} = \frac{\frac{1}{2}m(v^2 - u^2)}{t}$

$P = \frac{1}{2} \times \frac{2.05 \times 10^6 \times \left[(25)^2 - (5^2)\right]}{5 \times 60}$

P = 2.05×10^6 W = 2.05 MW

99. **(d)** $m = 10 \times 0.8\text{kg} = 8\text{kg}$

height of iron chain = 5m

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

100. **(c)** The law of conservation of momentum is true in all type of collisions, but kinetic energy is conserved only in elastic collision. The kinetic energy is not conserved in inelastic collision but the total energy is conserved in all type of collisions.

101. **(c)** In a perfectly inelastic collision, the two bodies move together as one body.

102. **(b)** In an inelastic collision, momentum remains conserved, but K.E is changed.

103. **(c)**

104. **(a)** During elastic collision between two equal masses, the velocities get exchanged. Hence energy transfer is maximum when $m_1 = m_2$.

105. (a) In an elastic collision

$$V_1 = \frac{(m_1 - m_2)}{m_1 + m_2} u_1 ; V_2 = \frac{2m_1u_1}{m_1 + m_2}$$

$\therefore$ if $m_1 = m_2$, then $V_1 = 0$; and $V_2 = \frac{2\cancel{m_1}v_1}{2\cancel{m_1}} = u_1$

106. (c)

107. (c) Apply conservation of momentum,

$m_1v_1 = (m_1 + m_2)v$; $v = \frac{m_1 v_1}{(m_1 + m_2)}$

Here v_1 = 36 km/hr = 10 m/s, m_1 = 2 kg, m_2 = 3 kg

$$v = \frac{10 \times 2}{5} = 4 \text{ m/s}$$

$$\text{K.E. (initial)} = \frac{1}{2} \times 2 \times (10)^2 = 100\text{ J}$$

$$\text{K.E. (Final)} = \frac{1}{2} \times (3+2) \times (4)^2 = 40 \text{ J}$$

Loss in K.E. = 100 – 40 = 60 J

Alternatively use the formula

$$-\Delta E_k = \frac{1}{2}\frac{m_1m_2}{(m_1 + m_2)}(u_1 - u_2)^2$$

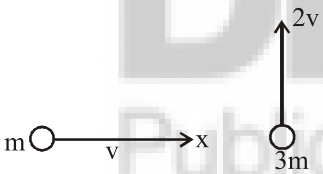
108. (a)

109. (b) $m_1v_1 + m_2v_2 = (m_1 + m_2)v_{sys.}$

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

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

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



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

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

111. (d) K. E. of colliding body before collision $= \frac{1}{2}mv^2$

After collision its velocity becomes

$$v' = \frac{(m_1 - m_2)}{(m_1 + m_2)}v = \frac{m}{3m}v = \frac{v}{3}$$

$\therefore$ K. E. after collision $= \frac{1}{2}\frac{mv^2}{9}$

$$\text{Ratio of kinetic energy} = \frac{K.E._{before}}{K.E._{after}} = \frac{\frac{1}{2}mv^2}{\frac{1mv^2}{2 \times 9}} = 9:1$$

112. (d) For the object of mass 2.0 kg.

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

Kinetic energy transferred

$$\frac{\Delta k}{k} = \frac{4m_1m_2}{(m_1 + m_2)^2}$$

Here, m_1 = 2.0 kg, m_2 = M

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

113. (a) Initial, $K.E. = \frac{1}{2}mv^2 = \frac{1}{2} \times \frac{20}{1000} \times 600 \times 600 = 3600\text{ J}$

Change in K.E. = P.E.

