



# MP - PSC

State Civil Services

**PRE**

**Madhya Pradesh Public Service Commission**

**Volume - 6**

**Science and Technology**



# MP-PSC PRE

## SCIENCE & TECH

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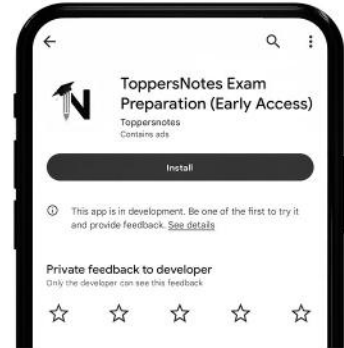
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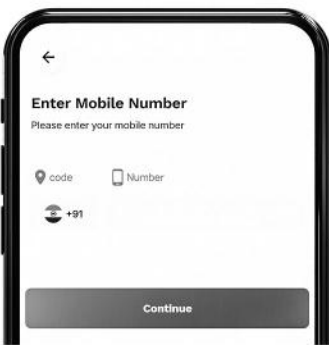
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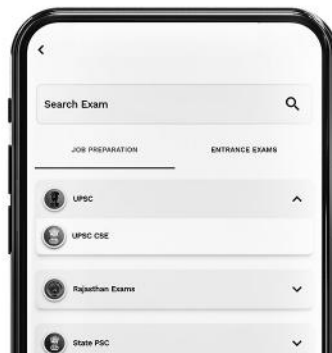
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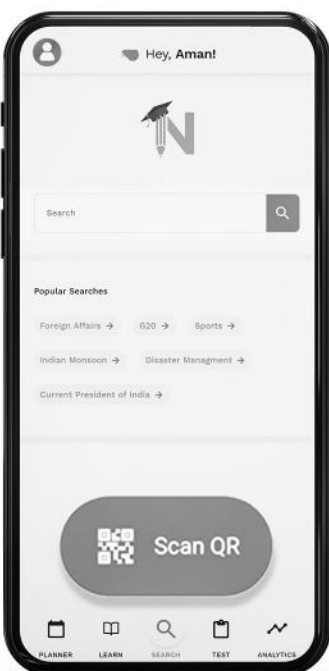
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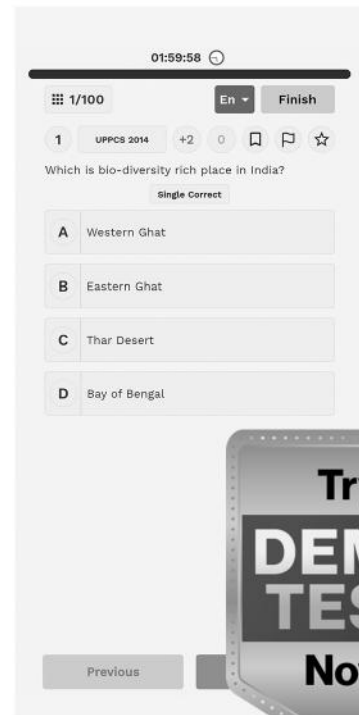
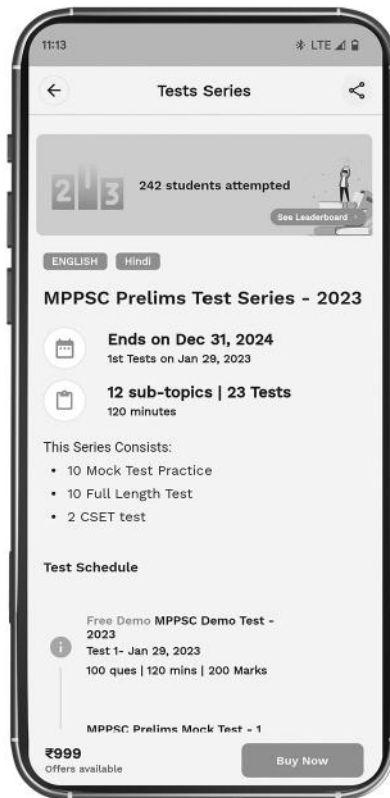
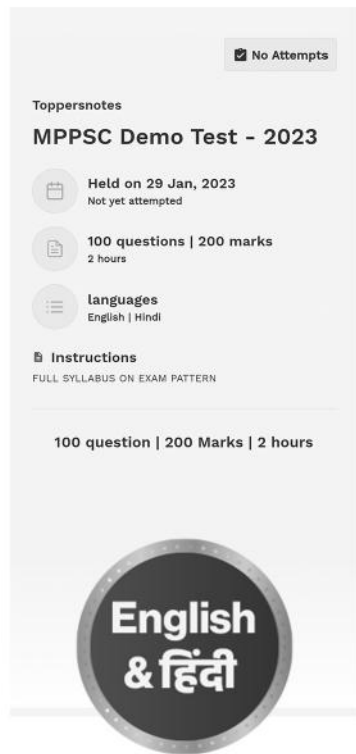
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# 1 CHAPTER

# Work, Power and Energy

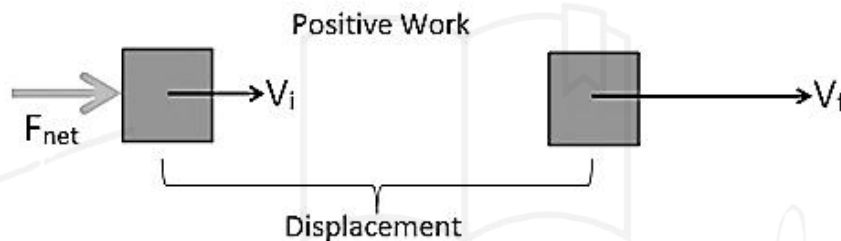


## Work

- When a **force acts on an object** → **displacement**, force has **done work** on the object.
- **2 conditions** need to be satisfied for work to be done:
  - A **force should act** on object
  - The **object** must be **displaced**
- **Work = Force x Displacement**
- **Unit- Joule**
- **1 Joule work** is said to be done **when 1 Newton force** is applied on an object and it shows the **displacement by 1 meter**.

