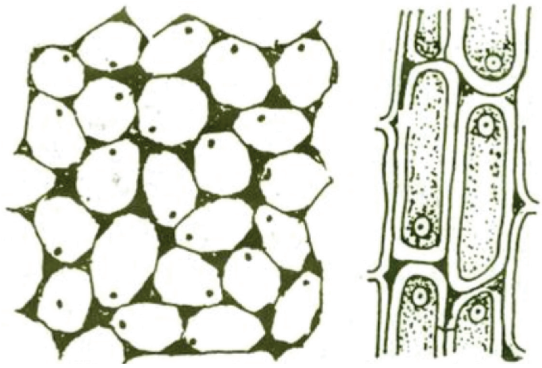
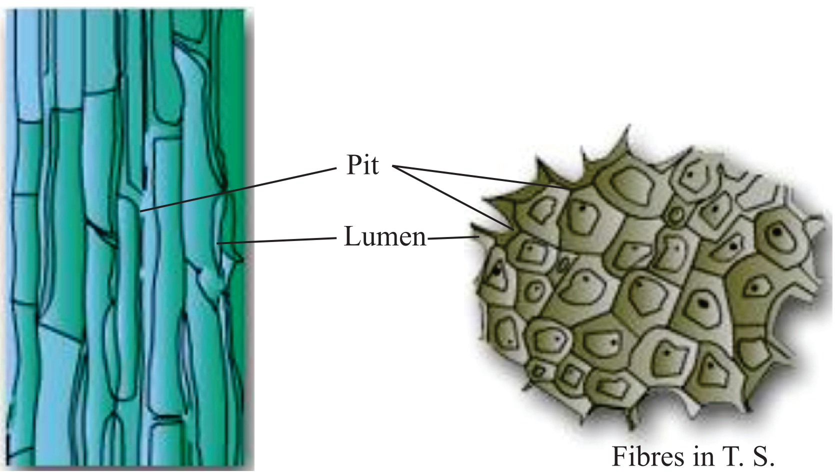


## Collenchyma

- Elongated cells with thick corners.
- Localized cellulose & pectin thickening.
- Provides flexibility to plant parts & easy bending of various parts of plant.
- Present only in herbaceous dicot stem.
- Present at thin margin of leaves.
- Few chloroplasts may be present.
- Gives mechanical strength & elasticity to the growing stems.

(iii) Sclerenchyma : (Scleras – hard) Strengthening tissue.




Fibres in T. S.

Fibres in L. S.

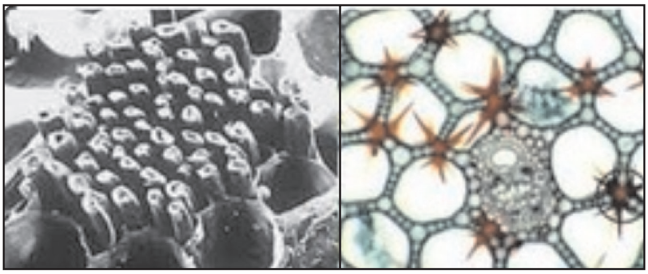
- Composed of extremely thick walled cells with little or no protoplasm.
- Cells are dead & possess very thick lignified walls.
- Lignin is water-proof material.
- Intercellular spaces are absent.

***Cells of sclerenchyma are of two types :***

*Sclereids :*

- These are also called grit cells or stone cells.
- These are small cells, where lumen is so small due to higher thickening of cell wall, as present in drup fruit (mango, coconut, walnut) in legume seeds (Macrosclereid).

Fiber Sclereids



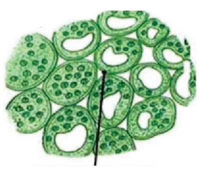
*Fibers :*

- They are very long, narrow, thick, lignified cells. Lumen is large as compared to sclereids. Generally 1-3 mm long.
- In the thick walls of both the fibres and sclereids are present thin areas called as pits.

***Sclrenchyma Fibres***

- These are used in the manufacture of ropes, mats & certain textile fibres.
- Jute and coir are obtained from the thick bundle of fibres.

### *Difference between Parenchyma, Collenchyma and Sclerenchyma*

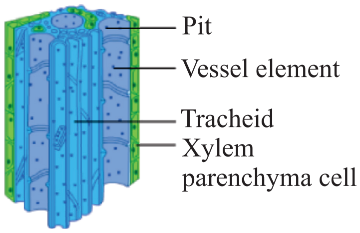
| Features | Parenchyma | Collenchyma | Sclerenchyma |
|---|---|---|---|
| |  |  |  |

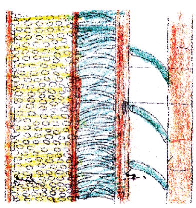
| | | | |
|---|---|---|---|
| 1. Cell shape | Isodiametric cells which are oval, spherical or polygonal in shape. | Circular, oval or polyhedral. | Variable in shape. Fibres and sclereids. |
| 2. Cell wall | Thin cellulosic cell wall. | Uneven thickening on their cell wall. | Lignified secondary cell wall present. |
| 3. Cytoplasm | Abundant | Present | Absent |
| 4. Nucleus | Present (Living tissue) | Present (Living tissue) | Absent (Dead tissue) |
| 5. Vacuoles | Large vacuole | Vacuolated | Absent |
| 6. Intercellular spaces | Present | Absent | Absent |
| 7. Occurrence | Basically packing tissue, all soft part of plant- pith, cortex, medullary rays. | Dicot stems, petiole and beneath the epidermis. Absent in monocot and roots. | Dicot hypodermis, bundle sheath, pericycle, seed, pulp of fruits. |
| 8. Functions | Food storage, photosynthesis. | Provide tensile strength, mechanical support, photosynthesis. | Protection from stress and strain, mechanical strength. |

***(B) Complex Permanent Tissues***

- It consists of more than one type of cells which work together as a unit.
- It helps in transportation of organic materials, water & minerals.
- It is also known as conducting or vascular tissue.
- Xylem & phloem together form vascular bundles.

***Xylem :*** Also known as wood and is a vascular and mechanical tissue. Thick walled cells are found in the form of tubular passages.



***Xylem consists of four types of cells called as elements :***

(i) Tracheids :

- They are elongated angular dead cells (primitive elements) mainly involved in conduction of water and minerals in gymnosperms.

(ii) Vessles : They are advance element (generally found in angiosperms).

- Vessels are cylindrical tube like structures placed one above the other end to end which form a continuous channel for efficient conduction of water.

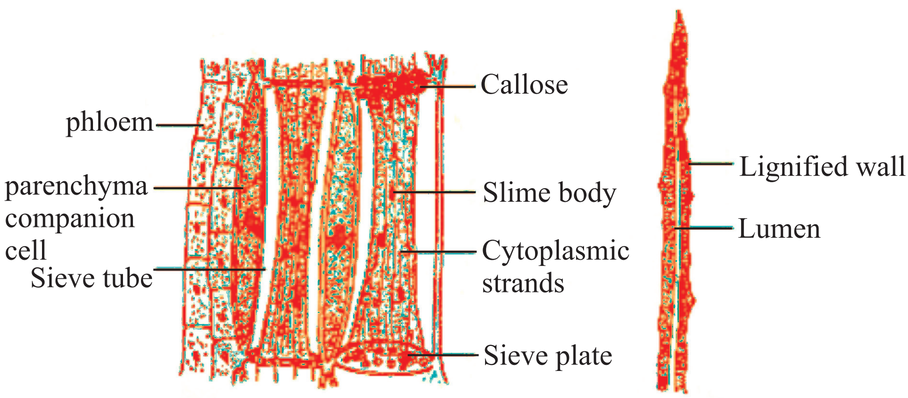
(iii) Xylem parenchyma :

- They are small & thick walled parenchymatous cells subjected for storage of starch (food).

(iv) Xylem sclerenchyma :

- Thy are non-living fibres with thick walls and narrow cavities provide mechanical support.
- Except xylem parenchyma all other xylem elements are dead.
- The annual rings present in the trunk of a tree are xylem rings.
- By counting the number of annual rings, we can determine the age of a tree.

***Phloem :*** They also consist of both parenchymatous and schlerenc- -hymatous cells.




Phloem fibre (bast fibre)

Phloem consists of four types of element :

(i) Sieve tubes :

- Sieve tubes are slender tube like structures made up of elongated, thin walled cells placed end to end.
- The end walls of sieve tube cells are perforated by numerous pores, called as sieve plates.
- Nucleus of sieve cell degenerates at maturity. However, cytoplasm

persists, because of protoplasmic continuation of sieve tube with companion cell through plasmodesmata.

- Sieve cells possess slime protein or protein which is concerned with growth and repair of sieve cells.

(ii) **Companion cells :**

- Companion cells have dense cytoplasm and prominent nuclei.

* *Sieve cells & companion cells are so called sister cells because they originate from single mother cell.*

(iii) **Phloem fibre :**

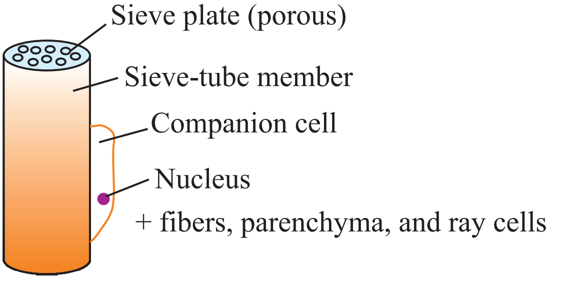
- They give mechanical support to sieve tubes.

(iv) **Phloem parenchyma :**

- They store food and help in radial conduction of food.

(v) **Leptome :**

- Main part of phloem involved in conduction of food, which is sieve tube.
- In xylem, only unidirectional movement is possible while in phloem bidirectional movement can occur.
- In phloem, except phloem sclerenchyma all elements are living.



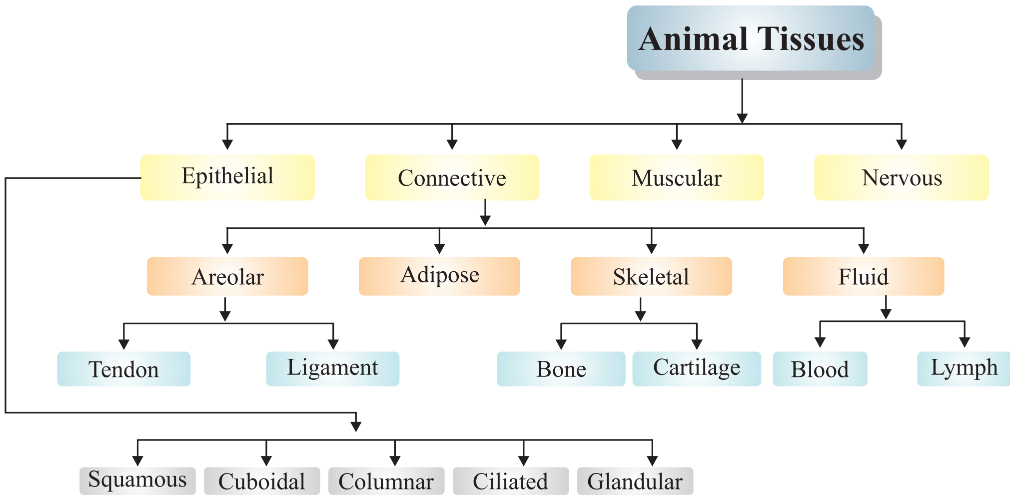

Components of Phloem

### *Xylem and Phloem*

| Features | Xylem | Phloem |
|---|---|---|
| Cells : Living/dead | Dead | Living |
| Cell walls : | | |
| Thickness | Thick | Thin |
| Material | Lignin | Cellulose |
| Permeability | Impermeable | Permeable |
| Cross walls | None | Sieve plates |
| Cytoplasm | None | Yes |
| Function | Carries water and salts | Carries sugars |

| | | |
|---|---|---|
| Direction of flow | Upwards | Down and up |
| Special features | Fibres | Companion cells |

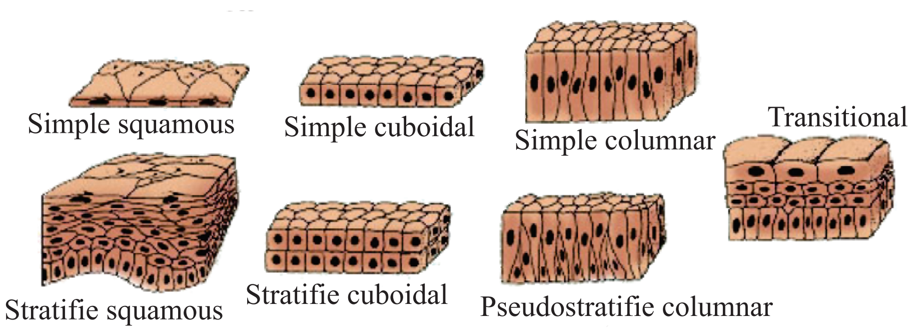
## ANIMAL TISSUE




## EPITHELIAL TISSUE

- Always grows on some other types of tissue.
- Cells of epithelium are set very close to each other and the tissue rests on a non-cellular basement membrane.
- Consists of single layer of cells.
- Blood vessels are absent and non-nervous in nature.
- It covers all the organs and lines the cavities of hollow organs like stomach.
- It is primarily protective in function.

***Types of Epithelium***




***Epithelium tissues are classified as :***

*(a)* *Squamous epithelium :* Also called pavement epithelium.

- Cells arranged end to end like tiles on a floor.

- Cells are polygonal in surface view.
- It forms the delicate lining of cavities (mouth, oesophagus, nose, pericardium, alveoli etc.) blood vessels and covering of the tongue and skin.
- Epithelial cells are arranged in many layers (stratum) to prevent wear and tear in skin. This pattern is stratified squalors epithelium.

