

Chapter

7

Energy and Power

- What is the definition of work, energy and power?
- What is meant by gravitational potential energy, elastic potential energy and kinetic energy?
- What is the Principle of Conservation of Energy?



Let's study

- ▶ Work, energy and power
- ▶ Potential energy and kinetic energy
- ▶ Principle of Conservation of Energy

Science Gallery



Activities such as climbing stairs can:

- maintain the health of body organs such as the heart and lungs
- ensure a more efficient blood circulation process in the body
- reduce the risk of heart attack, diabetes, high blood pressure and colon cancer
- increase the body's immunity
- produce healthy bones and reduce the risk of osteoporosis
- strengthen muscles
- facilitate the burning of body fat and thus maintain body weight



Hospital staff and visitors of Shah Alam Hospital, Selangor, are encouraged to use the stairs. Would you climb the stairs or use the lift? Why?

Other than the number of steps, state another factor that determines the total amount of work done in climbing the stairs. What is the effect of climbing stairs within a short time on our health?

Keywords

- ◆ Work
- ◆ Energy
- ◆ Power
- ◆ Gravitational potential energy
- ◆ Elastic potential energy
- ◆ Kinetic energy
- ◆ Displacement
- ◆ Average force
- ◆ Principle of Conservation of Energy
- ◆ Oscillation of a simple pendulum
- ◆ Oscillation of a loaded spring
- ◆ Closed system

7.1

Work, Energy and Power

Work

What is the meaning of work? Compare and contrast your meaning of work with the definition of work in science as follows:

Work, W , is defined as the product of **force, F** , and **displacement, s** , in the direction of the force, that is $W = Fs$.

The S.I. unit for work is **joule (J)**.

1 joule (J) of work is done when a **force of 1 newton (N)** is used to move an object over a distance of **1 metre (m)** in the **direction of the force**, that is $1 \text{ J} = 1 \text{ Nm}$.

Moment of force and **energy** are two physical quantities other than work which are measured in units of newton metre (Nm). Larger units such as kilojoule (kJ) and megajoule (MJ) are also used in the measurement of work.

 **SCIENCE INFO**

Displacement is the distance travelled in a specified direction.

 **BRAIN TEASER**

Complete the following:

- (a) $1 \text{ kJ} = \underline{\hspace{2cm}} \text{ J}$
 (b) $1 \text{ MJ} = \underline{\hspace{2cm}} \text{ J}$

Examples of Calculation of Work in Daily Activities

Study Figure 7.1 and Photograph 7.1. The figure and photograph show several activities in daily life.



Figure 7.1 Daily activity related to work

Activity B

Pushing a trolley over a distance of 5 m with a force of 10 N.



Activity C

Pulling a drawer over a distance of 30 cm with a force of 2 N.

Photograph 7.1 Daily activities related to work

The work done in Activities A, B and C are shown in Table 7.1.

Table 7.1 Work done in Activities A, B and C

Daily activity	Force (N)	Direction of force	Displacement in the direction of the force (m)	Work done
A	20	Vertical	1	$W = Fs$ $= 20 \text{ N} \times 1 \text{ m}$ $= 20 \text{ J}$
B	10	Horizontal	5	$W = Fs$ $= 10 \text{ N} \times 5 \text{ m}$ $= 50 \text{ J}$
C	2	Horizontal	0.3	$W = Fs$ $= 2 \text{ N} \times 0.3 \text{ m}$ $= 0.6 \text{ J}$

Calculating Work Done

Example 1

Figure 7.2 shows a student weighing 400 N carrying a load of 100 N while climbing a flight of stairs of a vertical height of 3 m. Calculate the work done.

Solution

$$\begin{aligned}
 W &= Fs \\
 &= (400 + 100) \text{ N} \times 3 \text{ m} \\
 &= 500 \text{ N} \times 3 \text{ m} \\
 &= 1\,500 \text{ J}
 \end{aligned}$$

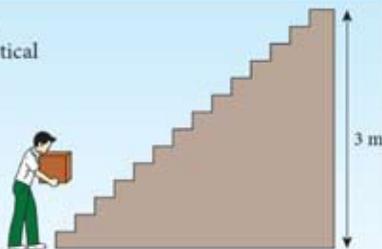


Figure 7.2

Example 2

Figure 7.3 shows Ali lifting a box of mass 10 kg from the floor to the top of a cupboard. How much work is done by Ali?

(Assume gravitational force acting on an object of mass 1 kg = 10 N)

Solution

$$\begin{aligned}\text{Weight of box} &= 10 \times 10 \text{ N} \\ &= 100 \text{ N} \\ W &= Fs \\ &= 100 \text{ N} \times 2 \text{ m} \\ &= 200 \text{ J}\end{aligned}$$



Figure 7.3

Example 3

A labourer pulled a bucket of cement weighing 300 N from the ground to the first floor of a building using a pulley system. The first floor is 10 m from the ground. What is the work done by the labourer?

Solution

$$\begin{aligned}W &= Fs \\ &= 300 \text{ N} \times 10 \text{ m} \\ &= 3\,000 \text{ J}\end{aligned}$$

BRAIN TEASER

Is work done in the situation shown in the photograph?



