

CLASS 9 SCIENCE — CHAPTER 7

WORK, ENERGY, AND SIMPLE MACHINES



 **New *Exploration* Science Textbook | 2026–27**

Chapter 7 covers **work, energy, power, kinetic and potential energy, work-energy theorem, conservation of energy, and simple machines such as pulleys, inclined planes and levers**. These are also the concepts specifically listed in the 2026–27 syllabus.

 **Formula format:** All formulas are written in simple **text format** for easy copying.

1. What Is Work?

In everyday language, we use the word "work" for many activities. 🤔

For example:

-  Studying
-  Cleaning
-  Running
-  Typing
-  Lifting a weight

But in science, **work has a specific meaning**.

Scientific Definition

Work is said to be done when a force acting on an object causes displacement of the object in the direction of the force.

So, two things are important:

1.  Force must act.

2.  The object must undergo displacement.
-



2. Formula for Work

When a constant force acts in the direction of displacement:

$$\text{Work} = \text{Force} \times \text{Displacement}$$

or

$$W = F \times s$$

Where:

W = Work

F = Force

s = Displacement



3. SI Unit of Work

The SI unit of work is:

Joule (J)

One joule is the work done when a force of 1 N produces a displacement of 1 m in the direction of the force.

$$1 \text{ J} = 1 \text{ N m}$$



4. Example of Work

A force of 10 N moves an object through 5 m in the direction of the force.

$$W = F \times s$$

$$W = 10 \times 5$$

$$W = 50 \text{ J}$$

5. When Is No Scientific Work Done?

There are situations where we may feel tired, but scientifically no work is done.

Example

A student pushes a wall with great force.

The wall does not move.

Therefore:

$$\text{Displacement} = 0$$

So:

$$W = F \times s$$

$$W = F \times 0$$

$$W = 0 \text{ J}$$



6. Holding an Object Stationary

Suppose you hold a heavy bag in your hand.

 You apply force upward.

But:

 The bag does not move.

Therefore:

Scientific work done on the bag = 0

Even though your muscles may become tired.

7. Positive Work

Work is positive when:

Force and displacement are in the same direction.

Example:

 Force

 Displacement

Example 

A person pushes a trolley forward and the trolley moves forward.

Therefore:

Positive work is done.

8. Negative Work

Work is negative when:

Force and displacement are in opposite directions.

Example:

A moving bicycle slows down because friction acts opposite to its displacement.

 →

← Friction

Therefore:

Friction does negative work.

9. Zero Work

Work is zero when:

1. Displacement is zero

or

2. Force is perpendicular to displacement.

Example

A person carries a bag horizontally at constant height.

The upward force exerted by the person and the horizontal displacement are perpendicular.

Therefore, the work done by the upward force on the bag is:

Zero



10. Positive, Negative and Zero Work

Type	Force & Displacement	Example
 Positive	Same direction	Pushing a trolley forward
 Negative	Opposite directions	Friction on a moving object
 Zero	No displacement / perpendicular	Holding a stationary bag



11. Energy

 **Definition**

Energy is the capacity to do work.

An object having energy can do work.

Examples:

 Battery → Electrical energy

 Sun → Solar energy

 Food → Chemical energy

 Moving person → Kinetic energy

 Raised object → Potential energy



12. SI Unit of Energy

The SI unit of energy is:

Joule (J)

★ Work and energy have the same SI unit.

$$1 \text{ J} = 1 \text{ N m}$$



13. Forms of Energy

Energy exists in different forms.

 Electrical energy

Energy associated with electricity.

 Thermal energy

Energy associated with temperature and heat.

 Chemical energy

Stored in chemical substances.

Example:



Food



Fuel



Batteries



Solar energy

Energy obtained from the Sun.



Light energy

Energy carried by light.



Sound energy

Energy associated with sound.



Mechanical energy

Energy associated with motion or position.



14. Energy Conversion

Energy can change from one form to another.