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

$$\Rightarrow 3600 - \frac{1}{2} \times \frac{20}{1000} \times {v_1}^2 = 4 \times 10 \times 80$$

$$\Rightarrow v_1 = 200\text{ m/s}$$

114. (c) Initial kinetic energy of the system

$$K.E_i = \frac{1}{2}mu^2 + \frac{1}{2}M(0)^2 = \frac{1}{2} \times 0.5 \times 2 \times 2 + 0 = 1\text{J}$$

For collision, applying conservation of linear momentum

$m \times u = (m + M) \times v$

$\therefore$ $0.5 \times 2 = (0.5 + 1) \times v$

$$\Rightarrow v = \frac{2}{3}\text{ m/s}$$

Final kinetic energy of the system is

$$K.E_f = \frac{1}{2}(m+M)v^2 = \frac{1}{2}(0.5+1) \times \frac{2}{3} \times \frac{2}{3} = \frac{1}{3}\text{J}$$

$\therefore$ Energy loss during collision $= \left(1 - \frac{1}{3}\right)\text{J} = 0.67\text{J}$

115. (a)

116. (a) As the floor exerts a force on the ball along the normal, & no force parallel to the surface, therefore the velocity component along the parallel to the floor remains constant. Hence $V \sin\theta = V^1 \sin\theta^1$.

117. (b) The law of conservation of energy is valid at any instant & in all circumstances.

118. (b) As no external force is acting on system so, $P_i = P_f$

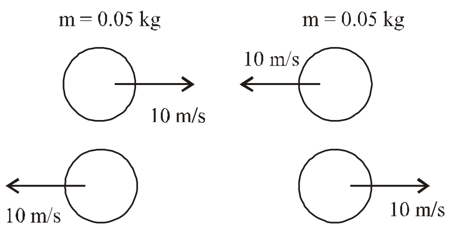
$0.2 \times 10 = 10 \times v \Rightarrow v = 0.2$ m/sec

$$\text{Loss in K.E.} = \frac{1}{2} \times (0.2) \times 10^2 - \frac{1}{2} \times 10(0.2)^2$$

$$= \frac{1}{2} \times 10 \times (0.2)\,[10 - 0.2] = 9.8\text{ J}$$

119. (b)

120. (b)



Chnage in momentum of any one ball

$$|\Delta\vec{P}| = 2 \times 0.05 \times 10 = 1$$

$$|\vec{F}_{av}| = \frac{|\Delta\vec{P}|}{\Delta t} = \frac{1}{0.005} = \frac{1000}{5} = 200\text{ N}$$

EXERCISE - 2

1. **(b)** When electron and proton are moving under influence of their mutual forces, then according to the flemings left hand rule, the direction of force acting on a charge particle is perpendicular to the direction of motion.
In magnetic field, work-done = $F.\,s.\,\cos\theta$
$= F.\,s.\,\cos 90° = 0.$
So magnetic forces do not work on moving charge particle.

2. **(c)** Forces between two protons is same as that of between proton and a positron.
As positron is much lighter than proton, it moves away through much larger distance compared to proton.
Work done = Force × Distance
As forces are same in case of proton and positron but distance moved by positron is larger, hence, work done on positron will be more than proton.

3. **(d)** When the man squatting on the ground he is tilted somewhat, hence he also has to apply frictional force besides his weight.
R (reactional force) = friction force (f) + mg *i.e.*, $R > mg$
When the man does not squat and gets straight up in that case friction (f) ≈ 0
R (Reactional force) ≈ mg
Hence, the reaction force (R) is larger when squatting and become equal to mg when no squatting.

4. **(c)** According to the question, work done by the frictional force on the cycle is :
$= 200 \times 10 = -2000$ J
As the road is not moving, hence work done by the cycle on the road is zero.

5. **(c)** As the body is falling freely under gravity and no external force act on body in vaccum so law of conservation, the potential energy decreases and kinetic energy increases because total mechanical energy (PE + KE) of the body and earth system will be remain constant.

6. **(c)** According to the question, consider the two bodies as system, the total external force on the system will be zero.
Hence, in an inelastic collision KE does not conserved but total linear momentum of the system remain conserved.