Energy and Power

Energy is defined as the ability to do work. The S.I. unit for energy is **joule (J)**. When a force of 1 N is used to move an object over a distance of 1 m in the direction of the force, 1 J of energy is used.



Study Figure 7.4. If Kamal and Ah Kit climbed the steps starting from the ground floor simultaneously, who has a higher power? Why?

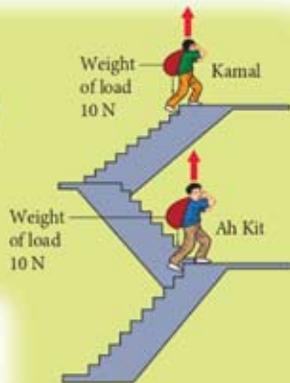


Figure 7.4

Power, P , is defined as the rate of doing work, W , that is:

$$\text{Power, } P = \frac{\text{Work done, } W}{\text{Time taken, } t}$$

The S.I. unit for power is **watt (W)**. When 1 **joule (J)** of work is done in 1 **second (s)**, power of 1 **watt (W)** is used, that is $1 \text{ W} = 1 \text{ J s}^{-1}$.

Examples of Calculation of Power in Daily Activities

Figure 7.5 shows several activities in daily life.

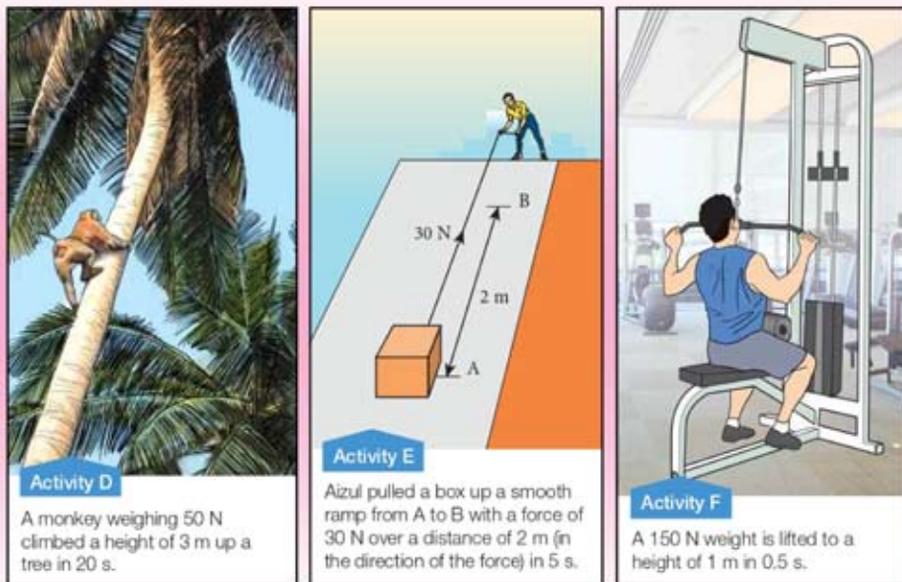


Figure 7.5 Daily activities related to power

Work done and power needed in activities D, E and F are shown in Table 7.2.

Table 7.2 Work done and power needed in Activities D, E and F

Daily activity	D	E	F
Force (N)	50	30	150
Displacement in the direction of force (m)	3	2	1
Work done	$W = Fs$ $= 50 \text{ N} \times 3 \text{ m}$ $= 150 \text{ J}$	$W = Fs$ $= 30 \text{ N} \times 2 \text{ m}$ $= 60 \text{ J}$	$W = Fs$ $= 150 \text{ N} \times 1 \text{ m}$ $= 150 \text{ J}$
Time taken (s)	20	5	0.5
Power needed	$P = \frac{W}{t}$ $= \frac{150 \text{ J}}{20 \text{ s}}$ $= 7.5 \text{ W}$	$P = \frac{W}{t}$ $= \frac{60 \text{ J}}{5 \text{ s}}$ $= 12 \text{ W}$	$P = \frac{W}{t}$ $= \frac{150 \text{ J}}{0.5 \text{ s}}$ $= 300 \text{ W}$

Activity 7.1

Inquiry-based activity

Aim: To calculate work and power needed

Materials

100 g weight, thread and wooden block

Apparatus

Spring balance, metre rule and stopwatch

Instructions

1. Set up the apparatus as shown in Figure 7.6.

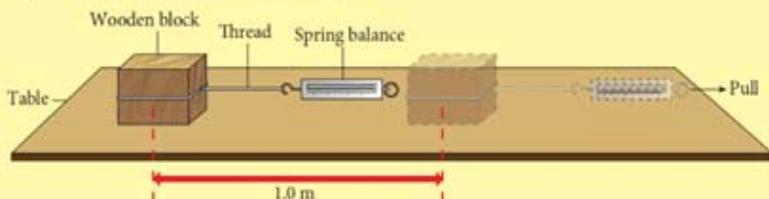


Figure 7.6

2. Pull the spring balance until the wooden block starts to move and record the force shown on the spring balance.
3. Pull the wooden block over a distance of 1.0 m with the force as shown in Figure 7.6. Ask your friend to measure the time taken to move the wooden block by using a stopwatch.
4. Record the time taken. Calculate and record the work done and power needed in a table.
5. Set up the apparatus as shown in Figure 7.7.
6. Lift the 100 g weight to a vertical height of 0.5 m from the floor by using the spring balance.
7. Record the force shown on the spring balance.
8. Ask your friend to measure the time taken to move the weight by using the stopwatch.
9. Record the time taken. Calculate and record the work done and power needed in a table.

