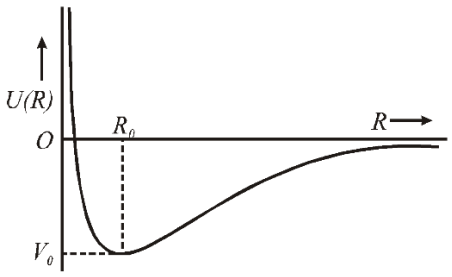
**CLASS XI : ASSIGNMENT : CH-8 : MECHANICAL PROPERTIES OF SOLIDS : PHYSICS**

## STRESS, STRAIN AND MODULUS OF ELASTICITY

1. What is the nature of intermolecular forces?
2. Distinguish between elasticity and plasticity of materials.
3. What is a perfectly elastic body? Give an example.
4. What is a perfectly plastic body? Give an example.
5. No material is perfectly elastic. Why?
6. Stress and pressure are both forces per unit area. How do you differentiate between them?
7. When does a body acquire a permanent set?
8. Which is more elastic: water or air?
9. On what factors does the elastic limit of a material depend?
10. What does the slope of the stress versus strain graph indicate?
11. The ratio stress/strain remains constant for small deformation. What will be the effect on the ratio when the deformation is very large?
12. A thick wire is suspended from a rigid support, but no load is attached to its free end. Is this wire under stress?
13. When we stretch a wire we have to perform work. Why? What happens to the energy given to the wire in this process?
14. What will happen to the potential energy of the atoms of a solid when (i) compressed and (ii) on stretching a wire?
15. Why does a wire get heated when it is bent back and forth?
16. Explain how the maximum height of a mountain on Earth can be estimated from the elastic behavior of the Earth.
17. Why are electric poles given hollow structures?
18. A hollow shaft is found to be stronger than a solid shaft made of the same equal material. please justify.
19. Which state of matter (solid, liquid or gas) has volume elasticity?
20. Which type of strain is there, when a spiral spring is stretched by a force?
21. A cable (elastic wire) is cut to half its original length. How would it affect the maximum load that the wire can support?
22. What are the factors which affect the elasticity of a material?
23. Why a spring balance does not give correct measurement when it has been used for a long time?
24. Why the bridges are declared unsafe after long use?
25. Graphite consists of planes of carbon atoms. Between atoms in the planes, there are only weak forces. What kind of elastic properties do you expect from graphite?
26. Two identical solid balls, one of ivory and the other of wet clay, are dropped from the same height on the floor. Which will rise to a greater height after striking the floor and why?
27. In the figure: a graph between the intermolecular force F acting between the molecules of a solid and the distance r between them is shown. Explain the graph.

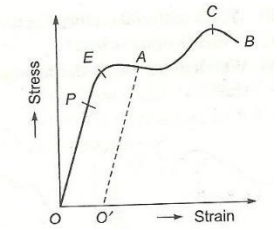


**28.** The stress-strain graph for a metal wire is shown in the figure. Upto the point, E the wire returns to its original state O along the curve EPO when it is gradually unloaded. Point B corresponds to the fracture of the wire.

(i) Upto which point on the curve, Hooke's law is fully obeyed? This point is sometimes called the "proportionality limit"

(ii) Which point on the curve corresponds to the elastic limit and yield point of the wire?

(iii) Indicate the elastic and plastic elastic and plastic regions of the stress-strain graph.




(iv) Describe what happens when the wire is loaded up to a stress corresponding to point A on the graph, and then unloaded gradually. In particular, explain the dotted curve.

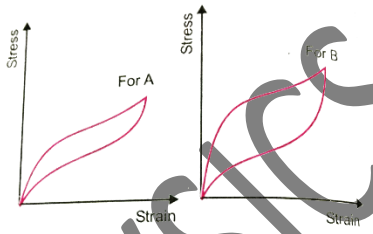
(v) What is peculiar about the portion of the stress-strain graph from C to B? Up to what stress can the wire be subjected without causing fracture?

**29.** Two different types of rubber are found to have stress-strain curves as shown in the figure

(i) In which significant ways do these curves differ from the stress-strain curve of a metal wire shown in the figure?

(ii) A heavy machine is to be installed in a factory. To absorb the vibrations of the machine, a block of rubber is placed between the machinery and the floor. Which of the two rubbers A & B would you prefer to use for this purpose? Why?

(iii) Which of the two rubber materials would you choose for a car tyre?



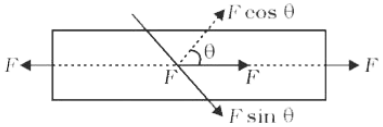

**30.** A bar of cross Section A is subjected to equal and opposite tensile forces at its ends. consider a plane section of the bar whose normal makes an angle θ with the axis of the bar.

(i) What is the tensile stress on this plane?

(ii) What is the shearing stress on this plane?

(iii) For what value of θ is the tensile stress maximum?

(iv) For what value of θ is the shearing stress maximum?