Electric bulb

Electrical energy → Light energy + Heat energy



Car

Chemical energy of fuel → Thermal energy → Mechanical energy



Solar panel

Solar energy → Electrical energy



Battery-powered toy

Chemical energy → Electrical energy → Mechanical energy

15. Mechanical Energy

Mechanical energy is associated with:

 **Position**

or

 **Motion**

It has two important forms:

1 Kinetic energy

2 Potential energy

16. Kinetic Energy

 **Definition**

Kinetic energy is the energy possessed by an object due to its motion.

Examples:

 Moving car

 Running person

 Moving ball

 Moving air

17. Formula for Kinetic Energy

$$\text{Kinetic Energy} = \frac{1}{2} \times \text{Mass} \times \text{Velocity}^2$$

or

$$\text{KE} = \frac{1}{2}mv^2$$

Where:

m = Mass

v = Velocity



18. SI Unit of Kinetic Energy

Joule (J)



19. Example — Kinetic Energy

An object has:

Mass = 4 kg

Velocity = 5 m/s

Using:

$$\text{KE} = \frac{1}{2}mv^2$$

$$\text{KE} = \frac{1}{2} \times 4 \times 5^2$$

$$\text{KE} = 2 \times 25$$

$$\text{KE} = 50 \text{ J}$$



20. Factors Affecting Kinetic Energy

From:

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

we can see that kinetic energy depends on:

 **Mass**

Greater mass → Greater kinetic energy.

 **Velocity**

Greater velocity → Much greater kinetic energy.

★ Since velocity is squared:

Doubling velocity makes kinetic energy four times.

21. Potential Energy

 **Definition**

Potential energy is the energy possessed by an object due to its position or configuration.

Example:

 A box kept at a height

 A stretched bow

 A compressed spring

22. Gravitational Potential Energy

An object raised above the ground possesses gravitational potential energy.

Formula:

Potential Energy = Mass × Acceleration due to gravity × Height

or

$$\mathbf{PE = mgh}$$

Where:

m = Mass

g = Acceleration due to gravity

h = Height



23. Example — Potential Energy

A 5 kg object is raised to a height of 2 m.

Take:

$$g = 9.8 \text{ m/s}^2$$

Using:

$$\mathbf{PE = mgh}$$

$$\mathbf{PE = 5 \times 9.8 \times 2}$$

$$\mathbf{PE = 98 \text{ J}}$$

$$\mathbf{PE = 98 \text{ J}}$$



24. Factors Affecting Potential Energy

From:

$$\mathbf{PE = mgh}$$

Potential energy depends on:

 Mass

 Gravitational acceleration

 Height

Therefore:

Greater height $\rightarrow$ Greater potential energy.

Greater mass $\rightarrow$ Greater potential energy.

25. Conversion of Potential Energy into Kinetic Energy

Consider a ball held at a height.

At the top:

 Potential energy = High

 Kinetic energy = Low/zero if initially at rest

When the ball falls:

 Potential energy decreases

 Kinetic energy increases

Just before reaching the ground:

 Kinetic energy is maximum

 Potential energy is minimum relative to the ground.

26. Conservation of Mechanical Energy

If friction and air resistance are ignored:

Total mechanical energy remains constant.

Mechanical energy:

Mechanical Energy = Kinetic Energy + Potential Energy

or

ME = KE + PE

During free fall:

Loss of PE = Gain in KE

The textbook syllabus specifically includes conversion between potential and kinetic energy during free fall and conservation of energy.



27. Example of Energy Conservation

Imagine a ball falling from a height.

At the top:

PE = Maximum

KE = Minimum

During falling:

PE ↓

KE ↑

Near the ground:

PE ↓

KE ↑

If no energy is lost:

PE + KE = Constant



28. Law of Conservation of Energy



Statement

Energy can neither be created nor destroyed. It can only be transformed from one form to another.

Therefore:

Total energy remains constant.