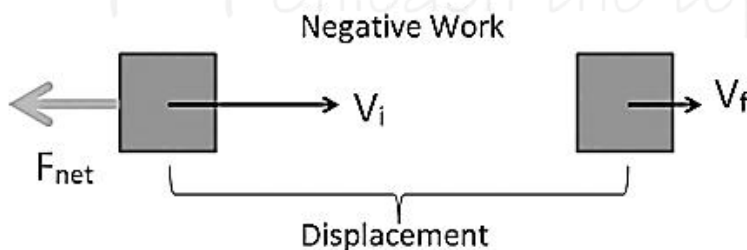


## Positive work



- When **force and displacement** are in **same direction**
- **Eg:** :a baby pulling a toy car parallel to the ground.
- **Work done** = product of the force and displacement.

## Negative work



- When **force and displacement** are in **opposite direction**.
- **Eg.** work done by the frictional force, when we walk.

## Power

### What is Power ?

- We can **define power** as the **rate of doing work**, it is the **work done in unit time**.
- The **SI unit** of power is **Watt (W)** which is **joules per second (J/s)**.
- Sometimes the **power** of **motor vehicles** and **other machines** is given in terms of **Horsepower (hp)**, which is **approximately equal to 745.7 watts**.

### What is Average Power ?

- We can define average power as the **total energy consumed divided by the total time taken**.
- In simple language, we can say that **average power** is the **average amount of work done or energy converted per unit of time**.

## Power Formula

- **Power** is defined as the **rate at which work is done** upon an object.
- **Power** is a **time-based quantity**.
- Which is **related to how fast a job is done**.
- The **formula** for power is mentioned below.
  - **Power = Work / time (P = W / t)**

## Unit of Power

- The **unit for standard metric work** is the **Joule** and the **standard metric unit for time** is the **second**, so the **standard metric unit for power** is a **Joule / second**, defined as a **Watt** and **abbreviated W**.

## Energy

- **Capacity** of a body to do work.
- **SI unit:** Joule (J).
- Forms
  1. **Kinetic Energy**
    - Energy possessed by a body due to its motion.
    - Increases with speed.
    - Kinetic energy of body moving with a certain velocity = work done on it to make it acquire that velocity
  2. **Potential Energy**
    - Energy possessed by a body due to its position or shape.

### Gravitational Potential Energy: (GP)

- **When an object is raised against gravity.**
- **Energy possessed by such object** is gravitational potential energy.

## Conservation of Energy or the first law of thermodynamics:

- **Energy can neither be created nor destroyed** but only **changed from one form to another**.
- **Total energy before and after transformation** always **remains constant**.

## Force

- An **external agent** capable of **changing state** of rest or **motion** of a particular body.
- Has both **magnitude** and **direction**.
- **Measured** using a **spring balance**.
- **SI unit:** Newton(N) or Kgm/s<sup>2</sup>.
- **Effects:**
  - Can **make a body move from rest**
  - Can **stop a moving body** or slow it down.
  - Can **accelerate speed** of a moving body.
- **Formula:**  $F = ma$   
Where, m = mass, a = acceleration

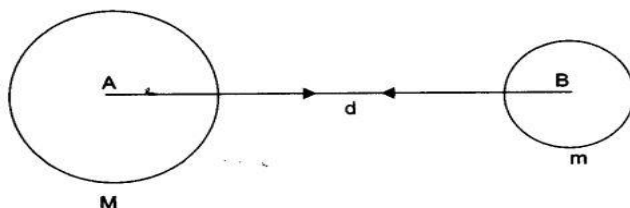


## Gravitational Force

- **Force that attracts a body towards centre** of earth, or **towards any other physical body** having mass.
- **Every object** that has **mass exerts a gravitational pull** or force on every other mass.
- **Strength** of this pull **depends on the masses of objects**
- **Gets weaker** with **distance**.
- **Keeps planets in orbit** around sun and moon around the Earth
- **First discovered** in 1687 by Sir Isaac **Newton**.

## Universal law of gravitation:

- Every object in the universe **attracts** every **other object with a force** which is **proportional to the product** of their **masses** and **inversely proportional** to the **square** of the **distance** between them.
- The **force is along the line joining the centres of two objects**.



Gravitational force between two uniform objects is directed along the line joining their centres.

**Formula:**

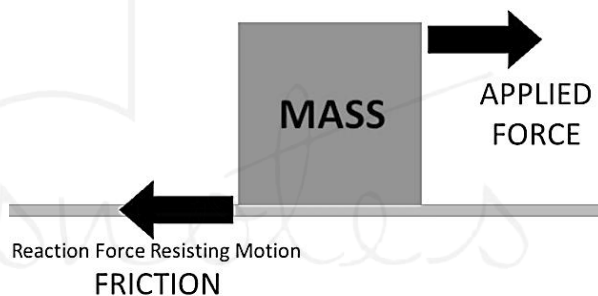
$$F = \frac{G \times M \times m}{d^2}$$

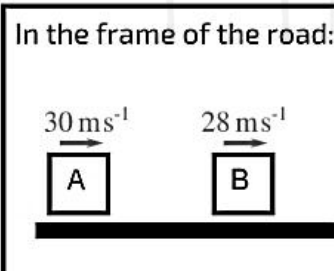
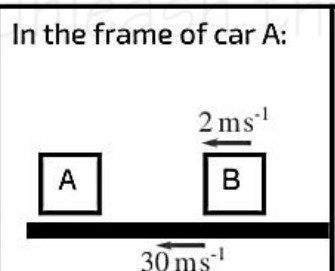
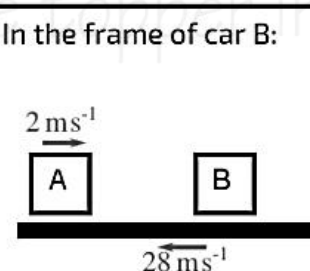
- Here M and m = masses of the objects interacting
- d- distance between the center of the masses
- G -gravitational constant ( $6.674 \times 10^{-11} \text{ m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}$ )

## Friction

- **Friction force:** The **external force that opposes relative motion** between 2 surfaces in contact.
- **Friction acts on the surface of contact** of both the bodies.

