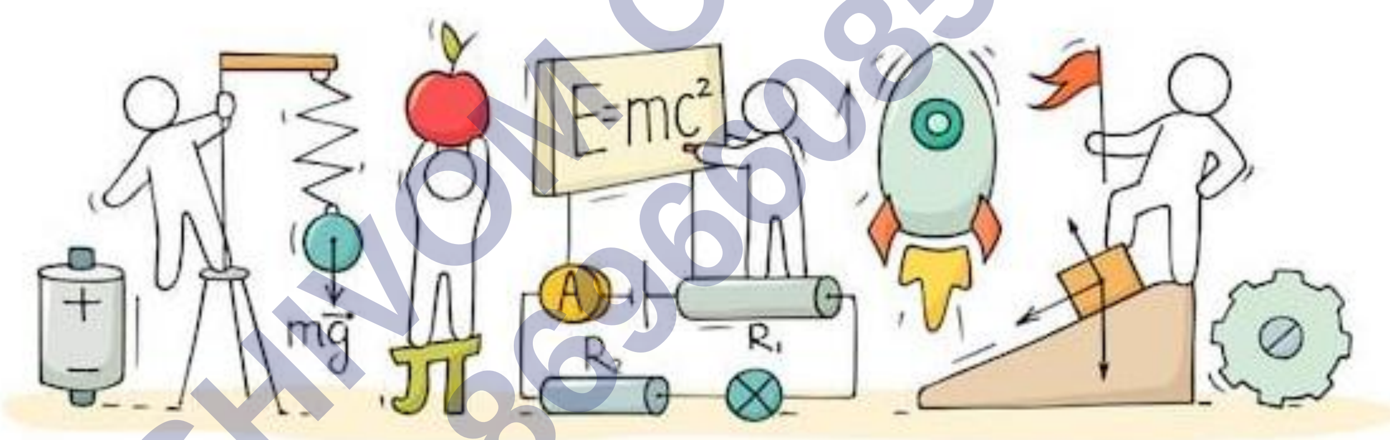
PHYSICS

Chapter 9: Mechanical Properties of Solids

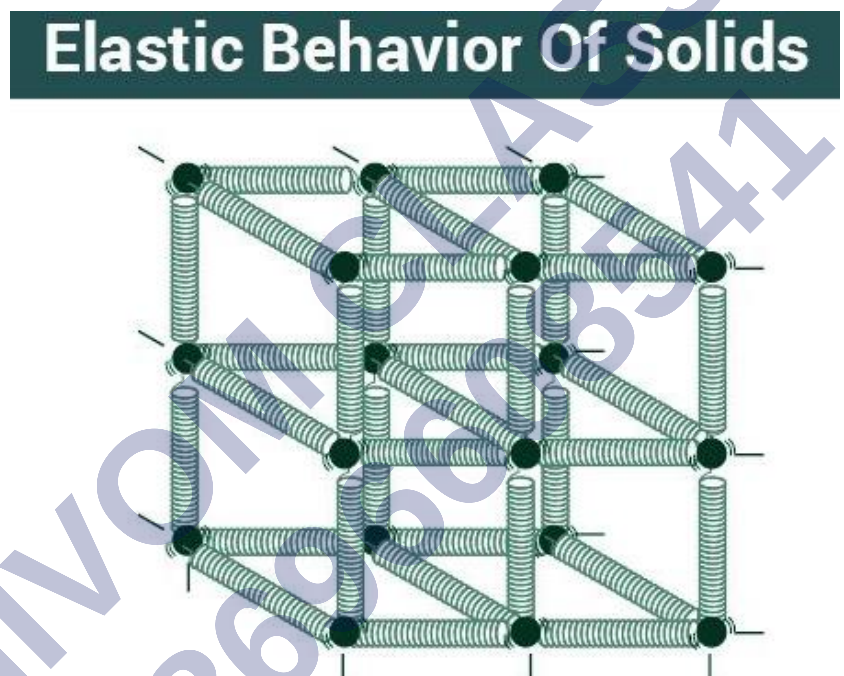


Mechanical Properties of Solids

Elastic Behaviour of Solids

Elastic Behavior of Solids – What happens to a rubber band when you stretch it and let go? It deforms but regains its original nature when you stop applying a force. But say, you take an aluminium rod and try to bend it using your arm strength. You somehow do manage to bend it a little and then stop applying force. Does the rod regain its original shape? of course not. It is referred to as the Elastic Behavior of Solids

What happens to a rubber band when you stretch it and let go? It deforms but regains its original nature when you stop applying force. But suppose you try to bend an aluminium rod using your arm strength. You somehow do manage to bend it a little and then stop applying force. Does the rod regain its original shape? Of course not.



This difference in the behaviour of the materials is based on their elastic and plastic nature. The rubber band has high elasticity. Elasticity is the ability of a body to resist any permanent changes to it when stress is applied. The body regains its original shape and size when stress application ceases.

All materials have an elastic limit beyond which, if continuous stress is applied, they will start losing their ability to exhibit perfect elastic behaviour and start deforming. In contrast, plastic deformation is the non-reversible deformation of solid materials on the application of forces.

Important Points on Elastic Behaviour of Solids

An elastic body is one that regains its original shape and size when deforming forces are removed

A plastic body is one that succumbs to deforming forces (however small) and cannot return to its original shape and size

Elasticity is the property of a body to regain its original shape and size when deforming forces are removed. It exhibits an opposition to change.

Elasticity

This difference in the behaviour of the material is based on their elastic and plastic nature. The rubber band has high elasticity. Elasticity is the ability of a body to resist any permanent changes to it when stress is applied. the body regains its original shape and size when stress application ceases.

Difference Between Elasticity and Plasticity

All materials have an elastic limit beyond which, if continuous stress is applied, they will start losing their ability to exhibit perfect elastic behaviour and start deforming. In contrast, plasticity is the non-reversible deformation of solid materials on the application of forces.

Looking at the elasticity in the atomic level, solids are made of atoms (or molecules). They are surrounded by other such atoms which are held in a state of equilibrium by interatomic forces. When an external force is applied these particles are displaced, resulting in the deformation of the solid. When the application of the deforming force is stopped, interatomic forces drive the atoms to regain their state of equilibrium.

The concept of elasticity is an idealization as no material is perfectly elastic. For example, if you use a hair tie to groom yourself, you may have noticed that its size tends to deform after prolonged use. After a point, it may snap as well. This is because the hair tie eventually loses its elastic nature.

