2. Work and Energy

1. Write detailed answers?

a. Explain the difference between potential energy and kinetic energy.

Ans.

Aspect	**Potential Energy**	**Kinetic Energy**
Definition	Energy possessed due to **position or condition**	Energy possessed due to **motion**
Depends on	Height, shape, or position	Mass and speed (velocity)
Formula	PE=mgh	KE= ½ mv^2
Example	Water stored in a dam, book on a shelf	A moving car, a rolling ball
Energy Type	Stored (inactive) energy	Active (moving) energy
Conversion	Can change into kinetic energy when object moves downward	Can come from potential energy

b. Derive the formula for the kinetic energy of an object of mass m, moving with velocity v.

Ans.

To derive: Kinetic Energy (K.E) of an object of mass m, moving with velocity v.

Work done (W) = Force (F) × Displacement (s)

From Newton's law, $F = ma$

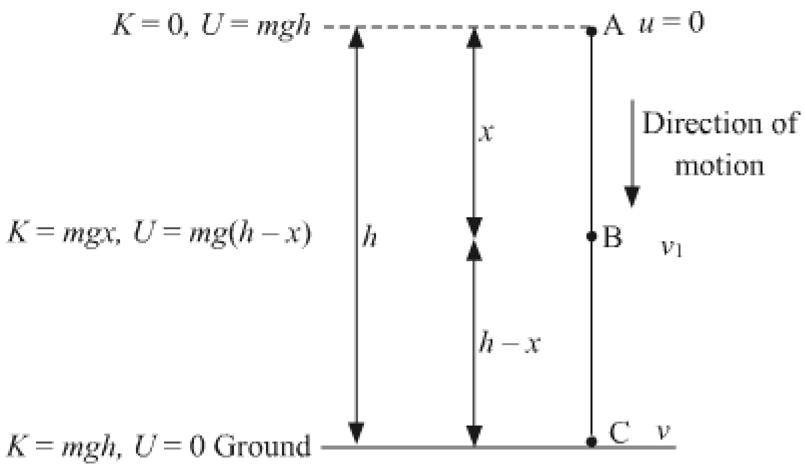
From motion equation, $v^2 = u^2 + 2as$. If $u = 0$, then $v^2 = 2as \rightarrow s = \frac{v^2}{2a}$

Now, $W = F \cdot s = ma \cdot \frac{v^2}{2a} = \frac{1}{2}mv^2$

Hence, Kinetic Energy (K.E) = $\boxed{\frac{1}{2}mv^2}$

c. Prove that the kinetic energy of a freely falling object on reaching the ground is nothing but the transformation of its initial potential energy.

Ans.



Free fall of a body

Let the object be at point A, at height h above the ground.

At point A:

Initial velocity $u = 0$

Kinetic energy, $KE = \frac{1}{2}mu^2 = 0$

Potential energy, $PE = mgh$

Total energy = $0 + mgh = mgh$ ... (i)

At point B:

Let the object fall through distance x, and its velocity be v_1.

Using $v_1^2 = u^2 + 2gx$, and $u = 0$,

$v_1^2 = 2gx$

Kinetic energy, $KE = \frac{1}{2}mv_1^2 = \frac{1}{2}m(2gx) = mgx$

Potential energy, $PE = mg(h - x)$

Total energy = $mgx + mg(h - x) = mgh$ ... (ii)

At point C (ground):

Let velocity be v_2, and object has fallen through h.

Using $v_2^2 = 2gh$

Kinetic energy, $KE = \frac{1}{2}mv_2^2 = \frac{1}{2}m(2gh) = mgh$

Potential energy = 0 (at ground)

Total energy = $mgh + 0 = mgh$ ... (iii)

From (i), (ii), and (iii): Total energy at points A, B, and C is the same.

Hence, total energy is conserved.

∴ The kinetic energy of a freely falling object on reaching the ground is nothing but the transformation of its initial potential energy.

d. Determine the amount of work done when an object is displaced at an angle of 30^0 with respect to the direction of the applied force.

Ans.

Work done,

$W = F \times s \cos\theta$

Here,

$\theta = 30^\circ$

$\cos 30^\circ = \frac{\sqrt{3}}{2}$

Thus,

$W = F \times s \cos 30^\circ$

$W = \frac{\sqrt{3}}{2}Fs$

e. If an object has 0 momentum, does it have kinetic energy? Explain your answer.

Ans.

Momentum of an object,

Momentum of an object,

$P = mv$

If $P = 0$

$\Rightarrow v = 0$

This is because **mass of the object can never be zero.**

Now, kinetic energy of the object,

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

Since $v = 0$

$\Rightarrow K = 0$

Hence, when the object has zero momentum, its kinetic energy is also zero.

f. Why is the work done on an object moving with uniform circular motion zero?

Ans.

Work done on an object is given as:

$$W = F \times s\cos\theta$$

In **circular motion**, the direction of force acting on the object is **radially inward**, and the direction of motion of the object is **tangential to the circular path** at every instant.

Thus, the angle θ between the force vector and displacement vector is always 90°.

$$\theta = 90^\circ \quad \text{and} \quad \cos 90^\circ = 0$$

Therefore,

$$W = F \times s\cos 90^\circ = 0$$

Hence, the work done on an object moving in uniform circular motion is zero.

2. Choose one or more correct alternatives.

a. For work to be performed, energy must be ….

(i) transferred from one place to another (ii) concentrated

(iii) transformed from one type to another (iv) destroyed

Ans. For work to be performed, energy must be **transferred from one place to another.**

b. Joule is the unit of …

(i) force (ii) work (iii) power (iv) energy

Ans. Joule is the unit of work and **energy**

c. Which of the forces involved in dragging a heavy object on a smooth, horizontal surface, have the same magnitude?