**Relative motion:** When one **object moves relative to another** it is called a relative motion.



In the frame of the road:	In the frame of car A:	In the frame of car B:
		

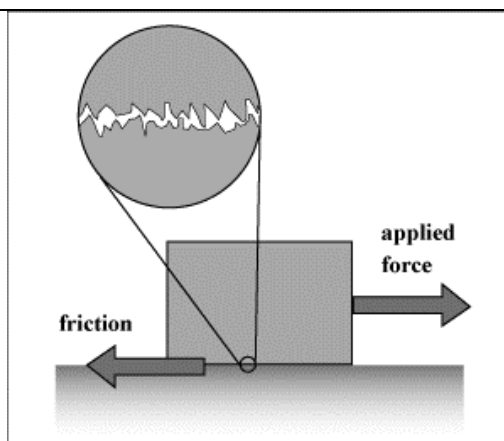
## Causes of Friction

### Surface irregularities

- All surfaces when **zoomed into a microscopic level** contain **hills and valleys** that **interlock** when they **move or rub on top of each other**.
- This **unevenness** of the **surface** is called as **surface irregularities** or **roughness**.
- **Rough surfaces** have **larger irregularities** while **smoother surfaces** have **lesser irregularities**.

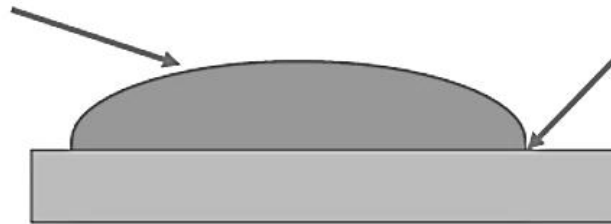
### Adhesive forces

- When **two surfaces** are **in contact** they start to **form bonds** and begin to **stick to each other**. This **phenomenon** is called as **Adhesion**.
- When we try to **move objects** that are on **top of another**, we are **basically breaking the bonds or overcoming the adhesive forces**.





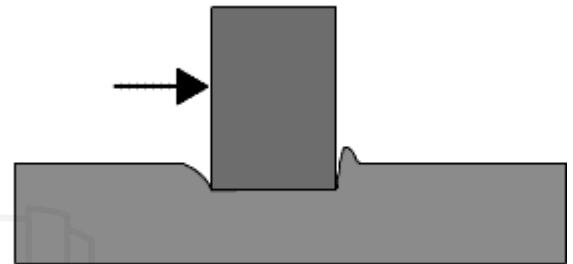
**Cohesive forces** is the attraction forces between the water molecules. This causes fluids to form round shapes where the molecules can be as closely packed together as possible.



**Adhesive forces** are the forces which attract the water molecules to other surfaces causing them to stick.

### Plowing effect

- When **surfaces** are **soft** or can **change their shape easily**, they **get deformed** when they come in contact with another object.
- **Ex:** carpets, when a heavy object is placed on them, it looks like a valley that is caused by the deformation of the shape.
- This **effect** of the **surfaces sinking** into each other is **known as Plowing effect**.



### Factors Affecting Friction

**Depends on the nature of surfaces in contact.** (Friction exists between two surfaces) E.g.: glass and rubber

#### Nature of surface in contact

- **Friction depends on how hard the two surfaces pressed together**, as **more surface in contact** and **more bonds** are formed → more bonds to break → means **more friction**.
- **Only the normal reaction force** (exactly perpendicular) to the two surfaces **increases friction**.

### Atmospheric pressure

- The **weight** of a **column** of air contained in a **unit area** from the **mean sea level** to the **top** of the **atmosphere** is called the **atmospheric pressure**.
- It is **measured** in force per unit area.
- It is **expressed** in 'milibar' or **mb unit**.
- In the **application level**, the **atmospheric pressure** is stated in **kilo-pascals**.
- It is **measured** by the **aneroid barometer** or **mercury barometer**.
- In the **lower atmosphere**, the **pressure declines rapidly** with height.
- The vertical pressure gradient force is much **larger than** that of the **horizontal pressure gradient** and is **commonly balanced** by an **almost equal but opposite** gravitational force.
- The **low-pressure system** is **encircled** by **one or more isobars** with the **lowest pressure** at the centre.
- The **high-pressure system** is also **encircled** by **one or more isobars** with the **highest pressure** in the centre.
- **Isobars** are **lines connecting** places **having equal pressure**.

# 2 CHAPTER

# Units and Measurements

## Mass

- **Quantity of matter** contained in a **body**.
- A **scalar** quantity.
- **Unit** - kilogram.
- A body **contains** the **same quantity** of **matter** whether it be on the **earth, moon** or even in **outer space**. Thus, **mass** is **constant** and **does not change** from place to place.
- **Denoted** by the small letter '**m**'.
- **Cannot be zero**.



## Weight

- Measure of **force of gravity** acting on a body.
- **Formula** :  $w = mg$
- **Unit**- Newton (as it is a force).
- **Vector** quantity



### Difference between Mass and Weight

Mass	Weight
<ul style="list-style-type: none"> <li>• <b>Quantity of matter</b> possessed by a body</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Force</b> with which a <b>body</b> is <b>attracted</b> towards the <b>centre</b> of the earth.</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Scalar</b> quantity.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Vector</b> quantity.</li> </ul>
<ul style="list-style-type: none"> <li>• S.I. unit - <b>kilogram</b> (kg.)</li> </ul>	<ul style="list-style-type: none"> <li>• S.I. unit - <b>Newton</b> (N).</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Remains constant</b> at all places</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Changes</b> from place to place.</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Never zero</b>.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Becomes zero</b> at the centre of the earth.</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Measured</b> by a <b>beam balance</b>.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Measured</b> by a <b>spring balance</b>.</li> </ul>

### Every measurement has two parts.

- The **first** is a **number** (n) and the **next** is a **unit** (u).
- **Q = nu**.
- **For Example**, the **length** of an **object** = **40 cm**.
- The **number** **expressing** the **magnitude** of a **physical quantity** is **inversely proportional** to the **unit** **selected**.
- If **n1** and **n2** are the **numerical values** of a **physical quantity** corresponding to the **units u1** and **u2**, then **n1u1 = n2u2**.
- **For Example**,
  - 2.8 m = 280 cm
  - 6.2 kg = 6200 g.

## Fundamental Quantities

The **quantities** that are **independent** of **other quantities** are called **fundamental quantities**.