Stress

Stress is defined as the ratio of the internal force F, produced when the substance is deformed, to the area A over which this force acts. In equilibrium, this force is equal in magnitude to the externally applied force. In other words,

Stress is of two types:

(i) Normal stress: It is defined as the restoring force per unit area perpendicular to the surface of the body. Normal stress is of two types: tensile stress and compressive stress.

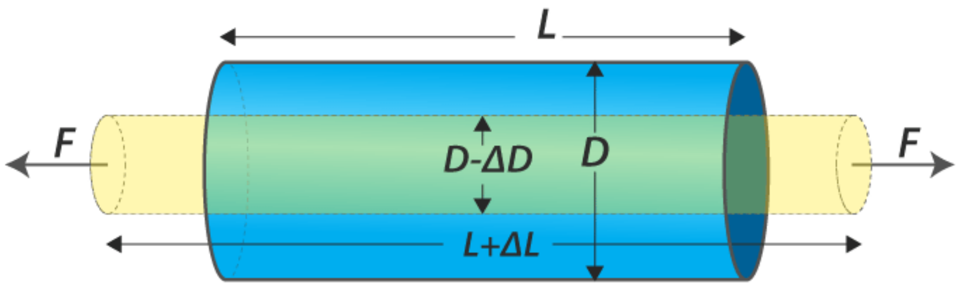
(ii) Tangential stress: When the elastic restoring force or deforming force acts parallel to the surface area, the stress is called tangential stress.

Strain

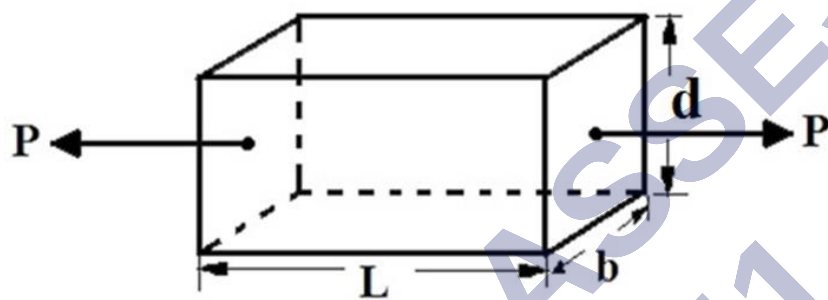
It is defined as the ratio of the change in size or shape to the original size or shape. It has no dimensions; it is just a number.

Strain is of three types:

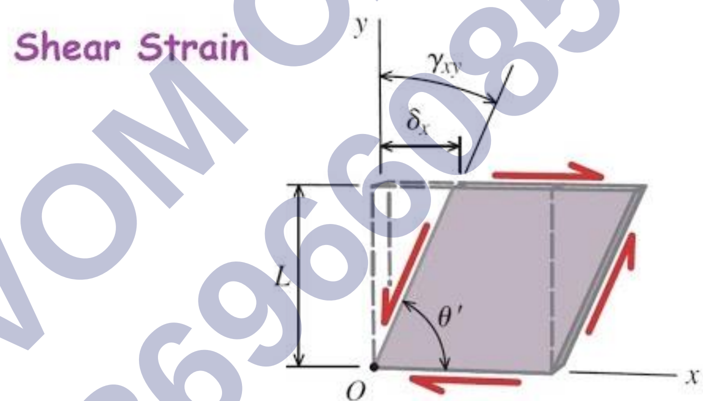
(i) Longitudinal strain: If the deforming force produces a change in length alone, the strain produced in the body is called longitudinal strain or tensile strain. It is given as:



(ii) Volumetric strain: If the deforming force produces a change in volume alone, the strain produced in the body is called volumetric strain. It is given as:



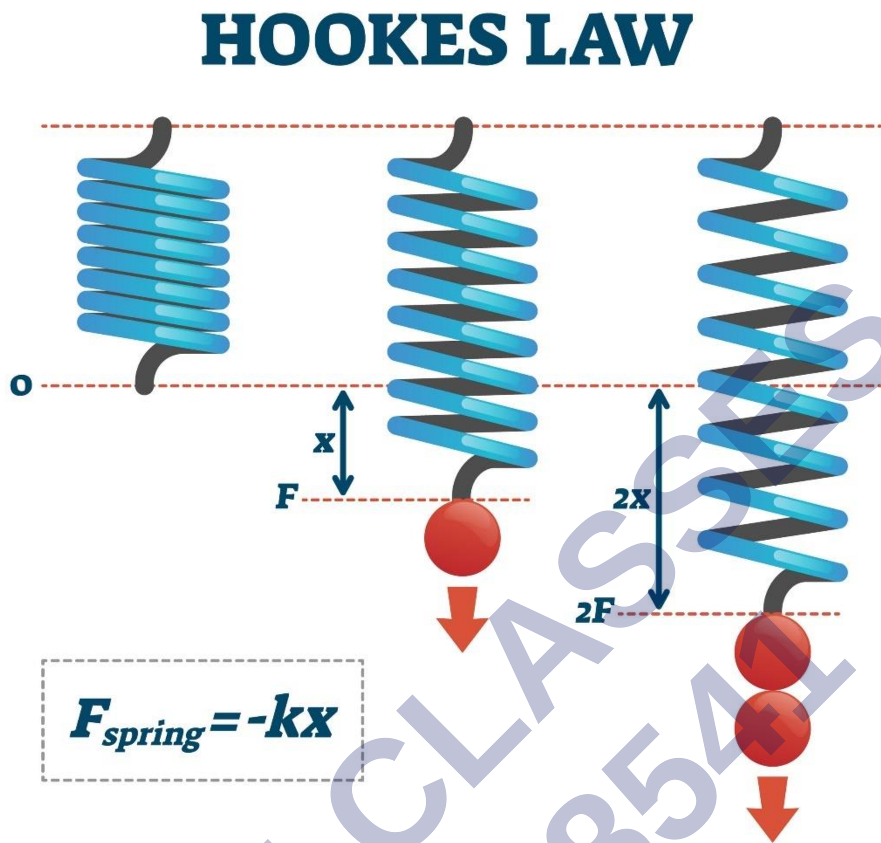
(iii) Shear strain: The angle tilt caused in the body due to tangential stress expressed is called shear strain. It is given as:



The maximum stress to which the body can regain its original status on the removal of the deforming force is called elastic limit.

