Stress and Strain

1. **Deforming force :** The external force acting on a body on account of which its size or shape or both change is defined as the deforming force.

2. **Restoring force :** The force which restores the size and shape of the body when deformation forces are removed is called restoring force. Deforming force and restoring force are not action reaction pair. Restoring force opposes the change in the size and shape of a body.

3. **Rigid body :** A body whose shape and size cannot be changed however large the applied force is called rigid body. There is no perfectly rigid body in nature.
4. **Elasticity :** The property of a body by virtue of which it regains its original size and shape immediately after the deformation forces are removed is called elasticity. Elasticity is a molecular phenomenon. It is because of cohesive forces.
5. **Elastic body :** A body which shows elastic behaviour is called elastic body. E.g. steel, rubber. Quartz is very nearly perfectly elastic body.
6. **Plastic body :** A body which does not show elastic behaviour is called plastic body. E.g. putty, clay, mud, wax, lead, dough, chewing gum, butter wax etc.

7. Out of the given materials, a body in which it is more difficult to produce strain is more elastic. OR The body which requires greater deforming force to produce a certain change in dimension is more elastic.
   a) steel is more elastic than rubber
   b) glass is more elastic than rubber
   c) water is more elastic than air
   d) springs are made of steel but not of copper because steel is more elastic than copper.
8. By the process of hammering or rolling the body elasticity increases.
9. By the process of annealing, the elastic property of a body is reduced.
10. For invar steel (Fe-64%, Ni-36%) the elastic property is constant irrespective of change in temperature. (used in making pendulum clocks)

11. **FACTORS EFFECTING ELASTICITY :**
    a. Effect of temperature : In general as the temperature increases the elastic property of a material decreases.
    b. Effect of impurities : Addition of impurity to metal may increase or decrease the elasticity. If the impurity has more elasticity than the material to which it is added, it increases the elasticity.
    If the impurity is less elastic than the material it decreases the elasticity.

12. **Stress :** The restoring force developed per unit area of cross-section of the deformed body is called stress.

$$\text{Stress} = \frac{\text{Restoring force}}{\text{Cross} - \text{sectional area}} = \frac{F}{A}$$

$$\text{Unit} = \frac{\text{N}}{\text{m}^2}, \frac{\text{dyne}}{\text{cm}^2}, \text{pascal}$$

Dimensional formula : $M^1L^{-1}T^{-2}$

13. i) Pressure is always normal to the area, while stress can be either normal or tangential.
    ii) Pressure on a body is always compressive, while stress can be compressive or tensile.
    iii) Pressure is a scalar, while stress is a tensor.

14. **Stress is of three types :**
    i) **Longitudinal stress :** If the restoring forces are perpendicular to the area of cross-section and are along the length of the wire, the stress is called longitudinal stress.
    During longitudinal stress, the body undergoes change in length but not in shape and volume.
    ii) **Tangential stress** (or shearing stress) : If the restoring forces are parallel to the surface, the stress is called shearing stress.
    iii) **Bulk stress** (or volume stress) : If a body is subjected to equal forces normally on all the faces, the stress involved is called bulk stress.
15. **Strain :** The deformation produced per unit magnitude is called strain.

a) longitudinal strain $= \frac{\text{change in length}}{\text{original length}} = \frac{e}{l}$

b) shearing strain = $\theta = \frac{\textit{lateral}\ \text{displacement between two layers}}{\text{perpendicular distance between the two layers}}$

$= \frac{\Delta l}{l}$

c) Bulk strain $= \frac{\text{change in volume}}{\text{original volume}} = \frac{-\Delta v}{v}$

d) Transverse strain or lateral strain

$= \frac{\text{change in radius}}{\text{original radius}} = \frac{-\Delta r}{r}$

e) shearing strain = 2 x longitudinal strain

f) bulk strain = 3 x longitudinal strain

g) longitudinal strain : shearing strain : bulk strain
= 1:2:3

Shear strain is equivalent to two equal longitudinal elongation and compressional strains in mutually perpendicular directions.

The maximum value of the stress within which the body regains its original size and shape is called elastic limit.