7. **(c)** As the (inclined surface) are frictionless, hence, mechanical energy will be conserved. As both the tracks having common height, h (and no external force acts on system).
KE & PE of stone I at top = KE + PE at bottom of I.
From conservation of mechanical energy,
$$0 + \frac{1}{2}mv_1^2 = mgh + 0 \Rightarrow v_1 = \sqrt{2gh} \text{ similarly } v_2 = \sqrt{2gh}$$
Hence, speed is same for both stones.
For stone I, acceleration along inclined plane $a_1 = g \sin\theta_1$
Similarly, for stone II $a_2 = g \sin\theta_2$
$\sin\theta_1 < \sin\theta_2$ Thus, $\theta_2 > \theta_1$ hence $a_2 > a_1$.
a_2 is greater than a_1 and both length for track II is also less hence, stone II reaches earlier than stone I.

8. **(b)** Total Mechanical energy is E = PE + KE at any instant.
When particle is at $x = x_m$ i.e., at extreme position, partical returns back and its velocity become zero for an instant.
Hence, at $x = x_m$; $x = 0$, K.E. = 0.
From Eq. (i), $E = \text{PE} + 0 = \text{PE} = V(x_m) = \frac{1}{2}kx_m^2$
but at mean position at origin $V(x_m) = 0$.

9. **(b)** If two bodies of equal masses collides elastically, their velocities are interchanged.
When ball 1 collides with ball-2, then velocity of ball-1, v_1 becomes zero and velocity of ball-2, v_2 becomes v, *i.e.*, similarly then its own all momentum is mV.
So, $v_1 = 0 \Rightarrow v_2 = v, P_1 = 0, P_2 = mV$
Now ball 2 collides to ball 3 and its transfer it's momentum is mV to ball 3 and itself comes in rest.
So, $v_2 = 0 \Rightarrow v_3 = v, P_2 = 0, P_3 = mV$
So, ball 1 and ball 2, become in rest and ball 3 move with velocity v in forward direction.

10. **(b)** As we know that,
$$\text{W.D.} = \int_{x_1}^{x_2} \vec{F}\cdot\vec{dx} = \int_{x_1}^{x_2} m\vec{a}_0 \cdot \vec{dx}$$
As given that, $m = 0.5$ kg, $a = 5\ \text{m}^{-1/2}\,\text{s}^{-1}$,
$v = ax^{3/2}$
We also know that Acceleration,
$$a_0 = \frac{dv}{dt} = v\cdot\frac{dv}{dx} = ax^{3/2}\frac{d}{dx}(ax^{3/2})$$
$$= ax^{3/2} \times a \times \frac{3}{2} \times x^{1/2} = \frac{3}{2}a^2x^2$$
Now, force $= ma_0 = m\frac{3}{2}a^2x^2$
From (i), work done $= \int_{x=0}^{x=2} F dx$
$$= \int_0^2 \left[\frac{3}{2}ma^2x^2\right] dx = \frac{3}{2}ma^2 \times \left(\frac{x^3}{3}\right)_0^2 = \frac{1}{2}ma^2 \times 8 = 50 \text{ J}$$

11. **(b)** As given that power = constant
As we know that power (P)
$$P = \frac{dW}{dt} = \frac{\vec{F}\cdot\vec{dx}}{dt} = \frac{F\,dx}{dt}$$
As the body is moving unidirectionally.
Hence, $F\cdot dx = Fdx\cos 0° = Fdx$
$P = \frac{Fdx}{dt}$ = constant ($\because$ P = constant by question)
$L^2 \propto T^3 \Rightarrow L \propto T^{3/2} \Rightarrow$ Displacement (d) $\propto t^{3/2}$
Verifies the graph (b).

12. **(d)** 13. **(c)**

14. **(a)** As given that, mass (m) = 5 kg, n = 300 revolution
Radius (R) = 1 m; t = 60 sec
$$\omega = \left(\frac{2\pi n}{t}\right) = (300 \times 2 \times \pi)\text{ rad} / 60\text{s} = 10\pi \text{ rad/s}$$
linear speed (v) = $\omega R = (10\pi \times 1) \Rightarrow v = 10\pi$ m/s
$$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 5 \times (10\pi)^2 = 250\pi^2\text{J}$$
So, verifies the option (a).