(b) *Cubical epithelium :*

- They are cube like cells that fit closely, cells look like squares in section, but free surface appears hexagonal.
- It is found in kidney tubules, thyroid vesicles & in glands (salivary glands, sweat glands).
- It forms germinal epithelium of gonads (testes & ovaries).
- It involves in absorption, excretion & secretion. It also provides mechanical support.

(c) *Columnar epithelium :*

- Columnar means 'pillar-like' epithelium. It forms lining of stomach.
- Small intestine & colon, forming mucous membranes.
- Border of micro villi is present at the free surface end of each cell which increases absorption efficiency in small intestine.

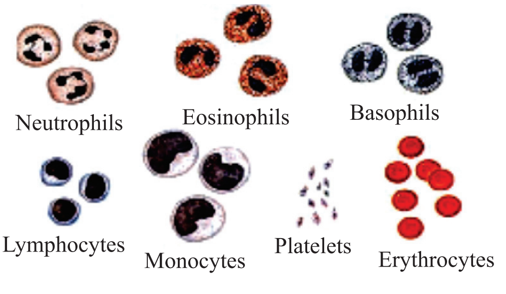
(d) *Ciliated epithelium :*

- Cells may be cubical or columnar.
- On its free surface are present protoplasmic outgrowths called cilia.
- It helps in the movement of ova in the fallopian tube.

## CONNECTIVE TISSUE

- The cells of the connective tissue are widely spaced and embedded in an intercellular matrix.
- The mature of matrix decides the function of tissue.
- White and yellow fibres are present in the matrix.
- Their basic function is to provide support to different organs & keeping them in place.

(a) *Fluid or vascular tissue :*



Blood and lymph

- Blood is a connective tissue, fluid matrix of blood is plasma having wandering or floating cells, called corpuscles, blood helps in the transportation of various materials such as nutritive substances, gases, excretory products, hormones etc.

Plasma

- Form 55% part of blood. Constitution : 90-91% : water, 7% : protein (Albumin, fibrinogen, globulin), 0.9% : inorganic salt etc.

Corpuscles

- Forms 45% part of blood.

RBCs

- They are also called as erthyrocytes, containing red coloured respiratory pigment called haemoglobin that helps in transportation of oxygen.

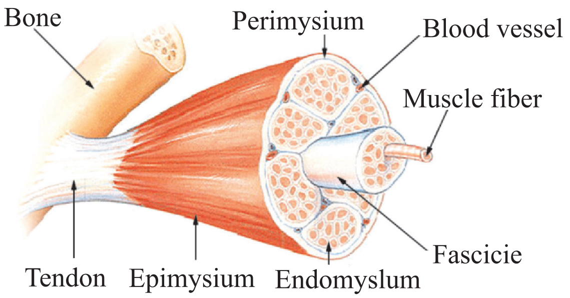
WBCs (Leucocytes : They are also called as 'Soldiers of the body'.)

- They are irregular, amoeboid, phagocyte cells that protect our body by engulfing bacterial & other foreign particles. They are of five types : Monocytes, Lymphocytes, Basophiles, Neutrophiles, Eosinophils.

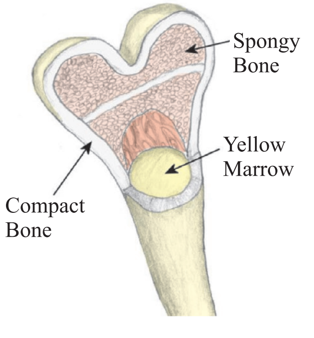
Blood platelets or thrombocytes

- They are spindle shaped cells which are involved in clotting of blood.

*(b)* *Skeletal Tissue*

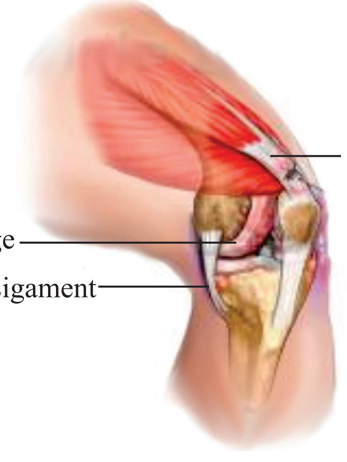



*It is hard connective tissue that forms supportive framework of the body. It is of two types :*



**Bone**

- Matrix of bone is very hard because of salts such as calcium phosphate, $CaCO_3$ (60-70%) etc. and a protein ossein.
- Bone cells (osteoblasts) are embedded in this hard matrix.
- Matrix is deposited in the form of concentric layers of lamellae formed round a central canal, the done cells occupy small spaces between the concentric layers of matrix.
- The long bones are usually hollow containing cavity called as marrow cavity. It is full of bone marrow.




**Cartilage**

- This tissue is elastic, less harder as compared to bones.
- Elasticity is due to presence of chondrin (protein). Cells are called as chondroblast, which are widely spaced and matrix is reinforced by fibres.
- It occurs at joint of bones, in the nose, ear, trachea & larynx.
- It provides flexibility and great tensile strength.

*(c) Connective tissue*

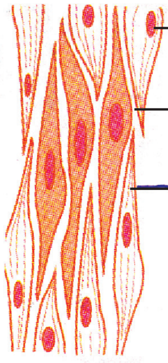
It is the most abundant type of connective tissue. It is further divided into following types :

(i) Yellow fibrous connective tissue

- They are very elastic due to the presence of a network of yellow fibres in its matrix called as ligament which attaches bone to bone.

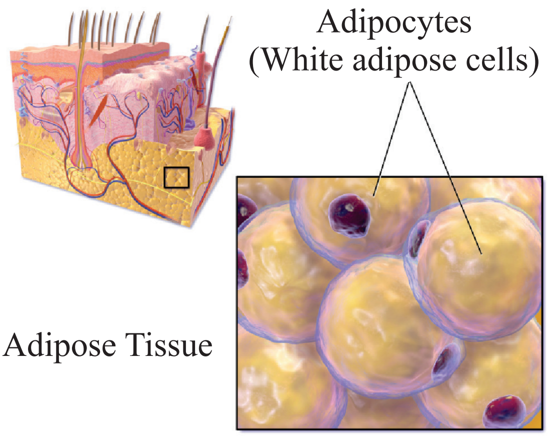
(ii) White fibrous connective tissue

- They are very little matrix containing abundant white fibres forming layers.
- Bundles of this tissue are called as tendons, which attaches muscles to the bones.



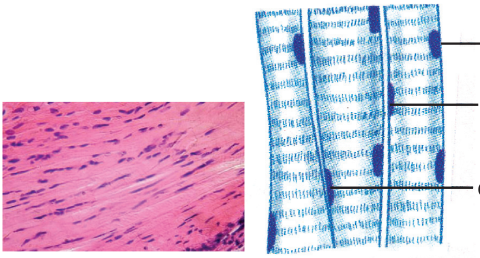

(d) *Aerolar tissue :*

- It is the most distributed connective tissue in the body.
- This tissue fills spaces inside organs and is found between the skin & muscles, around blood vessels, nerves and in the bone marrow.




(e) *Adipose tissue :*

- These are oval and round cells, filled with fat globules.
- The cells are called as adipocytes.
- It is found in subcutaneous layer below the skin, around the heart, brain and below the eyeballs. It acts as an insulator and prevents loss of heat from the body.



## MUSCULAR TISSUE

- Movements are brought about in our body with the help of muscular tissues.
- They are long fibre-like cells called muscle fibres.
- They are capable of contraction or relaxation.

***Types of Muscular Tissue***

**Skeletal Muscle**

**Cardiac Muscle**

**Smooth Muscle**

(a) *Striated muscles*

- They are also called as voluntary muscles because these are under the control of one's will.
- Muscle fibres or cells are multinucleated and unbranched.
- Each fibre is enclosed by thin membrane which is called as sarcolemma. Cytoplasm is called as sarcoplasm.
- These muscles get tired and need rest.

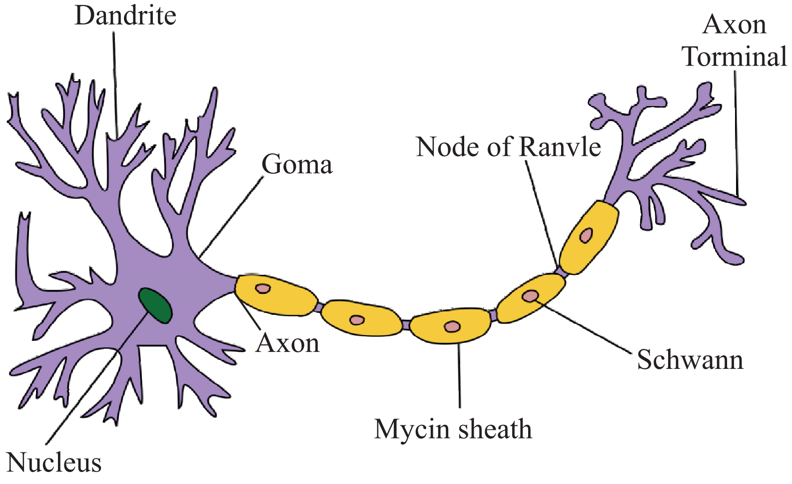
(b) *Cardiac muscle fibres*

- They are only involuntary muscles.
- Only found in the walls of heart.
- Their structure is in between the striated and non-striated muscles.
- They are uninucleated and branched. Branches are united by intercalated disc.
- In these muscles rhythmic contraction and relaxation occurs throughout the life.

(c) *Non-striated muscles*

- They are involuntary muscles also called as smooth muscles.
- These muscle fibres are uninucleated and spindle shaped.
- They are not enclosed by membrane but many fibres are joined together in bundles.
- Such muscles are found in the walls of stomach, intestine, urinary bladder, bronchi, iris of eye etc.
- Peristaltic movements in alimentary canal are brought about by smooth muscles.

## NERVOUS TISSUE




- They are highly specialized tissue due to which the animals are able to perceive and respond to the stimuli.
- Their functional unit is called as nerve cell or neuron.
- Cell body is cyton covered by plasma membrane.
- Short hair like extensions rising from cyton are Dendron which are further subdivided into dendrites.
- Axon is long, tail like cylindrical process with fine branches at the end. Axon is covered by a sheath.

- Axon of one neuron is very closely placed to the dendrons of another neuron to carry impulses from one to another neuron in the form of electrochemical waves. This close proximity is called as synapse.

# QUESTIONS

## VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

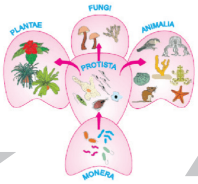
1. The tissue derived directly from the meristem of embryo is called as................ .
2. A group of cells with similar structure organized to do a common function is called as................ .
3. Which plant tissue remains in active metabolic state always ?
4. Sieve tubes and companion cells are found in................tissue. (Xylem/phloem/collenchyma)
5. Long, narrow, dead cells having a thick deposition of lignin in the cell wall are called................cells. (Parenchyma/cambium/sclerenchyma)
6. Which tissue is responsible for transport of water in plants ?
7. The special property of muscle fibres to contract forcefully and return to relaxed state is called................ . (excitability/contractibility/flexibility)
8. A branch of science dealing with the study of bones is called................ . (Ornithology/physiology/osteology)
9. The fluid matrix of blood is called................ . (plasma/lymph/serum)
10. Spindle-shaped, non-striated, involuntary muscle fibres present in hollow internal organs like urinary bladder are called................ . (smooth muscle fibres/striated muscle fibres/cardiac muscle fibres)

## SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. Define tissue.
2. What do you mean by division of labour ?
3. Name the different elements of xylem and phloem.
4. In hydrophytes xylem is less developed. Why ?
5. Write the composition of mammalian blood.
6. What is the function of nervous tissue ?
7. State the main features of muscular tissue.

## LONG ANSWER TYPE QUESTIONS (5 Marks)

1. What is tissue ? Explain meristematic plant tissue.
2. Mention the role of parenchyma, collenchyma and sclerenchyma.
3. Give summarized classification of animal-tissue.
4. Describe the structure of neuron with labelled diagram.




Chapter - 7

# Diversity in Living Organism

## CHAPTER AT A GLANCE

All living organism are grouped on the basis of their similarities and increasing complexities into different complexities.

