

WORK DONE BY FORCE

When a force causes an object to move,
work is said to be done.

FORMULA

$$W = F \times s$$

W = Work done (joule, J)

F = Force applied (newton, N)

s = Displacement (metre, m)

$$1 \text{ joule (J)} = 1 \text{ N} \times 1 \text{ m}$$

MEANING

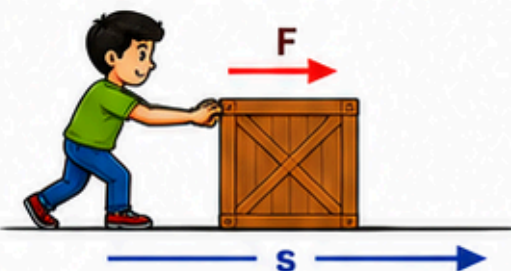
Work is done when a force acts on an object and causes it to move through a certain distance **in the direction of the force**.

UNIT

Joule (J)
 $1 \text{ J} = 1 \text{ N} \times 1 \text{ m}$

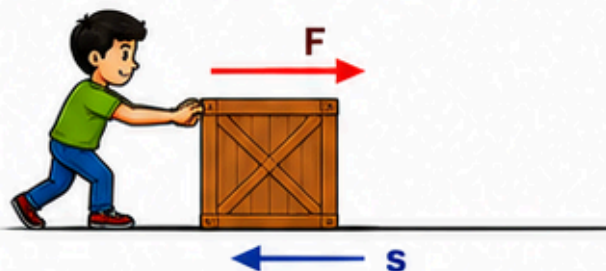
1. WORK DONE IN DIFFERENT SITUATIONS

(a) Force and displacement in the same direction



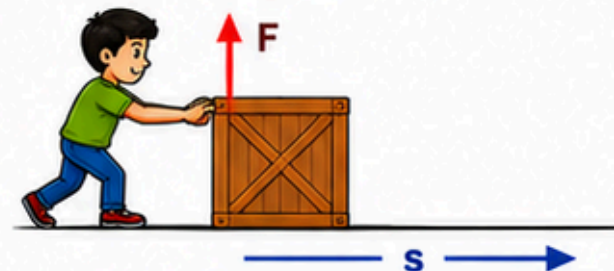
Work done, $W = F \times s$
(Positive work)

(b) Force and displacement in opposite directions



Work done, $W = -F \times s$
(Negative work)

(c) Force perpendicular to displacement



Work done, $W = 0$
(Zero work)

2. WORK DONE IN DIFFERENT CASES

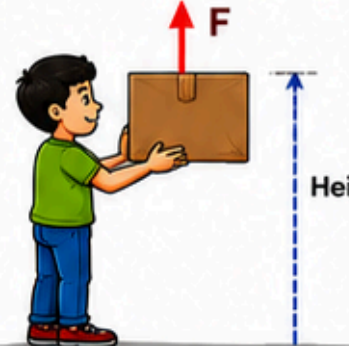
(a) Horizontal surface (no friction)



If a force F acts on an object and it moves a distance s in the same direction,

Work done, $W = F \times s$

(b) Vertical upward direction



If a force F is applied vertically upward and the object is raised to a height h ,

Work done, $W = F \times h$

Note

Work is a scalar quantity. Its value depends on the magnitude of force and the displacement in the direction of the force. If there is **no displacement**, no **work** is done.

3. SIGN OF WORK DONE

- ★ **Positive work (+)**
When force and displacement are in the same direction.
- ★ **Negative work (-)**
When force and displacement are in opposite directions.
- ★ **Zero work (0)**
When force is perpendicular to displacement or when there is no displacement.

KEY TAKEAWAY

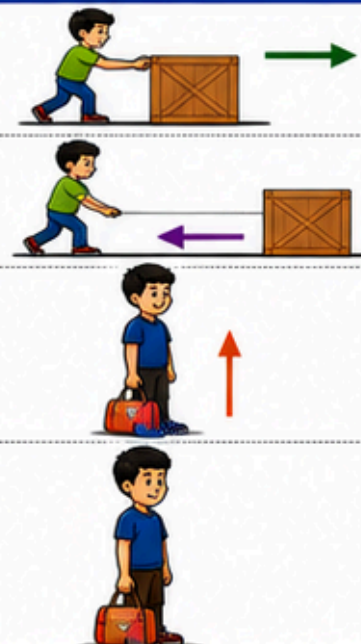


Work is done only when a force causes displacement in its direction. The greater the force or displacement, the greater the work done.

$$W = F \times s$$

4. EXAMPLES

- 1 **Pushing a box forward**
Force and displacement are in same direction. (Positive work)
- 2 **Pulling a box backward**
Force is opposite to displacement. (Negative work)
- 3 **Carrying a bag on level road**
Force (upward) is perpendicular to displacement (horizontal). (Zero work)
- 4 **Standing still while holding a bag**
No displacement, so no work is done. (Zero work)



WORK-ENERGY THEOREM

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

FORMULA

$$W = \Delta K$$

W = Work done (joule, J)
 ΔK = Change in kinetic energy (joule, J)

$$\Delta K = K_f - K_i$$

K_i = Initial kinetic energy

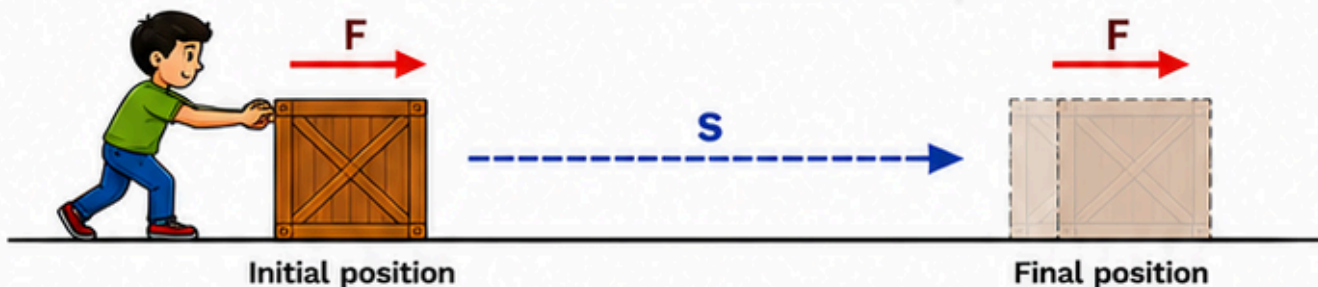
K_f = Final kinetic energy

DEFINITION

Work-Energy Theorem states that the net work done on an object is equal to the **change in its kinetic energy**.

1. WORK DONE ON AN OBJECT

When a **net external force** acts on an object and causes it to move through a distance s , work is said to be done on the object.



