NCERT Solutions for Class 9 Science (Exploration)
Chapter 7 Work, Energy, and Simple Machines

Revise, Reflect, Refine (NCERT Textbook Page No. 137)

Question 1.
State whether True or False.
(i) Work is said to be done when a force is applied, even if the object does not move.
(ii) Lifting a bucket vertically upward results in positive work done on the bucket.
(iii) The SI unit for both work and energy is joule (J).
(iv) A motionless stretched rubber band has kinetic energy
(v) Energy can change from one form to another.

Answer:
(i) False

Work is said to be done only when a force causes displacement in the direction of the force. If the object does not move, displacement is zero, so work done is zero.

(ii) True

When a bucket is lifted vertically upward, both force and displacement are in the upward direction. Therefore, positive work is done on the bucket.

(iii) True

The SI unit of both work and energy is the joule (J).

(iv) False

A motionless stretched rubber band has elastic potential energy, not kinetic energy. Kinetic energy is possessed by a moving object.

(v) True

Energy can change from one form to another. For example, electrical energy can change into light and heat energy in an electric bulb.

Question 2.
Fill in the blanks.

(i) Work done = …… × ……. (in the direction of force).

Answer:
Work done = Force × displacement in the direction of force.

(ii) 1 joule of work is done when a force of …… newton displaces an object by 1 metre in the direction of the force.

Answer:
1 joule of work is done when a force of 1 newton displaces an object by 1 metre in the direction of the force.

(iii) The expression for kinetic energy of a body of mass m and velocity v is …… .

Answer:
The expression for kinetic energy is 1/2 mv^2.

(iv) The potential energy of an object of mass m at a small height h from the Earth's surface is …… .

Answer:
The potential energy of the object is mgh.

(v) Power is defined as the …….. at which work is done.

Answer:
Power is defined as the rate at which work is done.

Question 3.
When a ball thrown upwards reaches its highest point, tick which of the following statement(s) are correct?
(i) The force acting on the ball is zero.
(ii) The acceleration of the ball is zero.
(iii) Its kinetic energy is zero.
(iv) Its potential energy is maximum.

Answer:
The correct statements are (iii) and (iv).

(i) The force acting on the ball is zero. — Incorrect

Even at the highest point, the force of gravity acts downward on the ball.

(ii) The acceleration of the ball is zero. — Incorrect

The acceleration due to gravity still acts downward. Its value is approximately 10 m/s^2 near the surface of Earth.

(iii) Its kinetic energy is zero. — Correct

At the highest point, the velocity of the ball becomes zero for an instant. Since kinetic energy depends on velocity, its kinetic energy is zero.

(iv) Its potential energy is maximum. — Correct

At the highest point, the ball is at its maximum height. Therefore, its gravitational potential energy is maximum.

Question 4.
For each of the following situations, identify the energy transformation that takes place:
(i) a truck moving uphill,
(ii) unwinding of a watch spring,
(iii) photosynthesis in green leaves,
(iv) water flowing from a dam,
(v) burning of a matchstick,
(vi) explosion of a firecracker,
(vii) speaking into a microphone,
(viii) a glowing electric bulb, and
(ix) a solar panel.

Answer:
(i) A truck moving uphill:

Chemical energy of fuel changes into kinetic energy and gravitational potential energy. As the truck gains height, its potential energy increases.

(ii) Unwinding of a watch spring:

Elastic potential energy stored in the wound spring changes into kinetic energy of the moving parts of the watch.

(iii) Photosynthesis in green leaves:

Light energy from the Sun changes into chemical energy stored in food.

(iv) Water flowing from a dam:

Gravitational potential energy of stored water changes into kinetic energy of flowing water. In a hydroelectric power station, this kinetic energy can change into electrical energy.

(v) Burning of a matchstick:

Chemical energy changes into heat energy and light energy.

(vi) Explosion of a firecracker:

Chemical energy changes into heat energy, light energy, sound energy, and kinetic energy of gases and particles.

(vii) Speaking into a microphone:

Sound energy changes into electrical energy.

(viii) A glowing electric bulb:

Electrical energy changes into light energy and heat energy.

(ix) A solar panel:

Solar energy or light energy changes into electrical energy.

Question 5.
A student is slowly lifted straight up in an elevator from the ground level to the top floor of a building. Later, the same student climbs the staircase, all the way to the top. Given that the height of the building is h = 72.5 m, acceleration due to gravity is g = 10 ms-2, and student's mass is m 50 kg.
(i) Find the gain in the potential energy if the student is lifted straight up to the top.
(ii) Find the gain in the potential energy when the student climbs the stairs to the same top.
(iii) What do you conclude about the dependence of the potential energy on the path taken?

Answer:
Given:

Mass of student, m = 50 kg
Height, h = 72.5 m
Acceleration due to gravity, g = 10 m/s^2

(i) Gain in potential energy when lifted by an elevator:

Potential energy gained = mgh

PE = 50 × 10 × 72.5
PE = 36,250 J

So, the gain in potential energy is 36,250 J.

(ii) Gain in potential energy when the student climbs the stairs:

The student reaches the same height of 72.5 m. Therefore,

PE = mgh
PE = 50 × 10 × 72.5
PE = 36,250 J

So, the gain in potential energy is again 36,250 J.

(iii) Conclusion:

The gain in potential energy depends only on mass, acceleration due to gravity, and vertical height gained. It does not depend on the path taken. Whether the student goes up by elevator or by stairs, the gain in potential energy is the same because the final height is the same.

