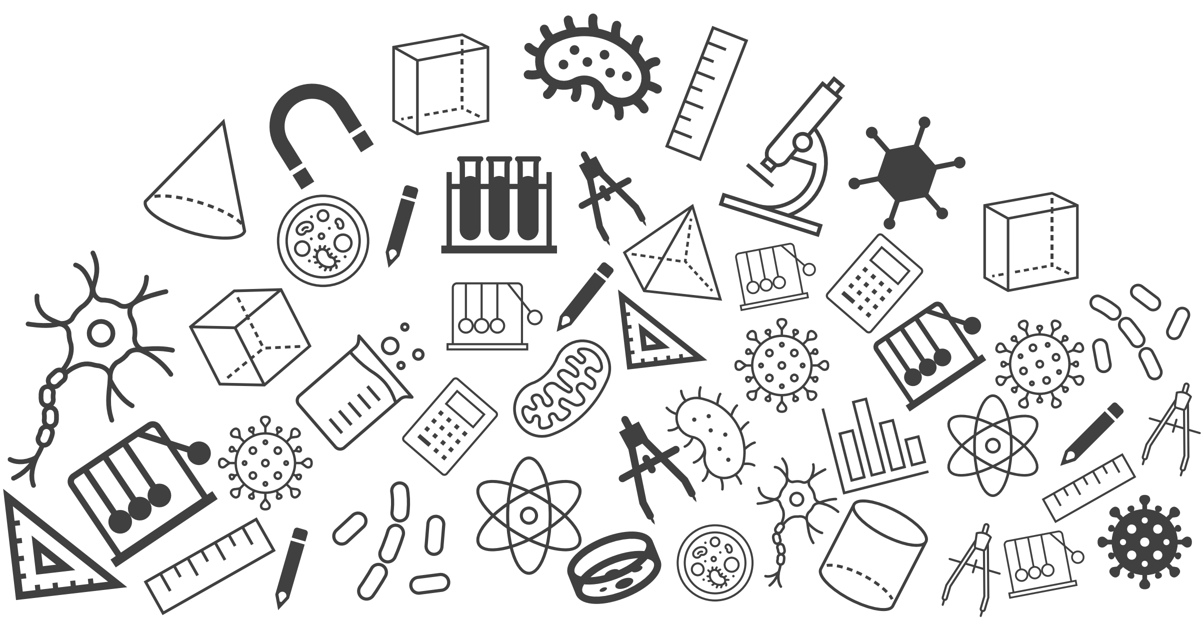
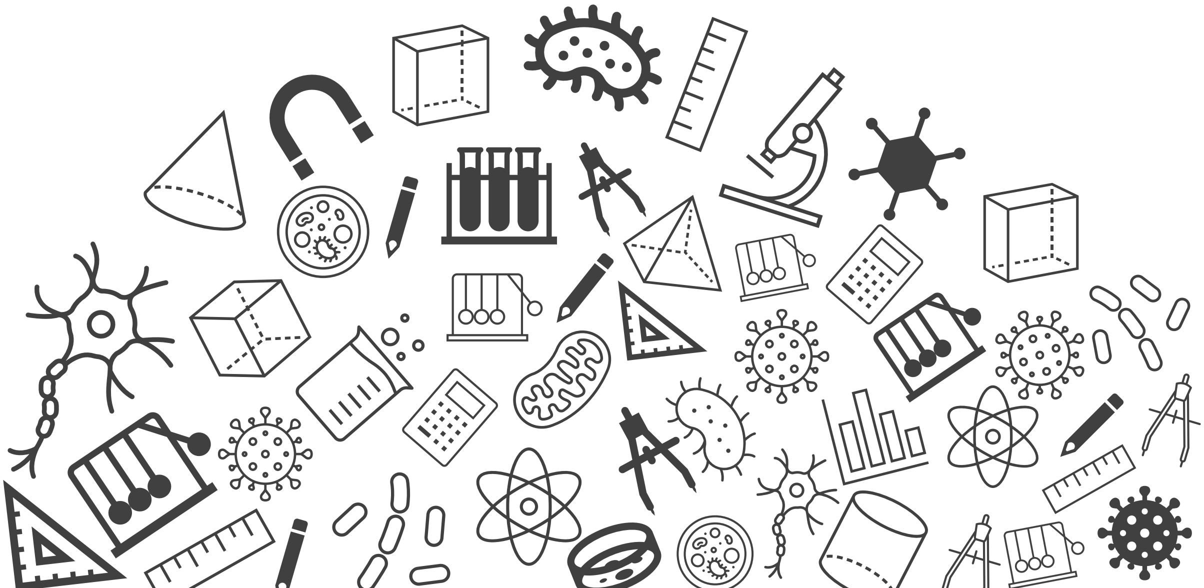
BYJU'S