**Organisms**

- Prokaryotes
  - Unicellular (Single-celled)
    - Monera (Bacteria)
- Eukaryotes
  - Unicellular
    - Protista Example, Amoeba
  - Multicellular
    - With cell wall
      - Do not perform photosynthesis (Without chlorophyll) Example, Fungi
      - Able to perform photosynthesis Example, Plantae
    - Without cell wall
      - Animalia

Kingdom → Phylum → Class → Order → Family → Genus → Species → Division (in plants)

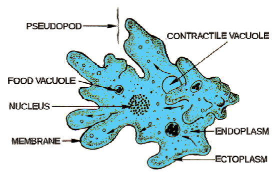
**Animalia**

- Cellular level (Porifera)
- Tissue level
  - No Coelem
    - (Colentrata, Platihelmenthes)
  - False Coelem
    - (Nematoda)
  - With Coelem
    - At the time of embryo cell to mesoderm (Anelida, Mollusca, Arthropoda)
    - Development of Coelem
      - Without notochord (Echinodermata)
      - With notochord (Chordata)
        - Piciese
        - Amphibia
        - Aves
        - Mammalia

# FIVE KINGDOM CLASSIFICATIONS

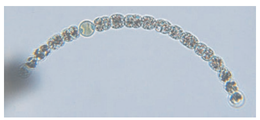
| MONERA (Unicellular Prokaryotes) | PROTISTA | FUNGI | PLANTAE | ANIMALIA |
|---|---|---|---|---|
| 1. No defined nucleus. | 1. Unicellular, eukaryotes. | 1. Eukaryotic, multicellular. | 1. Eukaryotic | 1. Eukaryotic |
| 2. No walled (defined cell organelles). | 2. Hair like cilia, flagella for movement. | 2. Hetrotrophic nutrition. | 2. Multicellular | 2. Multicellular |
| 3. Nutrition-Autotrophic & Heterotrophic (Autotrophic – made by self, Hetero – made by others) | 3. Nutrition – Autotrophic or heterotrophic. | 3. Consume organic decaying material called saprophytes. | 3. Autotrophs – Contain chlorophyll, do photosynthesis. | 3. Heterotrophs |
| Examples – Bacteria, Blue-green algae (cyano bacteria), mycoplasma. | Examples – Unicellular, algae, diatoms and protozoans. | 4. Cell made up of cell wall of tough complex sugar called chitin. Examples – Penicillium, Aspergillus, Agaricus. | 4. Cells have cell walls. | 4. Without cell wall.Further divided into 10 sub-groups on the basis of extent and type of body design differentiation. Examples – Tiger, peacock, ant, insects, fishes and soon. |
| | | | 5. All the green plants are there. Further divided into five sub-groups on the basis of : (a) Plant body well differentiated or not. (b) Special tissue for the transport of water are there or not. (c) Beer seeds, whether naked or enclosed within fruits. Examples – Pinus, algae, funeria, Mangifera indica. | |

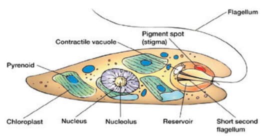

BACTERIA



AMOEBA


PENICILIUM


ANABAENA



EUGLENA


AGARICUS

**Biodiversity** means the variety of living organisms present on a particular region. There are about 20 lac organisms known on the earth which differ from one another in external form, internal structure, mode of nutrition, habitat, etc.

**Taxonomy :** It is a branch of biology which deals with identification, nomenclature and classification of organisms. Carolus Lannaeus is called the father of taxonomy.

**Classification :** The method of arranging organisms into groups or sets on the basis of similarities and differences is called classification.

***Importance of Classification***

- It makes the study of wide variety of organisms easy and in systematic manner.
- It helps to understand how the different organisms have evolved with time.
- It helps to understand the inter-relationships among different groups of organisms.
- It forms a base for the study of other biological sciences, like biogeography.

***Basis of Classification***

- There are certain features or properties used for the classification of living organisms which are known as characteristics. Organisms with same characteristics are placed in same groups.

***Classification System***

- **1. Two kingdom classification :** Carolus Linnaeus in 1758 classified the living organisms into two groups as plants and animals.
- **2. Five kingdom classification :** H. Whittaker in 1959 further classified the organisms into five kingdoms as Kingdom Monera, Kingdom Protista, Kingdom Fungi, Kingdom Plantae and Kingdom Animalia.

***Note :*** *Carl Woese in 1977 further divided Kingdom Monera into archaebacteria (or Archae) and Eubacteria (or Bacteria).*

**Hierarchy of Classification :** Linnaeus proposed a classification system by arranging organisms into taxonomic groups at different levels according to the characteristics they have. The groups or the levels from top to bottom are :

***The major characteristics considered for classifying all organisms into five major kingdoms are :***

- **Type of cellular organization**
  - **(a) Prokaryotic cells :** These are primitive and incomplete cells without well-defined nucleus.
  - **(b) Eukaryotic cells :** These are advanced and complete cells with well-defined nucleus.
- **Body organization**
  - **(a) Unicellular organisms :** These are organisms made up of single cell with all activities performed by the single cell.
  - **(b) Multicellular organisms :** These are organisms made up of large number of cells with different functions performed by different cells.
- **Mode of obtaining food**
  - **(a) Autotrophs :** These are the organisms that make their own food by photosynthesis.
  - **(b) Heterotrophs :** These are the organisms which depend on other organisms for food.

**Nomenclature :** An organism can have different names in different languages. This creates confusion in naming organism. A scientific name is needed which is same in all languages. Binomial nomenclature system given by Carolus Linnaeus is used naming different organisms.

***Following are some conventions in writing the scientific names :***

(1) Genus should be written followed by the species.

(2) First letter of the genus should be capital and that of the species should be in small letter.

(3) When printed the name should be written in italics and when written with hands genus and species should underlined separately.

*Example : Homo sapiens for humans, Panthera tigris for tiger.*

**Kingdom I : MONERA**

(i) Prokaryotic, unicellular.

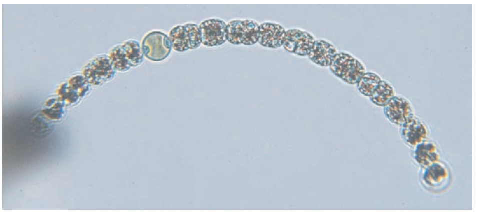
(ii) Can be autotrophs or heterotrophs.

(iii) May or may not have cell wall.

(iv) *Examples :* Anabaena and Bacteria (heterotrophic), Cyano-bacteria or

Blue-green algae (autotrophic).

BACTERIA



ANABAENA

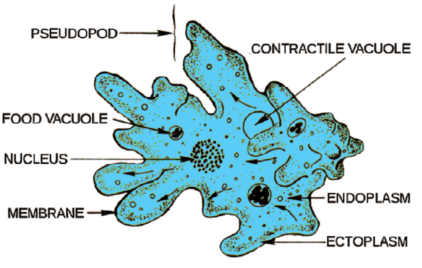
## Kingdom II : PROTISTA

(i) Eukaryotic, unicellular.

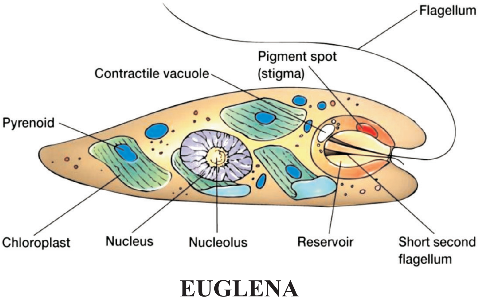
(ii) Can be autotrophic or heterotrophic.

(iii) May have cilia, flagella or pseudophodia for locomotion.

(iv) *Examples :* Plants like unicellular algae, diatoms; animals like protozoans (Amoeba, Paramecium, Euglena); fungi like slime molds and water molds.




AMOEBA




EUGLENA

## Kingdom III : FUNGI

(i) Eukaryotic.

(ii) Mostly multicellular but sometimes unicellular (yeast).

(iii) Source of food :

**(a) Mostly saprophytes :** These organisms use decaying material for food.

**(b) Some parasitic :** These organisms live inside body of other living organism to have food and can be disease causing.

**(c) Symbiotic relation :** These are relations between two organisms in which they live together for benefit of one or both. Lichens are a symbiotic relation between fungi and cyanobacteria. Here fungi gets food from cyanobacteria and in return cyanobacteria gets water and protection from sunlight through fungi.

(iv) Cell wall is made of chitin.

(v) *Examples :* Mushrooms (Agaricus), green mold (Penicillium), smut (Aspergilus).

PENICILIUM

AGARICUS

**Kingdom IV : PLANTAE**

(i) Eukaryotic, multicellular.

(ii) Autotrophs.

(iii) Cell wall present.

**Basis of division in Kingdom Plantae**

**(a) Differentiated body parts :** Body is differentiated into leaves, stems, roots, flowers, etc.

**(b) Presence of vascular tissue :** There are two types of vascular tissues present in the plants :

- **Xylem :** Helps in transport of water.
- **Phloem :** Helps in transport of food.

**(c) Reproduction through seeds or spores :**

- **Phanerogam :** Plants with seeds are called phanerogam. They contains embryo with stored food and are multicellular.
- **Cryotogam :** Plants with spores are called cryptogam. They contains only naked embryo and are generally unicellular.

**(d) Seeds are inside the fruit or naked :**

- **Angiospermae :** These are plants with seeds inside the fruit and bears flowers.

- **Gymnospermae :** These are plants with naked seeds and do not bear flowers.

**Division 1 : Thallophyta**

(i) Basic and elementary plants with undifferentiated body parts.

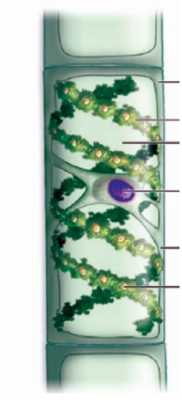
(ii) Generally called algae.

(iii) No vascular tissue present.

(iv) Reproduce through spores.

(v) Mainly found in water.

(vi) Example : Ulva, Spirogyra, Ulothrix, Cladophora, Chara.



**Spirogyra**


**ULVA**

**Division 2 : Bryophyta**

(i) Body structure differentiated but not fully developed.

(ii) No vascular tissues present.

(iii) Reproduce through spores.

(iv) Found on both land and water therefore known as **'Amphibians of Plantae Kingdom'**.

(v) *Example :* Liverwort (Marchantia, Riccia), Mosses (Funaria), Hornwort (Dendrocerous).


**FUNARIA**


**RICCIA**

**Division 3 : Pteridophyta**

(i) Differentiated body structure – leaves, stems, roots, etc.

(ii) Vascular tissues present.

(iii) Reproduce through spores.

(iv) *Examples :* Marsilea, fern, horsetails.

MARSILEA

FERN

**Division 4. Gymnosperms**

(i) Differentiated body parts.

(ii) Vascular tissues.

(iii) Naked seeds without fruits or flowers.

(iv) Perennial, evergreen and woody.

(v) *Examples :* Pinus (deodar), Cycus, Ginkgo.

PINUS

CYCUS

**Division 5 : Angiosperms**

(i) Also known as flower-bearing plants.

(ii) Later on flower becomes fruit.

(iii) Seeds are inside the fruit.

(iv) Embryos in seeds have structure called cotyledons. They are also called seed leaves because in many plants they emerge and become green when they germinate.

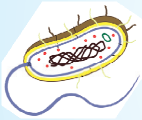
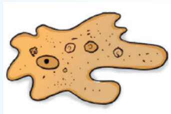
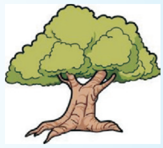
Angiosperms are further divided on the basis of number of cotyledons into two parts :

| S. No. | Features | Monocots | Dicots |
|---|---|---|---|
| 1. | Seed | One cotyledon | Two cotyledons |
| 2. | Root | Fibrous root | Prominent primary root |
| 3. | Stem | False or hollow | Strong |
| 4. | Leaf | Parallel venation | Reticulate venation |
| 5. | Flower (petals) | Five or multiple of five | Three or multiple of three |
| 6. | Example | Potato, Sunflower, Peanuts, Beans, Mango etc. | Banyan, Wheat etc. |

## Five Kingdom Classification

**R. H. Whittaker taxonomist was the first one to propose five kingdom classification.**

| | Monera | Protista | Fungi | Plantae | Animalia |
|---|---|---|---|---|---|
| **Type** | Unicellular Prokaryotic | Unicellular Eukaryotic | Multicellular Non-green Eukaryotic | Multicellular Eukaryotic | Multicellular Eukaryotic |
| **Mode of Nutrition** | Autotrophic or heterotrophic | Autotrophic or Heterotrophic | Saprophytic or Parasitic Sometimes symbiotic | Autotrophic | Heterotrophic |
| **Body** | Lack well-defined nucleus and cell organelles | Some organisms use pseudopodia or cilia or flagella for movement | Fungus is made up of long filaments called hyphae. The network of hyphae is mycelium. | Exhibits high level of tissue differentiation and have specialized body organs. | Exhibits high level of tissue differentiation and have specialized body organs. They have well developed nervous system. |

| | | | | | |
|---|---|---|---|---|---|
| **Examples** | Bacteria, Blue-green algae  | Amoeba, Paramecium, Euglena  | Yeast, Rhiozpus, Mushrooms moulds  | Trees, Plants, Shrubs  | Fish, Insects, Animals, Humans, Birds  |

**Kingdom V : ANIMALIA**

Basis of classification of Animalia kingdom :

**(i) Symmetry :**

**(a) Bilateral symmetry :** It is when an organism can be divided into right and left halves, identical but mirror images, by a single vertical plane.

**(b) Radial symmetry :** It is when an organism is equally spaced around a central point, like spokes on a bicycle wheel.

**(ii) Germ layers :** In embryonic stages there are different layers of cells called germ cells. The three different types of germ cells are :

- **Ectoderm :** It is the outermost layer which forms nail, hair, epidermis, etc.
- **Endoderm :** It is the innermost layer which forms stomach, colon, urinary, bladder, etc.
- **Mesoderm :** It is the middle layer between ectoderm and endoderm which forms bones, cartilage, etc.

So, according to the number of germ layers present in embryonic stage, animal could be :

- **Diploblastic :** Organisms which are derived from two embryonic germ layers (ecto and endo).
- **Triploblastic :** Organisms which are derived from all the three embryonic germ layers.

**(iii) Coelom :** Body cavity or coelom is important for proper functioning of various organs. For example, heart which has to contract and expand needs some cavity or empty space, which is provided by the coelom.

On the basis of presence or absence of coelom, organisms are divided into :

- **Acoelomates :** These are the simple organisms having no body cavity.
- **Coelomates :** These are complex organisms having true cavity lined by mesoderm from all sides. These are further sub-divided into **schizocoelomates** or **protostomes** (coelom formed due to splitting or mesoderm) and **enterocoelomates** or **dueterostomes** (coelom formed from pouches pinched off from endoderm).
- **Pseudo coelamate :** These are organisms having false coelom. They have pouches of mesoderm scattered between endoderm and ectoderm.

**(iv)Notochord :** It is a long rod like structure, which runs along the body between nervous tissues and gut and provides place muscle to attach for ease of movement.