- The **units** that are **used** to **measure** these **fundamental quantities** are called **fundamental units**.
- There are **four systems** of **units** namely
  - C.G.S,
  - M.K.S,
  - F.P.S,
  - SI.
- The **quantities** that are **derived** using the **fundamental quantities** are called **derived quantities**.
- The **units** that are **used** to **measure** these **derived quantities** are called **derived units**.

## Fundamental and Supplementary Physical Quantities in SI system

Fundamental Quantity	System of units		
	C.G.S.	M.K.S.	F.P.S.
Length	centimeter	Meter	foot
Mass	gram	Kilogram	pound
Time	second	Second	second

Physical quantity	Unit	Symbol
Length	Meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Intensity of light	candela	cd
Quantity of substance	mole	mol

### SI Units

- Most SI units are used in scientific research.
- SI is a coherent system of units.

### Coherent System Of Units

- A coherent system of units is **one in which the units of derived quantities are obtained as multiples or submultiples of certain basic units.**
- **SI system** is a **comprehensive, coherent and rationalized** M.K.S. Ampere system (RMKSA system) and was devised by **Prof. Giorgi.**
- **Meter:** A meter is equal to **1650763.73 times the wavelength of the light emitted in vacuum due to electronic transition from 2p<sub>10</sub> state to 5d<sub>5</sub> state in Krypton-86.**
  - But in **1983, 17th General Assembly of weights and measures adopted a new definition for the meter in terms of velocity of light.**
  - According to this definition, a **meter is defined as the distance traveled by light in vacuum during a time interval of 1/299, 792, 458 of a second.**
- **Kilogram:** The **mass of a cylinder of platinum-iridium alloy kept in the International Bureau of weights and measures preserved at Sèvres near Paris is called one kilogram.**
- **Second:** The **duration of 9192631770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of cesium-133 atoms is called one second.**
- **Ampere:** The **current which when flowing in each of two parallel conductors of infinite length and negligible cross-section and placed one meter apart in vacuum, causes each conductor to experience a force of  $2 \times 10^{-7}$  newtons per meter of length is known as one ampere.**
- **Kelvin:** The **fraction of 1/273.16 of the thermodynamic temperature of the triple point of water is called Kelvin.**
- **Candela:** The **luminous intensity in the perpendicular direction of a surface of a black body of area 1/600000 m<sup>2</sup> at the temperature of solidifying platinum under a pressure of 101325 Nm<sup>-2</sup> is known as one candela.**
- **Mole:** The **amount of a substance of a system which contains as many elementary entities as there are atoms in  $12 \times 10^{-3}$  kg of carbon-12 is known as one mole.**
- **Radian:** The **angle made by an arc of the circle equivalent to its radius at the center is known as radian.**
  - **1 radian = 57°17'45".**
- **Derived SI units with Special Names:**

Physical quantity	SI unit	Symbol
Frequency	hertz	Hz
Energy	joule	J
Force	newton	N
Power	watt	W
Pressure	pascal	Pa
Electric charge or quantity of electricity	coulomb	C
Electric potential difference and emf	volt	V
Electric resistance	ohm	$\Omega$
Electric conductance	siemen	S
Electric capacitance	farad	F
Magnetic flux	weber	Wb
Inductance	henry	H
Magnetic flux density	tesla	T
Illumination	lux	Lx
Luminous flux	lumen	Lm

### Dimensional Formulas for Physical Quantities

Physical quantity	Unit	Dimensional formula
Acceleration or acceleration due to gravity	$\text{ms}^{-2}$	$\text{LT}^{-2}$
Angle (arc/radius)	rad	$\text{M}^0\text{L}^0\text{T}^0$
Angular displacement	rad	$\text{M}^0\text{L}^0\text{T}^0$
Angular frequency (angular displacement/time)	$\text{rads}^{-1}$	$\text{T}^{-1}$
Angular impulse (torque x time)	Nms	$\text{ML}^2\text{T}^{-1}$
Angular momentum (lw)	$\text{kgm}^2\text{s}^{-1}$	$\text{ML}^2\text{T}^{-1}$
Angular velocity (angle/time)	$\text{rads}^{-1}$	$\text{T}^{-1}$
Area (length x breadth)	$\text{m}^2$	$\text{L}^2$
Boltzmann's constant	$\text{JK}^{-1}$	$\text{ML}^2\text{T}^{-2}\theta^{-1}$
Bulk modulus	$\text{Nm}^{-2}$ , Pa	$\text{M}^1\text{L}^{-1}\text{T}^{-2}$
Calorific value	$\text{Jkg}^{-1}$	$\text{L}^2\text{T}^{-2}$
Coefficient of linear or areal or volume expansion	$^{\circ}\text{C}^{-1}$ or $\text{K}^{-1}$	$\theta^{-1}$
Coefficient of surface tension (force/length)	$\text{Nm}^{-1}$ or $\text{Jm}^{-2}$	$\text{MT}^{-2}$
Coefficient of thermal conductivity	$\text{Wm}^{-1}\text{K}^{-1}$	$\text{MLT}^{-3}\theta^{-1}$
Coefficient of viscosity	poise	$\text{ML}^{-1}\text{T}^{-1}$
Compressibility (1/bulk modulus)	$\text{Pa}^{-1}$ , $\text{m}^2\text{N}^{-2}$	$\text{M}^{-1}\text{LT}^2$
Density (mass / volume)	$\text{kgm}^{-3}$	$\text{ML}^{-3}$
Displacement, wavelength, focal length	m	L
Electric capacitance (charge/potential)	$\text{CV}^{-1}$ , farad	$\text{M}^{-1}\text{L}^{-2}\text{T}^4\text{I}^2$
Electric conductance (1/resistance)	$\text{Ohm}^{-1}$ or mho or siemen	$\text{M}^{-1}\text{L}^{-2}\text{T}^3\text{I}^2$
Electric conductivity (1/resistivity)	siemen/metre or $\text{Sm}^{-1}$	$\text{M}^{-1}\text{L}^{-3}\text{T}^3\text{I}^2$
Electric charge or quantity of electric charge	coulomb	IT
Electric current	ampere	I
Electric dipole moment (charge x distance)	Cm	LTI
Electric field strength or Intensity of electric field (force/charge)	$\text{NC}^{-1}$ , $\text{Vm}^{-1}$	$\text{MLT}^{-3}\text{I}^{-1}$
Electric resistance	ohm	$\text{ML}^2\text{T}^{-3}\text{I}^{-2}$
Emf (or) electric potential (work/charge)	volt	$\text{ML}^2\text{T}^{-3}\text{I}^{-1}$
Energy (capacity to do work)	joule	$\text{ML}^2\text{T}^{-2}$
Energy density	$\text{Jm}^{-3}$	$\text{ML}^{-1}\text{T}^{-2}$
Entropy	$\text{J}\theta^{-1}$	$\text{ML}^2\text{T}^{-2}\theta^{-1}$
Force (mass x acceleration)	newton (N)	$\text{MLT}^{-2}$
Force constant or spring constant (force/extension)	$\text{Nm}^{-1}$	$\text{MT}^{-2}$
Frequency (1/period)	Hz	$\text{T}^{-1}$