29. Example of Conservation of Energy

In an electric bulb:

Electrical energy



Light energy + Heat energy

Energy has not disappeared.

It has simply changed form.



30. Work-Energy Theorem

The work-energy theorem states:

The net work done on an object is equal to the change in its kinetic energy.

Formula:

Net Work = Change in Kinetic Energy

or

$$W = KE(\text{final}) - KE(\text{initial})$$

Therefore:

$$W = \Delta KE$$

This connects force, displacement and motion.



31. Work-Energy Example

Suppose an object initially has:

$$KE = 20 \text{ J}$$

After a force acts, its KE becomes:

$$50 \text{ J}$$

Then:

$$\text{Work} = \text{Final KE} - \text{Initial KE}$$

$$\text{Work} = 50 - 20$$

$$\text{Work} = 30 \text{ J}$$



32. Power

Two people may do the same amount of work but take different amounts of time.

The person who does the work faster has greater:

Power



Definition

Power is the rate of doing work.



33. Formula for Power

Power = Work / Time

or

$$\mathbf{P = W / t}$$

Where:

P = Power

W = Work

t = Time



34. SI Unit of Power

The SI unit of power is:

Watt (W)

1 watt = 1 joule per second

or

$$\mathbf{1\ W = 1\ J/s}$$



35. Example — Power

A machine does 500 J of work in 10 seconds.

$$\mathbf{P = W / t}$$

$$\mathbf{P = 500 / 10}$$

$$P = 50 \text{ W}$$

36. Important Difference

Work

Tells us:

How much work is done.

Power

Tells us:

How quickly the work is done.

37. Same Work, Different Power

Suppose two students climb the same staircase.

Both do the same amount of work.

 Student A → 20 seconds

 Student B → 10 seconds

Student B takes less time.

Therefore:

Student B has greater power.

38. What Is a Machine?

A machine is a device that helps us perform tasks more conveniently.

Machines can help us:

-  Reduce the effort needed
-  Change the direction of force
-  Increase the distance over which effort acts

Examples:

-  Lever
 -  Pulley
 -  Inclined plane
-

39. Simple Machines

This chapter focuses on:

- 1 Pulley**
- 2 Inclined plane**
- 3 Lever**

These simple machines are specifically included in the 2026–27 syllabus.

40. Pulley

A pulley consists of a wheel with a groove through which a rope or cable passes.

It can help us:

-  Lift loads
-  Change the direction of effort
-  Reduce effort in suitable arrangements



41. Fixed Pulley

A fixed pulley remains attached to a fixed support.

Its main advantage is:

Changing the direction of effort

For an ideal fixed pulley:

Mechanical Advantage = 1

So the effort is ideally equal to the load.



42. Movable Pulley

A movable pulley moves along with the load.

It can provide:

Mechanical advantage greater than 1

This means the required effort can be less than the load in an ideal arrangement.



43. Mechanical Advantage

Mechanical advantage tells us how much a machine multiplies the applied effort.

Formula:

Mechanical Advantage = Load / Effort

or

$$MA = L / E$$

Where:

L = Load

E = Effort



44. Example — Mechanical Advantage

Load = 200 N

Effort = 50 N

MA = Load / Effort

MA = 200 / 50

MA = 4

The machine provides a mechanical advantage of 4.



45. Inclined Plane

An inclined plane is a:

Sloping surface

It allows a load to be raised through a longer distance using less effort.

Examples:



Sloping road



Ramp



Slide



Loading ramp



46. Advantage of Inclined Plane

An inclined plane reduces the force required to raise an object.

But:

The object moves through a greater distance.

★ A machine does not create energy.

It makes the task more convenient by changing the force and distance involved.



47. Inclined Plane and Work

Ideally:

Input Work = Output Work

The effort is smaller, but it acts over a greater distance.

Therefore, the machine does not reduce the total work in an ideal system.



48. Lever

A lever is a:

Rigid bar that can rotate around a fixed point.

The fixed point is called:

Fulcrum

A lever has three important parts:

Fulcrum

Fixed turning point.