Question 6.
A crane lifts a mass m to the 10th floor of a building in a certain time. It then raises the same mass to the 20th floor of the same building in double the time. How much more energy and power are required? Assume that the height of all floors is equal.

Answer:
Let the height of each floor be d.

Height of 10th floor = 10d
Height of 20th floor = 20d

Energy required to lift the mass to the 10th floor:

E1 = mg × 10d
E1 = 10mgd

Energy required to lift the same mass to the 20th floor:

E2 = mg × 20d
E2 = 20mgd

So, the energy required for the 20th floor is double the energy required for the 10th floor.

Extra energy required:

E2 - E1 = 20mgd - 10mgd
= 10mgd

Now, let the time taken to reach the 10th floor be t.

Power for the 10th floor:

P1 = E1 / t
P1 = 10mgd / t

Time taken to reach the 20th floor = 2t

Power for the 20th floor:

P2 = E2 / 2t
P2 = 20mgd / 2t
P2 = 10mgd / t

Therefore, the energy required is doubled, but the power required remains the same because the time is also doubled.

Question 7.
Which factors determine the energy required to raise a flag from the ground to the top of a tall flagpole using a pulley? Does raising the flag slowly or quickly change the amount of work done? If the speed at which the flag is raised is doubled, how does the power requirement change? Explain your answers.

Answer:
The energy required to raise the flag depends on:

Mass of the flag
Height of the flagpole
Acceleration due to gravity

The work done in raising the flag is:

W = mgh

This work depends only on the mass and height, not on how fast the flag is raised.

Raising the flag slowly or quickly does not change the total work done because the flag is raised through the same height.

However, power depends on time:

Power = Work done / Time taken

If the flag is raised faster, the same work is done in less time, so power increases. If the speed of raising the flag is doubled, the time taken becomes half. Therefore, the power required becomes double.

Question 8.
A man of mass 60 kg rides a scooter of mass 100 kg. He accelerates the scooter to a velocity v. The next day, his son, with a mass of 40 kg, joins him as a passenger. If the scooter reaches the same speed on both days in the same time interval, what is the ratio of the fuel of the tank used on the two days? Assume that the energy transfer to the scooter happens entirely due to fuel, and no other losses occur due to air resistance and friction.

Answer:
On the first day:

Mass of scooter = 100 kg
Mass of man = 60 kg

Total mass = 100 + 60 = 160 kg

Kinetic energy on the first day:

$KE1 = 1/2 \times 160 \times v^2$
$KE1 = 80v^2$

On the second day:

Mass of scooter and man = 160 kg
Mass of son = 40 kg

Total mass = 160 + 40 = 200 kg

Kinetic energy on the second day:

$KE2 = 1/2 \times 200 \times v^2$
$KE2 = 100v^2$

Since fuel energy is completely converted into kinetic energy, the ratio of fuel used is equal to the ratio of kinetic energies.

Fuel used on first day: Fuel used on second day

$= 80v^2 : 100v^2$
$= 80: 100$
$= 4: 5$

Therefore, the ratio of fuel used on the two days is 4: 5.

Question 9.
On a seesaw with sliding seats, a child is sitting on one side and an adult on the other side. The adult weighs twice that of the child. The seesaw, however, is balanced. Draw a figure which depicts this situation, showing the distances from the fulcrum where the child and the adult are seated.

Answer:
Let the weight of the child be W.

Then the weight of the adult = 2W.

For a seesaw to remain balanced:

Clockwise moment = Anticlockwise moment

Weight of child × distance of child from fulcrum = Weight of adult × distance of adult from fulcrum

$W \times d_{child} = 2W \times d_{adult}$

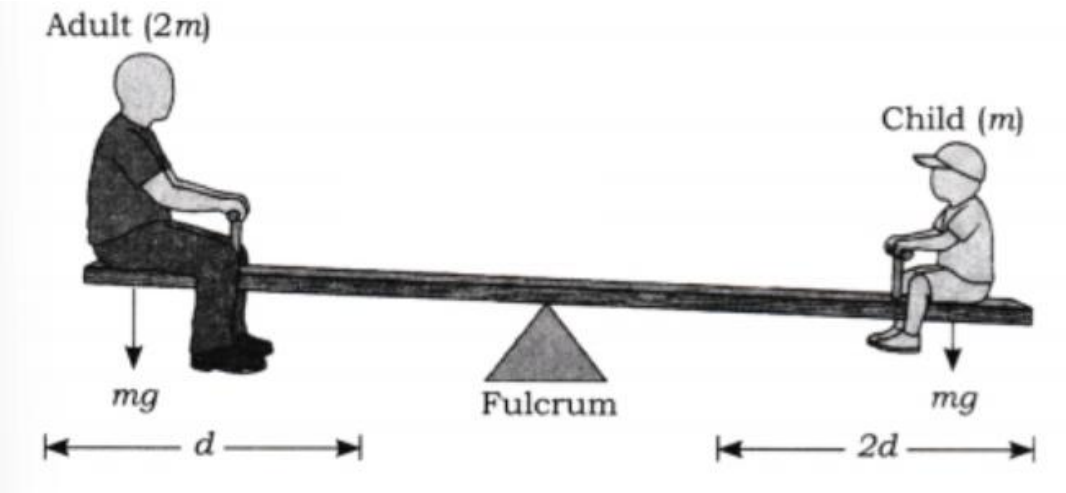
$d_{child} = 2d_{adult}$

Therefore, the child must sit twice the distance from the fulcrum compared to the adult.