If the force F acts in the direction of displacement, then the work done is

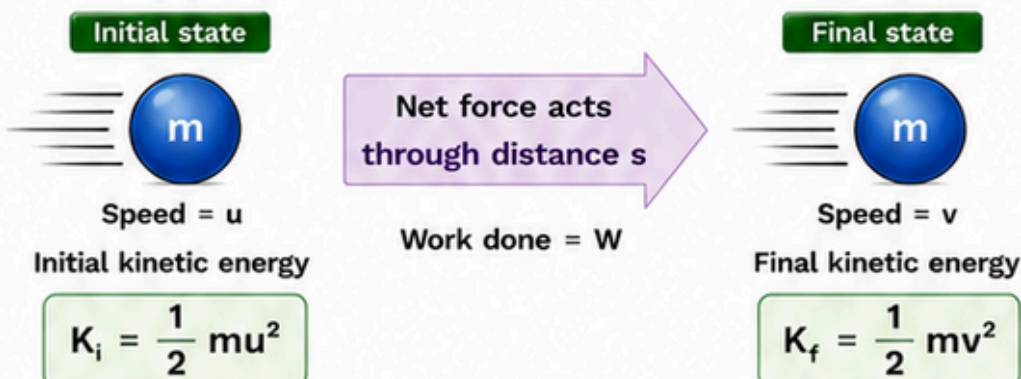
$$W = F \times s$$

Unit of work = joule (J)

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

2. WORK-ENERGY THEOREM

Consider a body of mass m . It has an **initial speed** u and **final speed** v after a force does work on it.



According to the Work-Energy Theorem,

$$W = \Delta K = K_f - K_i$$

$$W = \frac{1}{2} mv^2 - \frac{1}{2} mu^2$$

This means the work done on the object is equal to the change in its kinetic energy.

3. SPECIAL CASES

Case	Condition	Work Done (W)	Change in Kinetic Energy (ΔK)
1 Object starts from rest	$u = 0$, final speed = v	$W = \frac{1}{2} mv^2$	$\Delta K = \frac{1}{2} mv^2$
2 Object comes to rest	final speed = 0 , initial speed = u	$W = -\frac{1}{2} mu^2$	$\Delta K = -\frac{1}{2} mu^2$
3 No change in speed	$u = v$	$W = 0$	$\Delta K = 0$
4 Increase in speed	$v > u$	$W > 0$	$\Delta K > 0$
5 Decrease in speed	$v < u$	$W < 0$	$\Delta K < 0$

4. EXAMPLES

1 Pushing a cart

When you push a cart and it moves, positive work is done on it and its kinetic energy increases.



2 Applying brakes on a bicycle

While applying brakes, the bicycle slows down, negative work is done and its kinetic energy decreases.



3 Free fall

In free fall, gravity does positive work on the body and its kinetic energy increases.



KEY TAKEAWAY

- ✓ Work is done only when a force causes displacement.
- ✓ The work done on an object changes its kinetic energy.
- ✓ Positive work increases kinetic energy.
- ✓ Negative work decreases kinetic energy.
- ✓ $W = \Delta K$ is true for any object, in any situation.

MEMORY TIP

$$W = \Delta K$$

What you do
(Work)

What it changes
(Kinetic Energy)

UNITS TO REMEMBER

- Work → Joule (J)
- Kinetic Energy → Joule (J)
- 1 Joule = 1 Newton × 1 metre



FORMS OF ENERGY

Energy is the ability to **do work** or cause **change**.

KEY POINTS

- Energy exists in many forms.
- It can be **transformed** from one form to another.
- Energy **cannot be created** or destroyed.

MAJOR FORMS OF ENERGY

1 MECHANICAL ENERGY



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

Examples

- A moving car
- A ball in motion (Kinetic)
- A stone at the top of a hill (Potential)

2 THERMAL ENERGY



Energy that is associated with the temperature of a body.

Examples

- Heat from the sun
- Boiling water
- Heat from a stove

3 LIGHT ENERGY



Energy carried by light waves.

Examples

- Sunlight
- Light from a bulb
- Light from a torch

4 SOUND ENERGY



Energy produced by vibrating objects that can be heard.

Examples

- Sound of a drum
- Human voice
- Music from speakers

5 ELECTRICAL ENERGY



Energy produced by the flow of electric charges.

Examples

- Electricity from a socket
- Lightning
- Energy used to run appliances

6 CHEMICAL ENERGY



Energy stored in the chemical bonds of substances.

Examples

- Food we eat
- Batteries
- Fuel (petrol, diesel, LPG)
- Coal

7 NUCLEAR ENERGY



Energy stored in the nucleus of atoms.

Examples

- Energy from uranium
- Nuclear power plants
- Nuclear reactions in the sun

8 ELASTIC ENERGY

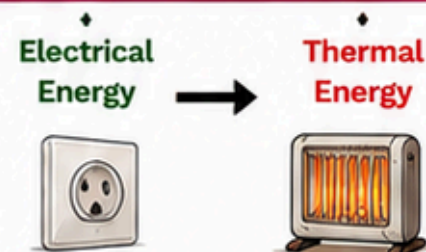
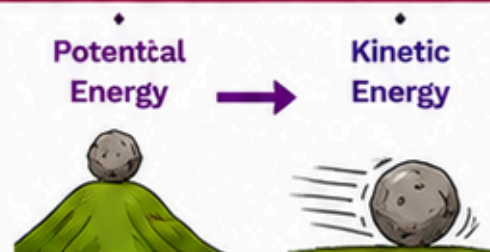
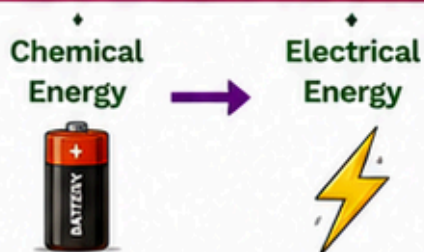
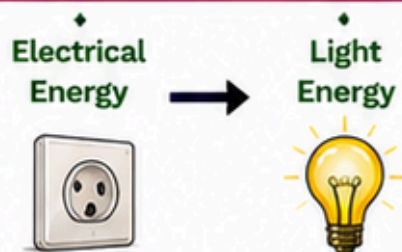


Energy stored in an object when it is stretched or compressed.

Examples

- Stretched rubber band
- Compressed spring
- Bow when pulled back

ENERGY TRANSFORMATION – Energy can change from one form to another.



REMEMBER!

- Energy makes things happen.
- It can change from one form to another.
- It is always **conserved**.



Energy is the **Power** behind every **Change**!

UNITS OF ENERGY

Joule (J)
1 J = 1 N × 1 m



KINETIC ENERGY

The energy possessed by an object due to its **motion**.

FORMULA

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

Where,

m = mass of the object (kg)

v = speed of the object (m/s)

SI Unit: Joule (J)

DEFINITION

Kinetic energy is the energy an object has because it is **moving**. If the object is at rest, its kinetic energy is **zero**.

HOW KINETIC ENERGY IS PRODUCED?