Effort

Force applied to the lever.

Load

Object or force that must be overcome.

49. Arms of a Lever

Load arm

Distance between:

Fulcrum and Load

Effort arm

Distance between:

Fulcrum and Effort

50. Principle of Lever

For a balanced lever:

$$\text{Effort} \times \text{Effort arm} = \text{Load} \times \text{Load arm}$$

or

$$E \times dE = L \times dL$$

Where:

E = Effort

dE = Effort arm

L = Load

dL = Load arm



51. Example — Lever

A load of 30 N is placed 1 m from the fulcrum.

An effort of 15 N is applied.

Find the effort arm.

Using:

Effort × Effort arm = Load × Load arm

$$15 \times dE = 30 \times 1$$

$$15dE = 30$$

$$dE = 30 / 15$$

$$dE = 2 \text{ m}$$



52. Classes of Levers

Levers are divided into:

1 Class I

2 Class II

3 Class III

The classification depends on the relative positions of:

 Fulcrum

 Effort

 Load

53. Class I Lever

Fulcrum is between effort and load.

Arrangement:

Effort — Fulcrum — Load

or

Load — Fulcrum — Effort

Examples:

 Scissors

 Crowbar

 Pliers

 Balance scale

 Seesaw

54. Class II Lever

Load is between fulcrum and effort.

Arrangement:

Fulcrum — Load — Effort

Examples:

 Lemon squeezer

 Wheelbarrow

 Bottle opener

Class II levers generally provide mechanical advantage greater than 1.

55. Class III Lever

Effort is between fulcrum and load.

Arrangement:

Fulcrum — Effort — Load

Examples:

 Tongs

 Tweezers

 Broom

 Some arrangements of the human arm

 Oar

The textbook's lever table gives the three classes and examples such as scissors, wheelbarrow, lemon squeezer, tongs, tweezers, broom and oar.

56. Classes of Levers — Quick Table

Class	Middle Part	Examples
 Class I	Fulcrum	Scissors, crowbar, pliers, seesaw
 Class II	Load	Wheelbarrow, lemon squeezer, bottle opener

 Class III Effort Tongs, tweezers, broom, oar

Memory Trick:

Class I → F in middle

Class II → L in middle

Class III → E in middle

57. Machines Do Not Create Energy

A machine cannot create energy.

It only helps us:

 Apply force more conveniently

 Change direction

 Change the distance over which force acts

In an ideal machine:

Input Work = Output Work

The textbook explicitly states that machines do not create energy; they help us use energy more effectively.

58. Why Real Machines Are Not 100% Efficient

In real machines, some energy is transferred to other forms because of:

 **Friction**

 **Heat**

 **Sound**

Therefore:

Useful output work < Input work



59. Efficiency

Efficiency tells us how effectively a machine converts input energy or work into useful output.

Formula:

Efficiency = (Useful Output Work / Input Work) × 100



60. Example — Efficiency

Input work = 500 J

Useful output work = 400 J

Efficiency = (400 / 500) × 100

Efficiency = 80%



61. Important Formula Sheet

Work

$W = F \times s$

Kinetic Energy

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

Potential Energy

$$PE = mgh$$

Mechanical Energy

$$ME = KE + PE$$

Work-Energy Theorem

$$W = \text{Final KE} - \text{Initial KE}$$

or

$$W = \Delta KE$$

Power

$$P = W / t$$

Mechanical Advantage

$$MA = \text{Load} / \text{Effort}$$

Efficiency

$$\text{Efficiency} = (\text{Useful Output Work} / \text{Input Work}) \times 100$$

Principle of Lever

$$\text{Effort} \times \text{Effort arm} = \text{Load} \times \text{Load arm}$$

or

$$E \times dE = L \times dL$$



62. Important SI Units

Quantity	SI Unit
Work	Joule (J)

Energy	Joule (J)
Force	Newton (N)
Power	Watt (W)
Mass	Kilogram (kg)
Velocity	m/s
Height	Metre (m)
Mechanical Advantage	No unit
Efficiency	Percentage (%)



63. Important Numerical Example

A force of 20 N moves an object through 10 m.