Diagram representation:

Child (W) —— 2d —— Fulcrum —— d —— Adult (2W)

This arrangement balances the seesaw because the lighter child sits farther from the fulcrum, while the heavier adult sits closer to the fulcrum.



Question 10.
A ball of mass 2 kg is thrown up with a velocity of 20 ms-1.
(i) Identify the sign of the work done by gravity on the ball during its upward motion and its downward motion.
(ii) If the ball reaches a height of 19.4 m, how much work was done by air resistance (assume g = 10 ms-2)

Answer:
(i) During upward motion:

The ball moves upward, but gravity acts downward. Since force and displacement are in opposite directions, the work done by gravity is negative.

During downward motion:

The ball moves downward, and gravity also acts downward. Since force and displacement are in the same direction, the work done by gravity is positive.

(ii) Given:

Mass of ball, m = 2 kg
Initial velocity, u = 20 m/s
Actual height reached, h = 19.4 m
$g = 10\ m/s^2$

Initial kinetic energy of the ball:

$KE = 1/2\ mv^2$
$KE = 1/2 \times 2 \times 20^2$
$KE = 400\ J$

Potential energy at actual height:

$PE = mgh$
$PE = 2 \times 10 \times 19.4$
$PE = 388\ J$

Work done by air resistance:

Wair = Final mechanical energy - Initial mechanical energy
Wair = 388 - 400
Wair = -12 J

Therefore, the work done by air resistance is -12 J. The negative sign shows that air resistance opposes the motion of the ball.

Question 11.
A 10.0 kg block is moving on horizontal floor with negligible friction. As shown in the Fig. 7.37, a variable force is applied on the block in its direction of motion from its position at o m till 4 m. If the block had a kinetic energy of 180 J when it was at 0 m, find the block's speed (i) at 0 m, and (ii) at 4 m. Does the block have negative acceleration in any portion of its motion?

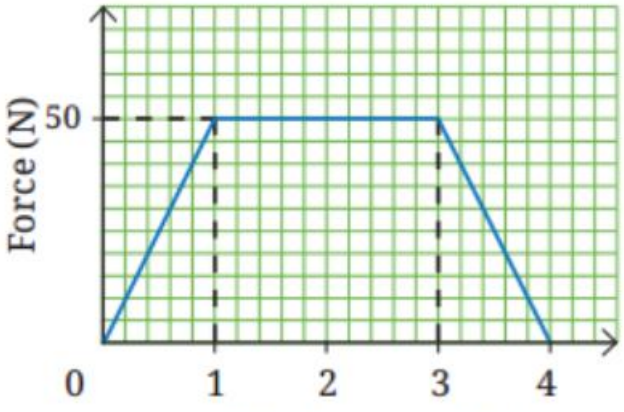


Fig. 7.37

Answer:
Given:

Mass of block, m = 10 kg
Initial kinetic energy = 180 J

(i) Speed at 0 m:

Kinetic energy is given by:

$KE = 1/2\ mv^2$

$180 = 1/2 \times 10 \times v^2$
$180 = 5v^2$
$v^2 = 36$
$v = 6$ m/s

So, the speed of the block at 0 m is 6 m/s.

(ii) Speed at 4 m:

Work done by variable force = Area under the force-displacement graph

From 0 m to 1 m:

Area of triangle = 1/2 × base × height
$W1 = 1/2 \times 1 \times 50$
$W1 = 25$ J

From 1 m to 3 m:

Area of a rectangle = length × breadth
$W2 = 2 \times 50$
$W2 = 100$ J

From 3 m to 4 m:

Area of triangle = 1/2 × 1 × 50
W3 = 25 J

Total work done:

W = 25 + 100 + 25
W = 150 J

By work-energy theorem:

Final kinetic energy = Initial kinetic energy + Work done

Final KE = 180 + 150
Final KE = 330 J

Now,

$KE = 1/2\ mv^2$

$330 = 1/2 \times 10 \times v^2$
$330 = 5v^2$
$v^2 = 66$
$v = \sqrt{66}$
$v \approx 8.1$ m/s

So, the speed of the block at 4 m is approximately 8.1 m/s.

The block does not have negative acceleration in any portion where the force is acting in the direction of motion. The force may become zero in some parts, but it does not act opposite to the motion. Hence, there is no negative acceleration.

Question 12.
The gravitational attraction on the surface of the Moon (lunar surface) is about 16 th of that on the surface of the Earth. An astronaut can throw a ball up to a height of 8 m from the surface of the Earth. How far up will the ball thrown with the same upward velocity travel from the surface of the Moon?

Answer:
The gravitational attraction on the Moon is 1/6 of that on Earth.

Height reached on Earth = 8 m

For the same initial velocity:

Maximum height is inversely proportional to acceleration due to gravity.

Since gravity on the Moon is 1/6 of gravity on Earth, the ball will rise 6 times higher on the Moon.

Height on Moon = 6 × height on Earth
Height on Moon = 6 × 8
Height on Moon = 48 m

Therefore, the ball will rise up to 48 m from the surface of the Moon.

Question 13.
A 1000 kg car is moving along a road at a constant speed. Suddenly, the driver notices some obstruction ahead and applies the brakes to come to a complete stop. The graphical representation of motion of the car starting from the instant the driver spots the traffic ahead is shown in Fig. 7.38.
(i) Describe how the car moves between positions A and B.
(ii) Calculate the kinetic energy of the car at A.