15. **(b)** P.E. is maximum when drop start falling at $t = 0$ as it fall is P.E. decrease gradually to zero. So, it rejects the graph (a), (c) and (d).
K.E. at $t = 0$ is zero as drop falls with zero velocity, its velocity increases (gradually), hence, first KE also increases. After sometime speed (velocity) is constant this

is called terminal velocity, so, KE also become constant. It happens when it falls $\left(\frac{3}{4}\right)$ height or remains at $\left(\frac{4}{4}\right)$ from ground, then PE decreases continuously as the drop is falling continuously.
The variation in PE and KE is best represented by (b).

16. **(d)** As given that, $h = 1.5\text{m}, v = 1\text{m/s}, m = 10\text{kg}, g = 10\ \text{ms}^{-2}$
By the law of conservation of mechanical energy as no force acts on shotput after thrown.

$$(PE)_i + (KE)_i = (PE)_f + (KE)_f$$

$$mgh_i + \frac{1}{2}mv_i^2 = 0 + (KE)_f$$

$$(KE)_f = mgh_i + \frac{1}{2}mv_i^2$$

Total energy when it reaches ground, so

$$(KE)_f = 10 \times 10 \times 1.5 + \frac{1}{2} \times 10 \times (1)^2$$

$E = 150 + 5 = 155$ J.

17. **(b)** First velocity of the iron sphere
$V = \sqrt{2gh}$ after sometime its velocity becomes constant, called terminal velocity. Hence, according first KE increases and then becomes constant due to resistance of sphere and water which is represented by (b).

18. **(c)** As given that,

$$m = 150\ \text{g} = \frac{150}{1000}\ \text{kg} = 0.15\ \text{kg}$$

Δt = time of contact = 0.001 s

$$u = 126\,\text{km/h} = \frac{126 \times 1000}{60 \times 60}\ \text{m/s} = 35\ \text{m/s}$$

$$v = -126\text{km/h} = -126 - \times \frac{5}{8} = -35\ \text{m/s}$$

So, final velocity is acc. to initial force applied by batsman.
So, change in momentum of the ball

$$\Delta p = m(v-u) = \frac{3}{20}(-35-35) = -\frac{21}{2}\text{kg-m/s}$$

As we know that, force

$$F = \frac{\Delta p}{\Delta t} = \frac{-21/2}{0.001}\text{N} = -1.05 \times 10^4\ \text{N}$$

Hence negative sign shown that direction of force will be opposite to initial velocity which taken positive direction. Hence verify the option (c).

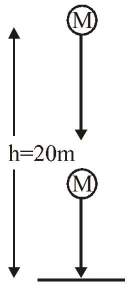
19. **(d)** Power $\vec{F}.\vec{V} = PA\vec{V} = \rho ghAV \left[\because P = \frac{F}{A} \text{ and } P = \rho gh\right]$

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

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

20. **(a)** When ball collides with the ground it loses its 50% of energy

$$\therefore \frac{KE_f}{KE_i} = \frac{1}{2} \Rightarrow \frac{\frac{1}{2}mV_f^2}{\frac{1}{2}mV_i^2} = \frac{1}{2}$$



$$\text{or } \frac{V_f}{V_i} = \frac{1}{\sqrt{2}}$$

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

$$\text{or, } 4gh = V_0^2 + 2gh \quad v \qquad \therefore V_0 = 20\text{ms}^{-1}$$

21. **(d)** As we know power $P = \frac{dw}{dt}$

$$\Rightarrow \quad w = Pt = \frac{1}{2}mV^2 \quad \text{So, } v = \sqrt{\frac{2Pt}{m}}$$

Hence, acceleration $a = \frac{dV}{dt} = \sqrt{\frac{2P}{m}} \cdot \frac{1}{2\sqrt{t}}$