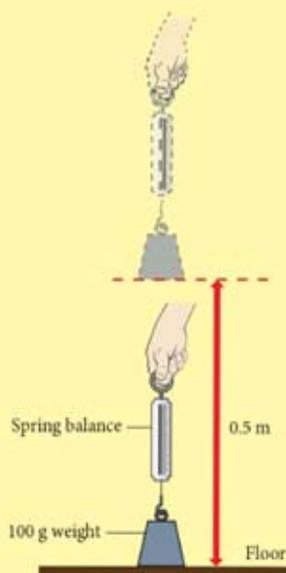


Figure 7.7

Activity	Force (N)	Distance (m)	Work (J)	Time (s)	Power (W)
Pulling a wooden block over a distance of 1.0 m horizontally					
Lifting a 100 g weight to a height of 0.5 m vertically					

Questions

- State the type of force to overcome when:
 - pulling a wooden block on the surface of the table
 - lifting a 100 g weight vertically from the floor
- Which activity involves more work?
- State **three** factors that affect power.
- Which activity is carried out with higher power?
- Give **one** example of an activity or object in daily life that involves high power.
 - Give **one** example of an activity or object in daily life that involves low power.



Today in history

A unit usually used for power in the olden days is horsepower (hp).

Formative Practice 7.1

- State the definition of work.
 - What is the S.I. unit for work?
- What is the meaning of energy?
- State the definition of power.
 - What is the S.I. unit for power?
- Figure 1 shows an electromagnetic crane lifting a load weighing 2 500 N to a height of 4 m.
 - Calculate the work done.
 - How much energy is used by the crane to lift the load?
 - If the time taken by the crane to lift the load is 1.2 minutes, calculate the power of the crane. 🍕



Figure 1

7.2

Potential Energy and Kinetic Energy

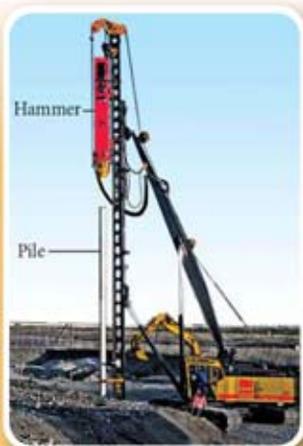
Gravitational Potential Energy

In a piledriver shown in Photograph 7.2, a hammer is pulled upwards and then released to fall and hit a pile. The force produced by the hammer in a vertical direction drives the pile into the ground.



VIDEO

Watch this video to see piling operations



(a) Hammer before being dropped



(b) Hammer after being dropped

Photograph 7.2 Gravitational potential energy is used in a piledriver

A hammer lifted to a height, h from the Earth's surface possesses gravitational potential energy. **Gravitational potential energy** is the work done to lift an object to a height, h , from the Earth's surface.

Gravitational potential energy = mgh

- m is the object mass in kg
- g is the gravitational acceleration in m s^{-2}
- h is the height in m

Why is work done?

What type of force is produced by the hammer?

Where does the energy to do the work come from?



i SCIENCE INFO

Weight = mass, $m \times$ gravitational acceleration, g where g is estimated at 10 m s^{-2} (or 10 N kg^{-1})

7.2.1

Relationship between Work and Gravitational Potential Energy

Figure 7.8 shows an object of mass, m , being lifted vertically to a height, h , from Earth's surface.

$$\begin{aligned}\text{Work done} &= \text{Force} \times \text{displacement in direction of force} \\ &= \text{Weight} \times \text{height lifted} \\ &= (m \times g) \times h \\ &= mgh\end{aligned}$$

Since there is no other form of energy produced, all work done on the object will be converted to gravitational potential energy.

$$\begin{aligned}\text{Gravitational potential energy} &= \text{work done} \\ &= mgh\end{aligned}$$

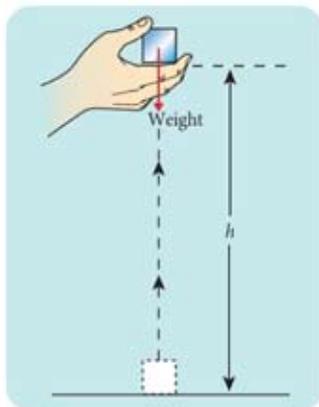


Figure 7.8

Example of numerical problem

Photograph 7.3 shows a lift at KLCC mall. The lift can carry a load of mass 1 500 kg to a height of 30 m.

- How much work is done by this lift?
- What is the gravitational potential energy of this lift at a height of 30 m?
- What is the relationship between work done by the lift and gravitational potential energy of the lift?
- What is the power of the lift in kW if the time taken to lift a load of mass 1 500 kg to a height of 30 m is 0.5 minutes?