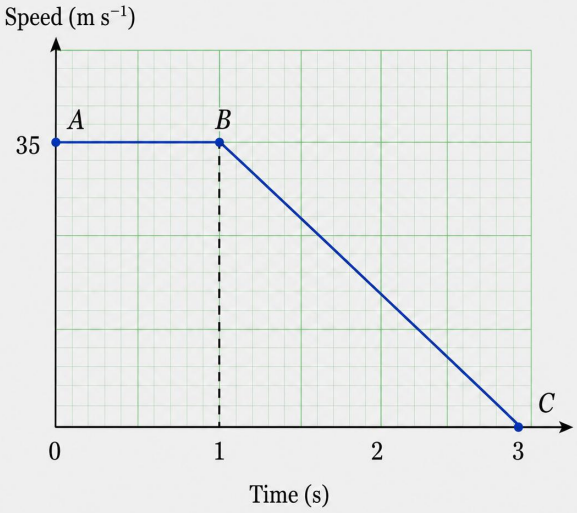


Fig. 7.38

(iii) State the work done by the brakes in bringing the car to a halt between B and C.
(iv) What does the kinetic energy of the car transform into?

Answer:
(i) Between positions A and B, the car moves with constant speed. This means the car is in uniform motion during this part.

(ii) Given:

Mass of car, m = 1000 kg
Speed of car at A, v = 35 m/s

Kinetic energy:

$KE = 1/2\ mv^2$
$KE = 1/2 \times 1000 \times 35^2$
$KE = 500 \times 1225$
$KE = 612{,}500\ J$

So, the kinetic energy of the car at A is 612,500 J or 6.125×10^5 J.

(iii) The brakes bring the car to rest. So, the final kinetic energy becomes zero.

Work done by brakes = Change in kinetic energy
Work done by brakes = Final KE - Initial KE
Work done by brakes = 0 - 612,500
Work done by brakes = -612,500 J

The negative sign shows that the braking force acts opposite to the motion of the car.

(iv) The kinetic energy of the car mainly transforms into heat energy due to friction in the brakes and tyres. A small part may also change into sound energy.

Question 14.
The potential energy-displacement graph of a 0.5 kg ball moving along a frictionless track is shown in Fig. 7.39. At 0, the velocity of the ball is 0 ms-1 and potential energy is 30 J. Calculate the velocity of the ball at P, Q and R.

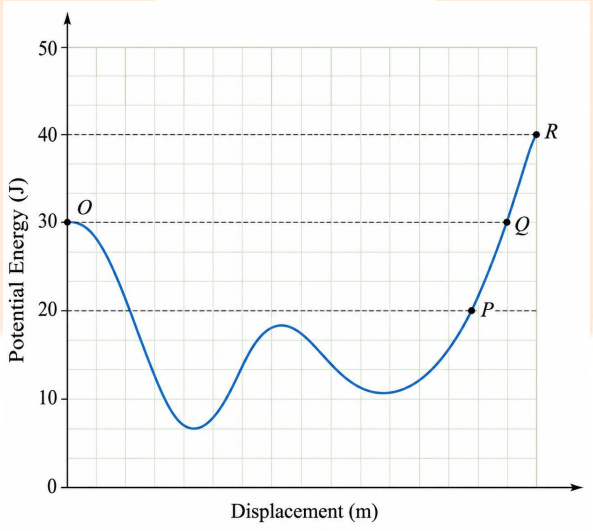


Fig. 7.39

Answer:
Given:

Mass of ball, m = 0.5 kg
At O, velocity = 0 m/s
Potential energy at O = 30 J

At O:

Kinetic energy = 0 J
Total mechanical energy = PE + KE
Total mechanical energy = 30 + 0 = 30 J

Since the track is frictionless, total mechanical energy remains constant at 30 J.

Using the graph:

At P, potential energy = 20 J

Kinetic energy at P = Total energy - Potential energy
KE = 30 - 20
KE = 10 J

Now,

$KE = 1/2\ mv^2$

$10 = 1/2 \times 0.5 \times v^2$
$10 = 0.25v^2$
$v^2 = 40$
$v = \sqrt{40}$
$v \approx 6.32$ m/s

So, velocity at P = 6.32 m/s.

At Q, potential energy = 30 J

Kinetic energy at Q = 30 - 30 = 0 J

So,

Velocity at Q = 0 m/s.

At R, potential energy = 10 J

Kinetic energy at R = 30 - 10
KE = 20 J

Now,

$20 = 1/2 \times 0.5 \times v^2$
$20 = 0.25v^2$
$v^2 = 80$
$v = \sqrt{80}$
$v \approx 8.94$ m/s

So, velocity at R = 8.94 m/s.

Question 15.
A coconut of mass 1.5 kg falls from the top of a coconut tree onto the wet sand on a beach. The height of the tree is 10 m. On impact, the coconut comes to rest by making a depression in the sand.
(i) Calculate the velocity of the coconut just before it hits the sand.
(ii) Assume that the average resistive force of sand is 3000 N and all of the coconut's energy is used to create the depression in the sand. Calculate the depth of the depression the coconut makes in the sand. Assume g =10 ms-2

Answer:
Given:

Mass of coconut, m = 1.5 kg
Height of tree, h = 10 m
Acceleration due to gravity, $g = 10$ m/s²
Resistive force of sand = 3000 N

(i) Velocity just before hitting the sand:

Using conservation of energy:

$mgh = 1/2\ mv^2$

Mass cancels out:

$gh = 1/2\ v^2$

$v^2 = 2gh$

$v = \sqrt{(2gh)}$
$v = \sqrt{(2 \times 10 \times 10)}$
$v = \sqrt{200}$
$v \approx 14.14$ m/s

So, the velocity of the coconut just before it hits the sand is approximately 14.14 m/s.