Therefore, force on the particle at time 't'

$$= ma = \sqrt{\frac{2Km^2}{m}} \cdot \frac{1}{2\sqrt{t}} = \sqrt{\frac{Km}{2t}} = \sqrt{\frac{mK}{2}}\, t^{-1/2}$$

22. **(b)** As we know work done in stretching spring

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

where k = spring constant
x = extension

Case (a) If extension (x) is same,

$$W = \frac{1}{2}K\,x^2. \text{ So, } W_P > W_Q \qquad (\because K_P > K_Q)$$

Case (b) If spring force (F) is same $W = \frac{F^2}{2K}$

So, $W_Q > W_P$

23. **(d)** From, F = ma

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

$$\text{So, } \int_{v_1}^{v_2} v\,dV = \int_{20}^{30} \frac{x}{100}dx$$

$$-\left.\frac{V^2}{2}\right|_{V_1}^{V_2} = \left.\frac{x^2}{200}\right|_{20}^{30} = \frac{30 \times 30}{200} - \frac{20 \times 20}{200} = 4.5 - 2 = 2.5$$

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

$$\text{Final K.E.} = \frac{1}{2}mv_2^2 = \frac{1}{2}mv_1^2 - 25 = \frac{1}{2} \times 10 \times 10 \times 10 - 25$$

$= 500 - 25 = 475$ J

24. **(d)** Given force $\vec{F} = 2t\hat{i} + 3t^2\hat{j}$
According to Newton's second law of motion,

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

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

$$\text{Power } P = \vec{F} \cdot \vec{v}\ (2t\,\hat{i} + 3t^2\hat{j}) \cdot (t^2\hat{i} + t^3\hat{j}) = (2t^3 + 3t^5)\text{W}$$

25. **(a)** Given: Mass of particle, $M = 10\text{g} = \frac{10}{1000}$kg
radius of circle R = 6.4 cm
Kinetic energy E of particle = 8×10^{-4}J
acceleration a_t = ?

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

$$\Rightarrow \quad v^2 = 16 \times 10^{-2} \Rightarrow v = 4 \times 10^{-1} = 0.4\ \text{m/s}$$

Now, using

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

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

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

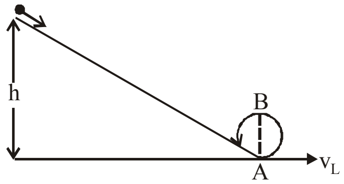
26. **(c)** From work-energy theorem,

$W_g + W_a = \Delta K.E$ or, $mgh + W_a = \frac{1}{2}mv^2 - 0$

$10^{-3} \times 10 \times 10^3 + W_a = \frac{1}{2} \times 10^{-3} \times (50)^2 \Rightarrow W_a = -8.75$ J

which is the work done due to air resistance
Work done due to gravity = mgh
$= 10^{-3} \times 10 \times 10^3 = 10$ J

27. **(c)** As track is frictionless, so total mechanical energy will remain constant



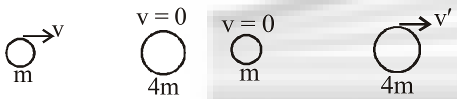
i.e., $0 + mgh = \frac{1}{2}mv_L^2 + 0$

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

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

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

28. **(b)**



According to law of conservation of linear momentum,

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

Coefficient of restitution,

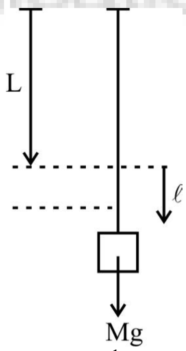
$e = \frac{\text{Relative velocity of separation}}{\text{Relative velocity of approach}}$

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

29. **(c)** Here,

$kx_0 = Mg$

where K = force constant



$DE = \frac{1}{2}Kx_0^2$

$= \frac{1}{2}\frac{Mg}{x_0} \times x_0^2$

$= \frac{1}{2}Mgx_0$

Stored elastic potential energy in extended wire, $= \frac{1}{2}Mg\ell$

[here $x_0 = \ell$]