Grade 09
Science Chapter Notes



Work and Energy



Work and Energy

1. A battery lights a bulb. Describe the energy changes involved in the process.
   [1 Mark]
   [NCERT]
   [Energy Conversion]

   Solution:
   When a bulb is connected to a battery, then the chemical energy of the battery is transferred into electrical energy. When the bulb receives this electrical energy, then it converts it into light and heat energy. Hence, the transformation of energy in the given situation can be shown as: Chemical Energy $\rightarrow$ Electrical Energy $\rightarrow$ Light Energy + Heat Energy. [1 Mark]

2. An object thrown at a certain angle to the ground moves in a curved path and falls back to the ground. The initial and the final points of the path of the object lie on the same horizontal line. What is the work done by the force of gravity on the object?
   [3 Marks]
   [NCERT]
   [Potential Energy]

   Solution:
   The energy stored in a body by virtue of its position or configuration is called potential energy.
   Work done by the force of gravity on an object depends only on vertical displacement.
   Vertical displacement is given by the difference in the initial and final positions / heights of the object, which is zero. [1 Mark]
   Work done by gravity is given by the expression,
   $W = \ mgh$
   Where, $h =$Vertical displacement $= 0$
   $W = mg \times 0 = 0\ J$
   Therefore, the work done by gravity on the given object is zero Joule. [2 Mark]

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Work and Energy

3. Calculate the work required to be done to stop a car of $1500\ kg$ moving at a velocity of $72\ kmph$?
[3 Marks]
[Work energy theorem]

Solution:
Kinetic energy, $E_k = \frac{1}{2}mv^2$
where, mass of car, $m = 1500\ kg$
velocity of car, $v = 72\ kmph = \frac{72\times5}{18}ms^{-1} = \frac{20}{1}ms^{-1}$
[1 Mark]

$\therefore E_k = \frac{1}{2}\times 1500 \times (20)^2 = 30\times10^4\ J$

Hence, $30\times10^4\ J$ of work is required to stop the car.
[2 Marks]

4. Find the energy in kWh consumed in 10 hours by four devices of power 500 W each.
[3 Marks]
[NCERT]
[Power]

Solution:
Energy consumed by an electric device can be obtained with the help of the expression for power,
$P = \frac{W}{T}$[1 Mark]
where,power rating of the device, $P = 500W = 0.50\ kW$
time for which the device runs, $T = 10\ h$
Work done = Energy consumed by the device
Therefore, energy consumed = Power $\times$ Time $= 0.50\times10 = 5\ kWh$ [1 Mark]
Hence, the energy consumed by four equal rating devices in $10\ h$ will be
$4\times5\ kWh = 20\ kWh$. [1 Mark]

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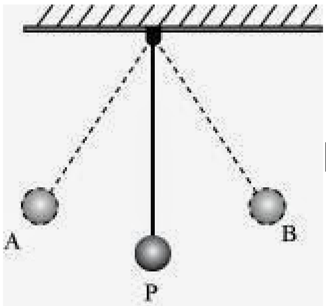
5. Illustrate the law of conservation of energy by discussing the energy changes which occur when we draw a pendulum bob to one side and allow it to oscillate. Why do the bob eventually come to rest? What happens to its energy eventually? Is it a violation of the law of conservation of energy?
[5 Marks]
[NCERT]
[Law of Conservation of Energy]

Solution:
The law of conservation of energy states that energy can be neither created nor destroyed. It can only be converted from one form to another. [1 Mark]
Consider the case of an oscillating pendulum.