Organisms could be :

- without notochord
- with notochord
- with notochord in initial embryonic stages and vertebral column in adult phase

**Phylum 1 : Porifera or Sponges**

(i) Cellular level of organization

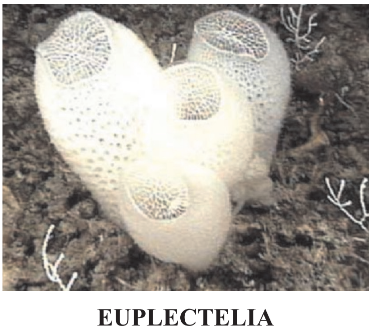
(ii) Non-motile animals

(iii) Holes on body which led to a canal system for circulation of water and food

(iv) Hard outside layer called as skeletons

(v) Examples : Sycon, spongilla, euplectelia

**SYCON**



**EUPLECTELIA**

**Phylum 2 : Coelenterata**

(i) Tissue level of organization

(ii) No coelom

(iii) Radial symmetry, diploblastic

(iv) Hollow gut

(v) Can move from one place to another

(vi) Examples : Hydra, sea anemone, jelly fish (solitary), corals (colonies)

SEA ANNEMON

CORALS

**Phylum 3 : Platyhelminthes**

(i) Also called flat worms

(ii) No coelom present

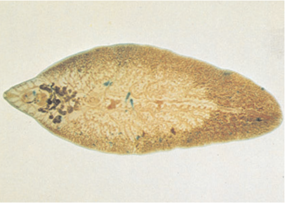
(iii) Bilateral symmetry, triploblastic

(iv) Free living or parasite

(v) Digestive cavity has one opening for both ingestion and egestion

(vi) Examples : Planaria (free living), liver fluke (parasitic)

PLANARIA



LIVER FLUKE

**Phylum 4 : Mollusca**

(i) Coelom present

(ii) Triploblastic, bilateral symmetry

(iii) Soft bodies sometimes covered with shell

(iv) Generally not segmented

(v) No appendages present

(vi) Muscular foot for movement

(vii) Shell is present

(viii) Kidney like organ for excretion

(ix) *Examples :* Chiton, octopus, pila, unio

CHITON

OCTOPUS

**Phylum 5 : Annelida**

(i) Second largest phylum

(ii) Coelom present

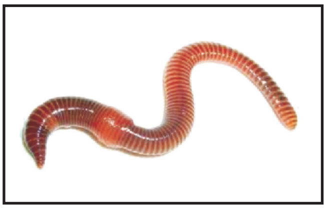
(iii) Bilateral, triploblastic

(iv) Segmented (segments specialized for different functions)

(v) Water or land

(vi) Extensive organ differentiation

(vii) *Examples :* Earthworm, leech, nereis



EARTHWORM

NEREIS

**Phylum 6 : Arthropoda**

(i) Largest phylum (consist of 80% of species)

(ii) Generally known as insects

(iii) Coelom present

(iv)Bilateral, triploblastic

(v) Segmented, sometimes fused

(vi) Tough exo-skeleton of chitin

(vii) Joing appendages like feet, antenna

(viii) *Examples :* Prawn, scorpio, cockroach, housefly, butterfly, spider

## Phylum 7 : Echinodermata

(i) Spiny skin, marine

(ii) No notochord

(iii) Coelom present, bilateral symmetry, triploblastic

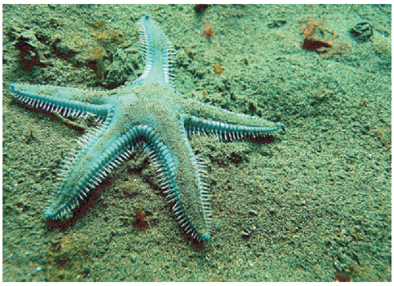
(iv) Endoskeleton of calcium carbonate

(v) Water vascular system for locomotion

(vi) Bilateral symmetry before birth and radial symmetry after birth

(vii) *Examples :* Antedon, sea cucumber, star fish, echinus

**SEA CUCUMBER**



**STARFISH**

## Phylum 8 : Hemichordata

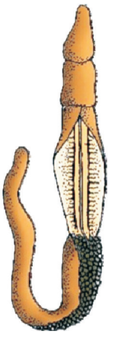
(i) Small group of marine animals

(ii) Cylindrical, bilateral symmetry, triploblastic

(iii) Coelom present

(iv) Gills for respiration

(v) *Examples :* Balanoglossus



**BALANOGLOSSUS**

**Phylum 9 : Chordata**

(i) Bilateral symmetry, triploblastic

(ii) Coelom present

(iii) Notochord

(iv) Gills present at some phase of life

(v) Dorsal nerve chord

(vi) Post anal tail present at some stage of life, for example, present in humans in embryonic stages

(vii) Sub-divided into two :

**(a) Prochordata**

- Notochord at some stage of life
- Marine
- Examples : Herdemania, amphioxus

**(b) Vertebrata**

- Notochord converted to vertebral column
- 2, 3, 4 chambered heart
- Organs like kidney for excretion
- Pair appendages
- Examples : Humans (4-chambered), frog (3-chambered), fishes (2-chambered)

**Vertebrates** are divided into five classes namely Pisces, Amphibia, Reptilia, Aves and Mammalia.

- **Warm blooded organisms :** These are organisms which maintain same body temperature irrespective of outside temperature. *Example :* Humans. Human's body temperature is approximately 37º.
- **Cold blooded organisms :** These are organisms which change their body temperature as per surrounding temperature. *Example :* Frog.
- Fishes are divided into two categories on the basis of skeleton :

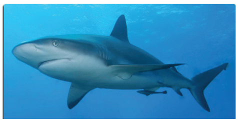
(i) Fishes with bony skeleton called **bony fishes.** Example : Tuna.

(ii) Fishes with cartilage skeleton called **cartilaginous fishes.** *Example :* Shark.

**(i) Pisces (Fishes)**

- They are fishes living in water.
- Their skin is covered with scales or plates.
- They respire using gills.
- They have streamlined body and fins which help them to move in water.
- They are cold blooded and their heart has only two chambers.
- They lay eggs from which the young ones hatch out.

Some fishes have skeleton made of cartilage like Sharks, Rays etc. and some have skeleton made of bones and cartilage like Tuna, Rohu etc.

**(ii) Amphibia (Amphibians)**

- They are found in land and water.
- They do not have scales but have mucous glands on their skin.
- They are cold blooded and the heart is three chambered.
- Respiration is through gills or lungs. They lay eggs in water.

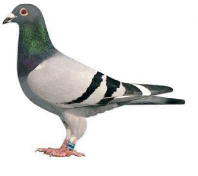
- *Example :* Frogs, Toads, Salamanders etc.

**(iii) Reptilia (Reptiles)**

- They have scales and breathe through lungs.
- They are cold blooded.
- Most of them have three chambered heart but crocodiles have four chambered heart.
- They lay eggs with hard covering in water.
- *Example :* Snakes, Turtles, Lizards, Crocodiles etc.

**(iv) Aves (Birds)**

- They are warm blooded animals.
- They have four chambered heart.
- They breathe through lungs.
- They have an outer covering of feathers.
- Their two fore limbs are modified into wings for flying. They lay eggs.
- *Example :* Crow, Sparrow, Pigeon, Duck, Stork, Ostrich etc.



### (v) Mammalia (Mammals)

- They are warm blooded animals.
- They have four chambered heart.
- They have mammary glands for production of milk to nourish their young ones.
- The skin has hairs and sweat glands. Most of them give birth to their young ones.
- Some of them lay eggs (like Platypus and Echidna).
- *Example :* Cat, Rat, Dog, Lion, Tiger, Whale, Bat, Humans etc.

| S. No. | Features | Pisces | Amphibian | Reptilia | Aves | Mammalia |
|---|---|---|---|---|---|---|
| 1. | Inhabit | Water | Water and land | Water and land | Water, land and air | Land or water |
| 2. | Respiratory organs | Gills | Gills, lungs | Lungs | Lungs | Lungs |
| 3. | Heart | 2-cham-bered | 3-cham-bered | 3-chambered | 4-cham-bered | 4-chambered |
| 4. | Maintenance of body temperature | Cold blooded | Cold blooded | Cold blooded | Warm blooded | Warm blooded |
| 5. | Youngones | Eggs | Eggs in water | Eggs with tough coating on land | Eggs | Young babies except platy-pus and echidna. |
| 6. | Skin | Skin covered with scales | Mucus glands in skin | Skins covered with scales | Skin covered with feathers | Hair, oil and sweat glands are present on the skin |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7. | Special features | Streamlined body | | | | Mammary glands which produces milk for children |
| 8. | *Example :* | Anabas, Dog fish, Angler fish, Mandarin fish, Electric ray, String fish, Sea horse, Flying fish. | Salamander, Common frog, Toad, Hyla (tree frog) | Turtle, Snakes, Lizard, Flying lizard, Crocodile, Chameleon | Ostrich, Sparrow, Crow, Pigeon, Tufted Duck, White Stork | Humans, Lion, Tiger, Cat, Bat, Whale |

# QUESTIONS

## VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

1. Define biodiversity.
2. Who wrote the book 'Origin of Species'.
3. What do you mean by primitive organism and advanced organism ?
4. Who is known as the father of taxonomy ?
5. Collect the range of variation that you see around you.
6. Whittaker's five kingdom classification in detail. The basis of five kingdom classification.
7. Write the correct sequence of five kingdom classification.
8. Write the examples of Archaebacteria and Eubacteria.
9. What are resting spore and heterocyst ?

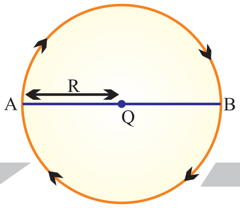
## SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. What is thallus ?
2. Why bryophytes are called amphibians of plant kingdom ?
3. Write the difference between cryptogams and phanerogams.

4. List the difference between monocots and dicots.
5. List the number of phyla that come under animal kingdom.
6. Use the same tips to study the animal kingdom.
7. Explain all the important characteristics of the given phyla :
   (a) Platihelminthes
   (b) Coelenterates
   (c) Annelida

## LONG ANSWER TYPE QUESTIONS (5 Marks)

1. Give two examples belonging to members of nematode.
2. What is the cause of elephantiasis ?
3. What is the most striking feature of phylum arthropoda ?
4. List the difference between annelids and arthropods.
5. What is notochord and describe its function.
6. Give two examples from phylum protochordata.
7. Bats and whales are classified as mammals. Why ?
8. Circulatory system found in the phylum molusca ?




Chapter - 8

# Motion

## CHAPTER AT A GLANCE

**Physical-State**
- Rest
- Motion

**Motion**
- Uniform motion
- Non-uniform motion

**Non-uniform Motion**
- Accelerated motion
  - Uniformly accelerated motion
  - Non-uniformly accelerated motion
- Decelerated motion
  - Uniformly decelerated motion
  - Non-uniformly decelerated motion

**Equations of Motion**
- $v = u + at$ → First equation
- $s = ut + \frac{1}{2}at^2$ → Second equation
- $v^2 = u^2 + 2as$ → Third equation

**Circular Motion**
- An-accelerated motion

**Contents :**



***Rest :*** A body is said to be in a state of rest when its position does not change with respect to a reference point.

***Motion :*** A body is said to be in a state of motion when its position change continuously with reference to a point.

Motion can be of different types depending upon the type of path by which the object is going through.

(i) Circulatory motion/Circular motion – In a circular path.

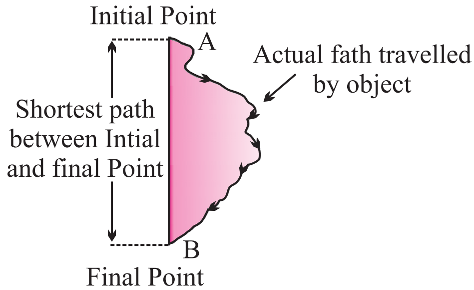
(ii) Linear motion – In a straight line path.

(iii) Oscillatory/Vibratory motion – To and fro path with respect to origin.

***Scalar quantity :*** It is the physical quantity having own magnitude but no direction *e.g.,* distance, speed.

***Vector quantity :*** It is the physical quantity that requires both magnitude and direction *e.g.,* displacement, velocity.

***Distance and Displacement :***




- The actual path or length travelled by a object during its journey from its initial position to its final position is called the distance.
- Distance is a scalar quantity which requires only magnitude but no

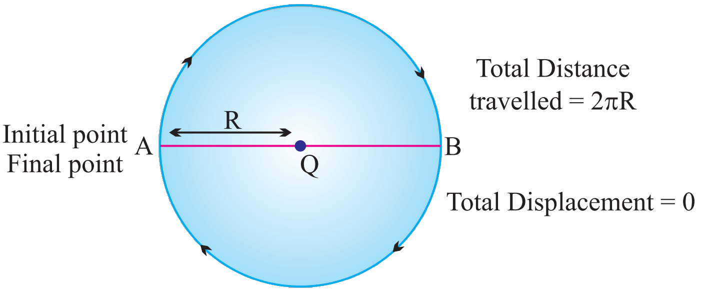
direction to explain it.

*Example,* Ramesh travelled 65 km. (Distance is measured by odometer in vehicles.)

- Displacement is a vector quantity requiring both magnitude and direction for its explanation.

  *Example,* Ramesh travelled 65 km south-west from Clock Tower.

- Displacement can be zero (when initial point and final point of motion are same) *Example,* circular motion.




## Difference between Distance and Displacement

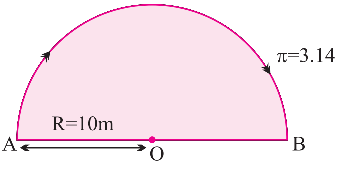
| Distance | Displacement |
|---|---|
| 1. Length of actual path travelled by an object. | 1. Shortest length between initial point and far point of an object. |
| 2. It is scalar quantity. | 2. It is vector quantity. |
| 3. It remains positive, can't be '0' or negative. | 3. It can be positive (+ve), negative (-ve) or zero. |
| 4. Distance can be equal to displacement (in linear path). | 4. Displacement can be equal to distance or its lesser than distance. |

**Example 1.** *A body travels in a semicircular path of radius 10 m starting its motion from point 'A' to point 'B'. Calculate the distance and displacement.*

**Solution :** Total distance travelled by body, S = ?

Given, $\pi = 3.14$, $R = 10$ m

$S = \pi R$



$= 3.14 \times 10$ m

$= 31.4$ m **Ans.**

Total displacement of body, D = ?