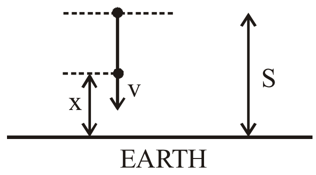
30. **(c)** Work done by variable force

Work done, $W = \int_{y_i}^{y_f} F dy \Rightarrow \int_{y=0}^{y_f=1} F \cdot dy$

where, $F = 20 + 10y$

$\therefore \quad W = \int_0^1 (20 + 10y)\,dy = \left[20y + \frac{10y^2}{2}\right]_0^1 = 25\,J$

31. **(a)** Let the height from the surface of the earth be x. When body from rest falls through height (S – x)
Then from $v^2 = u^2 + 2gs$



$v^2 = 0^2 + 2g(S - x)$

$\Rightarrow v = \sqrt{2g(S - x)}$ ...(i)

At this point,
$U = mgx$
From question, kinetic energy, K = 3U

$\therefore \frac{1}{2}m(v)^2 = 3 \times mg(x)$

$\Rightarrow \frac{1}{2} \times m \times 2g(S - x) = 3 \times mgx$ (using (i))

$\Rightarrow S - x = 3x$

$\therefore x = \frac{S}{4}$ ... (ii)

$\therefore v = \sqrt{2 \times g\left(S - \frac{S}{4}\right)} = \sqrt{\frac{3gS}{2}}$

32. **(c)** Power on turbine $P = \frac{d(mgh)}{dt}$

$= gh\frac{dm}{dt} = 10 \times 60 \times 15 = 9000W$

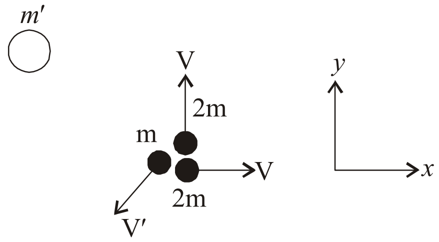
Due to frictional force, lossses are 10%
$\therefore$ Power generated

$= \left(1 - \frac{10}{100}\right) \times 9000 = 8.1$ kW

33. **(d)** Energy radiated = Power × time
$= 100$ kW × 1 hr $= 100$ kWh $= 100 \times 3.6 \times 10^6$ J $= 3.6 \times 10^8$ J
$= 36 \times 10^7$ J

34. **(b)** Power = F × V
$= (2000\,g + 3000) \times 1.5 = 23000 \times 1.5 = 34500$ watt

35. **(b)**



$\vec{P}_i = 0$

$\vec{P}_f = 2mv\hat{i} + 2mv\hat{j} + m\vec{v}^1$ as, $\vec{P}_i = \vec{P}_f$

$0 = m\vec{v}^1 + 2mv\hat{i} + 2mv\hat{j}$

$\vec{v} = -2v(\hat{i} + \hat{j}) \Rightarrow |\vec{v}| = 2v\sqrt{1^2 + 1^2} = 2\sqrt{2}v$

36. **(d)** Potential energy stored in spring (U) is given by

$U = \frac{1}{2}Kx^2$

Initially

$U_i = \frac{1}{2}K(2)^2$ where $x = 2$ cm

$\Rightarrow \quad U_i = \frac{1}{2}(K)\cdot(4) = 2K$ ...(i)

Finally

$U_f = \frac{1}{2}K(8)^2 = \frac{1}{2}K \times 64 = 32K$ ...(ii)

On dividing (i) by (ii)

$\frac{U_i}{U_f} = \frac{2K}{32K} = \frac{1}{16} \Rightarrow U_f = 16\,U$

37. **(a)** Given, displacement $x = 2t - 1$

$\therefore$ velocity

$v = \frac{dx}{dt} = 2ms^{-1}$

Therefore power $P = F.\,v = 2 \times 5 = 10$ W

38. **(b)** (A) → v_1 (B) ⇒ (A)(B) → v_2

(Before collision) rest (After collision)

