Mechanics of Solids II
Module-1

Engr. Usama Ali

NOTE: For video lectures please send me email at usamauet28@gmail.com

Mechanics of materials is a study of the relationship between the external loads applied to a body and the stress and strain caused by the internal loads within the body.

External forces can be of two types i.e. *Body forces* and *Surface forces.*

1. **Surface Forces:** *Surface forces* are caused by the direct contact of one body with the surface of another. In all cases these forces are distributed over the *area* of contact between the bodies. If this area is small in comparison with the total surface area of the body, then the surface force can be *idealized* as a single *concentrated force.*
2. **Body Forces:** A *body force* is developed when one body exerts a force on another body without direct physical contact between the bodies. Examples include the effects caused by the earth's gravitation or its electromagnetic field. These forces are normally represented by single concentrated force acting on the body.

Equations of Equilibrium: For any rigid body to remain in equilibrium, two conditions must be satisfied i.e. *Balance of Forces* and *Balance of moments.* These conditions can mathematically be represented as

$$\sum F=0$$

$$\sum M=0$$

Here, $\sum F=0$ represents the sum of all the forces acting on the body, and $\sum M=0$ is the sum of the moments of all the forces about any point O. If an *x*, *y*, *z* coordinate system is established with the origin at point *O*, the force and moment vectors can be resolved into components along each coordinate axis and the above two equations can be written in scalar form as six equations, namely,

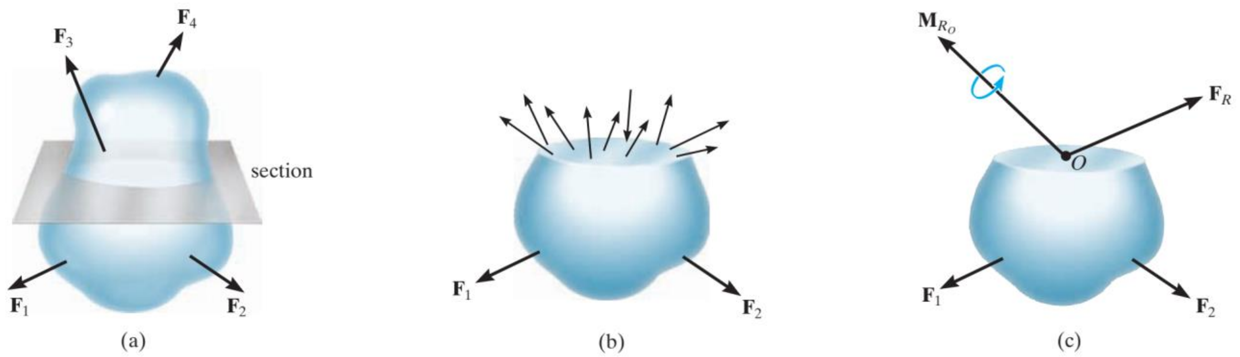
$\sum F_x=0$, $\sum F_y=0$, $\sum F_z=0$ & $\sum M_x=0$, $\sum M_y=0$, $\sum M_z=0$

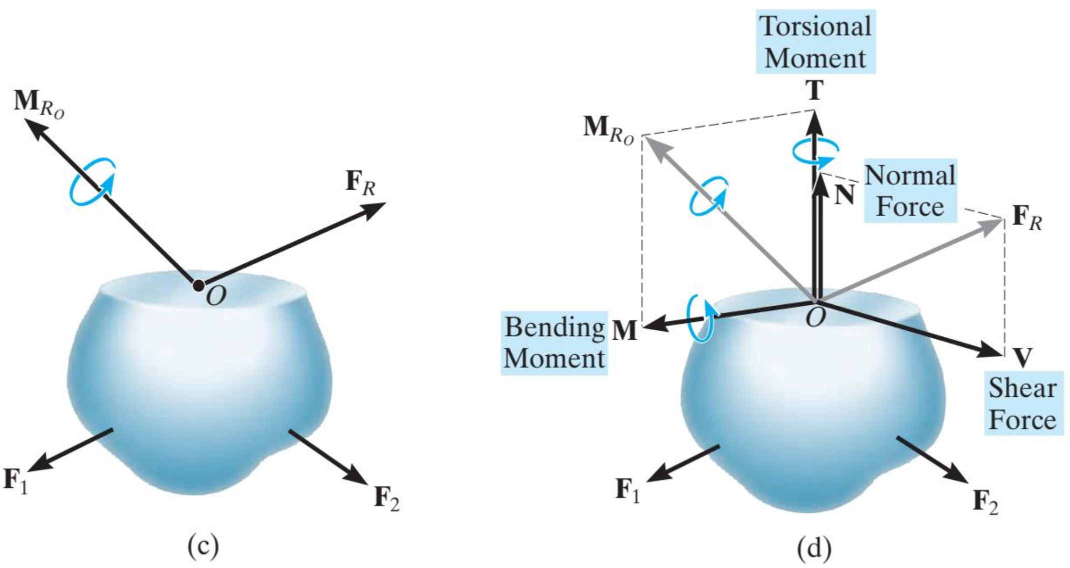
Often in engineering practice, for the sake of simplicity, the loading on a body can be represented as a system of *coplanar forces*. If this is the case, and the forces lie in the *x–y* plane, then the conditions for equilibrium of the body can be specified with only three scalar equilibrium equations; that is,

∑Fx=0, ∑Fy=0 & ∑Mz=0.

When applying the equations of equilibrium, it is important to first draw the *free-body diagram* for the body in order to account for all the terms in the equations.

The method of sections is used to determine the internal resultant loadings acting on the surface of the sectioned body. In general, these resultants consist of a normal force, shear force, torsional moment, and bending moment.





1. **Normal force, N.** This force acts perpendicular to the area. It is developed whenever the external loads tend to push or pull on the two segments of the body.
2. **Shear force, V.** The shear force lies in the plane of the area and it is developed when the external loads tend to cause the two segments of the body to slide over one another.

3. **Torsional moment or torque, T.** This effect is developed when the external loads tend to twist one segment of the body with respect to the other about an axis perpendicular to the area.
4. **Bending moment, M**. The bending moment is caused by the external loads that tend to bend the body about an axis lying within the plane of the area.

Coplanar Loadings: If the body is subjected to a coplanar system of forces as show in the figure below ,then only normal force, shear force, and bending- moment components will exist at the section. If we use the x, y, z coordinate axes, as shown on the left segment, then N can be obtained by applying $\sum Fx=0$, and V can be obtained from $\sum Fy=0$. Finally, the bending moment can be determined by summing moments about point O (the z axis) $\sum Mz=0$, in order to eliminate the moments caused by the unknowns N and V.