A force is applied on the object.



The object moves through a distance.



The object gains speed and has kinetic energy.



The **faster** the object moves or the **more massive** it is, the more kinetic energy it has.

FACTORS AFFECTING KINETIC ENERGY

1 Speed (v)

KE is directly proportional to the square of speed.

$$KE \propto v^2$$

Speed = v



Speed = 2v



If speed becomes double, KE becomes **4 times**.

2 Mass (m)

KE is directly proportional to mass.

$$KE \propto m$$

Mass = m



Mass = 2m



If mass becomes double, KE becomes **double**.

DERIVATION (From Work-Energy Theorem)

Consider a body of mass m. It starts from rest ($u = 0$) and moves with final speed v after a force acts on it through a distance s.

Initial state
($u = 0$)



Force acts

s

Final state
(speed = v)



Work done (W) = Force $\times$ distance = $F \times s$
According to Work-Energy Theorem, $W = \Delta KE$

$$W = \frac{1}{2} mv^2 - \frac{1}{2} mu^2 \quad \therefore u = 0$$

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

EXAMPLES

1 Moving Car



A car moving on a road has kinetic energy. If its speed increases, its KE increases.

2 Rolling Ball



A rolling ball has kinetic energy. If it rolls faster, its KE increases.

3 Cyclist



A cyclist has kinetic energy due to motion. More speed means more KE.

4 Bullet



A bullet has very high kinetic energy due to its very high speed.

KEY POINTS

- ★ An object at rest has zero kinetic energy.
- ★ Kinetic energy depends on both mass and speed.
- ★ Kinetic energy is always a positive quantity.
- ★ It is measured in **joule (J)**.
- ★ KE increases with increase in speed or mass.



SPEED Vs KINETIC ENERGY (For Same Mass)

Speed (m/s)	Calculation ($KE = \frac{1}{2} mv^2$) (For $m = 1 \text{ kg}$)	Kinetic Energy (J)
1	$\frac{1}{2} \times 1 \times 1^2$	0.5
2	$\frac{1}{2} \times 1 \times 2^2$	2
3	$\frac{1}{2} \times 1 \times 3^2$	4.5
4	$\frac{1}{2} \times 1 \times 4^2$	8

REMEMBER!

More **speed** or more **mass** means **more** kinetic energy!

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



PHYSICS CONCEPT

POTENTIAL ENERGY

The energy possessed by an object due to its **position or configuration**.

FORMULA

$$PE = mgh$$

Where,

m = mass of the object (kg)

g = acceleration due to gravity

($\approx 9.8 \text{ m/s}^2$)

h = height from the ground (m)

DEFINITION

Potential energy is the energy that a body possesses because of its **position, shape, or arrangement**. It has the **potential** to do work.

HOW IS POTENTIAL ENERGY STORED?

When work is done on an object against a force, the energy is stored in it as potential energy.



TYPES OF POTENTIAL ENERGY

1 Gravitational Potential Energy

Due to the position or height of an object above the ground.



2 Elastic Potential Energy

Due to the shape or configuration of an object when it is deformed or stretched.



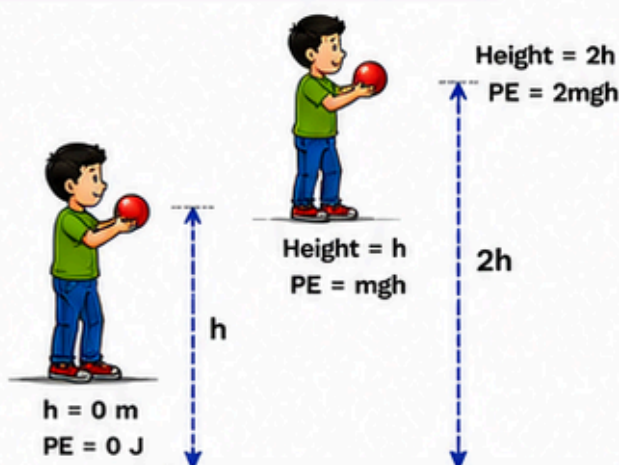
GRAVITATIONAL POTENTIAL ENERGY (GPE)

When an object of mass m is raised to a height h above the ground, **work** is done against gravity.

This work gets stored as gravitational potential energy.

Key Idea

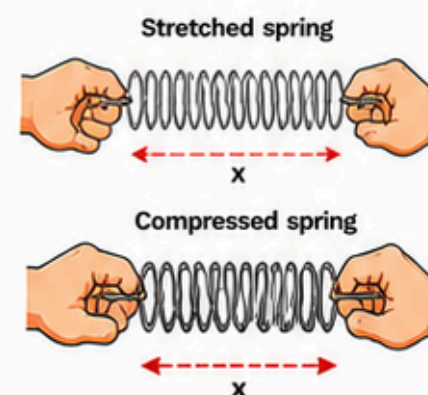
The higher the object or the more massive it is, the more potential energy it has.



$$PE = mgh$$

ELASTIC POTENTIAL ENERGY (EPE)

When an object is stretched, compressed or twisted, **work** is done on it and energy is stored in it as elastic potential energy.



$$EPE = \frac{1}{2} kx^2$$

Where, k = spring constant (N/m)

x = extension or compression (m)

FACTORS AFFECTING POTENTIAL ENERGY (GPE)

1 Mass (m)

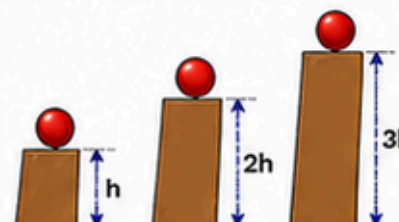
More mass means more potential energy.



$$PE \propto m$$

2 Height (h)

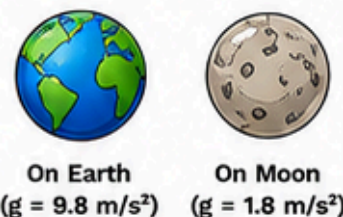
More height means more potential energy.



$$PE \propto h$$

3 Acceleration due to gravity (g)

More g means more potential energy.



$$PE \propto g$$

EXAMPLES OF POTENTIAL ENERGY

1 Water stored in a dam

Water at a height has gravitational potential energy.



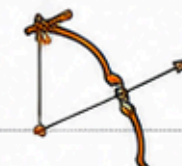
2 A book on a table

A book kept on a table has gravitational potential energy.



3 A stretched bow

A stretched bow stores elastic potential energy.



4 Compressed spring

A compressed spring stores elastic potential energy.



KEY POINTS

- ✓ Potential energy is stored energy.
- ✓ It depends on the **position**, shape or configuration.
- ✓ It has the ability to do work.
- ✓ When an object is released, potential energy can be converted into kinetic energy.
- ✓ Unit of potential energy is **joule (J)**.



CONVERSION OF ENERGY

Potential energy can be converted into kinetic energy.