Gravitational potential (work/mass)	$\text{Jkg}^{-1}$	$\text{L}^2\text{T}^{-2}$
Heat (energy)	J or calorie	$\text{ML}^2\text{T}^{-2}$
Illumination (Illuminance)	lux (lumen/metre <sup>2</sup> )	$\text{MT}^{-3}$
Impulse (force x time)	Ns or kgms <sup>-1</sup>	$\text{MLT}^{-1}$
Inductance (L) or coefficient of self-induction	henry (H)	$\text{ML}^2\text{T}^{-2}\text{I}^{-2}$
Intensity of gravitational field (F/m)	$\text{Nkg}^{-1}$	$\text{L}^1\text{T}^{-2}$
Intensity of magnetization (I)	$\text{Am}^{-1}$	$\text{L}^{-1}\text{I}$
Joule's constant or mechanical equivalent of heat	$\text{Jcal}^{-1}$	$\text{M}^0\text{L}^0\text{T}^0$
Latent heat ( $Q = mL$ )	$\text{Jkg}^{-1}$	$\text{M}^0\text{L}^2\text{T}^{-2}$
Linear density (mass per unit length)	$\text{kgm}^{-1}$	$\text{ML}^{-1}$
Luminous flux	lumen or ( $\text{Js}^{-1}$ )	$\text{ML}^2\text{T}^{-3}$
Magnetic dipole moment	$\text{Am}^2$	$\text{L}^2\text{I}$
Magnetic flux (magnetic induction x area)	weber (Wb)	$\text{ML}^2\text{T}^{-2}\text{I}^{-1}$
Magnetic induction ( $F = Bi$ )	$\text{NI}^{-1}\text{m}^{-1}$ or T	$\text{MT}^{-2}\text{I}^{-1}$
Magnetic pole strength (unit: ampere-meter)	Am	$\text{LI}$
Modulus of elasticity (stress/strain)	$\text{Nm}^{-2}$ , Pa	$\text{ML}^{-1}\text{T}^{-2}$
Moment of inertia (mass x radius <sup>2</sup> )	$\text{kgm}^2$	$\text{ML}^2$
Momentum (mass x velocity)	$\text{kgms}^{-1}$	$\text{MLT}^{-1}$
Permeability of free space	$\text{Hm}^{-1}$ or $\text{NA}^{-2}$	$\text{MLT}^{-2}\text{I}^{-2}$
Permittivity of free space	$\text{Fm}^{-1}$ or $\text{C}^2\text{N}^{-1}\text{m}^{-2}$	$\text{M}^{-1}\text{L}^{-3}\text{T}^4\text{I}^2$
Planck's constant (energy/frequency)	Js	$\text{ML}^2\text{T}^{-1}$
Poisson's ratio (lateral strain/longitudinal strain)	—	$\text{M}^0\text{L}^0\text{T}^0$
Power (work/time)	$\text{Js}^{-1}$ or watt (W)	$\text{ML}^2\text{T}^{-3}$
Pressure (force/area)	$\text{Nm}^{-2}$ or Pa	$\text{ML}^{-1}\text{T}^{-2}$
Pressure coefficient or volume coefficient	$^{\circ}\text{C}^{-1}$ or $\theta^{-1}$	$\theta^{-1}$
Pressure head	m	$\text{M}^0\text{L}^1\text{T}^0$
Radioactivity	Disintegrations per second	$\text{M}^0\text{L}^0\text{T}^{-1}$
Ratio of specific heats	—	$\text{M}^0\text{L}^0\text{T}^0$
Refractive index	—	$\text{M}^0\text{L}^0\text{T}^0$
Resistivity or specific resistance	-m	$\text{ML}^3\text{T}^{-3}\text{I}^{-2}$
Specific conductance or conductivity (1/specific resistance)	siemen/metre or $\text{Sm}^{-1}$	$\text{M}^{-1}\text{L}^{-3}\text{T}^3\text{I}^2$
Specific entropy (1/entropy)	$\text{KJ}^{-1}$	$\text{M}^{-1}\text{L}^{-2}\text{T}^2\theta$
Specific gravity	—	$\text{M}^0\text{L}^0\text{T}^0$
Specific heat ( $Q = mst$ )	$\text{Jkg}^{-1}\theta^{-1}$	$\text{M}^0\text{L}^2\text{T}^{-2}\theta^{-1}$
Specific volume (1/density)	$\text{m}^3\text{kg}^{-1}$	$\text{M}^{-1}\text{L}^3$
Speed (distance/time)	$\text{ms}^{-1}$	$\text{LT}^{-1}$
Stefan's constant	$\text{Wm}^{-2}\theta^{-4}$	$\text{ML}^0\text{T}^{-3}\theta^{-4}$
Strain (change in dimension/original dimension)	—	$\text{M}^0\text{L}^0\text{T}^0$
Stress (restoring force/area)	$\text{Nm}^{-2}$ or Pa	$\text{ML}^{-1}\text{T}^{-2}$
Surface energy density (energy/area)	$\text{Jm}^{-2}$	$\text{MT}^{-2}$
Temperature	$^{\circ}\text{C}$ or $\theta$	$\text{M}^0\text{L}^0\text{T}^0\theta$
Temperature gradient	$^{\circ}\text{Cm}^{-1}$ or $\theta\text{m}^{-1}$	$\text{M}^0\text{L}^{-1}\text{T}^0\theta$
Thermal capacity (mass x specific heat)	$\text{J}\theta^{-1}$	$\text{ML}^2\text{T}^{-2}\theta^{-1}$
Time period	second	T
Torque or moment of force (force x distance)	Nm	$\text{ML}^2\text{T}^{-2}$
Universal gas constant (work/temperature)	$\text{Jmol}^{-1}\theta^{-1}$	$\text{ML}^2\text{T}^{-2}\theta^{-1}$
Universal gravitational constant	$\text{Nm}^2\text{kg}^{-2}$	$\text{M}^{-1}\text{L}^3\text{T}^{-2}$
Velocity (displacement/time)	$\text{ms}^{-1}$	$\text{LT}^{-1}$
Velocity gradient ( $dv/dx$ )	$\text{s}^{-1}$	$\text{T}^{-1}$
Volume (length x breadth x height)	$\text{m}^3$	$\text{L}^3$
Water equivalent	kg	$\text{ML}^0\text{T}^0$
Work (force x displacement)	J	$\text{ML}^2\text{T}^{-2}$