(ii) Depth of depression:

Potential energy of coconut at the top:

$PE = mgh$
$PE = 1.5 \times 10 \times 10$
$PE = 150$ J

This energy is used to create a depression in the sand.

Work done against resistive force:

Work = Force × depth

$150 = 3000 \times$ depth

Depth = 150 / 3000
Depth = 0.05 m

0.05 m = 5 cm

Therefore, the depth of the depression is 0.05 m or 5 cm.

Think It Over (NCERT Textbook Page No. 116)

Question 1.
What will be the magnitude of velocity of the child at the bottom of the blue slide?

Answer:
The velocity of the child at the bottom of the slide can be found using conservation of mechanical energy.

At the top, the child has gravitational potential energy. At the bottom, this energy changes into kinetic energy.

$mgh = 1/2\ mv^2$

Mass cancels out:

$gh = 1/2\ v^2$

$v = \sqrt{(2gh)}$

Therefore, the magnitude of velocity at the bottom depends on the vertical height of the slide and acceleration due to gravity. If friction is ignored, it does not depend on the mass of the child or the shape of the slide.

Question 2.
Will two children of different masses reach the bottom of the same slide with the same velocity?

Answer:
Yes, if friction is ignored, two children of different masses will reach the bottom of the same slide with the same velocity.

Using the formula:

$v = \sqrt{(2gh)}$

The velocity depends only on height and acceleration due to gravity. Mass does not appear in the final expression because it gets cancelled.

Therefore, both children reach the bottom with the same velocity if they start from the same height.

Question 3.
Which slide will result in the largest magnitude of velocity at the bottom?

Answer:
The slide with the greatest vertical height will result in the largest magnitude of velocity at the bottom.

This is because:

$v = \sqrt{(2gh)}$

Here, velocity increases as height increases. Therefore, the slide that starts from the greatest height gives the maximum velocity at the bottom, if friction is neglected.

Pause and Ponder (NCERT Textbook Page No. 119)

Question 1.
In previous chapter, a weight lifter is shown holding a barbell steady in her hands (Fig.6.8). Is she doing any work on the barbell while holding it steady?

Answer:

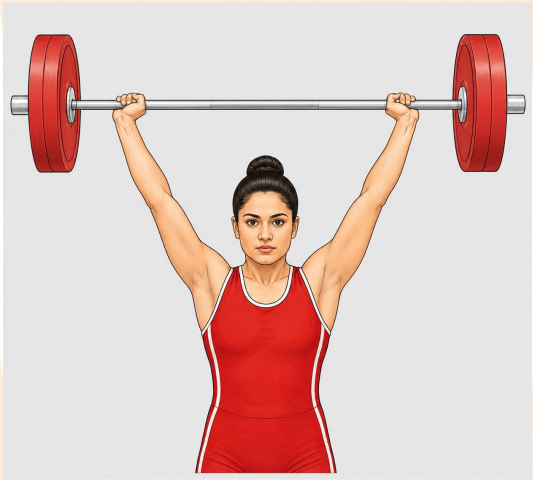


Fig. 6.8: *A weightlifter lifting barbell*

No, the weightlifter is not doing any work on the barbell while holding it steady.

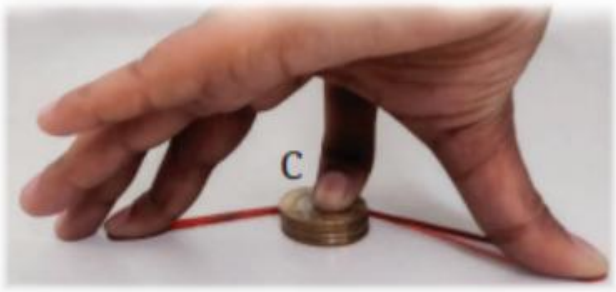
Work is done only when force causes displacement. In this case, the weightlifter applies an upward force, but the barbell does not move.

Displacement = 0

Work done = Force × displacement
Work done = F × 0
Work done = 0 J

So, scientifically, no work is done on the barbell. However, the weightlifter feels tired because her muscles use energy to maintain the force.

Question 2.
Is the work done by friction on the stack of coins that travels on a rough surface (Fig.6. 13e) positive, negative, or zero?



(c)

Answer:
The work done by friction is negative.

Friction acts opposite to the direction of motion of the stack of coins. Since the force of friction and displacement are in opposite directions, the work done by friction is negative.

Negative work reduces the kinetic energy of the object and slows it down.

Pause and Ponder (NCERT Textbook Page No. 121)

Question 3.
When you pedal a bicycle on a flat road, your muscles supply energy. In what forms does this muscular energy appear as you ride?

Answer:
When we pedal a bicycle, muscular energy changes into different forms of energy.

It appears as:

Kinetic energy of the bicycle and rider because both start moving.
Heat energy is due to friction in tyres, chains, bearings, and air resistance.
Sound energy due to the movement of bicycle parts and contact with the road.