By conservation of linear momentum,

$P_i = P_f$

$\Rightarrow mv_1 = mv_2 + mv_2 \Rightarrow mv_1 = 2\,mv_2$

$\therefore \frac{v_1}{v_2} = \frac{2}{1}$

EXERCISE-3

1. **(b)** (A) → (1); (B) → (1); (C) → (3); (D) → (3)
2. **(b)** (A)→(3); (B)→(1); C→(2); (D)→(1)
3. **(d)** (A)→(4); (B)→(1); C→(3); (D)→(2)
4. **(b)** In close loop, $s = 0$, and so $W = Fs = 0$.
5. **(b)**
6. **(d)** The billiard balls in an elastic collision are in a deformed state. Their total energy is partly kinetic and partly potential. So K.E. is less than the total energy. The energy spent against friction is dissipated as heat which is not available for doing work.
7. **(c)** If there were no friction, moving vehicles could not be stopped by looking the brakes. Vehicles are stopped by air friction only. So, this statement is correct.
8. **(c)** If there were no friction, moving vehicles could not be stopped by looking the brakes. Vehicles are stopped by air friction only. So, this statement is correct.
9. **(d)** force depends only on the end points.
This can be seen from the relation,
$W = K_f - K_i = V(X_i) - V(X_f)$
which depends on the end points.
A third definition states that the work done by this force in a closed path is zero. This is once again apparent from Eq. $K_i + v(X_i) = K_f + v(X_f)$, since $X_i = X_f$
10. **(d)**
11. **(b)** In elastic collision, total momentum and kinetic energy will remain conserved.
12. **(d)** Work done may be zero, even F is not zero.
also, $W = Fs\cos 0° = Fs$ (maximum). [when applied force and displacement is in the same direction]
13. **(c)** Change in kinetic energy = work done by net force. This relationship is valid for particle as well as system of particles.
14. **(d)** K.E. $= \frac{P^2}{2m} \Rightarrow E \propto \frac{1}{m}$ when P constant
15. **(a)** Power $= \frac{W}{t} = \frac{K}{1/n} = nK$
16. **(a)** Maximum energy loss $= \frac{P^2}{2m} - \frac{P^2}{2(m+M)}$

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

$= \frac{P^2}{2m}\left[\frac{M}{(m+M)}\right] = \frac{1}{2}mv^2\left\{\frac{M}{m+M}\right\}$

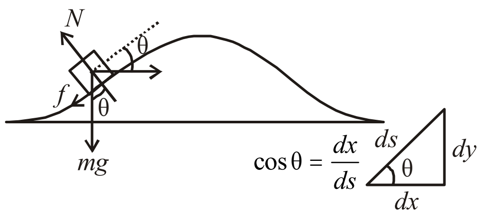
Reason is a case of perfectly inelastic collision.
By comparing the equation given in Assertion with above equation, we get

$f = \left(\frac{M}{m+M}\right)$

EXERCISE-4

1. **(c)** Work done by friction

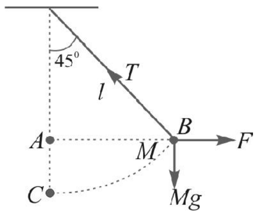
$$= \int \vec{F}\cdot\vec{ds} = \int_0^x \mu mg\cos\theta \frac{dx}{\cos\theta} = \mu mg\,x = 20\text{ J}$$



2. **(a)**
3. **(a)** By using work-energy theorem, $W_{all} = \Delta K$, we have
Work done by F + work done by $Mg = 0$
$F(AB) - Mg(AC) = 0$

$F = Mg\left(\frac{AC}{AB}\right) = \left[\frac{l - l/\sqrt{2}}{l/\sqrt{2}}\right]$

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



4. **(b)** The centripetal acceleration

$a_c = k^2 r t^2$ or $\frac{v^2}{r} = k^2 r t^2 \quad \therefore \quad v = krt$

So, tangential acceleration, $a_t = \frac{dv}{dt} = kr$

Work is done by tangential force.