Find the work done.

$$W = F \times s$$

$$W = 20 \times 10$$

$$W = 200 \text{ J}$$



64. Kinetic Energy Numerical

A 2 kg object moves at 10 m/s.

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

$$KE = \frac{1}{2} \times 2 \times 10^2$$

$$KE = 100 \text{ J}$$

$$\text{Answer} = 100 \text{ J}$$



65. Potential Energy Numerical

A 10 kg object is raised to a height of 5 m.

Take:

$$g = 9.8 \text{ m/s}^2$$

$$PE = mgh$$

$$PE = 10 \times 9.8 \times 5$$

$$PE = 490 \text{ J}$$



66. Power Numerical

A machine performs 2000 J of work in 20 seconds.

$$P = W / t$$

$$P = 2000 / 20$$

$$P = 100 \text{ W}$$



67. Mechanical Advantage Numerical

A machine lifts a load of 600 N using an effort of 150 N.

$$MA = \text{Load} / \text{Effort}$$

$$MA = 600 / 150$$

$$MA = 4$$



68. Efficiency Numerical

A machine receives 1000 J of input work and produces 800 J of useful output work.

$$\text{Efficiency} = (\text{Useful Output Work} / \text{Input Work}) \times 100$$

$$\text{Efficiency} = (800 / 1000) \times 100$$

$$\text{Efficiency} = 80\%$$



69. Competency-Based Question

A student pushes a box with a force of 50 N through a distance of 4 m.

Find the work done.

$$W = F \times s$$

$$W = 50 \times 4$$

$$W = 200 \text{ J}$$



70. Competency-Based Question

A student holds a 10 kg bag stationary for 2 minutes.

Is scientific work done on the bag?

✗ No.

The bag does not undergo displacement.

Therefore:

$$s = 0$$

$$W = F \times 0$$

$$W = 0 \text{ J}$$

71. Competency-Based Question

Two students climb the same staircase.

Student A takes 20 seconds.

Student B takes 10 seconds.

Both do approximately the same work.

Who has greater power?

 **Student B**

Because:

Power = Work / Time

Less time for the same work means greater power.

72. Competency-Based Question

A ball falls from a height.

What happens to its potential and kinetic energies?

During falling:

Potential Energy ↓

Kinetic Energy ↑

If air resistance is ignored:

Total mechanical energy remains constant.

73. Competency-Based Question

Why does an inclined plane make lifting a load easier?

Because it allows the load to be raised using a smaller force over a longer distance.

★ **Important:**

It does not create energy or reduce the ideal total work.

74. Competency-Based Question

A lever has:

Load = 30 N

Load arm = 1 m

Effort = 15 N

Find the effort arm.

Using:

$$E \times dE = L \times dL$$

$$15 \times dE = 30 \times 1$$

$$dE = 2 \text{ m}$$

✓ **Answer: 2 m**

75. Common Mistakes to Avoid

✗ **Mistake 1**

Thinking every activity in which we become tired is scientific work.

 Correct

Scientific work requires:

Force + Displacement

 Mistake 2

Thinking work is always positive.

 Correct

Work can be:

☒ Positive

☐ Negative

☐ Zero

 Mistake 3

Confusing energy and power.

 Correct

Energy → Capacity to do work

Power → Rate of doing work

 Mistake 4

Thinking a machine creates energy.

 Correct

A machine only helps us use force and energy more conveniently.

Mistake 5

Confusing kinetic and potential energy.

Correct

Kinetic → **Motion**

Potential → **Position/configuration**

Mistake 6

Confusing mechanical advantage with efficiency.

Correct

MA = Load / Effort

Efficiency = Useful Output Work / Input Work × 100



76. Important Exam Questions

Q1. Define work.