Thus, muscular energy is mainly converted into kinetic energy, but some part is lost as heat and sound.

Pause and Ponder (NCERT Textbook Page No. 123)

Question 4.
Two objects A and B of mass m and 4m have the same kinetic energy. What is the ratio of the magnitude of velocities of A and B'

Answer:
Given:

Mass of A = m
Mass of B = 4m
Kinetic energy of A = Kinetic energy of B

Using:

$KE = 1/2\ mv^2$

For A:

$KEA = 1/2\ m\ vA^2$

For B:

$KEB = 1/2 \times 4m \times vB^2$

Since both kinetic energies are equal:

$1/2\ m\ vA^2 = 1/2 \times 4m \times vB^2$

$vA^2 = 4vB^2$

Taking the square root:

$vA = 2vB$

Therefore,

$vA : vB = 2 : 1$

The ratio of the velocities of A and B is 2 : 1.

Question 5.
Does the kinetic energy of an object moving with constant velocity change with its position?

Answer:
No, the kinetic energy of an object moving with constant velocity does not change with its position.

Kinetic energy is given by:

$KE = 1/2\ mv^2$

It depends on mass and velocity. If the mass and velocity remain constant, kinetic energy also remains constant.

Therefore, the kinetic energy does not change merely because the object changes its position.

Pause and Ponder (NCERT Textbook Page No. 126)

Question 6.
Does the potential energy of an object near the surface of the Earth change if it moves with constant velocity in the horizontal direction? What is the object gradually raised in the vertical direction?

Answer:
If an object moves horizontally with constant velocity, its height from the ground does not change. Since gravitational potential energy depends on height, its potential energy remains the same.

$PE = mgh$

Here, h remains constant, so PE does not change.

If the object is gradually raised in the vertical direction, its height increases. Therefore, its gravitational potential energy also increases.

Thus, horizontal motion does not change potential energy, but vertical upward motion increases potential energy.

Pause and Ponder (NCERT Textbook Page No. 129)

Question 7.
For the situation depicted in Fig. 7.19, calculate the mechanical energy of the ball just before it hits the ground and show that even at this position, it is mgh.

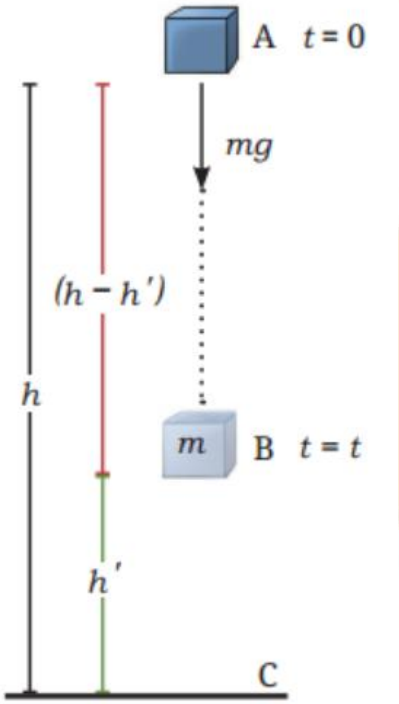


Fig. 7.19 An object falling freely due to gravity

Answer:
At the starting point, the ball is at height h and is at rest.

Initial potential energy = mgh
Initial kinetic energy = 0

Total mechanical energy = mgh

Just before the ball hits the ground:

Height = 0
Potential energy = 0

The potential energy gets converted into kinetic energy.

Using conservation of energy:

Kinetic energy just before hitting the ground = mgh

Therefore,

Mechanical energy = KE + PE
Mechanical energy = mgh + 0
Mechanical energy = mgh

Thus, even just before hitting the ground, the total mechanical energy of the ball is mgh.

Question 8.
You may have seen an exhibit like that in Fig. 7.22 in a science park, where a ball is released from the highest point. Describe how the kinetic energy and potential energy changes at points A, B and C. Why do subsequent points, such as C, D and E, usually have lower heights compared to the previous ones? Could it have anything to do with the energy lost due to friction?

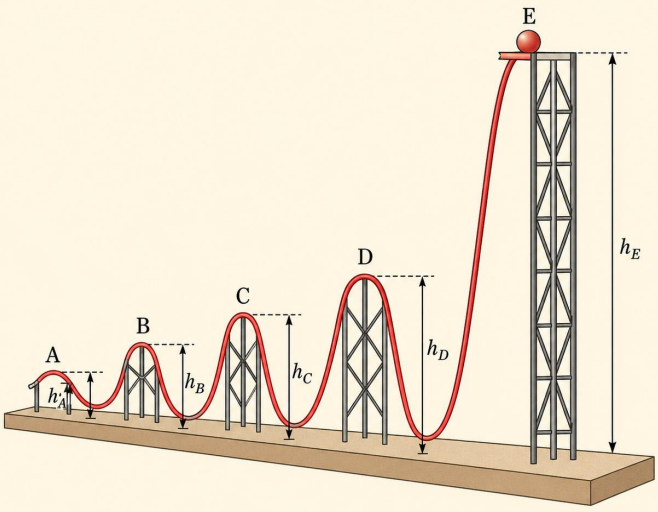


Fig. 7.22: Ball roller coaster in a science park

Answer:
At point A, the ball is at a higher position. So, it has more potential energy and less kinetic energy.

At point B, the ball is at the lowest position. Its potential energy is minimum, and its kinetic energy is maximum because it moves fastest at the bottom.