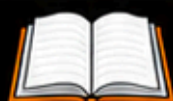
MEMORY TIP



Think PE as "**Stored Energy**" that is waiting to do work!

UNIT

Joule (J)
 $1 \text{ J} = 1 \text{ N} \times 1 \text{ m}$



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CONSERVATION OF MECHANICAL ENERGY

In an isolated system (no external forces like friction),
the total mechanical energy remains constant.

MECHANICAL ENERGY (ME)

$$ME = KE + PE$$

Where,

$$KE = \text{Kinetic Energy} \left(\frac{1}{2} mv^2 \right)$$

$$PE = \text{Potential Energy} (mgh)$$

1. FALLING OBJECT

As an object falls freely from a height, its potential energy decreases and kinetic energy increases. The total mechanical energy remains constant.

	PE = mgh	KE = $\frac{1}{2} mv^2$	ME = PE + KE
A At top $u = 0$ $v = 0$	mgh	0	mgh
B At middle $v = v_1$	$mg \frac{h}{2}$	$\frac{1}{2} mv_1^2$	mgh
C Just above ground $v = v_2$	$mg \frac{h}{4}$	$\frac{1}{2} mv_2^2$	mgh
D At ground $v = v_{\text{max}}$	0	$\frac{1}{2} mv_{\text{max}}^2$	mgh



At every position:

PE decreases ↓ KE increases ↑
Total **mechanical energy (ME)** remains constant.

Key Points

- ✓ At the highest point: KE = 0, PE = maximum, ME = maximum
- ✓ At the lowest point: PE = 0, KE = maximum, ME = same
- ✓ At all intermediate points: PE + KE = constant
- ✓ Mechanical energy is conserved in the absence of friction or air resistance.

MEMORY TIP

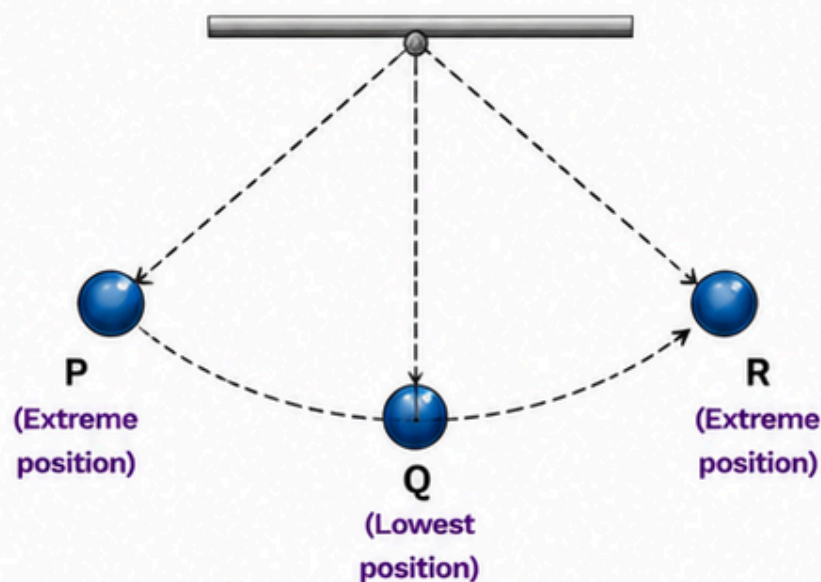
When an object falls,
PE turns into KE,
but **total energy** stays the same!

ENERGY CONVERSION (IDEAL CASE)

Extreme Position (P)	Moving towards Q	Lowest Position (Q)	Moving towards R	Extreme Position (R)
PE max KE = 0	PE ↓ KE ↑	PE = 0 KE max	PE ↑ KE ↓	PE max KE = 0

2. PENDULUM

As a pendulum swings, its potential energy and kinetic energy continuously change, but the total mechanical energy remains constant.



Position	Height (h)	PE = mgh ()	KE = $\frac{1}{2} mv^2$	ME = PE + KE	Speed (v)
P (Left extreme)	h	mgh	0	mgh	0
Q (Lowest)	0	0	$\frac{1}{2} mv_{\text{max}}^2$	mgh	v_{max}
R (Right extreme)	h	mgh	0	mgh	0

Observations

- ✓ At extreme positions (P and R): KE = 0, PE = maximum, speed = 0
- ✓ At lowest position (Q): PE = 0, KE = maximum, speed = maximum
- ✓ At all positions: PE + KE = constant
- ✓ ME is conserved if there is no friction or air resistance.

IMPORTANT FORMULA

For any position,

$$ME = KE + PE = \text{Constant}$$

(In the absence of non-conservative forces)



POWER

Power is the **rate** at which work is done or energy is transferred.

FORMULA

$$P = \frac{W}{t}$$

Where,

P = Power (Watt, W)

W = Work done (Joule, J)

t = Time taken (second, s)

SI Unit of Power = **Watt (W)**

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



DEFINITION

Power is the amount of work done **per unit time** or **energy** used per unit time.

WHAT DOES IT MEAN?

If the same amount of work is done in **less time**, the power is **greater**.



Work (W) done
Time taken = t_1
Power = P_1

Same work
Less time
More power



Work (W) done
Time taken = t_2 ($t_2 < t_1$)
Power = P_2 ($P_2 > P_1$)

IMPORTANT POINTS

- ★ Power depends on how fast the work is done.
- ★ If work is done in more time, power is less.
- ★ Power is a measure of the rate of doing work.
- ★ A powerful machine does the same work in less time.
- ★ Power can also be expressed as:

$$P = \frac{\text{Energy}}{\text{Time}}$$

SAME WORK, DIFFERENT POWER

More Time → Less Power



Work = 600 J
Time = 30 s
Power = $\frac{600}{30} = 20 \text{ W}$

Less Time → More Power



Work = 600 J
Time = 10 s
Power = $\frac{600}{10} = 60 \text{ W}$

Same Work
(600 J)

EXAMPLES

1 Lifting a weight



A weightlifter lifts the same weight in less time, so his power is more.

2 Climbing stairs



Reaching the same height in less time means greater power.

3 Vehicles



A car with more power reaches the same speed in less time.

REAL LIFE APPLICATIONS OF POWER

Electric Motors



High power motors do more work in less time.

Airplanes



Powerful engines help planes take off quickly.

Power Tools



Drills with more power can work faster.

Bulldozers



High power helps in moving heavy loads.

Pumps



High power pumps can lift more water quickly.

Trains



More power helps trains to move heavy loads fast.

MEMORY TIP

Power depends on Speed (time) !