Solution

- $$\begin{aligned}W &= Fs \\ &= mgh \\ &= 1\,500 \text{ kg} \times 10 \text{ m s}^{-2} \times 30 \text{ m} \\ &= 450\,000 \text{ J}\end{aligned}$$
- $$\begin{aligned}\text{Gravitational potential energy} &= mgh \\ &= 1\,500 \text{ kg} \times 10 \text{ m s}^{-2} \times 30 \text{ m} \\ &= 450\,000 \text{ J}\end{aligned}$$
- Work done by the lift = Gravitational potential energy of the lift
- $$\begin{aligned}\text{Power, } P &= \frac{W}{t} \\ &= \frac{450\,000 \text{ J}}{0.5 \text{ minutes}} \\ &= \frac{450\,000 \text{ J}}{30 \text{ s}} \\ &= 15\,000 \text{ W} \\ &= 15 \text{ kW}\end{aligned}$$



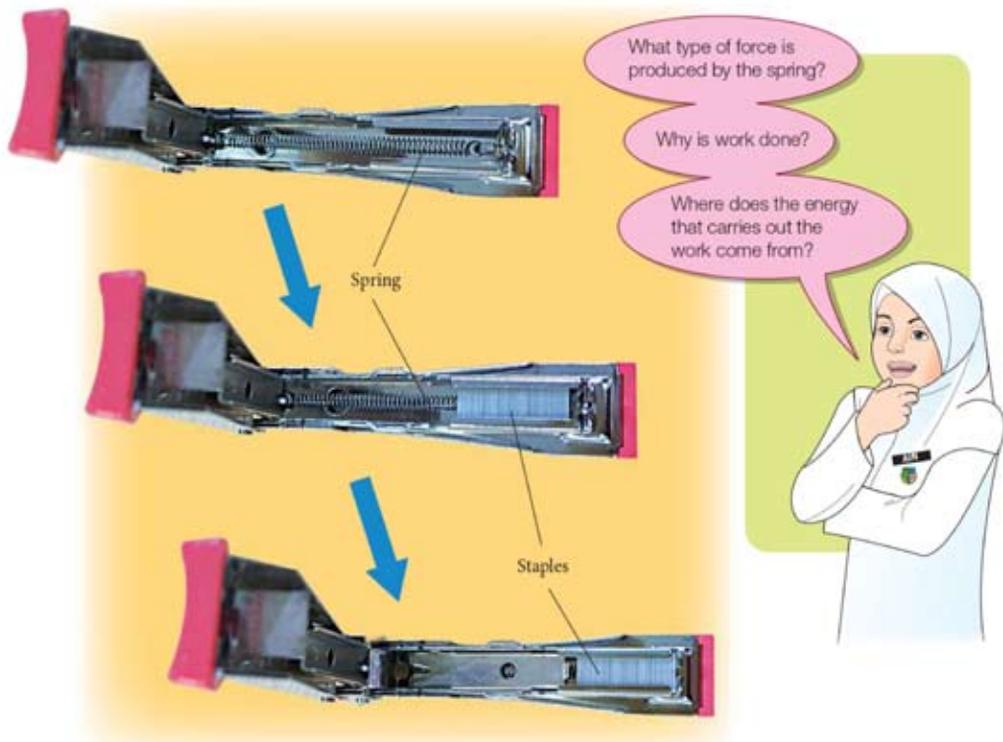
Additional Examples
<http://bt.sasbadi.com/sc3217>



Photograph 7.3

Elastic Potential Energy

Photograph 7.4 shows the steps to refill a stapler with staples. There is a spring that is stretched and then released. The force produced by the stretched spring moves the staples in the direction of the force.



Photograph 7.4 Elastic potential energy used in a stapler

A spring that is compressed or stretched possesses elastic potential energy. **Elastic potential energy** is the work done to compress or stretch an elastic material over a displacement of x from the position of equilibrium.

$$\text{Elastic potential energy} = \frac{1}{2} Fx$$

- F is the stretching or compression force in N
- x is the displacement from the equilibrium position in m

Relationship between Work and Elastic Potential Energy

Assume a spring is stretched x m with a force of F N (Figure 7.9(a)). So, the value of force acting on the spring changes from 0 N to F N as shown in the graph (Figure 7.9(b)). For situations involving springs, work done is equivalent to the area under the F - x graph.

$$\begin{aligned} \text{Elastic potential energy} &= \text{work done} \\ &= \text{area under the graph} \\ &= \frac{1}{2} Fx \end{aligned}$$

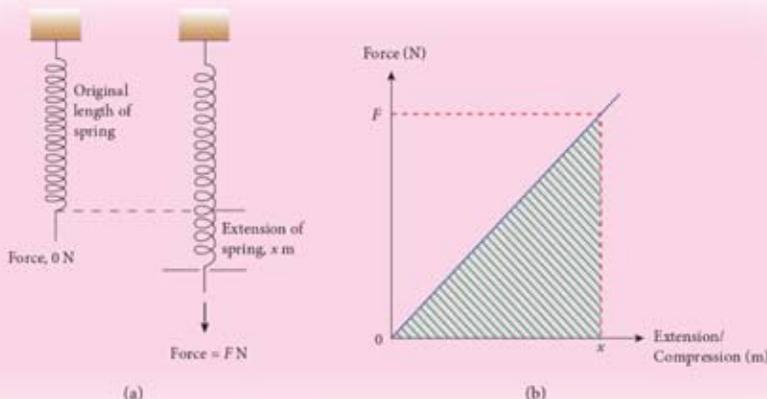


Figure 7.9 Relationship between work and elastic potential energy

Example of numerical problem

The original length of spring S is 20 cm. When the final force exerted on spring S is 20 N, its new length becomes 12 cm. Calculate the elastic potential energy possessed by the compressed spring S.