At point C, the ball again moves upward. Its kinetic energy decreases and changes back into potential energy.

In an ideal frictionless situation, the ball would reach the same height on the other side. But in real life, some mechanical energy is lost due to friction and air resistance. This energy changes into heat and sound.

Therefore, the subsequent points such as C, D, and E usually have lower heights than the previous ones because some energy is lost during motion.

Pause and Ponder (NCERT Textbook Page No. 132)

Question 9.
Explain why roads on hills are built to wind around in gentle slopes rather than going straight up.

Answer:
Roads on hills are built in gentle winding slopes because they act like inclined planes.

An inclined plane allows a vehicle to reach a height using less force, although it has to travel a longer distance. If the road went straight up, the slope would be very steep, and a much larger force would be needed.

In a winding road, the distance increases, but the effort required at any point decreases.

Thus, hill roads are made winding to reduce the force needed to climb the height safely and comfortably.

Question 10.
To reach a higher floor, we find climbing an inclined ladder easier in comparison to climbing a vertical ladder (Fig. 7.30). Explain why.

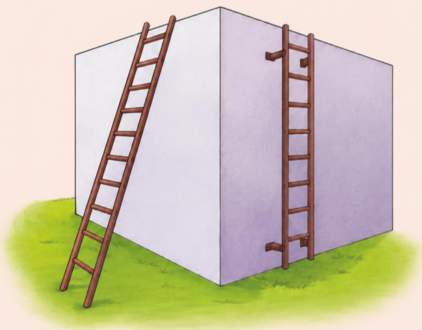


Fig. 7.30: Climbing ladders

Answer:
An inclined ladder works like an inclined plane.

When we climb a vertical ladder, we have to lift our body almost directly against gravity. This requires more effort at each step.

In an inclined ladder, the same height is reached over a longer distance. Since the distance is greater, the force required at each point becomes smaller.

Therefore, climbing an inclined ladder feels easier than climbing a vertical ladder, although the total work done is nearly the same.

Pause and Ponder (NCERT Textbook Page No. 135)

Question 11.
Why is it easier to open the lid of a can by using a spoon as shown in Fig. 7.35?



Fig. 7.35: Opening the lid by using a spoon

Answer:
It is easier to open the lid of a can using a spoon because the spoon acts as a lever.

The edge of the can works as the fulcrum. When force is applied at the longer end of the spoon, a larger force is produced at the shorter end near the lid.

This gives mechanical advantage and helps lift the lid with less effort.

Thus, the spoon makes the work easier by acting as a simple machine.

Question 12.
Why do you push an object closer to scissors (fulcrum) when you want to cut an object which is hard?

Answer:
Scissors work like a pair of levers.

When a hard object is placed closer to the fulcrum, the lever arm becomes shorter. A shorter lever arm increases the mechanical advantage.

This means a larger cutting force is produced at the blades for the same effort applied by the hand.

Therefore, we push a hard object closer to the fulcrum of the scissors to cut it more easily.

Question 13.
Throughout history, many design of perpetual machines (using wheels, weights or magnets) have been proposed, but none actually work. Why do all real machines eventually slow down and stop? Explain in terms of work and energy.

Answer:
All real machines eventually slow down and stop because some energy is always lost during their operation.

When a machine works, it uses energy to do useful work. But in real machines, friction, air resistance, and other resistive forces are always present. These forces convert some mechanical energy into heat and sound.

As a result, the useful mechanical energy of the machine keeps decreasing with time. Once there is not enough usable energy left to continue the motion, the machine slows down and stops.

A perpetual machine would require zero energy loss, but this is impossible in real life. Therefore, perpetual motion machines do not work.

Activity 7.1:
Let Us Investigate (NCERT Textbook Page No. 125)

Aim: To study the relationship between the height from which a ball is dropped and the depth of depression it creates in sand.



Fig. 7.17: Depressions created by a ball in sand dropped from different heights

Observations:

When the ball is dropped from a height of 1 m, it creates a small depression in the sand.

When the ball is dropped from a height of 2 m, the depression becomes deeper.

When the ball is dropped from a still greater height, the depression becomes the deepest.

Conclusion:
The activity shows that the potential energy of the ball increases with height.

Gravitational potential energy is given by:

PE = mgh

When the ball is raised to a greater height, it has more potential energy. On falling, this potential energy changes into kinetic energy. A ball falling from a greater height hits the sand with more energy and creates a deeper depression.

Thus, the greater the height, the greater is the potential energy of the ball.

Activity 7.2:
Let Us Experiment (NCERT Textbook Page No. 127)

Aim: To demonstrate conservation of mechanical energy using a simple pendulum.

Observations:
At point P, the pendulum bob is at an extreme position. Its height is maximum, so its potential energy is maximum. Its speed is zero, so kinetic energy is zero.

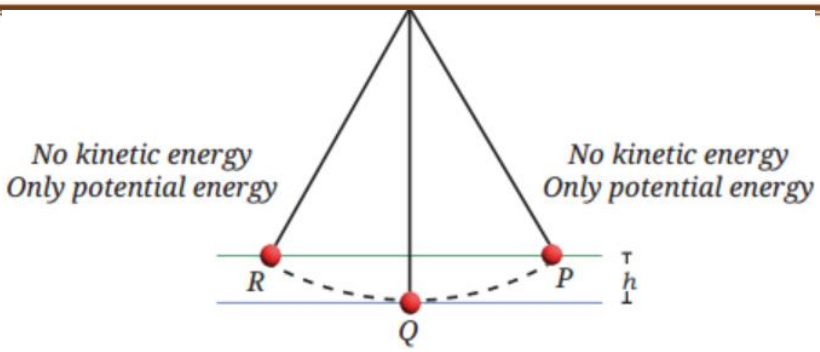


Fig. 7.20: A pendulum

At point Q, the bob is at the lowest position. Its potential energy is minimum, and kinetic energy is maximum because its speed is greatest.

