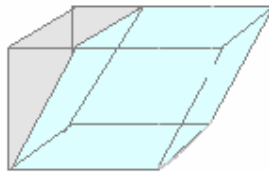
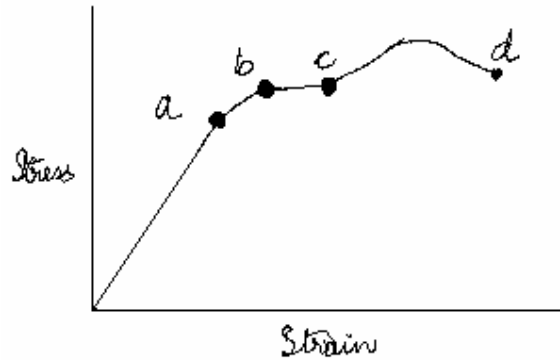


**9. MECHANICS OF SOLIDS**

1. Define elasticity, Hooke's Law, elastic limit, ultimate strength.
2. a) What are (i) Young's modulus (ii) Bulk modulus and (iii) Shear modulus.  
b) What are their units?
3. a) An iron rod 4 m long and  $0.5 \text{ cm}^2$  in x-section stretches when a mass of 225 kg is hung from its lower end. Find Young's modulus for iron.  
  
b) If we consider the rod of above problem to be a spring, within its elastic limit, what is the effective force constant of this spring?
4. A wire whose x-section is  $4 \text{ mm}^2$  is stretched by 0.1 mm by a certain weight. How far will a wire of the same material and length stretch if its cross-sectional area is  $8 \text{ mm}^2$  and the same weight is attached?
5. A steel piano wire has an ultimate strength of 3,50,000 Pa. How large a load can a 0.5 cm diameter steel wire hold before breaking?
6. A wire of original length  $L$  and cross-sectional area  $A$  is stretched, within its elastic limit, by a stress  $p$ . Show that the density of stored energy in the stretched wire is  $p^2/2Y$ .
7. Determine the fractional change in volume as the pressure of the atmosphere (0.1 MPa) around a metal block is reduced to zero by placing the block in vacuum. Bulk modulus for the metal is 1, 25,000 MPa.
8. The compressibility of water is  $5 \times 10^{-10} \text{ m}^2/\text{N}$ . Find the decrease in volume of 100 ml of water subjected to a pressure of 15 MPa.
9. What increase in the pressure is required to decrease the volume of 200 l of water by 0.004 %? Find  $\Delta V$  ( $B = 2,100 \text{ MPa}$ ).
10. Two parallel and opposite forces, each 4,000 N 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. Shear modulus for the metal is 80 GPa.
11. A block of gelatine is  $60 \text{ mm} \times 60 \text{ mm} \times 20 \text{ mm}$ , when unstressed. A force of 0.245 N is applied tangentially to the upper surface, causing a 5 mm displacement relative to the lower surface. Find  
(a) the shearing stress  
(b) the shearing strain  
(c) the shear modulus.
12. The figure shows a sheared cube. On the diagram indicate the direction in which force is applied to shear the cube. The sheared cube is in blue.

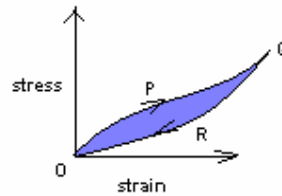


13. When stretched beyond its elastic limit, a metal rod such as steel
- becomes elastic
  - obeys Hook's Law
  - becomes plastic
14. On the graph label the elastic limit, proportional limit and fracture point. Also indicate the region in which the material will exhibit elastic behaviour and plastic behaviour.

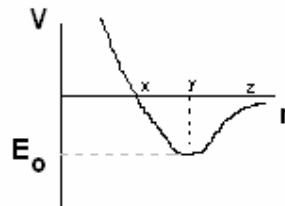


Stress-strain diagram for a ductile material under tension

15. The fig. shows the stress-strain variation of a sample of rubber when loaded and then unloaded. Which of the statement is correct? Correct the wrong statements.



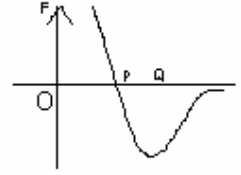
- QRO does not coincide with O P Q. This is called elastic stress.
  - The area under O P Q represents the work done per unit volume in stretching the rubber
  - The area under Q R O represents the energy taken by the rubber on contracting
  - The shaded area represents the energy 'lost' as heat during the loading and unloading cycle.
16. The fig. below shows how the potential energy  $V$  for two neighbouring atoms varies with their separation,  $r$ . Check if statements are true or false, if false correct the given statement.



- atoms are in equilibrium at a separation OX
- the force between atoms is attractive for separations greater than OY
- the atoms have maximum energy  $E_0$

17. The fig. shows roughly the force  $F$  between two adjacent atoms in a solid as it varies with separation,  $r$ . Check if statements are true or false, if false correct the given statement.

- (i) OQ is the equilibrium separation  
 (ii) Hooke's Law is obeyed around P



- (iii) the potential energy of the atoms is the gradient of the graph at all points.  
 (iv) the energy to separate the atoms completely, is obtained from the area enclosed below the axis of  $r$ .

18. Define stress and strain. Give their units and dimensions.  
 19. Give an example of shearing stress and longitudinal stress.  
 20. What is the length of a lead wire that will break under its own weight?  
 Breaking stress  $2 \times 10^7 \text{ Nm}^{-2}$ , density of lead =  $1.13 \times 10^3 \text{ kg m}^{-3}$ .  
 21. What is the density of ocean water at a depth where the pressure is 80 atmospheres.  
 Given:- density of water at surface =  $1.03 \times 10^3 \text{ kg/m}^3$ , compressibility of water =  $45.8 \times 10^{-11} \text{ Pa}^{-1}$ .  
 22. Will a hydraulic press work if its cylinder is filled with a gas instead of a liquid?  
 23. What will happen on dropping a solid body into water, given its density is exactly equal to that of water? Will it float or sink?  
 24. What is surface tension?  
 25. Explain why does mercury in a glass tube have a convex meniscus and water a concave meniscus?  
 26. Water rises to a height of 10 cm in a certain capillary tube. In the same tube, the level of mercury is depressed by 3.42 cm. Compare the surface tension of water and mercury. Specific Gravity of Hg is 13.6, angle of contact for water is zero and for Hg is 135 degrees.