Solution

$$\begin{aligned} \text{Distance of compression, } x &= \text{original length} - \text{new length} \\ &= 20 \text{ cm} - 12 \text{ cm} \\ &= 8 \text{ cm} \\ &= 0.08 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Elastic potential energy} &= \frac{1}{2} Fx \\ &= \frac{1}{2} \times 20 \text{ N} \times 0.08 \text{ m} \\ &= 0.8 \text{ J} \end{aligned}$$

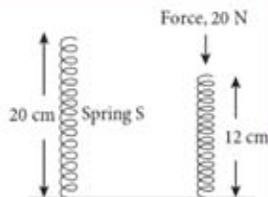


Figure 7.10



Additional Examples
<http://bt.sasbadi.com/sc3219>

Kinetic Energy

Kinetic energy is the energy possessed by a moving object.

$$\text{Kinetic energy} = \frac{1}{2} mv^2$$

- m is mass in kg
- v is velocity in m s^{-1}

Example of numerical problem

Example 1

When a train of mass 500 000 kilogram moves with a velocity of 360 km h^{-1} , how much kinetic energy is possessed by the train?

Solution

$$\begin{aligned}\text{Velocity of train} &= 360 \text{ km h}^{-1} \\ &= \frac{360 \text{ km}}{1 \text{ h}} \\ &= \frac{360\,000 \text{ m}}{3\,600 \text{ s}} \\ &= 100 \text{ m s}^{-1}\end{aligned}$$

$$\begin{aligned}\text{Kinetic energy} &= \frac{1}{2} mv^2 \\ \text{of train} &= \frac{1}{2} \times 500\,000 \text{ kg} \times (100 \text{ m s}^{-1})^2 \\ &= 2\,500\,000\,000 \text{ J}\end{aligned}$$

Example 2

A ball bearing of mass 0.2 kg possesses kinetic energy of 3.6 J. What is the velocity, v of the ball bearing?

Solution

$$\begin{aligned}\text{Kinetic energy} &= \frac{1}{2} mv^2 \\ 3.6 \text{ J} &= \frac{1}{2} \times 0.2 \text{ kg} \times v^2 \\ \therefore v^2 &= \frac{3.6 \text{ J}}{0.1 \text{ kg}} \\ &= 36 \text{ m}^2 \text{ s}^{-2} \\ v &= \sqrt{36 \text{ m}^2 \text{ s}^{-2}} \\ &= 6 \text{ m s}^{-1}\end{aligned}$$

Example 3

Calculate the kinetic energy of an electron of mass $9 \times 10^{-31} \text{ kg}$ and velocity $4 \times 10^6 \text{ m s}^{-1}$.

Solution

$$\begin{aligned}\text{Kinetic energy of electron} &= \frac{1}{2} mv^2 \\ &= \frac{1}{2} \times (9 \times 10^{-31} \text{ kg}) \times (4 \times 10^6 \text{ m s}^{-1})^2 \\ &= 7.2 \times 10^{-18} \text{ J}\end{aligned}$$

Let us carry out Activity 7.2 to discuss the meaning and examples of gravitational potential energy, elastic potential energy and kinetic energy in daily life.

Activity 7.2

To discuss the meaning and examples of gravitational potential energy, elastic potential energy and kinetic energy in daily life

21st Century Skills

- ICS, ISS
- Discussion activity

Instructions

1. Work in groups.
2. Each group needs to search for information on the meaning and examples of gravitational potential energy, elastic potential energy and kinetic energy in daily life.
3. Present the information in a mind map.

Formative Practice 7.2

1. (a) What is the relationship between gravitational potential energy and work?
(b) What is the relationship between elastic potential energy and work?
2. Liza lifts a chair weighing 40 N to a height of 50 cm.
 - (a) How much work is done by Liza to lift the chair?
 - (b) What is the form of energy possessed by the chair?
 - (c) How much energy is possessed by the chair?
3. Force, F , is exerted on a plank to compress a spring towards the wall as shown in Figure 1. Given that the original length of the spring is 50 cm, final length is 30 cm and final force exerted on the spring is 20 N. How much elastic potential energy is possessed by the compressed spring?
4. (a) Why are heavy vehicles shown in Figure 2 usually of low velocity but possess high kinetic energy?
(b) State **one** example of a daily object that possesses high kinetic energy in the following conditions:
 - (i) Object of small mass but high velocity
 - (ii) Object of large mass and high velocity

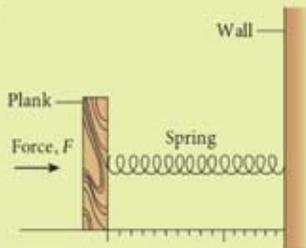


Figure 1



Figure 2

7.3

Principle of Conservation of Energy



Photograph 7.5 Roller coaster

The roller coaster shown in Photograph 7.5 involves transformation in the forms of energy. State the transformation in the forms of energy.

Principle of Conservation of Energy

The **Principle of Conservation of Energy** states that energy cannot be created or destroyed but can only be converted from one form to another.

