Chapter 3: Machines

◆ What is a Machine?

- A **machine** is a device that makes work easier by **multiplying force**, **changing the direction of effort**, or **increasing speed**.
- In physics, a machine receives an **input (effort)** and transfers it to an **output (load)**.

◆ Types of Simple Machines

1. **Lever**
2. **Wheel and Axle**
3. **Pulley**
4. **Inclined Plane**
5. **Wedge**
6. **Screw**

◆ Functions of Machines

1. **Force Multiplier** – Lifts heavy loads with less effort (e.g., jack, spade).
2. **Change Point of Application** – Applies effort at a convenient position (e.g., bicycle pedal).
3. **Change Direction of Effort** – Makes work easier (e.g., pulley for drawing water).
4. **Gain in Speed** – Small effort movement causes large load movement (e.g., scissors, tongs).

◆ Key Terms

- **Load (L):** The object lifted/resisted (Unit: Newton)
- **Effort (E):** The force applied to do work (Unit: Newton)
- **Mechanical Advantage (MA):**
  MA=$\frac{Load}{Effort}$
  No unit.

- **Velocity Ratio (VR):**

$$VR=\frac{Displacement\ of\ Effort}{Displacement\ of\ Load}$$

  No unit.
- **Efficiency (η):**

$$\eta = \frac{Work\ Output}{work\ input} \times 100\%$$

OR

$$\eta=\frac{MA}{VR}\times 100\%$$

◆ Types of Machines Based on MA and VR

Case	Mechanical Advantage	Use
MA > 1	Force Multiplier	e.g., jack
MA < 1	Gain in Speed	e.g., scissors
MA = 1	Change in Direction	e.g., single fixed pulley

A machine **cannot be** a force multiplier and speed multiplier at the same time.

◆ Work in Machines

- **Work Input** = Effort × Distance moved by effort
- **Work Output** = Load × Distance moved by load
- In **ideal machines**, Input = Output, so efficiency = 100%.

◆ Levers

- A **lever** is a rigid bar that pivots around a fixed point called a **fulcrum**.
- Works on the **principle of moments**:
  Load×Load Arm = Effort×Effort Arm

◆ Types of Levers

Type	Arrangement	Example	MA
Class I	Fulcrum in between	Seesaw, scissors	<, =, or > 1
Class II	Load in between	Nut cracker, wheelbarrow	Always > 1
Class III	Effort in between	Tongs, spade, fishing rod	Always < 1

◆ Levers in the Human Body

- **Class I**: Nodding head (spine = fulcrum)
- **Class II**: Standing on toes (toes = fulcrum)
- **Class III**: Lifting with forearm (elbow = fulcrum)

◆ Pulleys

◆ Single Fixed Pulley:

- MA = 1, VR = 1 → Changes direction only
- Efficiency < 100% due to friction

◆ Single Movable Pulley:

- MA = 2, VR = 2 → Force multiplier
- Efficiency = ~100% (ideal case)

◆ Pulley Systems:

1. **One Fixed + One Movable**
    - MA = 2^n (n = number of movable pulleys)
    - VR = 2^n
2. **Block and Tackle**
    - MA = Total number of pulleys
    - VR = Number of strands supporting the load

◆ Key Formulas Recap

Concept	Formula
Mechanical Advantage	MA= $\frac{L}{E}$
Velocity Ratio	VR=$\frac{dE}{dL}$
Efficiency	η=$\frac{MA}{VR}$×100%
Principle of Lever	L × LA = E × EA