# 3 CHAPTER

# Motion

## Motion

- An **object** is said to be in **motion** if it **changes its position with time**.
- A **body which does not move** is said to be at **rest, motionless, or stationary**.
- An **object's state of motion or rest cannot change unless it is acted upon by a force**.
- Described in terms of **displacement, velocity, and displacement**.

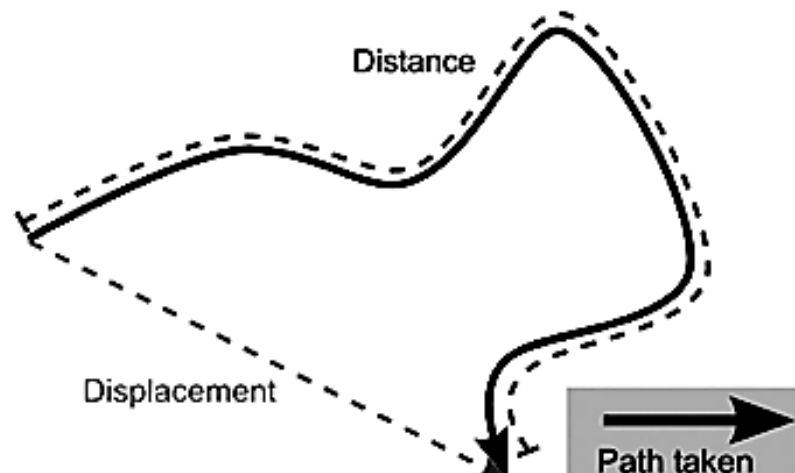


## Types of Motion

<b>Rotary Motion</b>	<ul style="list-style-type: none"> <li>• Anything <b>that moves in a circle</b>.</li> <li>• <b>Example:</b> spinning wheel on which people spun wool, working of car's engine</li> <li>• <b>Applications: rotary actuators</b> are used across a wide range of industries and can be electric, pneumatic and hydraulic options.</li> </ul>
<b>Oscillating Motion</b>	<ul style="list-style-type: none"> <li>• <b>Back and forth oscillation</b> causes this motion</li> <li>• If a <b>thing repeats the motion cycle</b> after a certain period is considered to be oscillating.</li> <li>• <b>Example:</b> sprinkler system, the pendulum of a clock, sound waves.</li> </ul>
<b>Linear Motion</b>	<ul style="list-style-type: none"> <li>• If <b>something moves in a straight line</b> like linear actuators then it is linear motion</li> <li>• <b>Time moves in a linear fashion</b>.</li> <li>• <b>Eg:</b> linear cylinders in electric, pneumatic or hydraulic options</li> <li>• <b>Application:</b> automation, manufacturing, robotics.</li> </ul>
<b>Uniform motion</b>	<ul style="list-style-type: none"> <li>• When an <b>object covers equal distances in equal intervals of time</b>.</li> </ul>
<b>Non-uniform motion</b>	<ul style="list-style-type: none"> <li>• When an <b>object covers unequal distances in equal intervals of time</b>.</li> </ul>

## Displacement

- **Shortest distance from the initial to the final position** of the object.
- **Represents the length and direction of the straight path**.
- **Vector quantity** as it has **both magnitude and direction**



## Distance

- **Scalar quantity** measuring only the length of path.

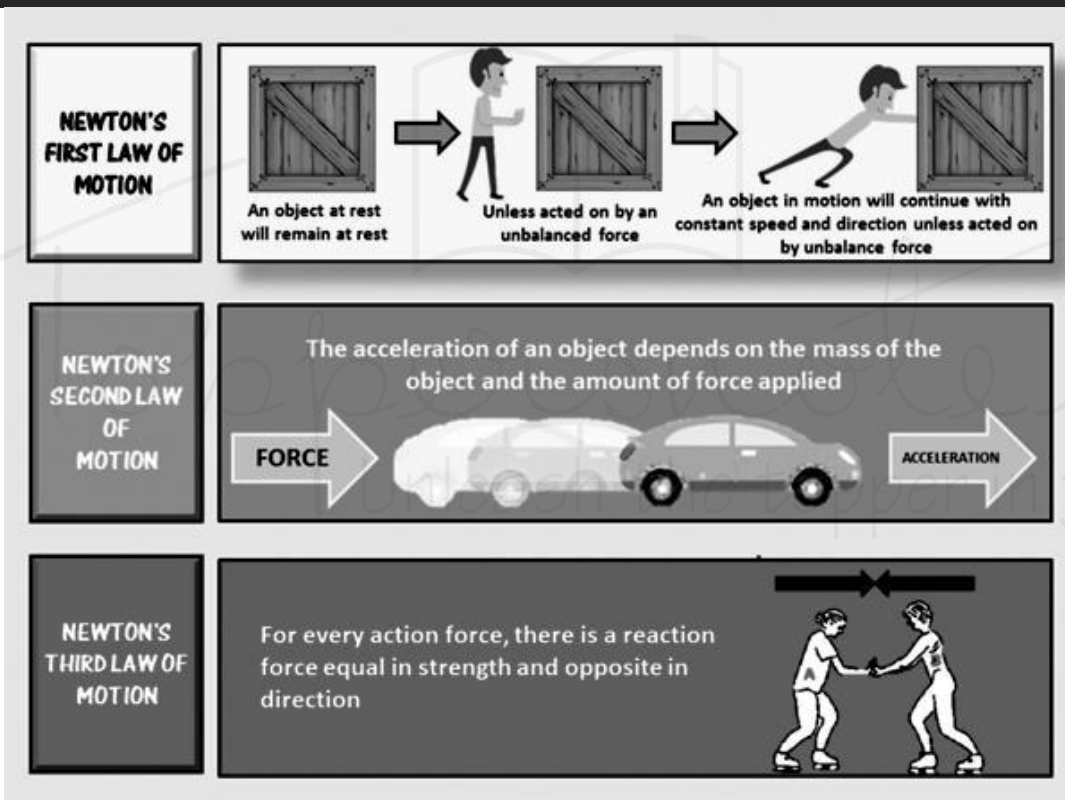
## Velocity

- **Speed in a given direction.**
- Describes only **how fast** an **object** is **moving** and **direction** of object's **motion**
- A **vector quantity**.
- **Unit** - meter per second (m/s).