## YOUNG'S MODULUS OF ELASTICITY

**31.** Which one is more elastic: rubber or steel?

**32.** What is the Young's modulus for a perfectly rigid body?

**33.** How does Young's modulus change with the temperature rise?

**34.** Write copper, steel, glass, and rubber in the order of increasing coefficient of elasticity.

**35.** Why are springs made of steel and not of copper?

**36.** A wire stretches by a certain amount under a load. If the load and radius are increased four times, find the stretch caused in the wire.

**37.** A wire of length l and radius r has a weight W and Young's modulus of elasticity Y. It is suspended vertically from a fixed point. Calculate the increase in the length of wire produced due to its weight.

**38.** If F is the breaking force of a wire, what will be the breaking force for (i) two parallel wires of the same size (ii) for a single wire of double the thickness?

**39.** A wire of length L and cross-sectional area A is made of material of Young's modulus Y. What is the work done in stretching the wire by an amount x? *(Ans: $YAx^2/2L$)*

**40.** There are two identical springs of copper and steel. They are stretched by equal forces. For which spring more work will have to be done?

**41.** When a weight W is hung from one end of the wire, the other end is fixed, the elongation produced in it is l. If this wire goes over a pulley and two weights W each are hung at the two ends, what will be the total elongation in the wire?

**42.** One end of a uniform rod of mass M and cross-sectional area A is suspended from a rigid support and an equal mass M is suspended from the other end. What is the stress at the midpoint of the rod? *(Ans: 3Mg/2A)*

**43.** Two wires made of the same material are subjected to forces in the ratio 1:4. Their lengths are in the ratio 2:1 and the diameters are in the ratio 1:3. What is the ratio of their extensions? *(Ans: 9:2)*

**44.** A cable is replaced by another cable of the same length and material but of double the diameter.
(i) Under a given load which cable will show greater extension?
(ii) How many times can the second cable support the maximum load without exceeding the elastic limit? *(Ans: elongation of the first cable is greater, $W_2 = 4W_1$)*

***45.*** A copper wire of negligible mass, length l, and cross-section A is kept on a smooth horizontal table with one end fixed. The wire and the ball are rotating with an angular velocity, ω if elongation in the wire is Δl, obtain the expression for Young's modulus.*(Ans: $ml^2\omega^2/A\Delta l$)*

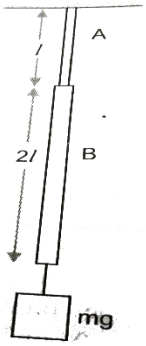
**46.** Calculate the percentage increase in length of a wire of diameter 1 mm stretched by a force of half kilogram weight. Young's modulus of elasticity of the wire is $12 \times 10^{11}$ dyne/cm$^2$. *(Ans: 0.0052%)*

**47.** A structural steel rod has a radius of 10 mm and a length of I m. A 100 KN force stretches it along its length. Calculate
(i) the stress
(ii) elongation and
(iii) Percentage strain on the road
Given that Young's modulus of elasticity of the structural steel is $2 \times 10^{11}$ N/m$^2$ *(Ans: $3.18 \times 10^8$N/m$^2$, 1.59.mm, 0.159%)*

**48.** A hollow cylindrical column of steel supports a load of 20,000 kg. The inner and outer radii of the column are 50 cm and 60 cm respectively. Assuming the load distribution to be uniform, calculate the compressional strain of the column given Young's modulus of steel = $2 \times 10^{11}$ N/m$^2$ and g = 10m/s$^2$. *(Ans: $2.895 \times 10^{-6}$)*

**49.** The Young's modulus for steel is $2 \times 10^{11}$ N/m$^2$. If the interatomic spacing for the metal is 2.8 A$^o$. find the increase in the interatomic spacing for a force of $10^9$ N/m$^2$ and force constant. *(Ans: 0.0014 A$^o$, 56 N/m)*

**50.** Two wires A & B of length l radius r and length 2l, radius 2 have the same Young's modulus, Y is hung with a weight mg. What is the net elongation in the two wires? *(Ans: $3mgl/2Y\pi r^2$)*



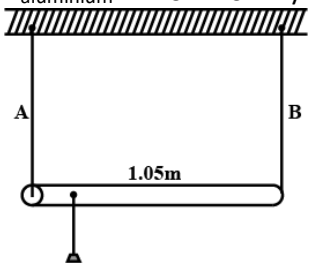

**51.** A rod of length 1.05 m having negligible mass is supported at its ends by two wires of steel (wire A) and aluminium (wire B) of equal lengths as shown in the figure. The cross-sectional area of wires A and B are 1mm$^2$ and 2mm$^2$ respectively. At what point along the rod should a mass m be suspended in order to produce

