Government of Tamilnadu

Department of Employment and Training

Course : TNPSC Group II Exam

Subject : Physics

Topic : **Mechanics & Properties of Matter**

Commissioner,
Department of Employment and Training.

MECHANICS & PROPERTIES OF MATTER

MECHANICS AND PROPERTIES OF MATTER

Elasticity

- The property of a material to regain its original state when the deforming force is removed is called elasticity

Stress and strain

- This restoring force per unit area of a deformed body is known as stress.

$$\text{Stress} = \frac{\text{Restoring Force}}{Area} = \frac{\text{Nm}^{-2}}{Area}$$

- Its dimensional formula is $ML^{-1}T^{-2}$.
- Strain produced in a body is defined as the ratio of change in dimension of a body to the original dimension.

$$\text{Strain} = \frac{\text{Change in Dimension}}{Original\ Dimension}$$

- Strain is the ratio of two similar quantities. Therefore it has no unit.

Elastic limit

- If an elastic material is stretched or compressed beyond a certain limit, it will not regain its original state and will remain deformed. The limit beyond which permanent deformation occurs is called the elastic limit.

Hooke's law

- Within the elastic limit, strain produced in a body is directly proportional to the stress that produces it. (i.e) stress α strain

$$\frac{Stress}{Strain} = \text{a constant}$$

Pascal's law

- Pascal's law states that if the effect of gravity can be neglected then the pressure in a fluid in equilibrium is the same everywhere.

Applications of Pascal's law

(i) Hydraulic lift

(ii) Hydraulic brake

Ball pen works on the principle of capillarity

Viscosity

- Viscosity is the property of the fluid by virtue of which it opposes relative motion between its different layers. Both liquids and gases exhibit viscosity but liquids are much more viscous than gases.

Co-efficient of viscosity

- The coefficient of viscosity of a liquid is numerically equal to the viscous force acting tangentially between two layers of liquid having unit area of contact and unit velocity gradient normal to the direction of flow of liquid.
- The unit of η is Ns m^{-2}. Its dimensional formula is $ML^{-1}T^{-1}$.

Streamline flow

- The flow of a liquid is said to be steady, streamline or laminar if every particle of the liquid follows exactly the path of its preceding particle and has the same velocity of its preceding particle at every point

Turbulent flow

- When the velocity of a liquid exceeds the critical velocity, the path and velocities of the liquid become disorderly. At this stage, the flow loses all its orderliness and is called turbulent flow.

Some examples of turbulent flow are:

1. After rising a short distance, the smooth column of smoke from an incense stick breaks up into irregular and random patterns.
2. The flash - flood after a heavy rain. Critical velocity of a liquid can be defined as that velocity of liquid upto which the flow is streamlined and above which its flow becomes turbulent.

Stoke's law (for highly viscous liquids)

1. Coefficient of viscosity η of the liquid depends on
2. Radius a of the sphere and
3. Velocity v of the spherical body.

Dimensionally it can be proved that

$$F = k \eta a v$$

Experimentally Stoke found that

$$k = 6\pi$$

$$\therefore F = 6\pi \eta a v$$

This is Stoke's law.

Application of Stoke's law

- **Falling of rain drops:** When the water drops are small in size, their

terminal velocities are small. Therefore they remain suspended in air in the form of clouds. But as the drops combine and grow in size, their terminal velocities increase. Hence they start falling as rain.

Surface tension Intermolecular forces

- The force between two molecules of a substance is called intermolecular force.
- The intermolecular forces are of two types. They are (i) cohesive force and (ii) adhesive force.

(i) Cohesive force

- Cohesive force is the force of attraction between the molecules of the same substance. This cohesive force is very strong in solids, weak in liquids and extremely weak in gases.

(ii) Adhesive force

- Adhesive force is the force of attraction between the moelcules of two different substances.
- For example due to the adhesive force, ink sticks to paper while writing. Fevicol, gum etc exhibit strong adhesive property.

Surface tension of a liquid

- Surface tension is the property of the free surface of a liquid at rest to behave like a stretched membrane in order to acquire minimum surface area.

Capillarity

- The property of surface tension gives rise to an interesting phenomenon called capillarity The rise of a liquid in a capillary tube is known as capillarity

Illustrations of capillarity:

(i) A blotting paper absorbs ink by capillary action. The pores in the blotting paper act as capillaries.