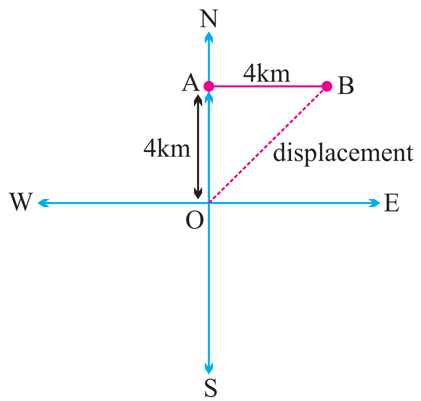
Given, R = 10 m

D = 2 × R

$= 2 \times 10$ m = 20 m **Ans.**

**Example 2.** *A body travels 4 km towards North then he turn to his right and travels another 4 km before coming to rest. Calculate (i) total distance travelled, (ii) total displacement.*

**Solution :**




Total distance travelled = OA + AB

= 4 km + 4 km

= 8 km **Ans.**

Total displacement = OB

$$OB = \sqrt{OA^2 + OB^2}$$

$$= \sqrt{(4)^2 + (4)^2}$$

$$= \sqrt{16+16}$$

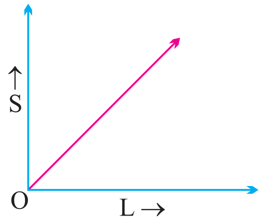
$$= \sqrt{32}$$

= 5.65 km **Ans.**

## *Uniform and Non-uniform Motions*

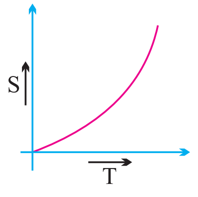
- ***Uniform Motion :***

  When a body travels equal distance in equal interval of time, then the motion is said to be uniform motion.

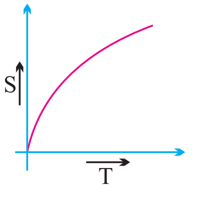



- **Non-uniform Motion :**

  In this type of motion, the body will travel unequal distances in equal intervals of time.



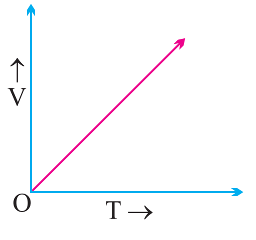

Continuous increase in slope of curve indicates accelerated non-uniform motion.



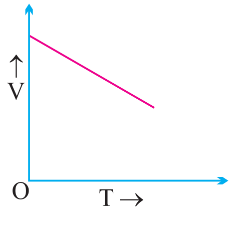

Continuous decrease in slope of curve indicates decelerate non-uniform motion.

Non-uniform motion is of two types :

***(i)*** ***Accelerated Motion :*** When motion of a body increases with time.




***(ii)*** ***De-accelerated Motion :*** When motion of a body decreases with time.




***Speed :*** The measurement of distance travelled by a body per unit time is called speed.

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

$$v = \frac{s}{t}$$

- SI unit = m/s (meter/second)
- If a body is executing uniform motion, then there will be a constant speed or uniform motion.
- If a body is travelling with non-uniform motion, then the speed will not remain uniform but have different values throughout the motion of such body.
- For non-uniform motion, average speed will describe one single value of speed throughout the motion of the body.

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

**Example :** *What will be the speed of body in m/s and km/hr if it travels 40 kms in 5 hrs ?*

**Solution :** Distance ($s$) = 40 km

Time ($t$) = 5 hrs.

$$\text{Speed (in km / hr)} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{40\text{ km}}{5\text{ hrs}}$$

= 8 km/hr **Ans.**

Speed (in m/s) = ?

40 km = 40 × 1000 m = 40,000 m

5 hrs = 5 × 60 × 60 sec.

$$= \frac{40 \times 1000\text{ m}}{5 \times 60 \times 60\text{ s}}$$

$$= \frac{80\text{ m}}{36\text{ s}}$$

= 2.22 m/s **Ans.**

**Conversion Factor**

Change from km/hr to m/s $= \dfrac{1000\ \text{m}}{60 \times 60\ \text{s}}$

$$= \frac{5}{18}\ \text{m/s}$$

***Velocity :*** It is the speed of a body in given direction.

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

- Velocity is a vector quantity. Its value changes when either its magnitude or direction changes.
- For non-uniform motion in a given line, average velocity will be calculated in the same way as done in average speed.

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

- For uniformly changing velocity, the average velocity can be calculated as follows :

$$\text{Avg velocity} = \frac{\text{Initial velocity} + \text{Final velocity}}{2}$$

$$V_{(avg)} = \frac{u+v}{2}$$

where, $u$ = initial velocity, $v$ = final velocity

SI unit of velocity = $ms^{-1}$

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

$\because$

- It can be positive (+ve), negative (-ve) or zero.

**Example 1 :** *During first half of a journey by a body it travel with a speed of 40 km/hr and in the next half it travels with a speed of 20 km/hr. Calculate the average speed of the whole journey.*

**Solution :** Speed during first half ($v_1$) = 40 km/hr

Speed during second half ($v_2$) $= 20$ km/hr

$$\text{Average speed} = \frac{v_1 + v_2}{2}$$

$$= \frac{40 + 20}{2} = \frac{60}{2}$$

$= 30$ km/hr

Average speed by an object (body) $= 30$ km/hr. **Ans.**

**Example 2 :** *A car travels 20 km in first hour, 40 km in second hour and 30 km in third hour. Calculate the average speed of the train.*

**Solution :** Speed in Ist hour $= 20$ km/hr, *Distance travelled during 1st hr* $= 1\times20 = 20$ *km*

Speed in IInd hour $= 40$ km/hr, *Distance travelled during 2nd hr* $= 1\times40 = 40$ *km*

Speed in IIIrd hour $= 30$ km/hr, *Distance travelled during 3rd hr* $= 1\times30 = 30$ *km*

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{20 + 40 + 30}{3} = \frac{90}{3} = \frac{20+40+30}{1+1+1}$$

$= 30$ km/hr **Ans.**

**Acceleration :** Acceleration is seen in non-uniform motion and it can be defined as the rate of change of velocity with time.

$$\text{Acceleration} = \frac{\text{Change in velocity}}{\text{Time}}$$

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

where, $v$ = final velocity, $u$ = initial velocity

If $v > u$, then '$a$' will be positive (+ve).

**Retardation/Deaceleration :** Deaceleration is seen in non-uniform motion during decrease in velocity with time. It has same definition as acceleration.

$$\text{Deaceleration} = \frac{\text{Change in velocity}}{\text{Change in time}}$$

$$a' = \frac{v - u}{t}$$

Here $v < u$, '$a$' = negative (-ve).

**Example 1 :** *A car speed increases from 40 km/hr to 60 km/hr in 5 sec. Calculate the acceleration of car.*

**Solution :** $$u = \frac{40\text{ km}}{\text{hr}} = \frac{40 \times 5}{18} = \frac{100}{9} = 11.11\text{ ms}^{-1}$$

$$v = \frac{60\text{ km}}{\text{hr}} = \frac{60 \times 5}{18} = \frac{150}{9} = 16.66\text{ ms}^{-1}$$

$a$ = ? $\qquad t$ = 5 sec.

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

$$= \frac{16.66 - 11.11}{5}$$

$$= \frac{5.55}{5}$$

$= 1.11\text{ ms}^{-2}$ **Ans.**

**Example 2.** *A car travelling with a speed of 20 km/hr comes into rest in 0.5 hrs. What will be the value of its retardation ?*

**Solution :**

$v$ = 0 km/hr

$u$ = 20 km/hr

$t$ = 0.5 hrs

Retardation, $a'$ = ?

$$a' = \frac{v - u}{t}$$

$$= \frac{0 - 20}{0.5}$$

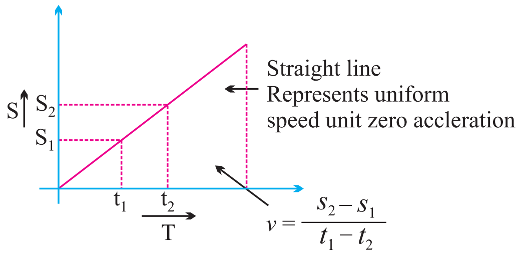
$$= -\frac{200}{5}$$

$= -40\text{ km/hr}^2$ **Ans.**

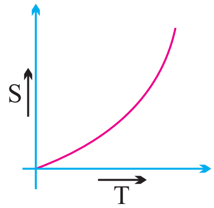
## Graphical Representation of Equation

### (i) Distance-Time Graph : *s/t* graph :

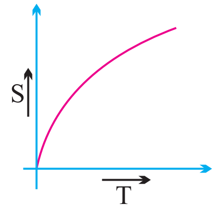
#### (a) *s/t* graph for uniform motion :




#### (b) *s/t* graph for non-uniform motion :

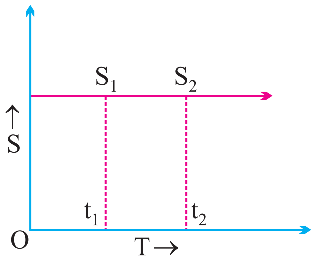



Continuous increase in slope of curve indicates accelerated non-uniform motion.




Continuous decrease in slope of curve indicates decelerate non-uniform motion.

#### (c) *s/t* graph for a body at rest :



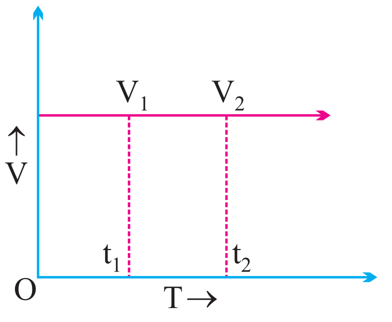

$$v = \frac{s_2 - s_1}{t_2 - t_1}$$

But, $s_2 = s_1$

$$\therefore \quad v = \frac{0}{t_2 - t_1} \quad \text{Or} \quad v = 0$$

**(ii) Velocity-Time Graph :** *v/t* graph :

**(a) *v/t* graph for uniform motion :**



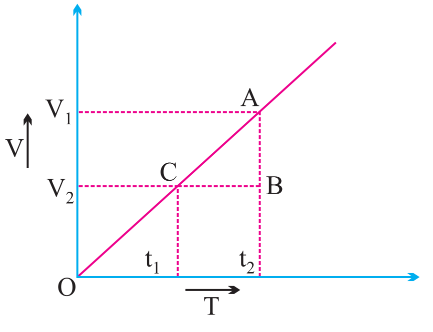

$$a = \frac{v_2 - v_1}{t_2 - t_1}$$

But, $v_2 = v_1$

$$\therefore \quad a = \frac{0}{t_2 - t_1} \quad \text{Or} \quad a = 0$$

**(b) *v/t* graph for non-uniform motion :**

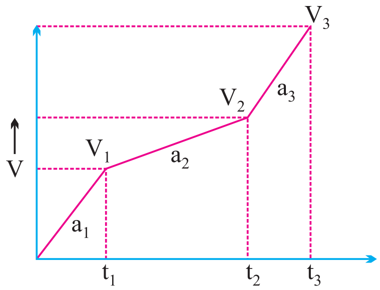
**(A) *v/t* graph for accelerated (uniform) motion :**




$$a = \frac{v_2 - v_1}{t_2 - t_1}$$

In uniformly accelerated motion, there will be equal increase in velocity in equal interval of time throughout the motion of body.

## (B) *v/t* graph for accelerated (non-uniform) motion :




Here if, $$t_2 - t_1 = t_2 - t_3$$

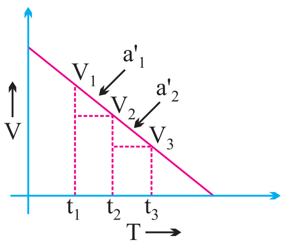
Then, $$v_2 - v_1 \neq v_3 - v_2$$

$$\frac{v_2 - v_1}{t_2 - t_1} \neq \frac{v_3 - v_2}{t_3 - t_2}$$

Or

Or $$a_2 \neq a_1$$

## (C) *v/t* graph for decelerated (uniform) motion :




Here, $$v_2 - v_1 = v_3 - v_2$$

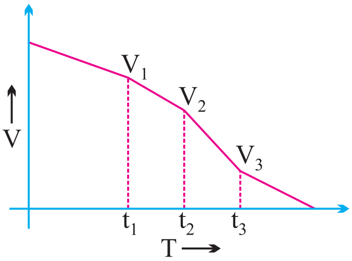
If $$t_2 - t_1 = t_3 - t_2$$

$$\frac{v_2 - v_1}{t_2 - t_1} = \frac{v_3 - v_2}{t_3 - t_2}$$

Then,

Or $$a'_1 = a'_2$$

## (D) *v/t* graph for decelerated (non-uniform) motion :



Here, $$v_2 - v_1 \neq v_3 - v_2$$

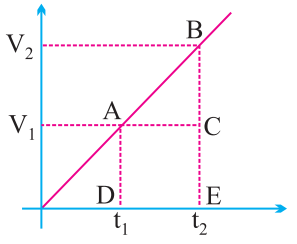
If $$t_2 - t_1 = t_3 - t_2$$

$$\frac{v_2 - v_1}{t_2 - t_1} \neq \frac{v_3 - v_2}{t_3 - t_2}$$

Then,

Or $$a'_1 \neq a'_2$$

***Note :*** *The area enclosed between any two time intervals is '$t_2 - t_1$' in v/t graph will represent the total displacement by that body.*

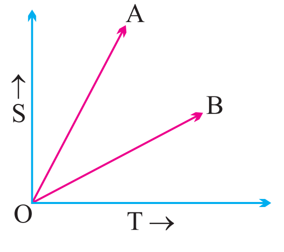



Total distance travelled by body between $t_2$ and $t_1$, time intervals

= Area of ΔABC + Area of rectangle ACDB

$= ½ \times (v_2 - v_1) \times (t_2 - t_1) + v_1 \times (t_2 - t_1)$

**Example :** *From the information given in s/t graph, which of the following body 'A' or 'B' will be more faster ?*




**Solution :** $V_A > V_B$

**Equation of Motion (For Uniformly Accelerated Motion)**

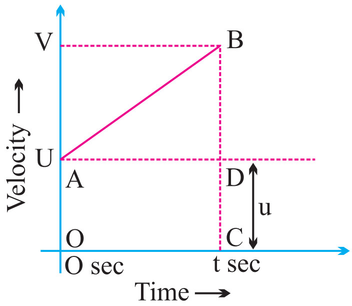
**(i) First Equation**

$$v = u + at$$

Or Final velocity = Initial velocity + Acceleration × Time

**Graphical Derivation :**

Suppose a body has initial velocity '$u$' (*i.e.,* velocity at time $t = 0$ sec.) at point 'A' and this velocity changes to '$v$' at point 'B' in '$t$' secs. *i.e.,* final velocity will be '$v$'.