Fast work → High Power

Slow work → Low Power

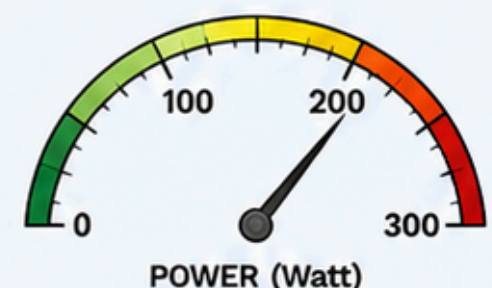
UNITS OF POWER

• 1 Watt (W) = 1 Joule per second

• 1W = 1 J/s

• 1000 W = 1 Kilowatt (kW)

• 1 MW = 10^6 W | 1 kW = 10^3 W



SIMPLE MACHINES &

MECHANICAL ADVANTAGE

Simple machines make our work easier by reducing the effort needed.

KEY IDEA

Machines do not reduce the amount of work. They make the work easier by **changing the size or direction** of the force.



WHAT IS A SIMPLE MACHINE?

A simple machine is a device that changes the **magnitude** or **direction** of a force to do work **more easily**.

HOW MACHINES MAKE WORK EASIER

They help us by:

- ★ Reducing the effort needed to lift or move a load.
- ★ Changing the direction of the effort.
- ★ Allowing us to apply force in a more convenient way.



MECHANICAL ADVANTAGE (MA)

It tells us how many times a machine multiplies the effort.

Formula

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

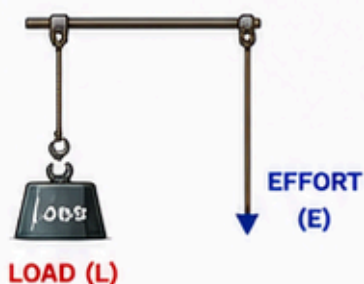
Where,

- L** = Load (the weight to be lifted)
- E** = Effort (the force applied)

Interpretation

- $MA > 1 \rightarrow$ Machine gives advantage
- $MA = 1 \rightarrow$ No advantage
- $MA < 1 \rightarrow$ Machine gives disadvantage

TWO IMPORTANT TERMS



1. Mechanical Advantage (MA)

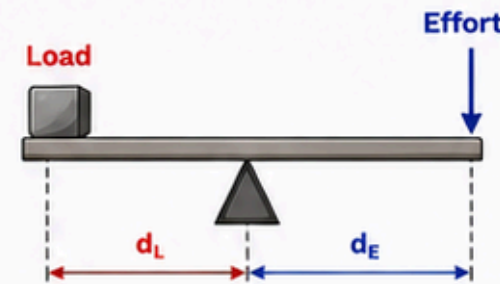
Tells how many times the machine multiplies the effort.

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

2. Velocity Ratio (VR)

Tells how many times the effort distance is greater than the load distance.

$$VR = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$$



In ideal machines (without friction): $MA = VR$ In real machines: $MA < VR$

1. PULLEY

Changes the direction of effort.



Ideal $MA = 1$

2. INCLINED PLANE

Reduces effort by increasing the distance.

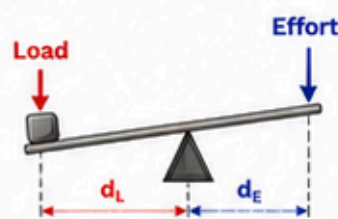


$MA > 1$

COMMON SIMPLE MACHINES & THEIR ADVANTAGE

3. LEVER

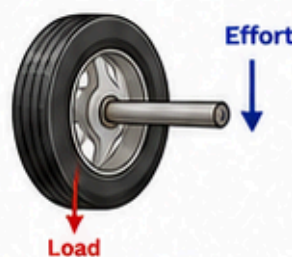
Gives advantage based on lengths of arms.



MA can be $>$, $=$ or < 1

4. WHEEL & AXLE

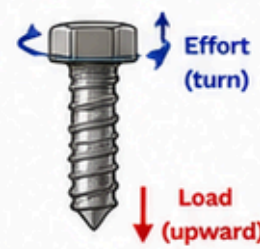
Reduces effort in moving heavy loads.



$MA > 1$

5. SCREW

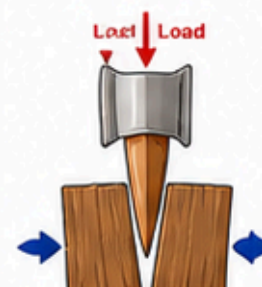
An inclined plane wrapped around a cylinder.



$MA > 1$

6. WEDGE

Used to split or separate objects.



$MA > 1$

REMEMBER!

- ✓ Simple machines make work easier, not less.
- ✓ They save effort, not energy.
- ✓ Friction in real machines reduces their advantage.



EXAMPLE

A machine lifts a load of 120 N with an effort of 30 N.

$$MA = \frac{L}{E} = \frac{120}{30} = 4$$

The machine gives 4 times advantage.



TYPES OF MACHINES

- ★ **Simple Machines** – Have few or no moving parts (e.g., lever, pulley).
- ★ **Complex Machines** – Have many moving parts and are made up of simple machines (e.g., bicycle, car, crane).



PULLEY & PULLEY SYSTEM

Pulleys are simple machines that help us lift loads by changing the **direction** of effort or **reducing** the effort needed.

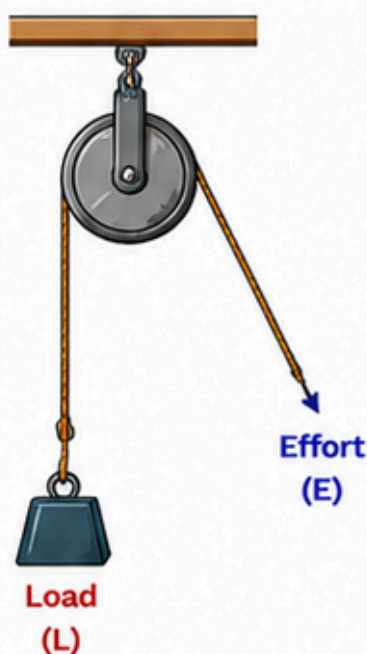
KEY IDEA

Pulleys do not reduce the work **done**, but they make the work easier by **changing** the **direction** of force or by increasing the **mechanical advantage**.



1. FIXED PULLEY

A fixed pulley is attached to a fixed support. It **changes the direction** of effort.