Work is done when a force acting on an object causes displacement in the direction of the force.

Q2. What is the SI unit of work?

Joule (J).

Q3. When is work positive?

When force and displacement are in the same direction.

Q4. When is work negative?

When force and displacement are in opposite directions.

Q5. When is work zero?

When displacement is zero or when the force is perpendicular to displacement.

Q6. What is energy?

Energy is the capacity to do work.

Q7. What is kinetic energy?

Energy possessed by an object due to its motion.

Q8. What is potential energy?

Energy possessed by an object due to its position or configuration.

Q9. State the work-energy theorem.

The net work done on an object is equal to the change in its kinetic energy.

Q10. State the law of conservation of energy.

Energy can neither be created nor destroyed; it can only be transformed from one form to another.

Q11. Define power.

Power is the rate of doing work.

Q12. What is a simple machine?

A device that helps us perform work more conveniently by changing the magnitude or direction of force or the distance over which effort acts.

Q13. What is mechanical advantage?

Mechanical advantage is the ratio of load to effort.

$$\text{MA} = \text{Load} / \text{Effort}$$

Q14. What is a fulcrum?

The fixed point about which a lever rotates.

77. QUICK REVISION

- ★ Work requires force and displacement.
- ★ $\text{Work} = \text{Force} \times \text{Displacement}$.
- ★ SI unit of work = Joule.
- ★ Positive work $\rightarrow$ Force and displacement same direction.
- ★ Negative work $\rightarrow$ Force and displacement opposite directions.
- ★ Zero work $\rightarrow$ No displacement or force perpendicular to displacement.
- ★ Energy = Capacity to do work.
- ★ SI unit of energy = Joule.
- ★ Kinetic energy $\rightarrow$ Energy due to motion.
- ★ $\text{KE} = \frac{1}{2}mv^2$.
- ★ Potential energy $\rightarrow$ Energy due to position/configuration.
- ★ $\text{PE} = mgh$.
- ★ Mechanical energy = KE + PE.
- ★ Work-energy theorem $\rightarrow$ Net work = Change in KE.
- ★ Energy can neither be created nor destroyed.
- ★ Power = Work / Time.
- ★ SI unit of power = Watt.
- ★ Simple machines make work more convenient.
- ★ Mechanical Advantage = Load / Effort.
- ★ Pulley can lift loads and change direction of effort.
- ★ Inclined plane reduces required force by increasing distance.
- ★ Lever rotates about a fulcrum.
- ★ Class I $\rightarrow$ Fulcrum in middle.

★ Class II → Load in middle.

★ Class III → Effort in middle.

★ Machines do not create energy.

78. MEMORY TRICKS

WORK

Work = Force × Displacement

$$W = F \times s$$

ENERGY

Motion → Kinetic

Position → Potential

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

$$PE = mgh$$

POWER

Power = Work / Time

$$P = W / t$$

👉 Power = How fast work is done

SIMPLE MACHINES

MA = Load / Effort

Remember:

$$L \div E$$

LEVERS

Class I $\rightarrow$ F in middle

Class II $\rightarrow$ L in middle

Class III $\rightarrow$ E in middle

79. CHAPTER 7 — FINAL TAKEAWAY

Work, energy and machines are closely connected. 

Work

$$W = F \times s$$

Energy

Energy is the capacity to do work.

Kinetic Energy

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

Potential Energy

$$PE = mgh$$

Conservation

Energy changes form but total energy is conserved.

Power

$$P = W / t$$

Simple Machines

$$\text{MA} = \text{Load} / \text{Effort}$$

The central idea of this chapter is:

 **Machines do not create energy. They make it easier or more convenient to use force by changing its magnitude, direction, or the distance over which it acts.**

 **Remember the complete chain:**

Force → Work → Energy → Power → Machines

This chapter's 2026–27 syllabus specifically expects students to calculate work, kinetic and potential energy, power and mechanical advantage, and explain energy conversion and conservation.