For such a body there will be an acceleration.

$$a = \frac{\text{Change in velocity}}{\text{Change in time}}$$

$$a = \frac{\text{OB} - \text{OA}}{\text{OC} - 0} = \frac{v-u}{t-0}$$

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

Or

Or $v = u + at$

**(ii) Second Equation**

$s = ut + ½at^2$

Distance travelled by object = Area of OABC (trapezium)

= Area of OADC (rectangle) + Area of ΔABD

= OA × AD + ½ × AD × BD

$= u \times t + ½ \times t \times (v - u)$

$= ut + ½ \times t \times at$

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

$s = ut + ½at^2$

**(iii) Third Equation**

$v^2 = u^2 + 2as$

$s$ = Area of trapezium OABC

$$s = \frac{(\text{OA} + \text{BC}) \times \text{OC}}{2}$$

$$s = \frac{(u+v)\times t}{2}$$

Or $$s = \left(\frac{u+v}{2}\right)\times\left(\frac{v-u}{a}\right)$$ $\left(\because \frac{v-u}{t} = a\right)$

$$s = \frac{v^2-u^2}{2a}$$

$\therefore$

Or $v^2 = u^2 + 2as$

**Example 1.** *A car starting from rest moves with uniform acceleration of 0.1 ms⁻² for 4 mins. Find the speed and distance travelled.*

**Solution :** $u = 0\ \text{ms}^{-1}$ $\because$ car is at rest.

$a = 0.1\ \text{ms}^{-2}$

$t = 4 \times 60 = 240$ sec.

$v = ?$

From, $v = u + at$

$v = 0 + 0.1 \times 240$

Or $v = 24\ \text{ms}^{-1}$ **Ans.**

**Example 2.** *The brakes applied to a car produces deceleration of 6 ms⁻² in opposite direction to the motion. If car requires 2 sec. to stop after application of brakes, calculate distance travelled by the car during this time.*

**Solution :** Deceleration, $a = -6\ \text{ms}^{-2}$

Time, $t = 2$ sec.

Distance, $s = ?$

Final velocity, $v = 0\ \text{ms}^{-1}$ $\because$ car comes to rest.

Now, $v = u + at$

Or $u = v - at$

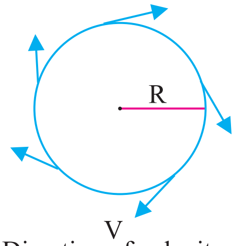
Or $u = 0 - (-6) \times 2 = 12\ \text{ms}^{-1}$

And, $s = ut + \frac{1}{2}at^2$

$= 12 \times 2 + \frac{1}{2} \times (-6) \times (2)^2$

$= 24 - 12 = 12$ m **Ans.**

### Uniform Circular Motion



Direction of velocity (Tangential)

If a body is moving in a circular path with uniform speed, then it is said to be executing uniform circular motion.

In such a motion the speed may be same throughout the motion but its velocity (which is tangential) is different at eact and every point of its motion. Thus, uniform circular motion is an accelerated motion.

# QUESTIONS

## VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

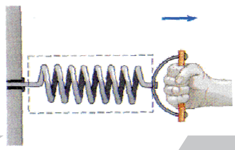
1. Change the speed 6 m/s into km/hr.
2. What do speedometer and odometer used for ?
3. What is the other name of negative acceleration ?
4. What does the slope of distance-time graph indicate ?
5. What can you say about the motion of a body if its speed-time graph is a straight line parallel to the time axis ?

## SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. A tortoise moves a distance of 100 m in 15 minutes. What is its average speed in km/hr ?
2. If a bus travelling at 20 m/s is subjected to a steady deceleration of 5 m/s$^2$, how long will it take to come to rest ?
3. What is the difference between uniform linear motion and uniform circular motion ?
4. Explain why the motion of a body which is moving with constant speed in a circular path is said to be accelerated.

## LONG ANSWER TYPE QUESTIONS (5 Marks)

1. Derive the equations $v = u + at$, $s = ut + ½at^2$ and $v^2 = u^2 + 2as$ graphically.
2. What is uniform circular motion ? Give two examples which force is responsible for that.



Chapter - 9

# Force And Laws Of Motion

## CHAPTER AT A GLANCE

**Force And Laws Of Motion**

- **Force**
  Force (f) = Mass (m) × Acceleration (a)
  Unit = Newton
  - Balanced force
  - Unbalanced force
- Newton's Law of Motion
  - Newton's first law of motion
    - Inertia
    - Mass
  - Newton's second law of motion
    - force = m × a
      Momentum = mv
      Unit of momentum = kgm/s
  - Newton's third law of motion
    - Law of Conservation of momentum
    - Action – Reaction

### Forces and Laws of Motion :

**Force :** It is the force that enables us to do any work. To do anything, either we pull or push the object. Therefore, pull or push is called force.

*Example,* to open a door, either we push or pull it. A drawer is pulled to open and pushed to close.

**Effect of Force**

(i) Force can make a stationary body in object. For example, a football can be set to move by kicking it, *i.e.,* by applying a force.

(ii) Force can stop a moving body. For example, by applying brakes, a running cycle or a running vehicle can be stopped.

(iii) Force can change the direction of a moving object. For example, by applying force, *i.e.,* by moving handle, the direction of a running bicycle can be changed. Similarly by moving steering, the direction of a running vehicle is changed.

(iv) Force can change the speed of a moving body. By accelerating, the speed of a running vehicle can be increased or by applying brakes the speed of a running vehicle can be decreased.

(v) Force can change the shape and size of an object. For example, by hammering, a block of metal can be turned into a thin sheet. By hammering, a stone can be broken into pieces.

***Forces are mainly of two types :***

(A) Balanced forces

(B) Unbalanced forces

**(A) Balanced Forces**

- If the resultant of applied forces is equal to zero, it is called balanced forces.

  *Example,* in the tug of war if both the team apply similar magnitude of forces in opposite directions, rope does not move in either side. This happens because of balanced forces in which resultant of applied forces become zero.

- Balanced forces do not cause any change of state of an object. Balanced forces are equal in magnitude and opposite in direction.

- Balanced forces can change the shape and size of an object. For example, when forces are applied from both sides over a balloon, the size and shape of balloon is changed.

### (B) Unbalanced Forces

- If the resultant of applied forces are greater than zero, the forces are called unbalanced forces. An object in rest can be moved because of applying balanced forces.
- Unbalanced forces can do the following :
  * Move a stationary object
  * Increase the speed of a moving object
  * Decrease the speed of a moving object
  * Stop a moving object
  * Change the shape and size of an object

## Laws of Motion :

**Galileo Galilei :** Galileo first of all said that object move with a constant speed when no foces act on them. This means if an object is moving on a frictionless path and no other force is acting upon it, the object would be moving forever. That is, there is no unbalanced force working on the object.

- But practically it is not possible for any object. Because to attain the condition of zero, unbalanced force is impossible. Force of friction, force of air and many other forces are always acting upon an object.

## Newton's Laws of Motion :

Newton studied the ideas of Galileo and gave the three laws of motion. These laws are known as Newton's laws of motion.

**Newton's First Law of Motion (Law of Inertia) :**

Any object remains in the state of rest or in uniform motion along a straight line, until it is compelled to change the state by applying external force.

**Explanation :** If any object is in the state of rest, then it will remain in rest until a external force is applied to change its state. Similarly, an object will remain in motion until any external force is applied over it to change its state. This means all objects resist to in changing their state. The state of any object can be changed by applying external forces only.

### Newton's First Law of Motion in Everyday Life :

(a) A person standing in a bus falls backward when bus starts moving suddenly. This happens because the person and bus both are in rest while bus is not moving, but as the bus starts moving, the legs of the person start moving along with bus but rest portion of his body has the tendency to remain in rest. Because of this, the person falls backward; if he is not alert.

(b) A person standing in a moving bus falls forward if driver applies brakes suddenly. This happens because when bus is moving, the person standing in it is also in motion along with bus. But when driver applies brakes the speed of bus decreases suddenly or bus comes in the state of rest suddenly, in this condition the legs of the person which are in contact with the bus come in rest while the rest part of his body have the tendency to remain in motion. Because of this person falls forward if he is not alert.

(c) Before hanging the wet clothes over laundry line, usually many jerks are given to the clothes to get them dried quickly. Because of jerks, droplets of water from the pores of the cloth falls on the ground and reduced amount of water in clothes dries them quickly. This happens because when suddenly clothes are made in motion by giving jerks, the water droplets in it have the tendency to remain in rest and they are separated from clothes and fall on the ground.

(d) When the pile of coin on the carom-board is hit by a striker, coin only at the bottom moves away leaving rest of the pile of coin at same place. This happens because when the pile is struck with a striker, the coin at the bottom comes in motion while rest of the coin in the pile has the tendency to remain in the rest and they vertically falls the carom-board and remain at same place.

### Mass and Inertia

- The property of an object because of which it resists to get disturb its state is called inertia. Inertia of an object is measured by its mass. Inertia is directly proportional to the mass. This means inertia increases with increase in mass and decreases with decrease in mass. A heavy object will have more inertia than the lighter one.
- In other words, the natural tendency of an object that resists the change in state of motion or rest of the object is called inertia.

- Since a heavy object has more inertia, thus it is difficult to push or pull a heavy box over the ground than the lighter one.

**Momentum**

- Momentum is the power of motion of an object.
- The product of velocity and mass is called the momentum. Momentum is denoted by 'p'.

  Therefore, Momentum of the object = Mass × Velocity

  Or, $p = m \times v$

Where, $p$ = momentum, $m$ = mass of the object and $v$ = velocity of the object.

Consider the following explanations to understand the momentum :

- A person get injured in the case of hitting by a moving object, such as stone, pebbles or anything because of momentum of the object.
- Even a small bullet is able to kill a person when it is fired from a gun because of its momentum due to great velocity.
- A person get injured severely when hit by a moving vehicle because of momentum of vehicle due to mass and velocity.

**Momentum and Mass and Velocity**

- Since momentum is the product of mass and velocity ($p = m \times v$) of an object. This means momentum is directly proportional to mass and velocity. Momentum increases with increase of either mass or velocity of an object.
- This means if a lighter and a heavier object is moving with same velocity, then heavier object will have more momentum than the lighter one.
- If a small object is moving with great velocity, it has tremendous momentum. And because of momentum, it can harm an object more severely. For example, a small bullet having a little mass even kills a person when it is fired from a gun.
- Usually, road accidents prove more fatal because of high speed than in slower speed. This happens because vehicles running with high speed have greater momentum compared to a vehicle running with slower speed.

**Momentum of an object which is in the state of rest :**

Let an object with mass '$m$' is in the rest.

Since, object is in rest, therefore, its velocity, $v = 0$

Now, we know that

$$\text{Momentum} = \text{mass} \times \text{velocity}$$

Or $$p = m \times 0 = 0$$

Thus, the momentum of an object in the rest *i.e.,* non-moving, is equal to zero.

**Unit of momentum :**

SI unit of mass = kg

SI unit of velocity = meter per second *i.e.,* m/s

We know that $$\text{Momentum } (p) = m \times v$$

Therefore, $$p = \text{kg} \times \text{m/s}$$

Or $$p = \text{kg m/s}$$

Therefore, SI unit of momentum = kg m/s

**Numerical Problems Based on Momentum**

**Type I. Calculation of Momentum**

**Example 1.** *What will be the momentum of a stone having mass of 10 kg when it is thrown with a velocity of 2 m/s ?*

**Solution :** Mass ($m$) = 10 kg

Velocity ($v$) = 2 m/s

Momentum ($p$) = ?

We know that, Momentum ($p$) = Mass ($m$) × Velocity ($v$)

Therefore, $p$ = 10 kg × 2 m/s = 20 kg m/s

Thus, the momentum of the stone = 20 kg m/s. **Ans.**

**Example 2.** *Calculate the momentum of a bullet of 25 g when it is fired from a gun with a velocity of 100 m/s.*

**Solution :** Given, Velocity of the bullet ($v$) = 100 m/s

Mass of the bullet ($m$) = 25 g = 25/1000 kg = 0.025 kg

Momentum ($p$) = ?