(i) the horizontal applied force (ii) gravitational force

(iii) reaction force in vertical direction (iv) force of friction

Ans. The gravitational force and the reaction force in vertical direction have same magnitude.

d. Power is a measure of the ....
(i) the rapidity with which work is done (ii) amount of energy required to perform the work
(iii) The slowness with which work is performed (iv) length of time
Ans. Power is a measure of the **rapidity with which work is done**
e. While dragging or lifting an object, negative work is done by
(i) the applied force (ii) gravitational force (iii) frictional force (iv) reaction force
Ans. While dragging or lifting an object, the negative work is done by **frictional and gravitational force, respectively.**

3. Rewrite the following sentences using proper alternative.
a. The potential energy of your body is least when you are .....
(i) sitting on a chair (ii) sitting on the ground (iii) sleeping on the ground (iv) standing on the ground
Ans. The potential energy of your body is least when you are **sleeping on the ground.**
b. The total energy of an object falling freely towards the ground …
(i) decreases (ii) remains unchanged (iii) increases (iv) increases in the beginning and then decreases
Ans. The total energy of an object falling freely towards the ground **remains unchanged.**
c. If we increase the velocity of a car moving on a flat surface to four times its original speed, its potential energy ….
(i) will be twice its original energy (ii) will not change
(iii) will be 4 times its original energy (iv) will be 16 times its original energy.
Ans. If we increase the velocity of a car moving on a flat surface to four times its original speed, its potential energy **will not change.**
d. The work done on an object does not depend on ….
(i) displacement (ii) applied force
(iii) initial velocity of the object (iv) the angle between force and displacement.
Ans. The work done on an object does not depend on **initial velocity of the object**.

4. Study the following activity and answer the questions.
1. Take two aluminium channels of different lengths.
2. Place the lower ends of the channels on the floor and hold their upper ends at the same height.
3. Now take two balls of the same size and weight and release them from the top end of the channels. They will roll down and cover the same distance.

Questions
1. At the moment of releasing the balls, which energy do the balls have?
2. As the balls roll down which energy is converted into which other form of energy?
3. Why do the balls cover the same distance on rolling down?
4. What is the form of the eventual total energy of the balls?
5. Which law related to energy does the above activity demonstrate ? Explain.

Ans.
1. Potential Energy
2. The potential energy of the balls converts to kinetic energy as they roll down.
3. They have same speed
4. The total energy of the ball will eventually be in the form of kinetic energy.
5. It demonstrates the **Law of Conservation of Energy**.

Explanation: Energy is **not created or destroyed**; it is **only converted** from one form to another (here, from potential to kinetic energy). The total energy remains constant.

5. Solve the following examples.

a. An electric pump has 2 kW power. How much water will the pump lift every minute to a height of 10 m?

Ans.

P = power (in watts) = 2000 W

m = mass of water (in kg)

g = 9.8 m/s^2 (acceleration due to gravity)

h = 10 m (height)

t = (1 minute) = 60 s

Power = P = $\frac{\text{workdone}}{\text{time}} = \frac{\text{mgh}}{\text{t}}$

m= $\frac{\text{Pt}}{\text{gh}} = \frac{2000 \text{ x } 60}{9.8 \text{ x } 10} = \frac{120000}{98}$ 1224.49 = 1224.5 Kg

The pump lifts about **1224.5 litres of water every minute** (since 1 kg of water ≈ 1 litre).

b. If a 1200 W electric iron is used daily for 30 minutes, how much total electricity is consumed in the month of April?

Ans.

Power = 1200 W

Daily use = 30 minutes = 0.5 hours

April has 30 days

Daily Consumption = Energy (in kWh)= $\frac{\text{1000Power (W)×Time (hr)}}{1000} = \frac{1200 \times 0.5}{1000}$ = 0.6 kWh

Monthly consumption= 0.6 x 30 = 18 kWh = 18 Units

c. If the energy of a ball falling from a height of 10 metres is reduced by 40%, how high will it rebound?

Ans.

h= 10mtr

At height h 10 mtr, Energy of the ball = *mgh* = 10*mg*

Let the ball rebounds to a height *h*' where the energy reduces by 40%. Thus,

Energy at height *h*' = *mgh*' = 60% of energy at height of 10 m

∴ *mgh’* = (60/100)×10mg=6mg

∴ *mgh*' = 6*mg*

∴ h’ = 6m

The ball will rebound to to a height of 6m.

d. The velocity of a car increases from 54 km/hr to 72 km/hr. How much is the work done if the mass of the car is 1500 kg ?

Ans.

Here, *v* = 72 km/h = 20 m/s, *u* = 54 km/h = 15 m/s, *m* = 1500 kg

Work done by the car = Change in kinetic energy of the car

i.e.

W=$K.E_f$ – $K.E_i$

W=(1/2)×m×v^2−(1/2)×m×u^2

=(1/2)×m(v^2−u^2)=(1/2)×1500(20^2−15^2) =131250 J

Work done by car = 131250 J

e. Ravi applied a force of 10 N and moved a book 30 cm in the direction of the force. How much was the work done by Ravi?

Ans.

Work done, $W = F \times s \times \cos\theta$

Here, $\theta = 0^{o}$

$F = 10$ N

$s = 30 \text{ cm} = \frac{30}{100} \text{ m} = 0.3 \text{ m}$

$\therefore W = 10 \times 0.3 \times \cos 0^{0} = 10 \times 0.3 \times 1 = 3 \text{ J}$

Work done by Ravi= 3 J