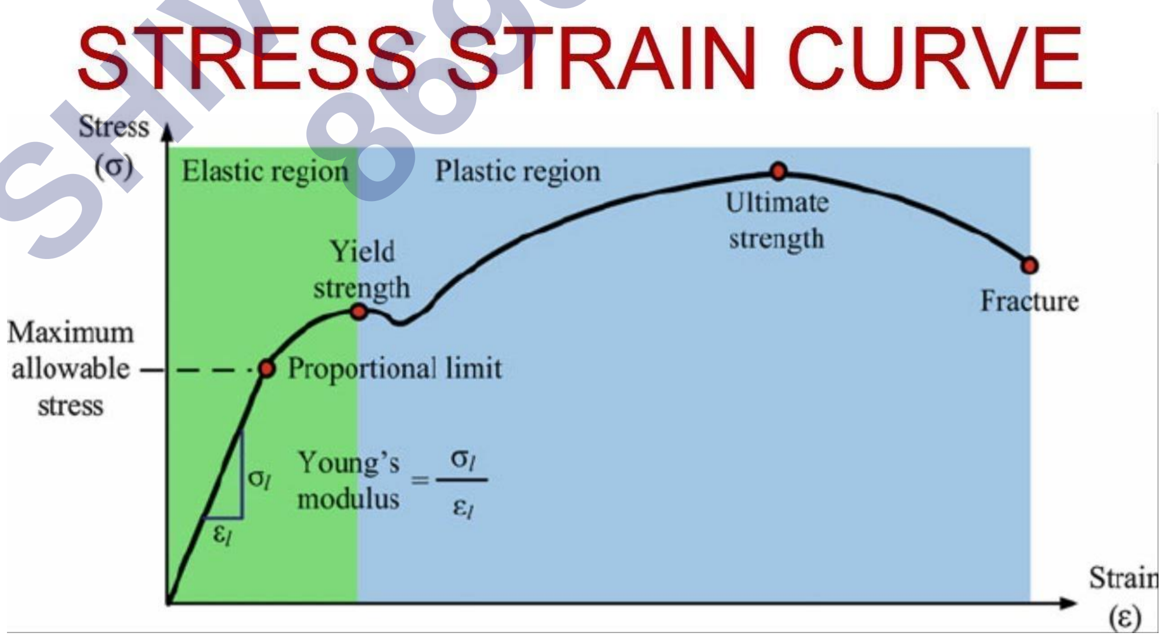
Hooke's Law

Hooke's law states that, within elastic limits, the ratio of stress to the corresponding strain produced is a constant. This constant is called the modulus of elasticity. Thus



Stress Strain Curve

Stress strain curves are useful to understand the tensile strength of a given material. The given figure shows a stress-strain curve of a given metal.

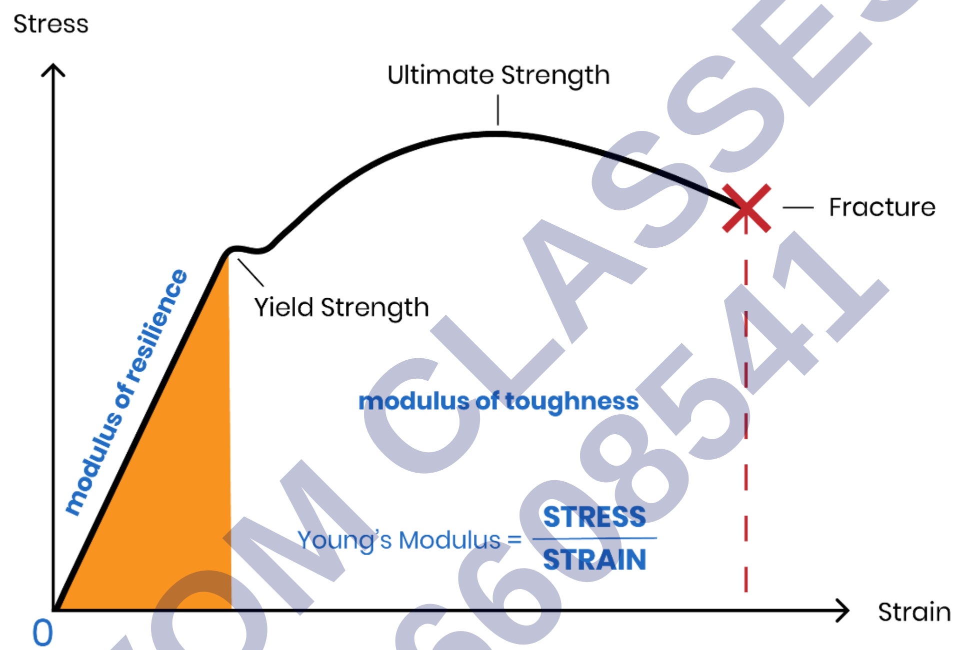


- The curve from O to A is linear. In this region Hooke's Proportional limit law is obeyed.
- In the region from A to 6 stress and strain are not . proportional. Still, the body regains its original dimension, once the load is removed.

- Point B in the curve is yield point or elastic limit and the corresponding stress is known as yield strength of the material.
- The curve beyond B shows the region of plastic deformation.
- The point D on the curve shows the tensile strength of the material. Beyond this point, additional strain leads to fracture, in the given material.

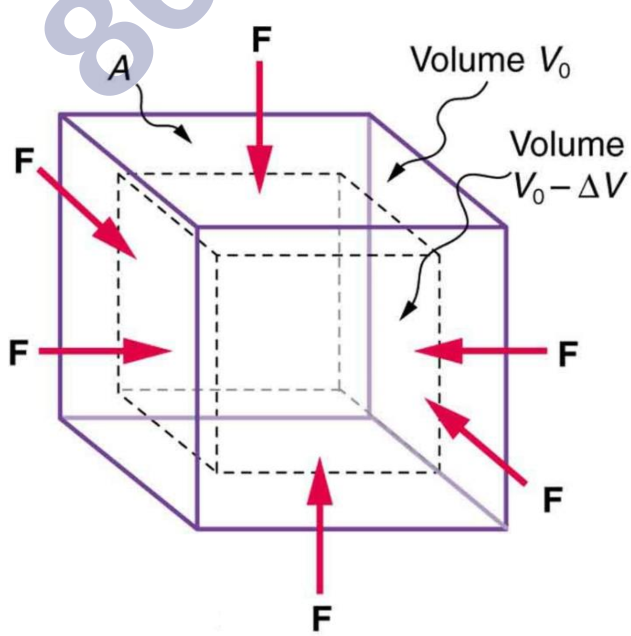
Young's Modulus

For a solid, in the form of a wire or a thin rod, Young's modulus of elasticity within elastic limit is defined as the ratio of longitudinal stress to longitudinal strain. It is given as:



Bulk Modulus

Within elastic limit the bulk modulus is defined as the ratio of longitudinal stress and volumetric strain. It is given as:



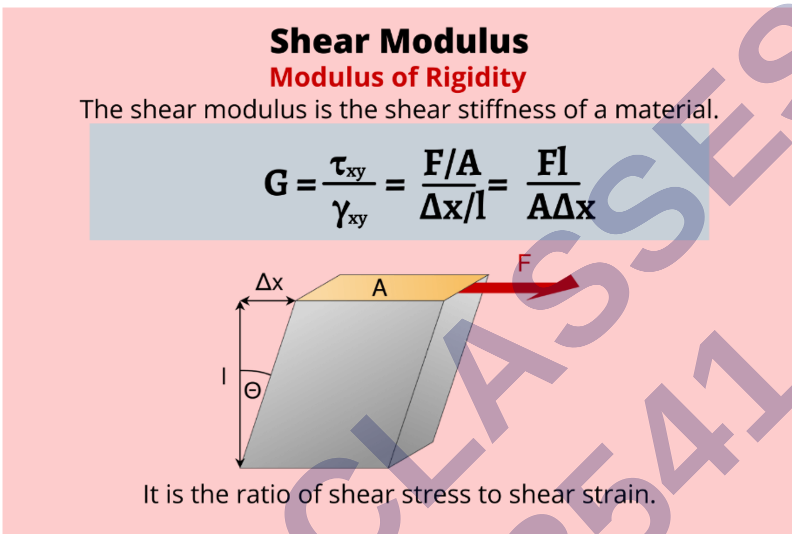
-ve indicates that the volume variation and pressure variation always negate each other.

Reciprocal of bulk modulus is commonly referred to as the "compressibility". It is defined as the fractional change in volume per unit change in pressure.

Shear Modulus or Modulus of Rigidity

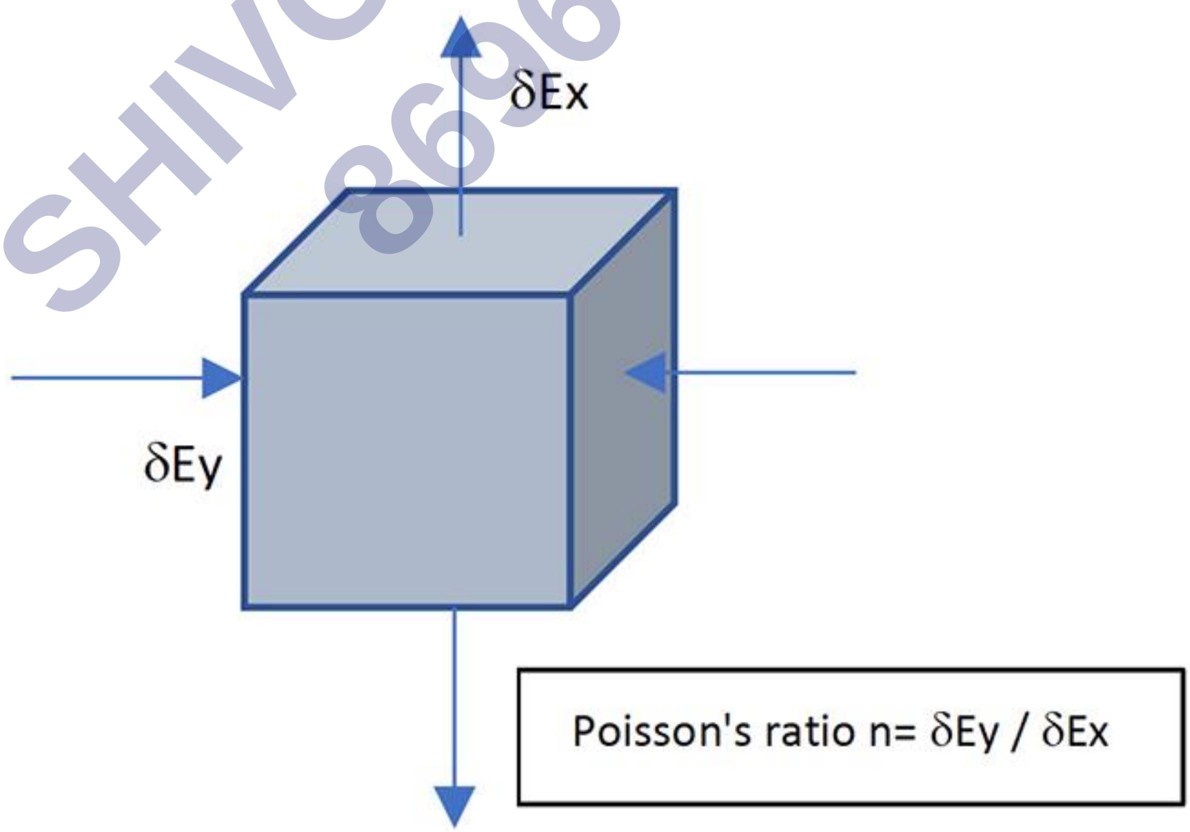
It is defined as the ratio of the tangential stress to the shear strain.

Modulus of rigidity is given by



Poisson's Ratio

The ratio of change in diameter (ΔD) to the original diameter (D) is called lateral strain. The ratio of change in length (Δl) to the original length (l) is called longitudinal strain. The ratio of lateral strain to the longitudinal strain is called Poisson's ratio.