Since, $p = m \times v$

So, $p = 0.025 \times 100 = 2.5$ kg m/s

Thus, momentum of the bullet = 2.5 kg m/s. **Ans.**

**Example 3.** *Calculate the momentum of a bullet having mass of 25 g is thrown using hand with a velocity of 0.1 m/s.*

**Solution :** Given, Velocity of the bullet ($v$) = 0.1 m/s

Mass of the bullet ($m$) = 25 g = 25/1000 kg = 0.025 kg

Momentum ($p$) = ?

We know that, Momentum ($p$) = Mass ($m$) × Velocity ($v$)

Therefore, $p = 0.025$ kg × 0.1 m/s

Or $p = 0.0025$ kg m/s

Thus, the momentum of the bullet = 0.0025 kg m/s. **Ans.**

**Example 4.** *The mass of a goods lorry is 4000 kg and the mass of goods loaded on it is 20000 kg. If the lorry is moving with a velocity of 2 m/s, what will be its momentum ?*

**Solution :** Given, Velocity ($v$) = 2 m/s

Mass of lorry = 4000 kg, Mass of goods on the lorry = 20000 kg

Therefore, Total mass ($m$) on the lorry = 4000 kg + 20000 kg = 24000 kg

Momentum ($p$) = ?

We know that, Momentum ($p$) = Mass ($m$) × Velocity ($v$)

Therefore, $p = 24000$ kg × 2 m/s

Or $p = 48000$ kg m/s

Thus, the momentum of the lorry = 48000 kg m/s. **Ans.**

**Example 5.** *A car having mass of 1000 kg is moving with a velocity of 0.5 m/s. What will be its momentum ?*

**Solution :** Given, Velocity of the car ($v$) = 0.5 m/s

Mass of the car ($m$) = 1000 kg

Momentum ($p$) = ?

We know that, Momentum ($p$) = Mass ($m$) × Velocity ($v$)

Therefore, $p$ = 1000 kg × 0.5 m/s = 500 kg m/s

Thus, momentum of the car = 500 kg m/s. **Ans.**

**Statement of Second Law**

Rate of change of momentum of an object is proportional to applied unbalanced force in the direction of force.

**Mathematical expression**

Suppose, Mass of an object = $m$ kg

Initial velocity of an object = $u$ m/s

Final velocity of an object = $v$ m/s

So, Initial momentum, $p_1 = mu$, Final momentum, $p_2 = mv$

$\therefore$ Change in momentum = Final momentum – Initial momentum

$= mv - mu$

$= m(v - u)$

$\therefore$ Rate of change of momentum $= \dfrac{\text{Change in momentum}}{\text{Time taken}}$

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

- According to IInd law, this rate of change is momentum is directly proportional to force.

$$\therefore \quad F \propto \frac{m(v-u)}{t}$$

We know that, $\dfrac{v-u}{t} = a$ (From Ist equation of motion)

So, $F = kma$

Where $k$ is a constant. Its value = 1.

$\therefore$ $F = 1 \times m \times a = ma$

SI unit $= \text{kg m/s}^2$ or Newton

**Q. Define 1 Newton.**

**Ans.** When an acceleration of 1 $\text{m/s}^2$ is seen in a body of mass 1 kg, then the force applied on the body is said to be 1 Newton.

**Proof of Newton's First Law of Motion from Second Law**

First law states that if external force F = 0, then a moving body keeps moving with the same velocity, or a body at rest continues to be at rest.

So, $F = 0$

We know $F = \dfrac{m(v-u)}{t}$

(a) A body is moving with initial velocity $u$, then

$$0 = \frac{m(v-u)}{t} \quad \Rightarrow \quad v - u = 0$$

So, $v = u$

Thus, final velocity is also same.

(b) A body is at rest *i.e.,* $u = 0$.

Therefore, from above $u = v = 0$

So, the body will continue to be at rest.

**Third Law of Motion**

To every action there is an equal an opposite reaction.

**Applications :**

(i) Walking is enabled by IIIrd law.

(ii) A boat moves back when we deboard it.

(iii) A gun recoils.

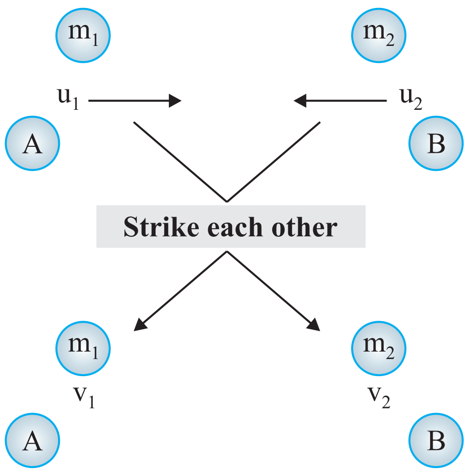
(iv) Rowing of a boat.

**Law of Conservation of Momentum**

When two (or more) bodies act upon one another, their total momentum remains constant (or conserved) provided no external forces are acting.

Initial momentum = Final momentum

Suppose, two objects A and B each of mass $m_1$ and mass $m_2$ are moving initially with velocities $u_1$ and $u_2$, strike each other after time $t$ and start moving with velocities $v_1$ and $v_2$ respectively.




Now,

Initial momentum of object A = $m_1u_1$

Initial momentum of object B = $m_2u_2$

Final momentum of object A = $m_1v_1$

Final momentum of object B = $m_2v_2$

So, Rate of change of momentum in A, $F_1 = \frac{m_1v_1 - m_1u_1}{t}$

$$= \frac{m_1(v_1 - u_1)}{t} \quad \text{...(i)}$$

And Rate of change of momentum in B, $F_2 = \frac{m_2 v_2 - m_2 u_2}{t}$

$$= \frac{m_2 (v_2 - u_2)}{t} \quad \text{...(ii)}$$

We know from IIIrd law of motion,

$$F_1 = -F_2$$

So, $\frac{m_1 (v_1 - u_1)}{t} = -\frac{m_2 (v_2 - u_2)}{t}$ [From equations (i) & (ii)]

Or $m_1 v_1 - m_2 v_2 = -m_2 v_2 + m_2 u_2$

So $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

Thus, Initial momentum = Final momentum

**Example 1.** *A bullet of mass 20 g is fired horizontally with a velocity of 150 m/s from a pistol of mass 2 kg. Find the recoil velocity of the pistol.*

**Solution :** Given, Mass ($m_1$) of bullet = 20 g = 0.02 kg

Mass ($m_2$) of pistol = 2 kg

Initially bullet is inside the gun and it is not moving.

So, Mass $= m_1 + m_2$ = (0.02 + 2) kg = 2.02 kg

And $u_1 = 0$

So, Initial momentum = 2.02 × 0 = 0 ...(i)

Finally let the velocity of pistol be $v_2$ and $v_1$ for bullet = 150

So, Final momentum $= m_1 v_1 + m_2 v_2$

$$= 0.02 \times 150 + 2v_2 \quad \text{...(ii)}$$

We know that Initial momentum = Final momentum

So, $0 = \frac{0.02 \times 150}{100} + 2v_2$ [From equations (i) and (ii)]

$$\Rightarrow \qquad 3 + 2v_2 = 0$$

$$\text{Or} \qquad 2v_2 = -3$$

$$\text{Or} \qquad v_2 = -1.5 \text{ m/s}$$ **Ans.**

(–)ve sign indicates that gun recoils in direction opposite to that of the bullet.

**Example 2.** *Two hockey players viz A of mass 50 kg is moving with a velocity of 4 m/s and another one B belonging to opposite team with mass 60 kg is moving with 3 m/s, get entangled while chasing and fall down. Find the velocity with which they fall down and in which direction ?*

**Solution :** Given, $m_A = 50$ kg, $u_A = 4$ m/s

$m_B = 60$ kg, $u_B = 3$ m/s

$$\text{Initial momentum}_A = m_A u_A$$

$$= 50 \times 4 = 200 \text{ kg m/s}$$

$$\text{Initial momentum}_B = m_B u_B$$

$$= 60 \times 3 = 180 \text{ kg m/s}$$

So, Total initial momentum $= 200 + 180 = 380$ kg m/s ...(i)

$$\text{Final momentum} = (m_A + m_B)v = (50 + 60)v$$

$$= 110v$$ ...(ii)

According to the law of conservation of momentum,

$$380 = 110v$$

$$\text{Or} \qquad v = \frac{380}{110} = 3.454 \text{ m/s}$$ **Ans.**

# QUESTIONS

## VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

1. Can force be (–)ve ? When ?
2. What is the tendency of a body to resist its change of state called ?
3. Inertia is also measured by.................of an object.
4. Higher the mass of an object, higher is its................. .
5. $\dfrac{\text{Force}}{\text{Acceleration}}$ is determined by.................which is also mass of the object.
6. Why does the load from the cage above the seats in a bus falls down when suddenly brakes are applied ?

## SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. Quantity of motion contained in a body is................. .
2. Unit of momentum is................. .
3. Define 1 Newton.
4. Although we know that a moving body keeps moving indefinitely until an external force is applied on it, then why does a ball stops when we slide it on ground (without stopping it) ?
5. Why is it difficult to stop a truck suddenly than a motorbike ?

## SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. When a metro suddenly stops all the passengers fell forward on its floor. Why do this happen ?
2. We have a huge atmosphere above us that exerts a huge pressure on our shoulders, head and whole body. Why don't we get crushed under it ?
3. A coin of mass 1 kg and a stone of mass 5 kg are thrown down the Eiffel Tower with an acceleration of 10 m/s$^2$. Which one would reach the ground early and why ?
4. Give applications of Ist law of motion i.e., inertia.
5. (a) Friction is measured in.................. .

   (b) Distinguish between balanced and unbalance forces.

## LONG ANSWER TYPE QUESTIONS (5 Marks)

1. (a) Derive first law of Newton from second law.

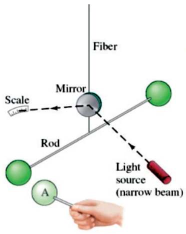
   (b) Find the force required to stop a car of mass 100 kg with two passengers each of 50 kg sitting inside, if it is moving at 60 km/hr speed and takes 5 s to stop.

2. Two balls A and B of masses 40 g and 50 g are moving at speeds of 40 m/s and 30 m/s respectively. If after colliding, B stars moving with a velocity of 25 m/s, what is the velocity of A ?

3. A girl of mass 30 kg jumps on a cart of mass 5 kg with a velocity of 10 m/s. Find the velocity with which she and cart start moving after she jumps on it.

### Answers to Long answer type questions

1. (b) - 2000/3 N    2. 46.25 m/s    3. 8.57 m/s




Chapter - 10

# Gravitation

## CHAPTER AT A GLANCE

**Gravitation**

reaction

**Newton's Universal law of gravitation**

Force (f) = $\frac{GM_1M_2}{R^2}$

G = Gravitational Constant

$M_1$ = Mass of object 1

$M_2$ = Mass of object 2

R = distance between object

↓

W = m × g

Weight = Mass × Gravity

**Buoyant force 'f'**

Trust → Pressure

P = F/A

P = Pressure

F = Force

A = Area

**Acceleration due to gravity (g) = 9.8 m/s$^2$**

$g = \frac{GM}{R^2}$

R = Radius of Earth

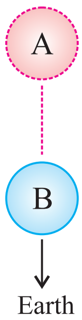
M = Mass of Earth

G = Gravitational constant

↓

Value of G = $6.67 \times 10^{-11}$ Nm$^2$/kg$^2$

## Gravitational Force of Earth



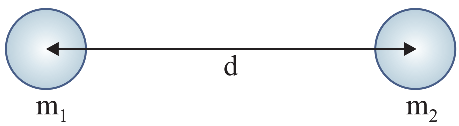

If we release a small stone without pushing it from a height, it accelerates towards earth. The stone is when accelerated towards earth, means some force is acting on it.

The force which pulls the objects towards the centre of the earth is known as gravitational force of the earth.

Here, stone also attracts earth. It means every object in universe attracts every other object.

### *Newton's Universal Law of Gravitation*

Sir Isaac Newton in 1687 proposed a law about the force of attraction between the two objects in the universe which is known as Newton's law of gravitation.




According to this law :

Every mass in this universe attracts every other mass with a force which is directly proportional to the product of two masses and inversely proportional to the square of the distance between them.

Let masses ($m_1$) and ($m_2$) of two objects are distance ($d$) apart, then force of attraction (F) between them

$$F \propto m_1 \times m_2$$

$$F \propto \frac{1}{d^2}$$

$$F \propto \frac{m_1 \times m_2}{d^2}$$

$$F = \frac{Gm_1 \times m_2}{d^2}$$

where G is a constant and is known as Gravitational constant.

> Value of G = $6.67 \times 10^{-11}$ $Nm^2/kg^2$
>
> G is called universal gravitational constant.

If unit of F is in Newton, $m$ is in kg, $d$ is in metre, then unit of G can be calculated as :

$$G = \frac{F \times d^2}{m_1 \times m_2} \text{ so unit be } \frac{Nm^2}{kg^2} \text{ or } Nm^2/kg^2$$

## Relation between Newton's third law of motion and Newton's law of gravitation

According to Newton's third law of motion, "Every object exerts equal and opposite force on other object but in opposite direction."

According to Newton's law of gravitation, "Every mass in the universe attracts the every other mass."

In case of freely falling stone and earth, stone is attracted towards earth means earth attracts the stone but according to Newton's third law of motion, the stone should also attract the earth and really it is true that stone also attracts the earth with the same force $F = m \times a$ but due to very less mass of the stone, the acceleration ($a$) in its velocity is 9.8 $m/s^2$ and acceleration ($a$) of earth towards stone is $1.65 \times 10^{-24}$ $m/s^2$ which is negligible and we cannot feel it.

***Importance of universal law of gravitation***

(i) The force that binds us to the earth.

(ii) The motion of moon around the earth.

(iii) The motion of earth around the sun.

(iv) The tides due to moon and the sun.