Features

- ★ Changes the **direction** of effort.
- ★ Does not reduce the effort needed.
- ★ Ideal Mechanical Advantage (MA) = 1

Ideal Case (No Friction)

$$MA = 1$$

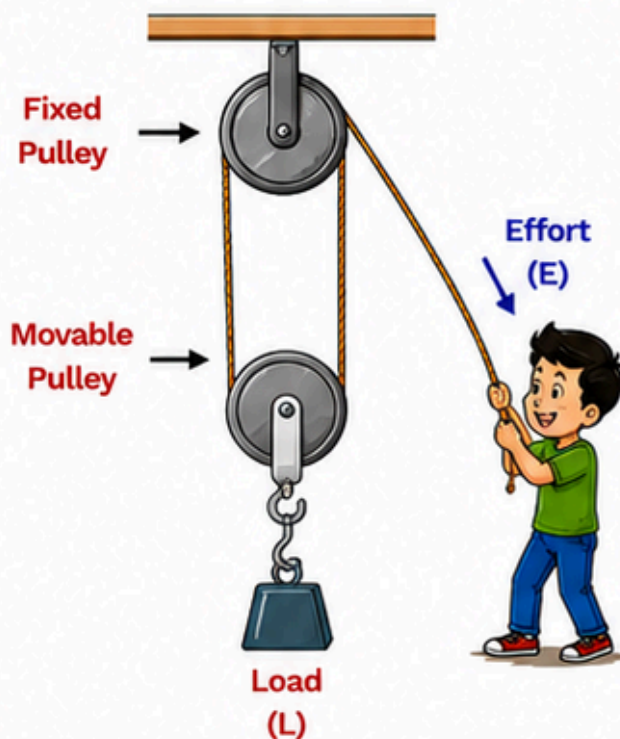
$$E = L$$

Example: In drawing water from a well.



2. PULLEY SYSTEM (COMBINATION OF PULLEYS)

A combination of fixed and movable pulleys. It **reduces the effort** needed to lift a load.



Features

- ★ Reduces the effort needed.
- ★ Does not change the direction of effort.
- ★ Mechanical Advantage (MA) is greater than 1.

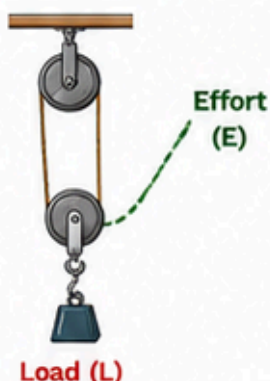
Ideal Case (No Friction)

MA = Number of rope segments supporting the movable pulley

$$E = \frac{L}{MA}$$

TYPES OF PULLEY SYSTEMS (IDEAL CASE)

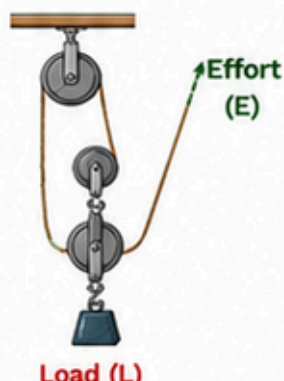
(a) One Movable Pulley



Number of supporting segments = 2

$$MA = 2 \quad E = \frac{L}{2}$$

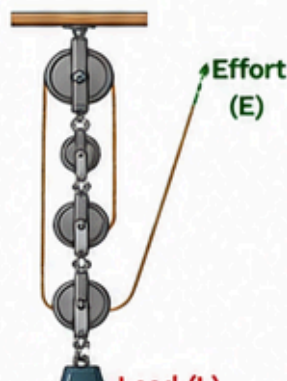
(b) Two Movable Pulleys



Number of supporting segments = 4

$$MA = 4 \quad E = \frac{L}{4}$$

(c) Three Movable Pulleys



Number of supporting segments = 6

$$MA = 6 \quad E = \frac{L}{6}$$

IMPORTANT POINTS

- ◆ In a fixed pulley, MA = 1 (only changes direction).
- ◆ In a pulley system, MA > 1 (reduces effort).
- ◆ More the supporting segments, greater the MA.
- ◆ Effort × distance moved by effort = Load × distance moved by load (Work is the same).
- ◆ In real machines (with friction), actual MA < ideal MA.



COMMON APPLICATIONS



Drawing water from a well



Hoisting flags on a pole



Cranes in construction



Lifting heavy objects

GENERAL FORMULAS

Mechanical Advantage:

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

Effort:

$$E = \frac{L}{MA}$$

SUMMARY CHART

Type of Pulley	Changes Direction	Reduces Effort	Ideal MA	Example
Fixed Pulley	Yes	No	1	Well pulley
Pulley System	No	Yes	> 1	Cranes, hoists

REMEMBER!



More pulleys
= More support segments
= Less effort!



INCLINED PLANE

An inclined plane is a sloping surface that is higher at one end. It helps us lift heavy loads with **less effort** by increasing the **distance** over which the **force** is applied.

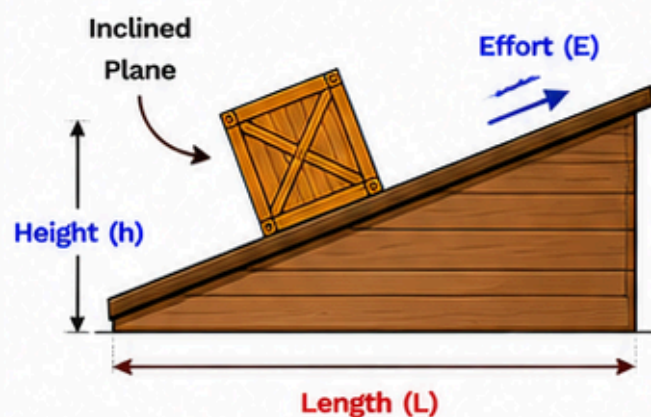
KEY IDEA

It reduces the effort needed to lift a load by increasing the distance over which the effort is applied.



WHAT IS AN INCLINED PLANE?

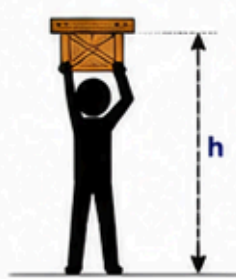
It is a simple machine in the form of a sloped surface. It allows us to raise a load to a certain height with **less effort**.



HOW DOES IT WORK?

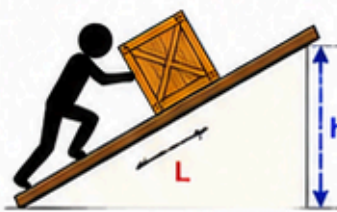
Instead of lifting the load vertically (height h), we push or pull it along the slope (length L). So, more distance is covered with less effort.

Lifting vertically



More Effort
Less Distance

Using inclined plane



Less Effort
More Distance

Work is the same in both cases (Ideal case).

ADVANTAGES

- ★ Reduces the effort required.
- ★ Makes lifting or moving heavy loads easier and safer.
- ★ Helpful in many daily life applications.

IDEAL INCLINED PLANE (No Friction)

In an ideal inclined plane (no friction):

$$MA = \frac{L}{h}$$

Where,

L = Length of the inclined plane

h = Height raised

MA = Mechanical Advantage

MECHANICAL ADVANTAGE (MA)

It tells us how many times the machine multiplies the effort.

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

Interpretation

- ▶ $MA > 1$ → Advantage (effort < load)
- ▶ $MA = 1$ → No advantage (effort = load)
- ▶ $MA < 1$ → Disadvantage (effort > load)

ACTUAL INCLINED PLANE (With Friction)

Due to friction, extra effort is required. So, actual MA is less than ideal MA.

$$\text{Actual MA} = \frac{\text{Load}}{\text{Effort}} < \frac{L}{h}$$

Remember!