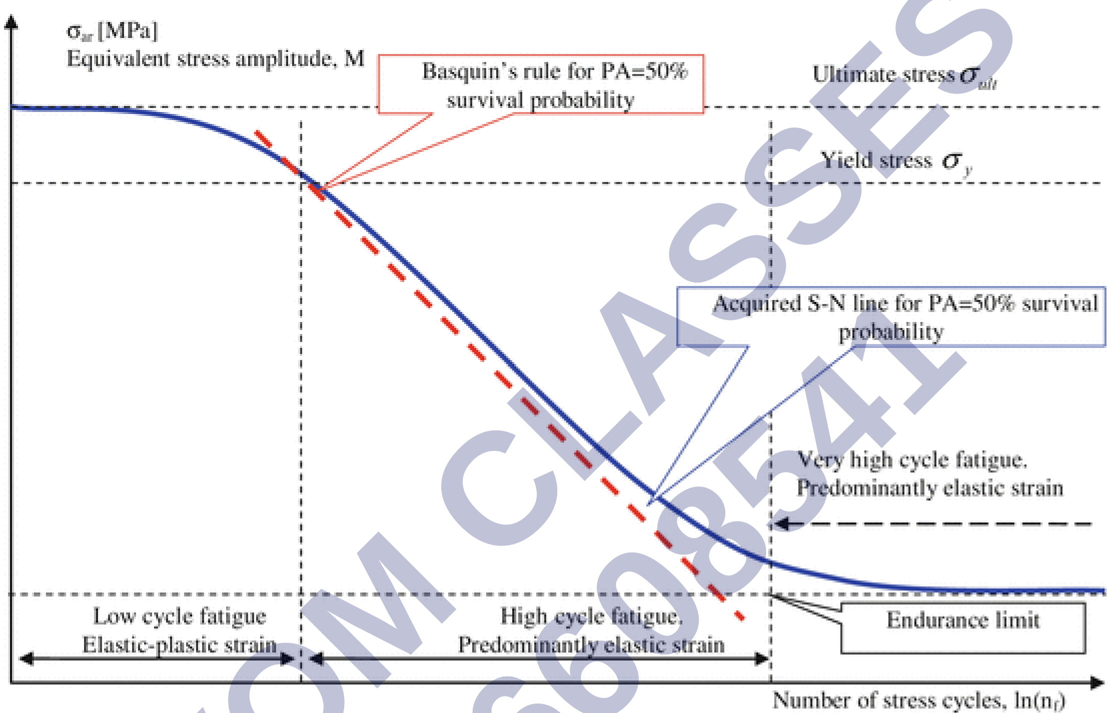


Elastic Fatigue

It is the property of an elastic body by virtue of which its behaviour becomes less elastic under the action of repeated alternating deforming forces.

Relations between Elastic Moduli

For isotropic materials (i.e., materials having the same properties in all directions), only two of the three elastic constants are independent. For example, Young's modulus can be expressed in terms of the bulk and shear moduli.



Breaking Stress

The ultimate tensile strength of a material is the stress required to break a wire or a rod by pulling on it. The breaking stress of the material is the maximum stress which a material can withstand. Beyond this point breakage occurs.

$$Formula\ used: \frac{Force}{Area}$$

Complete step-by-step solution -

The formula for breaking stress is given as

$$Breaking\ Stress = \frac{Force}{Area}$$

Breaking stress checks for metals determine how long a single alloy is stretched until it reaches its maximum tensile strength and how much metal can be loaded until structural stability is lost. Therefore, it is a very important concept in material science and for safety considerations.

Breaking stress is also known as the ultimate tensile stress or breaking strength.

Tensile stress is the stress state induced by the load being applied that appears to elongate the material in the load-axis, that is, the force generated by the material being tensioned. The power of equivalent cross-sectional structures charged with voltage is independent of the nature of the cross-section.

Note- Breaking stress is a limit state of tensile stress that leads to tensile failure in one of two manners: Ductile failure - Some yield as the first stage of failure, some hardening in the second stage and breakage after a possible "neck" formation. Brittle failure - It is defined as the abrupt breaking of the material into two or more pieces at a low stress state.

Bulk Modulus

Bulk modulus is the ratio of hydraulic stress to the corresponding hydraulic strain.

Denoted by 'B'

$$B = -\frac{p}{\frac{\Delta V}{V}}$$

Where p = hydraulic stress, $\frac{\Delta V}{V}$ = hydraulic strain

(-) ive signs show that the increase in pressure results in decrease in volume.

S.I. Unit: N/m^2 or Pascal (Pa)

B(solids) > B(liquids) > B(gases)

Compressibility

Compressibility is the measure of compression of a substance.

Reciprocal of bulk modulus is termed as 'Compressibility'.

Mathematically:

$$k = \frac{1}{B} = -\left(\frac{1}{p}\right)\left(\frac{\Delta V}{V}\right)$$

It is denoted by 'k'.

k(solids) < k(liquids) < k(gases)

Hydraulic Stress

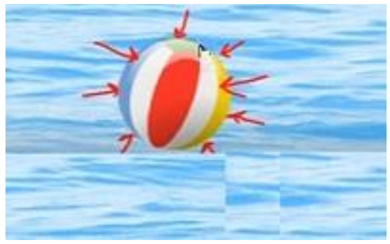
Hydraulic stress is the restoring force per unit area when force is applied by a fluid on the body.

For example:

Consider a rubber ball and if it is dipped in the pond. Due to the pressure of water from all directions force acts on the ball as a result, the ball seems to be slightly contracted.

Because of the force exerted by the water there is restoring force which develops in the ball which is equal in magnitude to the force applied by the water but in opposite direction.

This type of stress is known as hydraulic stress.



Ball under the water

Top Formulae

Normal stress	S = F/a, where $a = \pi r^2$
Longitudinal strain	$\frac{\Delta \ell}{\ell}$
Young's modulus	$Y = \frac{\text{tensile stress}}{\text{tensile strain}} = \frac{F/A}{\Delta L/L_0} = \frac{F}{A}\frac{L_0}{\Delta L}$
Breaking force	= breaking stress × area of cross-section
Volumetric strain	$\frac{\Delta V}{V}$
Bulk modulus	$B = \frac{\text{Bulk stress}}{\text{Bulk strain}} = -\frac{\Delta p}{\Delta V/V_0} = -\frac{\Delta p V_0}{\Delta V}$
Shearing strain	$\frac{\Delta L}{L} = \theta$
Shear modulus	$\eta = \frac{\text{Shear stress}}{\text{Shear strain}} = \frac{F/A}{x/h} = \frac{F}{A}\frac{h}{x}$
Modulus of rigidity	$G = \frac{F}{a\theta}$
Elastic potential energy of a stretched wire	=(1/2) × stress × strain × volume

Class : 11th Physics
Chapter- 9 : Mechanical Properties of Solids

Mechanical Properties of Solids

Elasticity

Property of material by virtue of which it regains it original shape & size after the removal of deforming force

Relation between Y, B, η & σ

(i) $Y = 3B(1 - 2\sigma)$

(ii) $Y = 2\eta(1 + \sigma)$

(iii) $\sigma = \frac{3B - 2\eta}{2\eta + 6B}$

(iv) $\frac{9}{Y} = \frac{1}{B} + \frac{3}{\eta}$ or $Y = \frac{9B\eta}{\eta + 3B}$