At point R, the bob reaches the other extreme position. Its speed again becomes zero, so kinetic energy becomes zero, and potential energy becomes maximum.

Conclusion:
The activity shows that potential energy and kinetic energy keep changing into each other during the motion of a pendulum.

In an ideal case, the total mechanical energy remains constant:

Mechanical energy = KE + PE

In real life, the pendulum gradually slows down because some energy is lost due to air resistance and friction at the support. This lost energy changes mainly into heat.

Activity 7.3:
Let Us Experiment (NCERT Textbook Page No. 131)

Aim: To determine if an inclined plane reduces the force needed to raise an object.

Observation:
When the cart is pulled up an inclined plank, the spring balance reading is less than the force required to lift it vertically.

When the plank is made less steep, the force required decreases further. However, the distance over which the cart is pulled increases.



(a)



(b)

Fig. 7.27: Measuring the force required to pull up a cart along an inclined plank of (a) smaller length, and (b) larger length

Conclusion:
An inclined plane reduces the effort needed to raise an object to a height.

The same work is done over a longer distance, so the force required becomes smaller. This is why ramps and sloping roads make it easier to move heavy objects upward.

Activity 7.4:
Let Us Investigate (NCERT Textbook Page No. 133)

Aim: To demonstrate how a lever can lift a heavier object with a lighter force.

Observations:
When the heavier stapler is placed close to the fulcrum and the lighter eraser is placed farther away, the eraser can lift the stapler.

This happens because the effort arm is longer than the load arm.

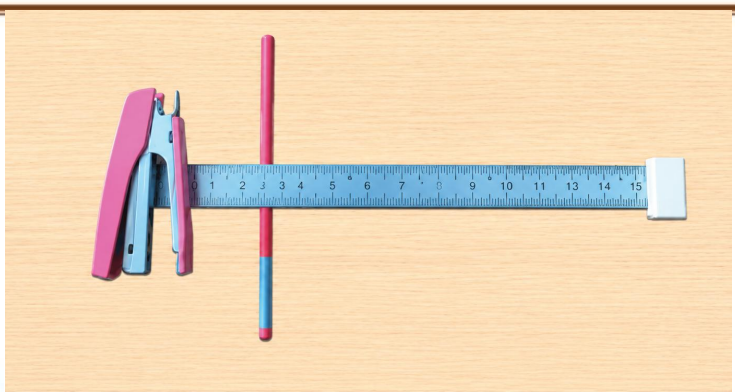


Fig. 7.31: Lifting a heavier object with lighter object

Conclusion:
A lever works on the principle:

Effort × effort arm = Load × load arm

If the effort arm is increased, a smaller effort can lift a larger load.

This is why a lever provides mechanical advantage and helps us lift heavy objects with less force.

Activity 7.5:
Let Us Experiment (NCERT Textbook Page No. 133)

Aim: To verify the law of levers using a beam balance with coins.

Observation:

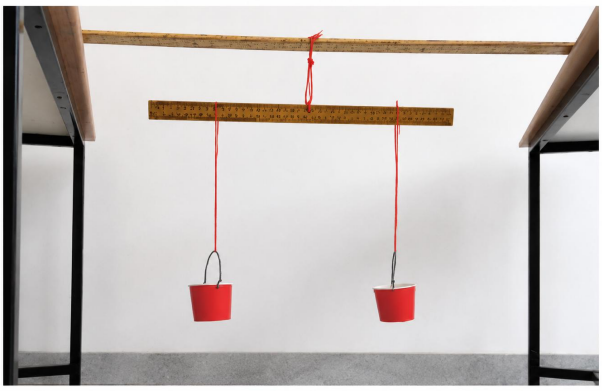


Fig. 7.33: Balancing cups hung on a scale

Table 7.1: Number of Coins in the Left Pan and Its Distance from the Fulcrum

Number of Coins in Left Pan, n_1 (Effort)	Distance of Left Pan from the Fulcrum, L_1 (cm)	Number of Coins in Right Pan, n_2 (Load)	Distance of Right Pan from the Fulcrum, L_2 (cm)
1	_____	1	_____
1	_____	2	_____

When coins are placed at different distances from the fulcrum, the beam balances only when the moments on both sides are equal.

If more coins are placed on one side, they can still be balanced by placing fewer coins farther from the fulcrum on the other side.

Result:

Number of Coins in Left Pan (Effort), n_1	Distance of Left Pan from the Fulcrum, L_1 (cm)	Number of Coins in Right Pan (Load), n_2	Distance of Right Pan from the Fulcrum, L_2 (cm)
1	L_1	1	L_1 (equal)
1	$2L_1$	2	L_1

Conclusion:
The activity verifies the law of levers.

A lever balances when the clockwise moment is equal to the anticlockwise moment.
Increasing the effort arm reduces the effort needed to balance or lift the load.

Mechanical advantage of a lever is:

MA = Load / Effort = Effort arm / Load arm

Thus, a lever helps us do work more easily by increasing the effect of the applied force.