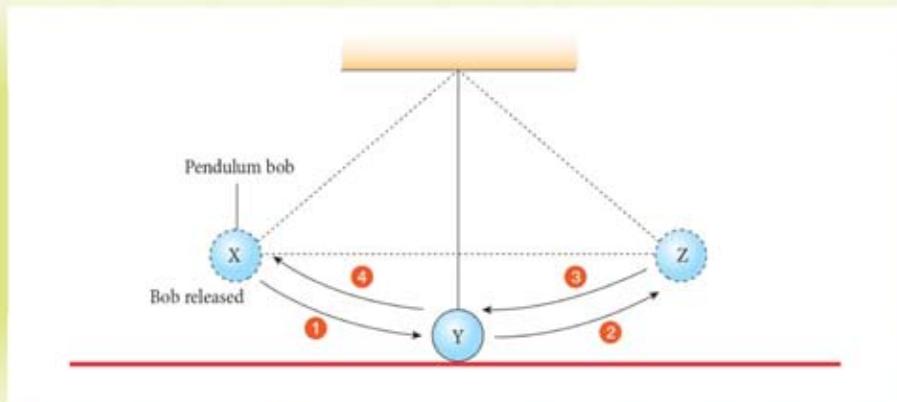
Oscillating systems such as the oscillation of a simple pendulum and the oscillation of a loaded spring always experience transformation in the forms of energy between **gravitational potential energy** or **elastic potential energy** and **kinetic energy**. Do oscillating systems obey the Principle of Conservation of Energy?

i SCIENCE INFO

Useful energy is energy in a form that can be easily converted into other forms to do work. For example, chemical energy stored in fossil fuels is useful energy because the chemical energy can be easily converted to heat energy and light energy through the combustion of fossil fuels.

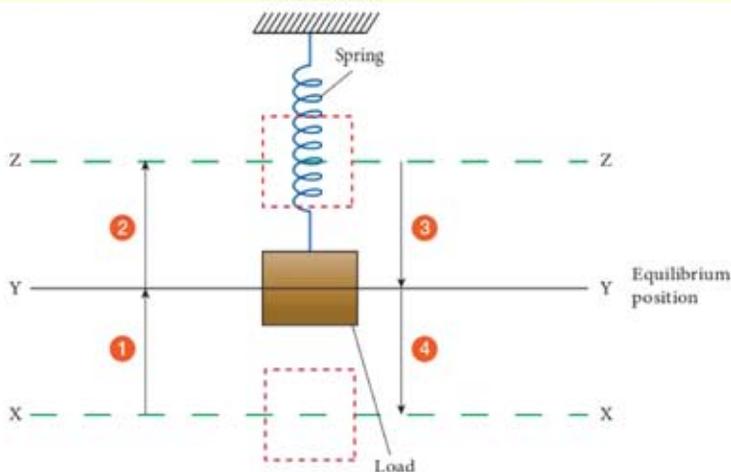
Oscillating Systems Obey the Principle of Conservation of Energy

Study Figures 7.11 and 7.12. Let us observe the transformation in the forms of energy that occurs in the oscillation of a simple pendulum and a loaded spring which are the examples of the Principle of Conservation of Energy.



Condition of pendulum bob	Transformation in the forms of energy for the bob between gravitational potential energy (gravitational P.E.) and kinetic energy (K.E.)	
At position X	Gravitational P.E. = maximum K.E. = zero	(bob at maximum height) (bob stationary, speed = zero)
1 From position X to Y	Gravitational P.E. of bob decreasing K.E. of bob increasing	(height of bob decreasing) (speed of bob increasing)
At position Y	Gravitational P.E. = minimum K.E. = maximum	(bob at minimum height) (bob at maximum speed)
2 From position Y to Z	Gravitational P.E. of bob increasing K.E. of bob decreasing	(height of bob increasing) (speed of bob decreasing)
At position Z	Gravitational P.E. = maximum K.E. = zero	(bob at maximum height) (bob stationary, speed = zero)
3 From position Z to Y	Gravitational P.E. of bob decreasing K.E. of bob increasing	(height of bob decreasing) (speed of bob increasing)
At position Y	Gravitational P.E. = minimum K.E. = maximum	(bob at minimum height) (bob at maximum speed)
4 From position Y to X	Gravitational P.E. of bob increasing K.E. of bob decreasing	(height of bob increasing) (speed of bob decreasing)
At position X	Gravitational P.E. = maximum K.E. = zero	(bob at maximum height) (bob stationary, speed = zero)

Figure 7.11 Oscillation of a simple pendulum



Condition of loaded spring

Transformation in the forms of energy for the load between elastic potential energy (elastic P.E.) and kinetic energy (K.E.)