## Acceleration

- **Rate of change of velocity with time.**
- **Rate** at which an **object speeds up** or **slows down**.
- **Positive Acceleration:** If the object speeds up.
- **Negative Acceleration:** If the object slows down.
- A **vector quantity**.
- **SI unit:** meter per second squares (m/s<sup>2</sup>).

## Laws of Motion



### Inertia:

- **Resistance** of any physical object to **any change in its velocity**.
- **Includes changes** to the **object's speed**, or **direction of motion**.
- **Tendency of objects** to **keep moving** in a **straight line** at a **constant speed** or to **remain** in state of **rest** when **no forces** act upon them, according to the first law of motion.

# 4 CHAPTER

# Sound

## SOUND

- A form of energy which produces a sensation of hearing in our ears.
- Produced due to vibration of different objects.
- Propagate as compressions & rarefactions in medium - longitudinal waves.
- Mechanical waves- need a material medium to travel.
- Medium: Matter or material through which sound propagates



## Medium of Propagation

- Sound is a sequence of waves of pressure which propagates through compressible media such as air or water.
- During their propagation, waves can be reflected, refracted, or attenuated by the medium.
- The purpose of this experiment is to examine what effect the characteristics of the medium have on sound.

## Ground Wave or Surface Wave Propagation

- A ground wave travels along the surface of the earth.
- These waves are vertically polarized.
- So, vertical antennas are useful for these waves. If a horizontally polarized wave is propagated as a ground wave, due to the conductivity of the earth, the electric field of the wave gets short-circuited. As the ground wave travels away from the transmitting antenna it gets attenuated. To minimize this loss the transmission path must be over the ground with high conductivity.
- With respect to this condition, sea water should be the best conductor but it was observed that large storage of water in ponds, sandy or rocky soil shows maximum losses.
- Hence, high power low-frequency transmitters, using ground wave propagations, are preferably located on Ocean fronts.
- As ground losses increase rapidly with frequency, this propagation is used practically for signals up to frequency 2 MHz only.

## Sky Wave Propagation

- Every long radio communication of medium and high frequencies are conducted using skywave propagation.
- In this mode reflection of EM waves from the ionized region in the upper part of the atmosphere of the earth is used for transmission of waves to longer distances.
- This part of the atmosphere is called ionosphere which is at about 70-400 km height.
- Ionosphere reflects back the EM waves if the frequency is between 2 to 30 MHz's. Hence, this mode of propagation is also called as Short wave propagation.
- Using sky wave propagation point to point communication over long distances is possible. With the multiple reflections of sky waves, global communication over extremely long distances is possible.

## Space Wave Propagation

- When we are dealing with EM waves of frequency between 30 MHz to 300 MHz, then space wave propagation is useful.
- Here properties of Troposphere are used for transmission. When operating in space wave propagation mode, the wave reaches the receiving antenna directly from the transmitter or after reflection from troposphere which is present at about 16km above the earth surface. Hence space wave mode consists of two components.i.e. direct wave and indirect wave.
- Short wave broadcasting usually takes place in the frequency range of 1.7 - 30 MHz.
- As we have seen above the frequencies in this range are propagated through Skywave propagation mode.



- Depending on the **frequency or wavelength** the **electromagnetic waves produce** different **Effects** in **various materials and devices**.
- Hence, the **different parts** of the **electromagnetic spectrum** are **utilized** for **various applications**

## Audible and Inaudible sound

### Inaudible sound

- **Human ear cannot detect** sound **frequencies less than 20 vibrations per second** i.e. 20 Hz.
- So any **sound below** this **frequency** will be **inaudible sound for humans**.
- In the **high-frequency range**, the **human ear cannot detect** frequencies **above 20000 vibrations per second** (20 kHz) and the **amplitude** of the **wave** would **be dependent** on the **loudness** of the **sound**.
- So the **frequencies below 20 Hz** and **above 20 kHz** comes **under** the **category** of **inaudible frequencies**. The **low-frequency sound** which the **human ear cannot detect** is also **known** as **infrasonic sound**. Whereas the **higher range inaudible frequency** is also **known** as **ultrasonic sound**.
- Some **animals** like **dogs** have the **ability** to **hear sounds** having **frequencies higher** than **20 kHz**.
- The **police department** uses **whistles** with **frequencies higher** than **20 kHz** so that **only dogs** can **listen** to it.
- **Inaudible frequencies** are **helpful** for **many purposes**.
- These are **used** in **many fields** like **research** and **medicine**.
- The **ultrasound equipment** used for **tracking** and **studying** many **medical problems** works at **frequencies above 20 kHz**.

### Audible Sound

- The **human ear** can **easily detect** frequencies **between 20 Hz and 20 kHz**.
- Hence, **sound waves** with **frequency ranging** from **20 Hz to 20 kHz** is **known** as **audible sound**.
- The **human ear** is **sensitive** to **every minute pressure** difference in the **air** if they are in the **audible frequency range**.
- It can **detect pressure difference** of **less than one billionth** of **atmospheric pressure**.
- As we **grow older** and are **exposed to sound** for a **longer period** of time, our **ears** get **damaged** and the **upper limit** of **audible frequencies** **decreases**.
- For a **normal middle-aged adult person**, the **highest frequency** which they can **hear clearly** is **12-14 kilohertz**.