[1 Mark]

When a pendulum moves from its mean position P to either of its extreme positions A or B, it rises through a height h above the mean level P. At this point, the kinetic energy of the bob changes completely into potential energy. The kinetic energy becomes zero, and the bob possesses only potential energy. As it moves towards point P, its potential energy decreases progressively. Accordingly, the kinetic energy increases. As the bob reaches point P, its potential energy becomes zero and the bob possesses only kinetic energy. This process is repeated as long as the pendulum oscillates.
[1.5 Mark]
The bob does not oscillate forever. It comes to rest because air resistance resists its motion. The pendulum loses its kinetic energy to overcome this friction and stops after some time.
The law of conservation of energy is not violated because the energy lost by the pendulum to overcome friction is gained by its surroundings. Hence, the total energy of the pendulum and the surrounding system remain conserved. [1.5 Mark]

6. Water stored in a dam possesses________.
[1 mark]
[Potential Energy]

Solution:
potential energy [1 mark]

Water stored in a dam possesses potential energy. When we release water from the dam, the water fall from the height. When it falls, the potential energy of the water gets converted into kinetic energy and this kinetic energy is used to run the turbines to produce electricity.

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7. A body moves in a vertical semicircle of radius r from the lowest point to highest point. What is the amount of work done? (Assume mass of the body to be 'm' kg and acceleration due to gravity to be $g\,ms^{-2}$)
[1 Mark]
[Work done]

Solution:
As the body moves in a vertical semicircle from its lowest to the highest point, net displacement is equal to 2r. The only force acting is gravity in vertical direction i.e., the direction of displacement. So total work done = force due to gravity $\times$ net displacement = mg $\times$ 2r = 2mgr.
[1 Mark]

8. Can any object have momentum even if its mechanical energy is zero? Explain.
[1 mark]
[Mechanical Energy]

Solution:
When the mechanical energy is zero, there is no potential energy and no kinetic energy. The kinetic energy being zero implies the velocity is zero. Hence, there will be no momentum. Therefore an object cannot have momentum if its mechanical energy is zero. [1 mark]

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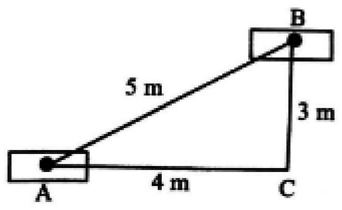
9. A box of mass 2 kg is lifted diagonally from point A to point B as shown in the given figure. Given that the acceleration due to gravity is 10 ms^{-2}, what is the gravitational potential energy gained by the box?
[2 Marks]



Solution:
Given, mass of the box, $m = 2\ kg$, vertical height, $h = 3\ m$ and acceleration due to gravity, $g = 10\ ms^{-2}$.
We know that, gravitational potential energy = $mgh = 2 \times 10 \times 3\ =\ 60\ Joule$
[1 Mark]
The gravitational potential energy gained by the object does not depend on its path. Instead, it depends only on its initial and final position.
[1 Mark]

10. What are conservative forces?
[2 marks]
[Conservative force]

Solution:
A conservative force is a force whose work done is independent of the path taken and depends only on the initial and final position.
[1 Mark]

Many forces of nature are conservative, like Gravitational Force, Electrostatic Force, Magnetic Force, Elastic Force (Spring's Force).
[1 Mark]

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Work and Energy

11. Breifly explain potential energy and kinetic energy.
[3 marks]

Solution:
Energy is the ability to do work. Objects can have stored, or potential, energy when work has been done (such as raising an object in the air) or by virtue of their position (such as sitting at the top of a hill). Potential energy changes to kinetic energy when the object moves. Examples include holding a stretched spring (potential energy) and then releasing it (kinetic energy) or holding a box above the ground (potential energy) and then dropping it (kinetic energy). [1 Mark]

Kinetic energy is a form of energy that results from an object's motion. There are many types of motion that use kinetic energy: translation (moving from one place to another), rotation, and vibration. The measurement of kinetic energy in an object is calculated based on the object's mass and velocity. It is measured in Joules. [1 Mark]

Potential energy is a form of energy that results from an object's position or arrangement of parts. It is stored energy that can become kinetic energy. It includes potential electrical, chemical, and nuclear energy. The measurement of potential energy in an object is calculated based on the object's mass and its height or distance. It is measured in Joules.
[1 Mark]

12. Define watt. Express kilowatt in terms of joule per second. A 150 kg car engine develops 500 W for each kg. What force does it exert in moving the car at a speed of $20\ ms^{-1}$?
[3 Marks]
[Physical Science - AP SCERT]
[Meaning of Power]