At position X	Elastic P.E. = maximum K.E. = zero	(spring is most stretched) (spring is stationary, speed = zero)
1 From position X to Y	Elastic P.E. decreasing K.E. increasing	(spring is gradually becoming less stretched) (speed of spring increasing)
At position Y	Elastic P.E. = minimum K.E. = maximum	(spring at equilibrium) (speed of spring at maximum)
2 From position Y to Z	Elastic P.E. increasing K.E. decreasing	(spring is gradually becoming more compressed) (speed of spring decreasing)
At position Z	Elastic P.E. = maximum K.E. = zero	(spring is most compressed) (spring is stationary, speed = zero)
3 From position Z to Y	Elastic P.E. decreasing K.E. increasing	(spring is gradually becoming less compressed) (speed of spring increasing)
At position Y	Elastic P.E. = minimum K.E. = maximum	(spring at equilibrium) (speed of spring at maximum)
4 From position Y to X	Elastic P.E. increasing K.E. decreasing	(spring is gradually becoming more stretched) (speed of spring decreasing)
At position X	Elastic P.E. = maximum K.E. = zero	(spring is most stretched) (spring is stationary, speed = zero)

Figure 7.12 Oscillation of a loaded spring

Transformation of Kinetic Energy and Potential Energy in a Closed System

In a **closed system**, the transformation of energy between potential energy and kinetic energy obeys the Principle of Conservation of Energy. Therefore, the total potential energy and kinetic energy in a closed oscillation system is **constant**. An example of a closed oscillation system is shown in Figure 7.13(a). Figure 7.13(b) shows the transformation of energy in a graph.

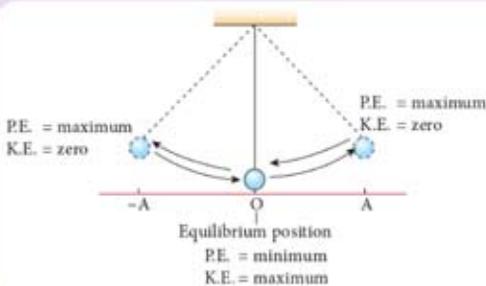


Figure 7.13(a) Oscillation of a pendulum in a closed system

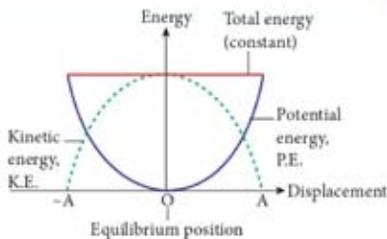


Figure 7.13(b) Graph of the transformation in the forms of energy

i SCIENCE INFO

Based on the Principle of Conservation of Energy, energy can transform from one form to another. When energy transforms, a small portion of the energy is converted into useful energy. A large portion of the energy is converted into wasted energy such as heat energy caused by friction. A closed system is a system in which there is no external force such as friction. Hence, heat energy is not produced in a closed system.

Let us carry out Activity 7.3 to discuss daily situations involving transformation of energy.

Activity 7.3

To discuss daily situations involving transformation of energy

Instructions

1. Work in groups.
2. Each group needs to gather information on transformation of energy in daily situations such as the oscillation of a swing, an object falling from a certain height, a roller coaster and toys with springs such as toy cars and pistols.
3. Label and state the form and transformation of energy at certain positions.
4. Present the outcome of your group discussion in class.

21st Century Skills

- ICS, ISS
- Discussion activity

Example of numerical problem

Figure 7.14 shows a toy pistol. The length of the spring in the toy pistol is 300 mm. If a force of 5 N is used to compress the spring until its length becomes 50 mm, calculate the maximum speed of the plastic ball of mass 50 g when it is fired from the pistol. State an assumption that is made in solving this problem.

Solution

Based on the Principle of Conservation of Energy,
elastic potential energy stored in the spring = kinetic energy
of the plastic ball.

$$\frac{1}{2} Fx = \frac{1}{2} mv^2$$
$$\frac{1}{2} \times 5 \text{ N} \times \frac{250}{1000} \text{ m} = \frac{1}{2} \times \frac{50}{1000} \text{ kg} \times v^2$$
$$\therefore v^2 = 25 \text{ m}^2 \text{ s}^{-2}$$
$$v = \sqrt{25 \text{ m}^2 \text{ s}^{-2}}$$
$$= 5 \text{ m s}^{-1}$$



Additional Example
<http://bt.sasbadi.com/sc3226>

Assumption: No energy loss into the surroundings.



Figure 7.14

Formative Practice 7.3

1. State the Principle of Conservation of Energy.
2. An oscillating loaded spring as shown in Figure 1 is a closed oscillation system.
 - (a) State the position of the load where the elastic potential energy of the system is maximum.
 - (b) State the position of the load where the elastic potential energy of the system is minimum.
3. Figure 2 shows a metal sphere of mass 2 kg released from a height of 2.5 m from the surface of Earth.
 - (a) Calculate the gravitational potential energy possessed by the metal sphere before being released.
 - (b) What is the maximum speed of the metal sphere after being released?