Poision's ratio

$$\text{Poision's ratio}(\sigma) = \frac{\text{Laternal strain }(\beta)}{\text{Longitudinal strain }(\alpha)} = \frac{\Delta d / d}{\Delta l / l}$$

Value of σ lies between 0 and 0.5

Elastic potential energy

Elastic potential energy in a stretched

$$\text{wire} = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume of the wire}$$

Hooke's low

Within the elastic limit, stress is directly proportional to strain. i.e., stress ∝ strain

Stress

Restoring force per unit area

i.e., stress= $\frac{F}{A}$

Types

(i) Longitudinal stress

$$= \frac{\text{Deforming force applied normal}}{\text{Area}} = \frac{F_n}{A}$$

(ii) Volumetric stress

$$= \frac{\text{Force Changing Volume}}{\text{Area}} = \frac{F_V}{A}$$

(iii) Shearing area or tangential stress

$$= \frac{\text{Tangential Force}}{\text{Area}} = \frac{F_t}{A}$$

Strain

Ratio of change in configuration to original configuration

$$\text{Strain} = \frac{\text{change in configuration}}{\text{original configuration}}$$

Types

(i) Longitudinal strain $= \frac{\text{change in length}}{\text{original length}} = \frac{\Delta l}{l_o}$

(ii) Volumetric strain $\varepsilon_V = \frac{\text{change in volume}}{\text{original volume}} = \frac{\Delta V}{V_o}$

(iii) Shearing strain=angular displacement of the plane perpendicular to the fixed surface = θ

Types of Modulus of Elasticity

Young's Modulus

Young's modulus of elasticity

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{F/A}{l/\Delta l}$$

$$Y = \frac{F\Delta l}{Al} = \frac{Mg\Delta l}{\pi r^2 l}$$

Modulus of Rigidity

Rigidity or shear modulus of elasticity

$$\eta = \frac{\textit{tangential stress}}{\textit{shearing strain}}$$

$$\eta = \frac{\sigma_s}{\varepsilon_s} = \frac{F/A}{\theta} = \frac{F}{A\theta}$$

Bulk Modulus

Bulk modulus or volume modulus of elasticity

$$B = \frac{\text{hydraulic stress}}{\text{volume strain}}$$

$$B = -\frac{\Delta P}{\frac{\Delta V}{V}};\ \frac{1}{B} = \text{compressibility}$$

Important Questions

Multiple Choice questions-

1. The ratio of the change in dimension at right angles to the applied force to the initial dimension is known as

(a) Youngs modulus

(b) Poissions ratio

(c) Lateral strain

(d) Shearing strain

2. Hookes law essentially defines

(a) Stress

(b) Strain

(c) Yield point

(d) Elastic limit

3. Theoretical value of Poissions ratio lies between

(a) -1 to 0.5

(b) -1 to -2

(c) 0.5 to 1

(d) None

4. A wire suspended vertically from one of its ends is stretched by attaching a weight of 100N to its lower end. What is the elastic potential energy stored in the wire, if the weight stretches the wire by 1.5 mm?

(a) 5×10^{-2} J

(b) 10^{-3} J

(c) 2.5×10^{-3} J

(d) 7.5×10^{-2} J

5. An iron bar of length l m and cross section A m^2 is pulled by a force of F Newton from both ends so as to produce and elongation in meters. Which of the following statement statements is correct?

(a) Elongation is inversely proportional to length l

(b) Elongation is directly proportional to cross section A

(c) Elongation is inversely proportional to A

(d) Elongation is directly proportional to Youngs modulus

6. temperature?

(a) Copper

(b) Invar steel

(c) Brass

(d) Silver

7. Longitudinal strain is possible in the case of

(a) Gases

(b) Liquid

(c) Only solids

(d) Only gases & liquids

8. Two wires A and B are of the same length. The diameters are in the ratio 1 : 2 and the Youngs modulus are in ratio 2 : 1. if they are pulled by the same force, then their elongations will be in ratio

(a) 4 : 1

(b) 1 : 4

(c) 1 : 2

(d) 2 : 1

9. A body of mass 500 g is fastened to one end of a steel wire of length 2 m and area of cross-section 2 mm^2. if the breaking stress of he wire is 1.25 × 107 N/m^2, then the maximum angular velocity with which the body can be rotated in a horizontal circle is

(a) 2 rad/s

(b) 3 rad/s

(c) 4 rad/s

(d) 5 rad/s

10. If a material is heated and annealed, then its elasticity is

(a) Increased

(b) Decreased

(c) Not change

(d) Becomes zero

Very Short:

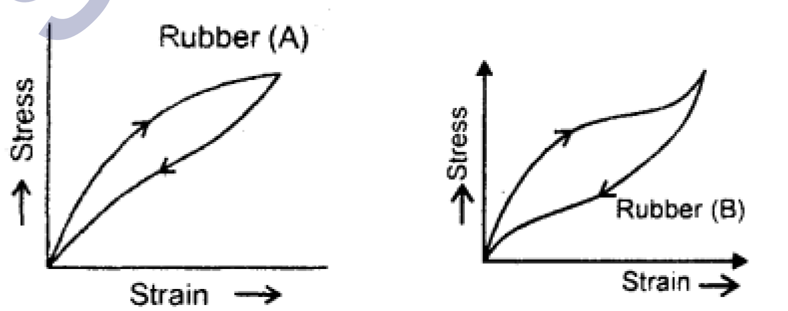
1. Give an example of pure shear.
2. What is an elastomer?
3. What is breaking stress?
4. What is the:

   (a) value of modulus of rigidity of a liquid?

   (b) order of strain within the elastic limit?
5. A wire is stretched to double its length. What is the value of longitudinal strain?
6. Mention a situation where the restoring force is not equal and opposite to the applied force.
7. What is a Cantilever?
8. A wire is suspended from a roof but no weight is attached to the wire. Is the wire under stress?
9. Why strain has no units?
10. What is Poisson's ratio?

Short Questions:

1. What are the factors due to which three states of matter differ from one's Other?
2. When we stretch a wire, we have to perform work Why? What happens to the energy given to the wire in this process?
3. Why are the bridges declared unsafe after long use?
4. Why are the springs made of steel and not of copper?
5. A heavy machine is to be installed in a factory. To absorb vibrations of the machine, a block of rubber is placed between the machinery and the floor. Which of the two rubbers (A) and (B) of Figure would you prefer to use for this purpose? Why?



6. Metal wires after being heavily loaded dop'\ regain their lengths completely explain why?
7. Explain. Why spring balances show wrong readings after they have been, Used for a long time?