Solution:
One watt is the power of an agent which does work at the rate of $1\ Js^{-1}$
Total Power $= 150 \times 500 = 7.5 \times 10^4 W$ [1 Mark]
$Power = Force \times velocity$ [1 Mark]
$Force = \frac{Power}{velocity} = \frac{7.5 \times 10^4}{20} = 3.75 \times 10^3\ N$
$Force = 3750\ N$ [1 Mark]

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Work and Energy

13. A truck of mass 5000 kg is moving with a velocity of 20 ms^{-1}. To avoid an accident, the driver applies brakes to stop the truck in 5 seconds. Calculate the force applied by the brakes in order to stop the truck in the given time using work-energy theorem.
[3 Marks]
[Work-Energy Theorem]

Solution

<u>Given</u> : Mass of truck = 5000 kg, Initial velocity = 20 ms^{-1}, Final velocity = 0 ms^{-1}, Time to stop the truck = 5 seconds.

Using the work energy theorem,
$1/2\ mv^2 - 1/2\ mu^2 = F \times s$ ......(1)

To calculate 's', we'll have to use the equations of motion.
Using 1st equation of motion,
$v = u + at$
=> $0 = 20 + a \times 5$
=> $a = -4\ ms^{-2}$
[1 Mark]

Now, using 3rd equation of motion,
$v^2 - u^2 = 2as$
=> $0 - (5)^2 = 2 \times (-4) \times s$
=> $s = 25/8$ m
[1 Mark]

Now, substituting the value of 's' in equation (1),
=> $1/2 \times 5000 \times (0)^2 - 1/2 \times 5000 \times (5)^2 = F \times 25/8$
=> $- 1/2 \times 5000 \times 25 = F \times 25/8$
=> $F = - 20{,}000$ J
[1 Mark]

Negative sign implies force and the displacement are in opposite directions.

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14. Sam throws a stone of mass 0.5 kg in the upward direction from the ground with a velocity of 10 ms^{-1}. Calculate the kinetic energy and mechanical energy of the stone when it reaches (4/5)th of its maximum height.
Take g = 10 ms^{-2}.
[5 marks]

Solution:
Given : Mass of stone = 0.5 kg, initial velocity of stone = 10 ms^{-1}, g = 10 ms^{-2}

To calculate maximum height of the stone,
Use 3rd equation of motion,
$v^2 - u^2 = 2gh$ ....(Taking upward direction as positive)
$0 - (10)^2 = 2 \times (-10) \times h$
=> h = 5 m
[2 marks]

Now, Mechanical Energy at h = 5 m will be equal to the potential energy at h = 5 m (Since KE will become 0)
Thus, Mechanical Energy at top = Potential Energy at top = mgh = 0.5 x 10 x 5 = 25 J
[1.5 marks]
Mechanical Energy at h = (4/5)th of max height will also be 25 J (Since mechanical energy remains conserved)

Now, KE at height (4/5)th of max height = ME - PE = 25 - {0.5 x 10 x (4/5) x 5} = 25 - 20 = 5 J
[1.5 marks]

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15. Compare the power at which each of the following is moving upwards against the force of gravity?
    (i) A butterfly of mass 1.0 g that flies upward at a rate of $0.5\ ms^{-1}$
    (ii) A 250 g squirrel climbing up on a tree at a rate of $0.5\ ms^{-1}$
    [5 Marks]

Solution:
We know, $power = \frac{work\ done}{time}$ [1 Mark]
Let m be the mass of the object, g be the acceleration due to gravity, h be the height (distance) and t be the time taken.
Therefore, power $p = \frac{mgh}{t}$
We know, velocity, $v = \frac{distance}{time} = \frac{h}{t}$
$\Rightarrow$ power, $p = mgv$ [1 Mark]
Acceleration due to gravity, $g = 10\ ms^{-2}$
(i) Given mass, $m = 1\ g = \frac{1}{1000} = 0.001\ kg$ and velocity, $v = 0.5\ ms^{-1}$
Power, $p = 0.001 \times 10 \times 0.5 = 0.005 = 5 \times 10^{-3}\ W$
[1.5 Marks]

(ii) Given, mass, $m = 250\ g = \frac{250}{1000} = 0.25\ kg$ and velocity, $v = 0.5\ ms^{-1}$
Power, $p = 0.25 \times 10 \times 0.5 = 1.25\ W$
[1.5 Marks]
Hence, the power with which the squirrel is climbing is much higher than that of a butterfly flying

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