Work Done (ideal) = Load $\times$ Height = Effort $\times$ Length
Therefore,

$$\text{Load} \times h = \text{Effort} \times L \quad (\text{in ideal case})$$

(Work in = Work out)

EXAMPLE

A load of 600 N is raised to a height of 3 m using an inclined plane of length 9 m. Find the effort required (ideal case).

Given:

Load (L) = 600 N

Height (h) = 3 m

Length (L) = 9 m

Effort (E) = ?

Solution:

$$MA = \frac{L}{h} = \frac{9}{3} = 3$$

$$\text{Effort} = \frac{\text{Load}}{MA} = \frac{600}{3}$$

Effort = 200 N

So, only 200 N effort is needed instead of 600 N.

REAL LIFE APPLICATIONS



Loading goods into a truck



Wheelchair ramps



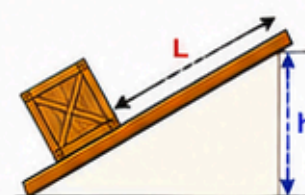
Mountain roads



Moving walkways

FACTORS AFFECTING THE ADVANTAGE

- Longer the length (L) for the same height (h), greater the mechanical advantage.
- Greater the height (h) for the same length (L), lesser the mechanical advantage.
- Friction reduces the actual mechanical advantage.



KEY POINTS

- ✓ Inclined plane is a simple machine with a sloping surface.
- ✓ It **reduces effort** by increasing the distance.
- ✓ Ideal $MA = \frac{L}{h}$ (No friction)
- ✓ Actual $MA <$ Ideal MA (Due to friction)
- ✓ Used in many daily life situations to make work easier.



FORMULA SUMMARY

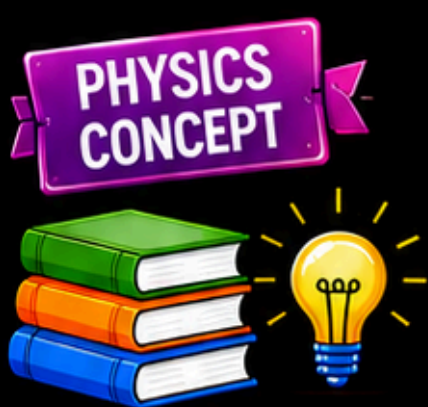
$$\begin{aligned} \text{Ideal MA} &= \frac{L}{h} \\ \text{Actual MA} &= \frac{\text{Load}}{\text{Effort}} \\ \text{Work (Ideal)} &= \text{Load} \times h = \text{Effort} \times L \\ \text{Efficiency } (\eta) &= \frac{\text{Actual MA}}{\text{Ideal MA}} \times 100\% \end{aligned}$$

MEMORY TIP



"Longer slope,
Less effort,
Same work,
Made easier!"





LEVER

& THREE CLASSES OF LEVERS

A lever is a simple machine that helps us lift or move loads with **less effort**.

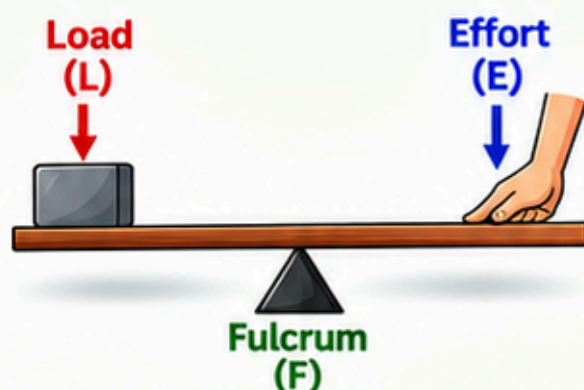
KEY IDEA

Levers make our work easier by changing the **magnitude** or **direction** of force.



WHAT IS A LEVER?

A lever is a **rigid bar** that can rotate around a fixed point called the **fulcrum**.



L = Load (the resistance to be overcome)
E = Effort (the force applied)
F = Fulcrum (the fixed point)

HOW DO LEVERS WORK?

- ✓ When we apply effort on the lever, it turns about the fulcrum.
- ✓ A small effort can balance or lift a large load.
- ✓ Levers can change the magnitude or direction of the effort.
- ✓ Levers follow the principle of moments.

PRINCIPLE OF MOMENTS

For a lever in equilibrium:

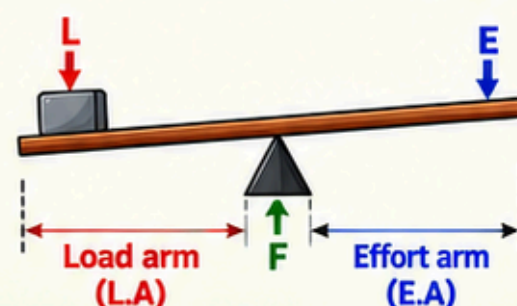
$$E \times E.A = L \times L.A$$

(Effort arm = Load arm when balanced)

PARTS OF A LEVER

A lever has three main parts:

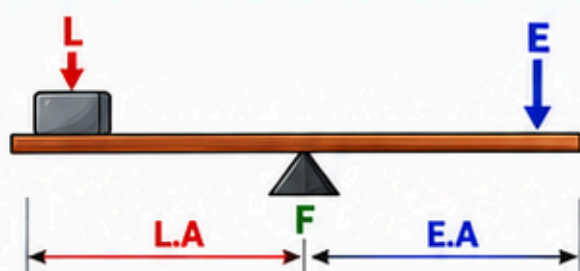
- **Load (L)** : The resistance that has to be overcome.
- **Effort (E)** : The force applied to the lever.
- **Fulcrum (F)** : The fixed point about which the lever turns.



THREE CLASSES OF LEVERS

1. FIRST CLASS LEVER

The fulcrum is between the load and the effort.



Examples:

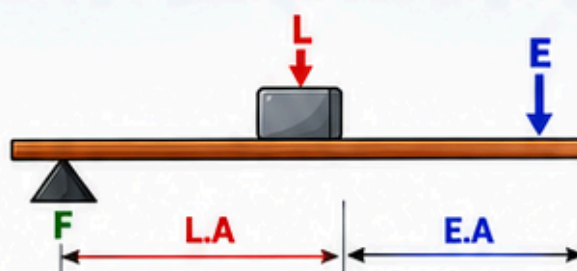


Mechanical Advantage:

MA can be > 1 , $= 1$ or < 1
 (Depends on the lengths of arms)

2. SECOND CLASS LEVER

The load is between the fulcrum and the effort.



Examples:



Mechanical Advantage:

MA is always greater than 1
 (MA > 1)

3. THIRD CLASS LEVER

The effort is between the fulcrum and the load.