8. Elasticity is said to be the internal property of matter. Explain.

Long Questions:

1. (a) Derive the expression for the orbital velocity of an artificial Earth's satellite. Also, derive its value for an orbit near Earth's surface.

   (b) Derive the expression for escape velocity of a body from the surface of Earth and show that it $\sqrt{2}$ times the orbital velocity close to the surface of the Earth. Derive its value for Earth.

2. (a) Explain Newton's law of gravitation.

   (b) Define gravitational field intensity. Derive its expression at a point at a distance x from the center of Earth. How is it related to acceleration due to gravity?

3. Discuss the variation of acceleration due to gravity with:

   (a) Altitude or height

   (b) Depth

   (c) Latitude i.e. due to rotation of Earth.

Assertion Reason Questions:

1. ***Directions:***

   (a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
   (b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
   (c) If assertion is true but reason is false.
   (d) If the assertion and reason both are false.

Assertion: Steel is more elastic than rubber.
Reason: Under given deforming force, steel is deformed less than rubber.

2. ***Directions:***

   (a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
   (b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
   (c) If assertion is true but reason is false.
   (d) If the assertion and reason both are false.

Assertion: Glassy solids have sharp melting point.
Reason: The bonds between the atoms of glassy solids get broken at the same temperature.

✓ Answer Key:

Multiple Choice Answers-

1. Answer: (c) Lateral strain
2. Answer: (d) Elastic limit
3. Answer: (a) -1 to 0.5
4. Answer: (d) 7.5×10^{-2} J
5. Answer: (c) Elongation is inversely proportional to A
6. Answer: (b) Invar steel
7. Answer: (c) Only solids
8. Answer: (d) 2 : 1
9. Answer: (d) 5 rad/s
10. Answer: (b) Decreased

Very Short Answers:

1. Answer: The twisting of a cylinder produces pure shear.
2. Answer: It is a substance that can be elastically stretched to large values t of strain.
3. Answer: It is defined as the ratio of maximum load to which the wire is < subjected to the original cross-sectional area.
4. Answer:

   (a) zero.

   (b) 10^{-3} cm per cm = 10^{-3} cm/cm.
5. Answer: Unity.
6. Answer: This happens when the body is deformed beyond the elastic limit.
7. Answer: It is a beam loaded at one end and free at the other end.
8. Answer: Yes, the weight of the wire itself acts as the deforming force.
9. Answer: As it is the ratio of two similar quantities.
10. Answer: It is the ratio of lateral strain to linear strain.

Short Questions Answers:

1. Answer:

   Three states of-matter differ from each other due to the following two factors:

   (a) The different magnitudes of tester atomic and intermolecular forces.

   (b) The degree of random thermal motion of the atoms and molecules of a substance depends upon the temperature.

2. Answer: In a normal situation, the atoms of a solid are at the locations of minimum potential energy. When we stretch a wire, the work has to be done against interatomic forces. This work is stored in the wire in the form of elastic potential energy.
3. Answer: A bridge during its use undergoes alternative strains a large number of times each day, depending upon the movement of vehicles on it. When a bridge is used for a long time it loses its elastic strength, due to which the number of strains in the bridge for given stress will become large and ultimately the bridge may collapse. Thus, !» to avoid this, the bridges are declared unsafe after long use.
4. Answer: Spring will be a better one if a large restoring force is set up in it on being deformed, which in turn depends upon the elasticity of the material of the spring. Since Young's modulus of elasticity of steel is more than that of copper, hence steel is preferred in making the springs.
5. Answer: The area of this hysteresis loop measures the amount of heat energy dissipated by the material. Since the area of the loop B is more than that of A, therefore B can absorb more vibrations than that of Av Hence B is preferred.
6. Answer: A material regains its original Configuration (length, shape dr volume) only when the deforming force is within the elastic limit. Beyond the elastic limit, the bodies lose the property of elasticity and hence don't completely regain the length of being heavily loaded.
7. Answer: When spring balances are used for a long time, they get fatigued. So the springs of such balances will take time to recover their original configuration. Hence the readings shown by such spring balances will be wrong.
8. Answer: When a deforming force acts on a body, the atoms of the substances get displaced from their original positions. Due to this the configuration of the matter (substance) changes. The moment, the deforming force is removed, the atoms return to their original positions and hence the substance or matter regains its original configuration. Hence elasticity is said to be the internal property of matter.

Long Questions Answers:

1. Answer:

   (a) The following factors affect the elasticity of a material:

   - Effect of hammering and rolling: It causes a decrease in the plasticity of the material due to break-up of crystal grains into smaller units and hence – the elasticity of the material increases.
   - Effect of Annealing: Annealing results in the increases in the plasticity of the material due to, the formation of large crystal grains. Hence the elasticity of the material decreases.

- Effect of the presence of impurities: The effect of the presence of impurities in a material can be both ways i.e. it can increase as well as decrease the elasticity r of the material. The type of effect depends upon the
- nature of the impurity present in the material.
- Effect of temperature: The increase in the temperature of the material in most cases causes a decrease in the elasticity of the material. The elasticity of invar does not change with the change of temperature.

(b) Poisson's Ratio (σ): Within elastic limits, it is defined; as the ratio of lateral strain (β) to the linear strain i.e.

$$\sigma = \frac{\beta}{\alpha}$$

(c) Breaking Load: It is defined as the product of the breaking stress and area of cross-section of the given object. It is also called maximum load a body (cable/ wire) can support

i.e., breaking load = Breaking stress × area of cross-section. It should be noted that breaking stress is a constant for the given material.

2. Answer:

Let L, A be the length and area of the cross-section of the wire.

Also, let l be the extension produced on applying a force F, then

using the relation, $Y = \frac{\text{Stress}}{\text{Strain}}$, we get

$$Y = \frac{F/A}{l/L} = \frac{FL}{Al} \qquad \text{.... (1)}$$

where Y = Young's modulus.

Now when $F = T_1$ and $l = L_1 - L$.

Then $$Y = \frac{T_1 L}{A(L_1 - L)} \quad .... (2)$$

and when $F = T_2$, and $l = L_2 - L$,

Then $$Y = \frac{T_2 L}{A(L_2 - L)} \quad .... (3)$$

∴ From (2) and (3), we get

$$\frac{T_1 L}{A(L_1 - L)} = \frac{T_2 L}{A(L_2 - L)}$$

or $$T_1(L_2 - L) = T_2(L_1 - L)$$

or $$(T_2 - T_1)L = T_2 L_1 - T_1 L_2$$

or $$L = \frac{T_2 L_1 - T_1 L_2}{T_2 - T_1}.$$

Assertion Reason Answer:

1. (a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

   Explanation:

   Elasticity is a measure of tendency of the body to regain its original configuration. As steel is deformed less than rubber therefore steel is more elastic than rubber.