(i) Equal stresses and

(ii) Equal strains in both steel and aluminium wires. Given that

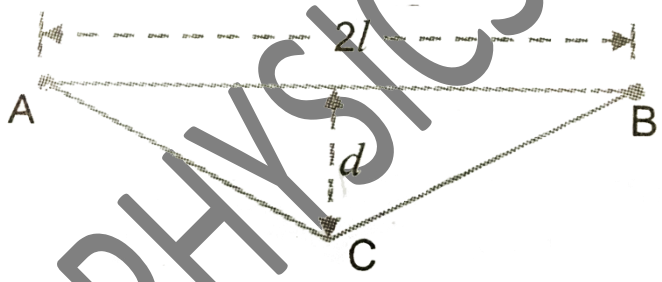
$Y_{steel} = 2 \times 10^{11}$ N/m$^2$

$Y_{aluminium} = 7.0 \times 10^{10}$ N/m$^2$




*(Ans: 43.2 cm)*

**52.** A wire of radius r stretched without tension along a straight line is tightly fixed at A and B. What is the tension in the wire when it is pulled in the shape ACB? Assume Young's modulus of the material of the wire to be Y. *(Ans: $Y \times \pi r^2 \times d^2/2l^2$)*




## BULK MODULUS OF ELASTICITY

**53.** What is the value of bulk modulus for an incompressible liquid?

**54.** One litre of an ideal gas is compressed isothermally at 0.72 m of Hg column so that its volume becomes 0.9 litre. Find its stress, if the density of mercury is 13.6 x 10$^3$ kg/m$^3$. *(Ans: 1.07 X 10$^4$N/m$^2$)*

**55.** The density of a metal at normal pressure is ρ. its density when it is subjected to an excess pressure p is ρ'. If B is the bulk modulus of the metal, then find the ratio ρ'/ρ. *(Ans: (1 + p/B)*

**56.** A sphere contracts in volume by 0.02% when taken to the bottom of the sea 2 Km deep. Find the value of the bulk modulus of the material of the sphere. The density of seawater = 1g/cc, g = 10 m/s$^2$. *(Ans: 10$^{11}$N/m$^2$)*

**57.** A cube is subjected to a pressure of 5 x 10$^5$ N/m$^2$. Each side of the cube is shortened by 1%. Find the volumetric strain and bulk modulus of elasticity of the cube. *(Ans: 1.67 x 10$^7$ N/m$^2$)*

**58.** The average depth of the Indian Ocean is about 3000 m. Calculate the fractional compression, ΔV/V of water at the bottom of the ocean. given that the bulk modulus of water is 2.2 x $10^9$ N/$m^2$, g = 10 m/$s^2$. *(Ans: 1.36 x $10^{-2}$).*

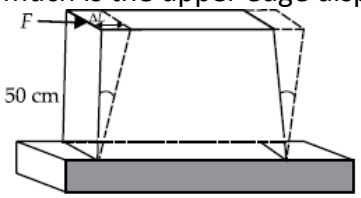
## MODULUS OF RIGIDITY

**59.** What is the value of the modulus of rigidity for a liquid?

**60.** A 5 cm cube has its upper face displaced by 0.2 cm by a tangential force of 8 N. Calculate the shearing strain, shearing stress, and modulus of rigidity of the material of the cube. *(Ans: 0.04, 3200 N/$m^2$, 8 x $10^4$N/$m^2$)*

**61.** Two metal plates are held together by two rivets width radii of 0.2 cm. If the maximum shear strain a single rivet can withstand is 5 x $10^8$ N/$m^2$, how much force must be applied parallel to the plates to shear off both rivets? *(Ans: 1.26 x $10^4$N)*

**62.** A square lead slab of side of 50 cm and thickness of 10 cm is subjected to a shearing force (on its narrow face) of magnitude 9 x $10^4$ N. The lower edge is riveted to the floor as shown in figure. How much is the upper edge displaced, if the shear modulus of lead is 5.6 x $10^9$ Pa? *(Ans: 1.6 x $10^{-4}$m).*




**63.** Two parallel and opposite forces, each 500 kgf are applied tangentially to the upper and lower faces of a cubical metal block 25 cm on a side. find the angle of shear and the displacement of the upper surface relative to the lower surface. The shear modulus of the metal is 8 x $10^{10}$ N/$m^2$. g = 10 m/$s^2$. *(Ans: $10^{-6}$rad, 25 x $10^{-8}$m)*

## ELASTIC POTENTIAL ENERGY

**64.** Calculate the increase in energy of a brass bar of length 0.4 m and cross-sectional area 1 $cm^2$. When compressed with a load of 4 kg wt along its length. Young's modulus of brass is 1 x $10^{11}$ N/$m^2$ and g = 10 m/$s^2$. *(Ans: 3.2 x $10^{-5}$J)*

**65.** When the load of a wire is increased from 3 kg wt to 5 kg wt, the elongation increases from 0.61 mm to 1.02 mm. How much work is done during this extension of wire? *(Ans: 16.023 x $10^{-3}$ J)*

**66.** A 45 Kg boy whose leg bones are 5 $cm^2$ in the area and 50 cm long falls through a height of 2m without breaking his leg bones. If the bones can stand a stress of 0.9 X $10^8$ N/$m^2$. Calculate the Young's Modulus for the material of the bone. Use g = 10m/$s^2$ *(Ans: 2.25 x $10^9$ N/$m^2$)*