Power $= F_t \cdot v \cdot \cos 0° = (ma_t)(krt) = (mkr)(krt) = mk^2 r^2 t$

5. **(b)** The required work done by man = kinetic energy of man + kinetic energy of boat

$= \frac{1}{2}\frac{p^2}{M} + \frac{1}{2}\frac{p^2}{m}$ (where $p = Mv$)

$\therefore \; W = \frac{1}{2}\left(\frac{M^2}{M} + \frac{M^2}{m}\right)v^2 = \frac{1}{2}\left(M + \frac{M^2}{m}\right)v^2$

6. **(b)**

7. **(d)** $P_{out} = \frac{mgh}{t} = \frac{9000 \times 10 \times 10}{5 \times 60} = 3000\ W$

$P_{in} = 10 \times 10^3$ W.

$\therefore \; \eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{3000}{10 \times 10^3} \times 100 = 30\%$

8. **(b)** Work done, $W = \int \vec{F} \cdot \vec{ds} = \left(-x\hat{i} \times y\hat{j}\right) \cdot \left(x\hat{i} + y\hat{j}\right)$

$\Rightarrow W = \int_1^0 x\,dx + \int_0^1 y\,dy = \left(0 + \frac{1}{2}\right) + \frac{1}{2} = 1$ J.

9. **(b)** Constant power of car $P_0 = F \cdot V = ma \cdot v$

$P_0 = m\frac{dv}{dt} \cdot v$

$P_0 dt = mvdv$. Integrating $P_0 \cdot t = \frac{mv^2}{2}$

$v = \sqrt{\frac{2P_0 t}{m}} \quad \because P_0, m$ and 2 are constant $\quad \therefore \; v \propto \sqrt{t}$

10. **(a)** Masses of the pieces are 1, 1, 3 kg. Hence $(1 \times 21)^2 + (1 \times 21)^2 = (3 \times V)^2$

That is, $V = 7\sqrt{2}$ m/s

11. **(b)**

12. **(c)** Only momentum is conserved. Some kinetic energy is lost when bullet penetrates the block.

13. **(a)** If an object of mass m is released from rest from top of a smooth inclined plane, its speed at the bottom is $\sqrt{2gh}$, independent of angle θ and mass.

14. **(a)**

15. **(d)** Here, F = 100 N, d = 5 m,

frictional force $f_r = 40$ N

$\therefore \; F - f_r = ma$

$100 - 40 = ma$

Now kinetic energy gained is = ma × d

$= 60 \times 5 = 300$ J

16. **(b)** Let the blow compress the spring by x before stopping.

Kinetic energy of the block = (P.E of compressed spring) + work done against function.

$\frac{1}{2} \times 2 \times (4)^2 = \frac{1}{2} \times 10,000 \times x^2 + (+15) \times x$

$10,000\,x^2 + 30x - 32 = 0$

$\Rightarrow 5000x^2 + 15x - 16 = 0$

$\therefore \; x = -\frac{15 \pm \sqrt{(15)^2 - 4 \times (5000)(-16)}}{2 \times 5000} = 0.055\text{m} = 5.5\text{cm}.$

17. **(d)** Centripetal force

$= \frac{mv^2}{R} = \left(\frac{1}{2}mv^2\right)\frac{2}{R} = \frac{2K}{R} = \frac{2aS}{R}$

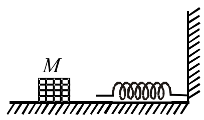
18. **(a)** $U_1 = \int_0^{\ell/3} -\frac{m}{\ell}gx\,dx = -\frac{1}{18}mg\ell;$

$U_2 = \int_0^{\ell} -\frac{m}{\ell}gx\,dx = -\frac{1}{2}mg\ell$

loss in P.E. $= U_1 - U_2 = \frac{4}{9}$mgl

$= \frac{4}{9} \times 0.1 \times 10 \times 2 = \frac{8}{9}$J = Final K.E.

19. **(b)** $\frac{1}{2}Mv^2 = \frac{1}{2}kL^2$



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

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

20. **(c)**