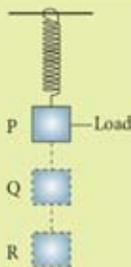


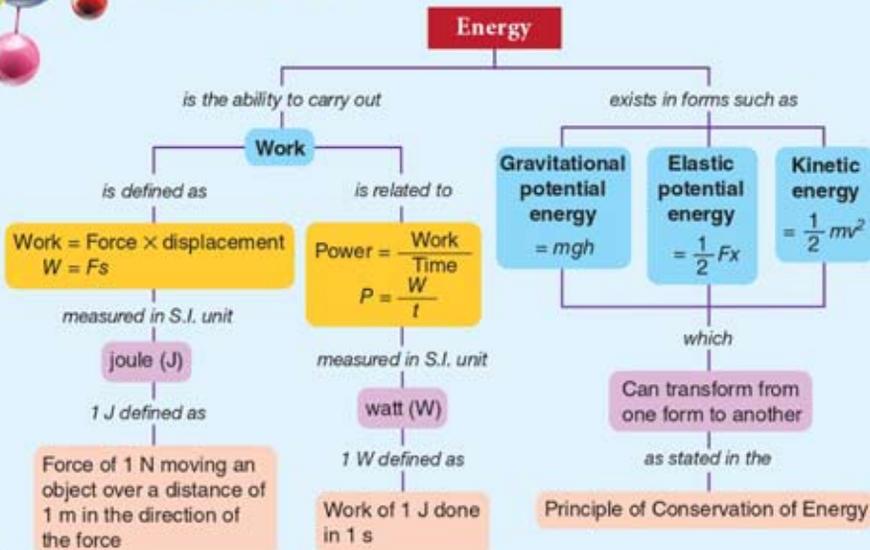
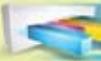
Figure 1



Figure 2



Summary

Self-reflection

After studying this chapter, you are able to:

7.1 Work, Energy and Power

- Define work and solve problems related to energy in the context of daily life.
- Relate power with work and solve problems in the context of daily life.

7.2 Potential Energy and Kinetic Energy

- Explain with examples gravitational potential energy and solve problems in the context of daily life.
- Calculate elastic potential energy in the context of daily life.
- Explain with examples kinetic energy in the context of daily life.

7.3 Principle of Conservation of Energy

- Explain with examples the Principle of Conservation of Energy.
- Solve qualitative and quantitative problems involving the transformation of kinetic energy and potential energy in a closed system.



Answer the following questions:

1. There are many forms of energy. Match the following form of energy with its correct definition.

Form of energy	Definition
(a) Potential energy	Ability to do work
(b) Kinetic energy	Energy possessed by a moving object
	Energy possessed by an object due to its position or condition

2. Underline the correct answers.

- (a) The unit for energy is (J s/N m).
(b) (Work/Power) is defined as the product of force and displacement in the direction of the force.
(c) A (stationary/moving) object does not possess kinetic energy.
(d) The Principle of Conservation of Energy states that energy (can/cannot) transform its form.
(e) Weight is the product of mass and (force/acceleration) of gravity.

3. Figure 1 shows a motor lifting a load of mass 5 kg to a height of 2 m.

- (a) Calculate the work done by the motor. 
(b) How much energy is used by the motor to lift the load?

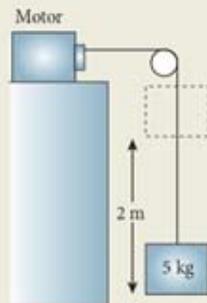


Figure 1

4. State the formula for the following energy:

- (a) Gravitational potential energy
(b) Elastic potential energy
(c) Kinetic energy

5. Figure 2 shows a female archer pulling her bowstring back 0.4 m with a maximum force of 200 N.

- (a) How much work is done?
(b) Calculate the elastic potential energy possessed by the stretched bowstring. 
(c) Not all the work done to pull the bowstring back is changed into elastic potential energy. Why?



Figure 2

Focus on HOTS

6. Figure 3 shows the oscillation of a simple pendulum in a closed system. The mass of the pendulum bob is 40 g.
- State the principle that needs to be obeyed by the oscillation of a simple pendulum in a closed system.
 - At which position does the pendulum possess gravitational potential energy and kinetic energy of equal value?
 - Calculate the difference in gravitational potential energy of the pendulum at positions X and Y.
7. Figure 4 shows a model of a simple roller coaster.

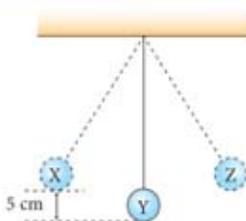
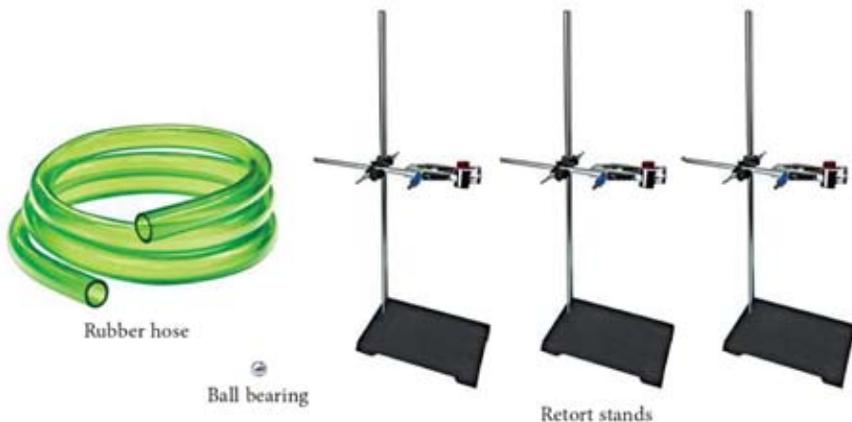


Figure 3



Figure 4

You are required to build a functional model of a roller coaster using the materials below.



Sketch your roller coaster model. Explain the special features of the model.