## Noise and Music

- The **unpleasant sounds** around us are **called noise**.
- **Noise** is **produced** by the **irregular vibrations** of the **sound producing source**.
- **For Ex:** **Running of mixer** and **grinder** in the **kitchen**, **blowing** of **horns** of **motor vehicles**, **bursting** of **crackers**, **barking** of **dogs**, **shattering** of **glass**, **landing** and **flying** of **aeroplane**, **sounds** coming from **construction site**, **all students** talking together **loudly** in a **classroom** etc.
- The **sounds** which are **pleasant** to **hear** are **called all musical sound**.
- They are **produced** by the **regular vibrations** of the **sound producing source**.
- All the **musical instruments** produce **musical sounds**.
- The **speakers** of **radio**, **stereo system** and **television** also **produce musical sound**.
- When a **person sing** a **song** he or she also **produces musical sound**.
- If **however** a **musical sound** becomes **too loud** it becomes **noise**.

## Terminology of Sound

<b>Wavelength</b>	<ul style="list-style-type: none"> <li>• <b>Distance between 2 successive crests or troughs.</b></li> <li>• Represented by <math>\lambda</math></li> <li>• <b>SI unit:</b> metre (m).</li> </ul>
<b>Time period</b>	<ul style="list-style-type: none"> <li>• <b>Time taken by 2 consecutive compressions or rarefactions to cross a fixed point</b></li> <li>• <b>SI unit:</b> seconds (s).</li> </ul>
<b>Frequency</b>	<ul style="list-style-type: none"> <li>• <b>Number of compressions or rarefactions per unit time.</b></li> <li>• Represented by <math>f</math></li> <li>• <b>SI unit:</b> Hertz (<math>s^{-1}</math>)</li> </ul>
<b>Amplitude</b>	<ul style="list-style-type: none"> <li>• <b>Magnitude of disturbance</b> in a <b>medium on either side</b> of the <b>mean value</b></li> </ul>
<b>Pitch</b>	<ul style="list-style-type: none"> <li>• <b>Directly proportional</b> to <b>frequency</b>.</li> </ul>
<b>Intensity</b>	<ul style="list-style-type: none"> <li>• <b>Amount of sound energy</b> <b>flowing per unit time</b> through a <b>unit area</b></li> </ul>

<b>Note and Tone</b>	<ul style="list-style-type: none"> <li>• <b>Sound of a single frequency - tone.</b></li> <li>• <b>Sound produced with a mixture of several frequencies- note.</b></li> </ul>
<b>Quality</b>	<ul style="list-style-type: none"> <li>• <b>Richness or timber of sound.</b></li> <li>• <b>Sound with the same pitch and loudness can be distinguished by quality.</b></li> <li>• <b>Eg. difference b/w sound of a flute and violin.</b></li> </ul>

- **Speed of sound:** Solids > Liquids > Gases

### Reflection of Sound

- **Reflects off a surface** in the same way as **light reflects** and **follows same rules of reflection.**
- **Incident sound** and **reflected sound** make **equal angles with the normal** and **all three are in the same plane.**

### Echo

- **Phenomenon where a sound produced is heard again due to reflection .**

Human range of hearing - 20Hz- 20kHz.

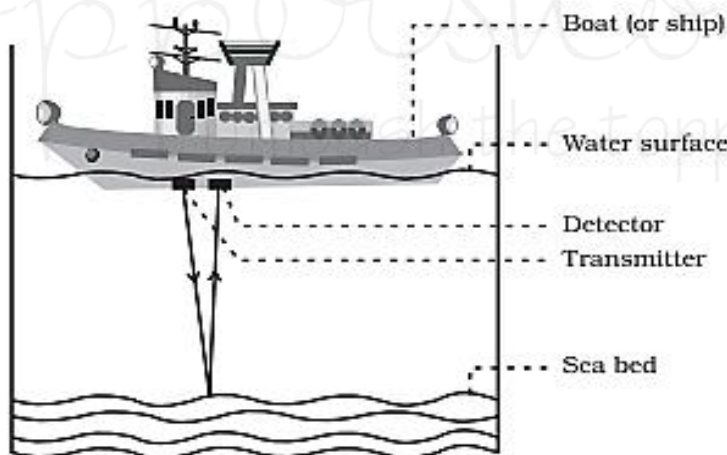
### Ultrasonic sounds/ Ultrasound

- **High-frequency** sound having a frequency > **20kHz** (inaudible range).
- **Applications:**
  - Scanning images of human organs
  - Detecting cracks in metal blocks
  - Cleaning parts that are hard to reach
  - Navigating, communicating or detecting objects on or under the surface of the water (SONAR).

### Infrasonic sounds

- **Low frequency** sound having frequency < **20 Hz.**
- **Animals like elephants** use infrasounds for communication.

## SONAR



**Fig : Ultrasound set by the transmitter and received by the detector**

- Stands for **“Sound Navigation And Ranging”**.
- A **technique** that **uses sound** or **ultrasonic waves** to **measure distance.**
- Consists of a **transmitter** and **detector mounted on a boat or ship.** **Transmitter sends ultrasonic** sound waves to **seabed** which **gets reflected back** and **picked up by the detector.**
- **Method k/a echo-location** or **echo ranging.**

### Reverberation

- **Repeated reflection** that **results in the persistence of sound**
- To **reduce highly undesirable reverberation sounds**, the **roof and walls** of the **auditorium** or big halls are **generally covered with sound-absorbent materials** like **compressed fibreboard, rough plaster** or **draperies.**
- The **seat materials** are also **selected** on the basis of their **sound absorbing properties.**

## Structure of Human Ear

- A sensitive organ of the body.
- **Function:** Detecting, transmitting and transducing sound and maintaining a sense of balance
- Parts:
  1. **Outer ear:**
    - **Pinna** - cartilaginous and directs sound wave towards external auditory canal.
    - **External auditory canal** - channels sound to tympanic membrane (eardrum).
    - **Eardrum**- Thin and semi-transparent.
      - **Vibrates when sound waves strike its surface.**
  2. **Middle Ear –**
    - **3 tiny bones** - hammer, anvil and stirrup
    - **Amplify vibrations and transmit** these to inner ear.
  3. **Inner Ear –**
    - aka **labyrinth.**
    - **Cochlea**- helps in hearing.
    - **Vestibular system**