(ii) The oil in a lamp rises up the wick through the narrow spaces between the threads of the wick.

(iii) A sponge retains water due to capillary action.

(iv) Walls get damped in rainy season due to absorption of water by bricks.

Factors affecting surface tension

Impurities present in a liquid appreciably affect surface tension. A highly soluble substance like salt increases the surface tension whereas sparingly soluble substances like soap decreases the surface tension. The surface tension decreases with rise in temperature. The temperature at which the surface tension of a liquid becomes zero is called critical temperature of the liquid.

Applications of surface tension

(i) During stormy weather, oil is poured into the sea around the ship. As the surface tension of oil is less than that of water, it spreads on water surface. Due to the decrease in surface tension, the velocity of the waves decreases. This reduces the wrath of the waves on the ship.

(ii) Lubricating oils spread easily to all parts because of their low surface tension. Detergent action is due to the reduction of surface tension of water when soap or detergent is added to water

(iii) Cotton dresses are preferred in summer because cotton dresses have fine pores which act as capillaries for the sweat.

Bernoulli's theorem

Streamline flow of a non-viscous and incompressible liquid, the sum of the pressure energy, kinetic energy and potential energy per unit mass is a constant.

$$\frac{P}{\rho} + \frac{V^2}{2} + gh = \text{constant}$$

This equation is known as Bernoulli's equation

Application of Bernoulli's theorem

(i) Lift of an aircraft wing
(ii) Blowing of roofs
(iii) Bunsen burner
(iv) Motion of two parallel boats

Liquids

Liquids flow from one place to another. They have a definite volume. They take the shape of the container. Liquids show very little change in volume even when large compressive forces are applied. So we assume that liquids are

Water drops are spherical because of its surface tension

incompressible. Pressure at any point inside a liquid is P = hpg. This shows that pressure increases with depth.

When a body floats or immerses in a liquid, the pressure on the bottom surface is more than that the pressure on the top surface. Due to the difference in pressure, an upward force acts on the body. **This upward force is called upthrust or buoyant force.** The buoyant force is equal to the weight of the liquid displaced.

Archimedes Principle

When a body is immersed in fluid (liquid or gas) it experiences an apparent loss of weight which is equal to the weight of the fluid displaced.

Density

Density of a body is defined as the mass per unit volume of the body.

$$Density = \frac{Mass}{Volume}$$

Unit of density is Kg m^{-3}

Relative density (Specific gravity)

Relative density is defined as the ratio of density of the body to the density of water.

$$\text{Relative density} = \frac{\text{Density of the body}}{\text{Density of water}}$$

It has no unit.

Laws of floatation

1. The weight of the floating body is equal to the weight of the liquid displaced by it.
2. The centre of gravity of the floating body and the centre of gravity of the liquid displaced (centre of buoyancy) are in the same vertical line. A ship made up of iron floats in water. This is because the ship is hollow and contains air. The large space inside the ship enables it to displace a volume of water much greater than the actual volume of iron that was used in the construction. So the weight of water displaced is greater than the weight of the ship.

Know more:

- The density of air is 14 times greater than that of hydrogen. The weight of a hydrogen filled balloon is much less than the weight of the air it displaces. The

When common salt is mixed with ice, the melting point is lowered.

difference between the two weights gives the lifting power of the balloon. Thus a hydrogen filled balloon flies high in the air.

Know more:

- Submarines float on the surface of the water and can also submerge below the surface of the water. They have ballast tanks which can be filled with sea water when the submarine wants to submerge.
- When it wants to surface, the tanks are emptied by blowing compressed air.

Hydrometers

- The laws of floatation are made use of in the construction of hydrometers used for the determination of the relative densities of solids and liquids. There are two types of hydrometers.
- The constant immersion hydrometer, in which the weight of the hydrometer is adjusted to make it sink to the same fixed mark in all liquids.
- The variable immersion hydrometer in which the weight of the hydrometer remains the same, but the depth to which it sinks in different liquids vary A common hydrometer used to test the purity of milk by noting its specific gravity is called a LACTOMETER.

When ice melts its volume will decrease