2. (d) If the assertion and reason both are false.

   Explanation:

   In a glassy solid (i.e., amorphous solid) the various bonds between the atoms or ions or molecules of a solid are not equally strong. Different bonds are broken at different temperatures. Hence there is no sharp melting point for a glassy solid.

Case Study Questions-

1. The pressure of the atmosphere at any point is equal to the weight of a column of air of unit cross-sectional area extending from that point to the top of the atmosphere. At sea level, it is 1.013×10^5 Pa (1 atm). Italian scientist Evangelista Torricelli (1608–1647) devised for the first time a method for measuring atmospheric pressure.
   $p = p_a + \rho gh$
   Where r is the density of mercury and h is the of the mercury column in the tube In the experiment it is found that the mercury column in the barometer has a height of about 76 cm at sea level equivalent to one atmosphere (1 atm). This can also be obtained using the value of r. A common way of stating pressure is in terms of cm or mm of mercury (Hg). A pressure equivalent of 1 mm is called a torr (after Torricelli). 1 torr = 133 Pa. The mm of Hg and torr are used in medicine and physiology. In meteorology, a

common unit is the bar and millibar.1 bar = 10^5 Pa. An open tube manometer is a useful instrument for measuring pressure differences.

i. **Who gave for the first time a method for measuring atmospheric pressure?**

a. Newton

b. Pascal

c. Torricelli

d. None of the above

ii. **1 torr is equal to**

a. 1000 pa

b. 133 pa

c. 50 pa

d. None of these

iii. **What is 1 torr? Where it is used?**

iv. **Which device is used for measurement of pressure difference?**

v. **What is atmospheric pressure?**

2. Whenever external pressure is applied on any part of a fluid contained in a vessel, it is transmitted undiminished and equally in all directions. This is another form of the Pascal's law and it has many applications in daily life. A number of devices, such as hydraulic lift and hydraulic brakes, are based on the Pascal's law. In these devices, fluids are used for transmitting pressure. Fluid flow is a complex phenomenon. Bernoulli's principle helps in explaining blood flow in artery. The artery may get constricted due to the accumulation of plaque on its inner walls. In order to drive the blood through this constriction a greater demand is placed on the activity of the heart. The speed of the flow of the blood in this region is raised which lowers the pressure inside and the artery may collapse due to the external pressure. The heart exerts further pressure to open this artery and forces the blood through. As the blood rushes through the opening, the internal pressure once again drops due to same reasons leading to a repeat collapse. This may result in heart attack. Dynamic lift is the force that acts on a body, such as airplane wing, a hydrofoil or a spinning ball, by virtue of its motion through a fluid. In many games such as cricket, tennis, baseball, or golf, we notice that a spinning ball deviates from its parabolic trajectory as it moves through air. This deviation can be partly explained on the basis of Bernoulli's principle. A ball which is spinning drags air along with it. If the surface is rough more air will be dragged. shows the streamlines of air for a ball which is moving and spinning at the same time. The ball is moving forward and relative to it the air is moving backwards. Therefore, the velocity of air above the ball relative to the ball is larger and below it is smaller .The stream lines, thus, get crowded above and rarified below. This difference in the

velocities of air results in the pressure difference between the lower and upper faces and there is a net upward force on the ball. This dynamic lift due to spining is called Magnus effect. The Venturi-meter is a device to measure the flow speed of incompressible fluid. The principle behind this meter has many applications. The carburetor of automobile has a Venturi channel (nozzle) through which air flows with a high speed. The pressure is then lowered at the narrow neck and the petrol (gasoline) is sucked up in the chamber to provide the correct mixture of air to fuel necessary for combustion. Filter pumps or aspirators, Bunsen burner, atomisers and sprayers used for perfumes or to spray insecticides work on the same principle.

i. **The Venturi-meter is a device used to measure the**
   a. Flow speed of incompressible fluid.
   b. Area occupied by fluid.
ii. **hydraulic brakes works on principle of**
   a. Pascal's law
   b. Newton's law
   c. Bernoulli's principle
   d. None of these
iii. **With the help of Bernoulli's principle. How heart attack happens?**
iv. **Explain Magnus effect with example of ball with spin in air.**
v. **What is dynamic lift?**

Case Study Answer-

1. Answer

i. (c) Torricelli
ii. (b) 133 pa
iii. A pressure equivalent of 1 mm is called a torr 1torr = 133 Pa.
The mm of Hg and torr are used in medicine and physiology.
iv. An open tube manometer is a useful instrument for measuring pressure differences.
v. The pressure of the atmosphere at any point is equal to the weight of a column of air of unit cross-sectional area extending from that point to the top of the atmosphere. At sea level, it is 1.013×10^5 Pa (1 atm). 76 cm at sea level equivalent to one atmosphere (1 atm).

2. Answer

i. (a) Flow speed of incompressible fluid.
ii. (a) Pascal's law

iii. With the help of Bernoulli's principle we can explain heart attack phenomenon. The artery may get constricted due to the accumulation of plaque on its inner walls. In order to flow the blood through this constriction a large pressure is exerted on heart. The speed of the flow of the blood in this region is raised which lowers the pressure inside and the artery may collapse due to the external pressure. The heart exerts further pressure to open this artery and forces the blood through. As the blood flows fast trough the opening, the internal pressure once again drops due to same reasons leading to a repeat collapse. This result in heart attack.

iv. A ball which is spinning drags air along with it. If the surface is rough more air will be dragged. When ball is moving forward and relative to it the air is moving backwards. Therefore, the velocity of air above the ball relative to the ball is larger and below it is smaller. This difference in the velocities of air results in the pressure difference between the lower and upper faces and there is a net upward force on the ball. This dynamic lift due to spining is called Magnus effect.

v. A ball which is spinning drags air along with it. If the surface is rough more air will be dragged. When ball is moving forward and relative to it the air is moving backwards. Therefore, the velocity of air above the ball relative to the ball is larger and below it is smaller. This difference in the velocities of air results in the pressure difference between the lower and upper faces and there is a net upward force on the ball. This dynamic lift due to spining is called Magnus effect.