Examples:



Mechanical Advantage:

MA is always less than 1
 (MA < 1)

COMPARISON OF LEVERS

Class	Position of Fulcrum (F)	Position of Load (L)	Position of Effort (E)	Mechanical Advantage
First Class	Between L and E	One side of F	Other side of F	> 1 , $= 1$ or < 1
Second Class	One end	Between F and E	Other end	> 1 (Always)
Third Class	One end	Other end	Between F and L	< 1 (Always)

IMPORTANT POINTS

- ✓ Levers make work easier.
- ✓ A longer effort arm gives more advantage.
- ✓ The principle of moments holds good for all levers.
- ✓ In ideal conditions (no friction),

$$MA = \frac{\text{Length of Effort Arm}}{\text{Length of Load Arm}}$$

REMEMBER!



- ★ First Class: F is in the middle.
- ★ Second Class: L is in the middle.
- ★ Third Class: E is in the middle.



ONLINE TEACHING
With Nikita



Understand
concepts,
apply **formulas**
and solve problems
step by step.



1. DISTANCE & DISPLACEMENT

- Distance is the total length of the actual path travelled.
- Displacement is the shortest distance from initial to final position in a given direction.



2. SPEED

- Speed is the distance travelled per unit time.

$$\text{Speed} = \frac{\text{Total Distance}}{\text{Total Time}}$$

SI Unit : m/s

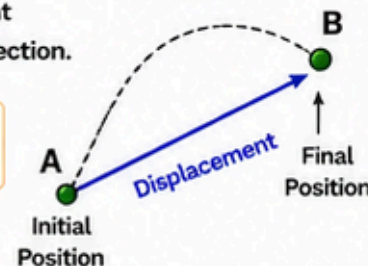


3. VELOCITY

- Velocity is the displacement per unit time in a given direction.

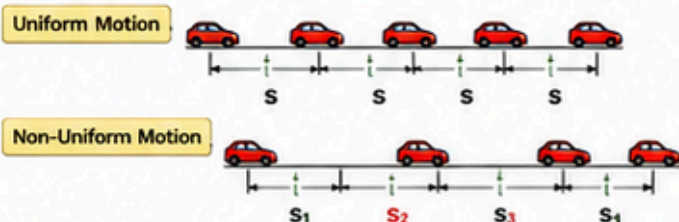
$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

SI Unit : m/s



4. UNIFORM & NON-UNIFORM MOTION

- Uniform Motion** : An object covers equal distances in equal intervals of time.
- Non-Uniform Motion** : An object covers unequal distances in equal intervals of time.



5. ACCELERATION

- Acceleration is the rate of change of velocity with time.

$$a = \frac{(v - u)}{t}$$

Where, u = Initial velocity
 v = Final velocity
 t = Time taken

SI Unit : m/s²



6. EQUATIONS OF MOTION

For uniformly accelerated motion:

$$1) \quad v = u + at$$

$$2) \quad s = ut + \frac{1}{2} at^2$$

$$3) \quad v^2 = u^2 + 2as$$

Where, u = Initial velocity
 v = Final velocity
 a = Acceleration, t = Time
 s = Displacement



7. KINETIC ENERGY

The energy possessed by a body due to its motion.

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

Where, m = Mass of the body
 v = Velocity of the body

SI Unit : Joule (J)



8. POTENTIAL ENERGY

The energy possessed by a body due to its position or state.

$$PE = mgh$$

Where, m = Mass of the body
 g = Acceleration due to gravity
($\approx 9.8 \text{ m/s}^2$)

h = Height

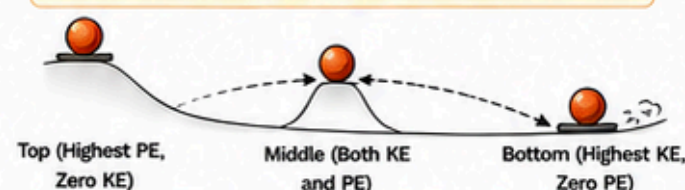
SI Unit : Joule (J)



9. CONSERVATION OF MECHANICAL ENERGY

In the absence of friction, the total mechanical energy of a system remains constant.

Mechanical Energy (ME)
= Kinetic Energy (KE) + Potential Energy (PE)
 $ME = KE + PE = \text{Constant}$



10. POWER

Power is the rate at which work is done or energy is transferred.

$$\text{Power} = \frac{\text{Work Done}}{\text{Time Taken}}$$

$$P = \frac{W}{t}$$

SI Unit : Watt (W)

1 Watt = 1 Joule / 1 second



11. SIMPLE MACHINES & MECHANICAL ADVANTAGE

Simple machines make our work easier. Mechanical Advantage (MA) tells us how many times the machine multiplies the effort.

$$MA = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

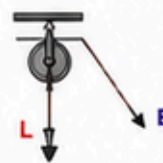
- $MA > 1 \rightarrow$ Advantage (Effort < Load)
- $MA = 1 \rightarrow$ No advantage (Effort = Load)
- $MA < 1 \rightarrow$ Disadvantage (Effort > Load)



12. PULLEY & PULLEY SYSTEM

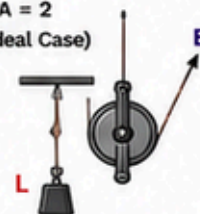
Fixed Pulley

- Changes the direction of effort.
- $MA = 1$



Movable Pulley

- Reduces the effort required.
- $MA = 2$ (Ideal Case)

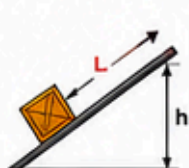


Pulley System

- Combination of fixed and movable pulleys.
- $MA = \text{Number of rope segments supporting the load (Ideal Case)}$

13. INCLINED PLANE

An inclined plane is a sloping surface used to raise loads to a height with less effort.



$$MA \text{ (Ideal, no friction)} = \frac{L}{h}$$

Where, L = Length of the incline
 h = Height raised

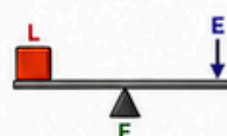
Actual $MA < \frac{L}{h}$ (Due to friction)

14. LEVER & THREE CLASSES OF LEVERS

Principle of Moments : Effort arm $\times$ Effort = Load arm $\times$ Load
 $E \times EA = L \times LA$

Class	Position of Fulcrum (F)	Position of Load (L)	Position of Effort (E)	Examples
First Class	Between L & E	One side of F	Other side of F	Scissors, Seesaw
Second Class	One end	Between F & E	Other end	Wheelbarrow, Nutcracker
Third Class	One end	Other end	Between F & L	Tweezers, Fishing rod

Lever Parts



L = Load (Resistance)
 E = Effort (Applied Force)
 F = Fulcrum (Fixed Point)

15. IMPORTANT POINTS

- ★ Motion is change in position with time.
- ★ Scalar quantities: mass, speed, distance, energy, power.
- ★ Vector quantities: displacement, velocity, acceleration.
- ★ In the absence of friction, mechanical energy is conserved.
- ★ Simple machines reduce the effort and make work easier.