***Free fall of an object and acceleration during free fall***

When an object is thrown upward, it reaches certain height, then it starts falling down towards earth. It is because the earth's gravitational force exerts on it.

This fall under the influence of earth is called 'free fall of an object'.

During this free fall direction do not change but velocity continuously changes which is called acceleration due to gravity.

It is denoted by '$g$'.

Its unit is same as acceleration $m/s^2$.

## Gravitational Acceleration and its value at the surface of earth

The uniform acceleration produced in a freely falling object due to the gravitational force of earth, is called acceleration due to gravity. It is represented by '$g$' and it always acts towards the centre of the earth.

**Value of '$g$' on the surface of earth**

The force acting on an object is

$$F = \frac{GM_e m}{R^2} \qquad \text{...(i)}$$

Where $M_e$ = Mass of earth

$m$ = Mass of an object

R = Radius of earth

and if acceleration due to gravity is '$g$' due to force F then,

$$F = m \times g \quad \text{...(ii)}$$

Equating (i) and (ii), we get $$m \times g = \frac{GM_e m}{R^2}$$

Or $$g = \frac{GM_e}{R^2}$$

If $G = 6.673 \times 10^{-11}$ Nm$^2$/kg$^2$, $M_e = 6 \times 10^{24}$ kg, $R^2 = (6.37 \times 10^6)^2$

Then, $$g = \frac{6.6734 \times 10^{-11} \times 6 \times 10^{24}}{(6.37 \times 10^6)^2}$$

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

***Relationship and difference between 'G' and 'g'***

G = Gravitational constant

$g$ = Acceleration due to gravity

$$g = \frac{GM}{R^2}$$

**Difference between G (Gravitational constant) and *g* (Acceleration due to gravity)**

| Gravitation Constant (G) | Gravitational acceleration ($g$) |
|---|---|
| 1. Its value is $6.6734 \times 10^{-11}$ Nm$^2$/kg$^2$. | 1. Its value is 9.8 m/s$^2$. |
| 2. Its value remains constant always and everywhere. | 2. Its value varies at various places. |
| 3. Its unit is Nm$^2$/kg$^2$. | 3. Its unit is m/s$^2$. |
| 4. It is a scalar quantity. | 4. It is a vector quantity. |

**Example.** *If two stones of 150 gm and 500 gm are dropped from a height, which stone will reach the surface of earth first and why ? Explain your answer.*

**Ans.** It was Galileo, who first time demonstrated and depicted that the acceleration of an object falling freely towards earth does not depend on the mass of the object.

It can be verified by universal law of gravitation. Let an object of mass $m$, is allowed to fall from a distance of R, from the centre of the earth.

Then, the gravitational force, $F = \frac{GM_e m}{R^2}$ ($M_e$ = Mass of the earth)

The force acting on the stone is $F = m \times a$

So, $m \times a = \frac{GM_e m}{R^2}$

Or $a = \frac{GM_e}{R^2}$

So, acceleration in an object falling freely towards earth depends on the mass of earth and height of the object from the centre of the earth. So stones of mass 150 gm and 500 gm will reach the earth surface together.

***Equation of motion when an object is falling freely towards earth or thrown vertically upwards :***

**Case 1.** When an object is falling towards earth with initial velocity ($u$), then

Velocity ($v$) after $t$ seconds, $v = u + gt$

Height covered in $t$ seconds, $h = ut + \frac{1}{2}gt^2$

Relation between $v$ and $u$ when $t$ is not mentioned :

$$v^2 = u^2 + 2gh$$

**Case 2.** When object is falling from rest position means initial velocity $u = 0$ (zero), then

Velocity ($v$) after $t$ seconds, $v = gt$

Height covered in $t$ seconds, $h = \frac{1}{2}gt^2$

Relation between $v$ and $u$ when $t$ is not mentioned :

$$v^2 = 2gh$$

**Case 3.** When an object is thrown vertically upwards with initial velocity $u$, the gravitational acceleration will be negative ($-g$), then

Velocity ($v$) after $t$ seconds, $v = u - gt$

Height covered in $t$ seconds, $h = ut - \frac{1}{2}gt^2$

Relation between $v$ and $u$ when $t$ is not mentioned :

$$v^2 = u^2 - 2gh$$

**Mass**

The mass of a body is the quantity of matter contained in it. Mass is a scalar quantity which has only magnitude but no direction.

SI unit of mass is kilogram which is written in short form as kg.

- Mass of a body is constant and does not change from place to place.
- Mass of a body is usually denoted by the small '*m*'.
- Mass of a body cannot be zero.

**Weight**

The force with which an object is attracted towards the centre of the earth, is called the weight of the object.

$$\text{Force} = m \times a$$

In case of earth, $a = g$

So, $F = m \times g$

But the force of attraction of earth on an object is called its weight (W). So,

$$W = m \times g$$

So, weight is the force and its SI unit is Newton (N). It depends on '*g*' and is a vector quantity.

**Relation between 1 kg wt and express it into Newton :**

We know that $W = m \times g$

If mass ($m$) = 1 kg, $g = 9.8$ m/s$^2$, then

$$W = 1 \text{ kg} \times 9.8 \text{ m/s}^2$$

Or $1 \text{ kg wt} = 9.8\text{N}$

So, the gravitational force of earth that acts on an object of mass 1 kg is called as 1 kg wt.

**Distinguish between Mass and Weight**

| Mass | Weight |
|---|---|
| 1. We can measure mass of an object by its inertia. | 1. Weight = mass × acceleration or $m \times g$. |
| 2. The total quantity of matter contained in an object is called mass of an object. | 2. The gravitational force by which earth attracts an object is called weight of the object. |
| 3. Mass of the object remains constant at all the places. | 3. Weight of the object is different at different places. |
| 4. Measurement of mass is done by using a pan or beam balance. | 4. Measurement of weight is done by using a spring balance. |

| | |
|---|---|
| 5. Mass does not change even value of $g$ is zero at any place. | 5. Weight of the object becomes zero if $g$ is zero. |

**Factors affecting value of *g***

Earth is not a perfect sphere. The radius of earth increases when we go from pole to equator. Therefore, in most of the calculation, we can take $g$ as constant at the surface of earth or closer to it. But, as we move away from earth, we can use equation $g = \frac{GM}{d^2}$ for solving problems.

**Example.** *Calculate the value of 'g' at a height of 12800 km from the centre of the earth (radius of earth is 6400 km). Draw its interpretation.*

**Solution :** We know that $g_1 = \frac{GM_e}{(2R_e)^2}$, $R_e = 6400$ km

Weight of the object from the centre of earth = 12800 km = $2R_e$

$$\therefore \qquad g_2 = \frac{GM_e}{(2R_e)^2}$$

Or $$\frac{g_1}{g_2} = \frac{G \cdot M_e}{(R_e)^2} \times \frac{(2R_e)^2}{G \cdot M_e}$$

$$\frac{g_1}{g_2} = \frac{4}{1} \qquad \text{Or} \qquad 4g_2 = g_1$$

So, the value of gravitational acceleration '$g$' at a distance of 12800 km from the centre of the earth is ¼.

The value of gravitational acceleration '$g$' decreases with increasing height.

***The weight of an object on moon is one-sixth of the weight on earth.***

Let mass of an object be $m$, its weight on earth means the force by which earth attracts it towards the centre.

Now, $$F_e = \frac{GM_e m}{R_e^2} \qquad \text{...(i)}$$

where G = Gravitational constant, $M_e$ = Mass of the earth, $m$ = Mass of object, $R_e$ = Radius of the earth

Weight of an object on moon,

$$F_m = \frac{GM_m m}{R_m^2} \qquad \text{...(ii)}$$

where $M_m$ = Mass of the moon, $R_m$ = Radius of the moon

Dividing equation (i) by equation (ii), we get

$$\frac{F_e}{F_m} = \frac{GM_e \cdot m}{R_e^{\ 2}} \times \frac{R_m^{\ 2}}{GM_m \cdot m}$$

$$\frac{F_e}{F_m} = \frac{M_e}{M_m} \times \left(\frac{R_m}{R_e}\right)^2$$

We know that mass of earth is 100 times the mass of the moon.

So, $M_e = 100M_m$

And radius of earth is 4 times the radius of moon.

So, $R_e = 4R_m$

Then, $$\frac{F_e}{F_m} = \frac{100M_m}{M_m} \times \left(\frac{R_m}{4R_m}\right)^2$$

$$\frac{F_e}{F_m} = \frac{100}{1} \times \frac{1}{16}$$

$$\frac{F_e}{F_m} = 6 \text{ times (approx.)}$$

Hence, $F_e = 6F_m$

**Thrust and Pressure**

**Thrust :** The force acting on an object perpendicular to the surface is called thrust.

**Pressure :** The effect of thrust per unit area is called pressure.

$$\text{Pressure (P)} = \frac{\text{Force (F)}}{\text{Area (A)}}$$

SI unit is $N/m^2$ or $Nm^{-2}$.

SI unit of pressure is Pascal denoted by 'Pa'.

**Factors on which pressure depends**

Pressure depends on two factors :

(i) Force applied

(ii) Area of surface over which force acts

*Examples :*

- The base of high buildings is made wider so that weight of walls act over a large surface area and pressure is less.
- School bags are having broad strap so that the weight of school bags fall over a larger area of the shoulder and produce less pressure and becomes less painful.
- The blades of knives are made sharp so very small surface area and on applying force, it produces large pressure and cuts the object easily.
- All liquids and gases are fluids and they exert pressure in all directions.

**Buoyancy**

The upward force experienced by an object when it is immersed into a fluid is called force of buoyancy. It acts in upward direction and it depends on the density of the fluid.

- Force of gravitational attraction of the earth on the surface of the object $\leq$ buoyant force exerted by fluid on the surface of the object.

***Result :*** The object floats.

- Force of gravitational attraction of the earth on the surface of the object $>$ buoyant force exerted by fluid on the surface of the object.

***Result :*** The object sinks.

That is why, allpin sinks and boat/ship floats on the surface of water. (Archimedes' principle)

**Density**

The mass per unit volume is called density of an object. If M is the mass and V is the volume, then density ($d$) is

$$\text{Density } (d) = \frac{\text{Mass}(\text{M})}{\text{Volume}(\text{V})}$$

SI unit = $kg/m^3$

**Archimedes' Principle**

It states, when a body is immersed fully or partially in a fluid, it experiences a upward force that is equal to the weight of the fluid displaced by it.

**Applications of Archimedes' Principle :**

(i) It is used in determining relative density of substances.

(ii) It is used in designing ships and submarines.

(iii) Hydrometers and lactometers are made on this principle.

It is because of this ship made of iron and steel floats in water whereas a small piece of iron sinks in it.

**Relative density**

The ratio of the density of a substance to that of the density of water is called relative density.

$$\text{Relative density} = \frac{\text{Density of a substance}}{\text{Density of water}}$$

It has no unit.

**Solved Numericals**

**Example 1.** *Relative density of gold is 19.3. The density of water is $10^3$ kg/m$^3$. What is the density of gold in kg/m$^3$ ?*

**Solution :** Given, Relative density of gold = 19.3

Density of water = $10^3$ kg/m$^3$

So, Density of gold = Relative density of gold × Density of water

$= 19.3 \times 10^3$

Hence, density of gold $= 19.3 \times 10^3$ kg/m$^3$. **Ans.**

**Example 2.** *Mass of 0.025 m$^3$ of aluminium is 67 kg. Calculate the density of aluminium.*

**Solution :** Given, Mass of aluminium = 67 kg

Volume of aluminium = 0.025 m$^3$

So, Density $= \frac{M}{V} = \frac{67}{0.025}$

$= 2680$ kg/m$^3$ **Ans.**

**Example 3.** *The mass of brick is 2.5 kg and its dimensions are 20 cm × 10 cm × 5 cm. Find the pressure exerted on the ground when it is placed on the ground with different faces.*

**Solution :** Given, Mass of the brick = 2.5 kg

Dimensions of the brick = 20 cm × 10 cm × 5 cm

So, Weight of the brick (Thrust/Force)

$= F = mg = 2.5 \times 9.8 = 24.5$ N

(i) When the surface area 10 cm × 5 cm is in contact with the ground, then

$$\text{Area} = 10 \times 5 = 50 \text{ cm}^2$$

$$= \frac{50}{10000} = 0.005 \text{ m}^2$$

So, $$P = \frac{F}{A} = \frac{24.5}{0.0050}$$

$$= 4900 \text{ N/m}^2$$ **Ans.**

(ii) When the surface area 20 cm × 5 cm is in contact with the ground, then

$$\text{Area} = 20 \times 5 = 100 \text{ cm}^2$$

$$= \frac{100}{10000} = 0.01 \text{ m}^2$$

So, $$P = \frac{F}{A} = \frac{24.5}{0.01}$$

$$= 2450 \text{ N/m}^2$$ **Ans.**

(iii) When the surface area 20 cm × 10 cm is in contact with the ground, then

$$\text{Area} = 20 \times 10 = 200 \text{ cm}^2$$

$$= \frac{200}{10000} = 0.02 \text{ m}^2$$

So, $$P = \frac{F}{A} = \frac{24.5}{0.02}$$

$$= 1225 \text{ N/m}^2$$ **Ans.**

**Example 4.** *A force of 20N acts upon a body whose weight is 9.8N. What is the mass of the body and how much is its acceleration ?*

**Solution :** Given, Force = 20N, Weight W = 9.8N

We know, $W = mg$

So, $9.8 = m \times 9.8$

Or $m = 1$ kg **Ans.**

And, $F = ma$

So, $20 = 1 \times a$

Or $a = 20 \text{ m/s}^2$ **Ans.**

**Example 5.** *A man weighs 1200N on the earth. What is his mass (take g = 10 m/s²) ? If he was taken to the moon, his weight would be 200N. What is his mass on*