1. Introduction:

Resistance of material or in Frence (Résistance De Matériaux RDM) or Strength of Materials is a fundamental subject needed primarily for the students of Mechanical sciences. As the engineering design of different components, structures etc. in practice are using different kinds of materials, so it is essential to understand the basic behavior of such materials. The objective of the present course is to make the students acquainted with the concept of loads resultant, consequences and how to their protection.

2. The main purpose of RDM:

The resistance of materials (RdM) studies the behavior of the deformable solid. It is particularly interested in calculating the dimensions of mechanical systems so that they are able to resist the forces applied to them during their service under the required security conditions

3. Hypotheses of material:

These hypotheses essentially concern the materials used, the shape of the solids studied and the type of mechanical action exerted.

- Homogeneity, isotropy and continuity of materials: it assumed that the material has the same elastic properties at all points of the body; in all directions and that, the material considered continuous (no macroscopic defect).
- The elasticity and linearity of the material: it assumed that at each point, stress and deformation are proportional and that after deformation, the element returns to its initial state.

4. Assumptions about beams:

4.1. Definition:

We call a beam a solid of which one of the dimensions is large compared to two others and which is subjected to a stress system which causes it to bend or deform.

4.2 Geometry:

A beam is generally a solid generated by a plane area (S) whose center of gravity (G) describes a curve (C). The plane of the area (S) remains normal to the curve (C), as show in figure 1.

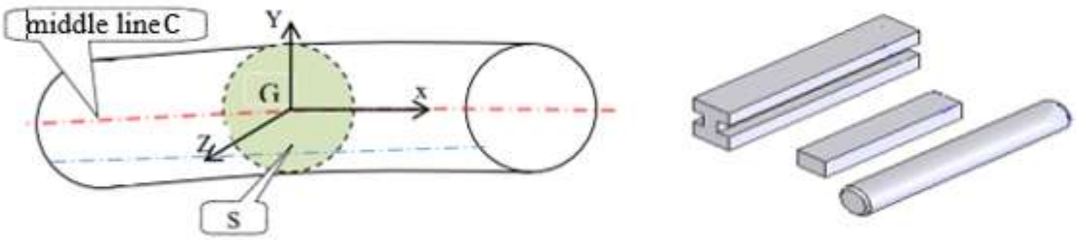


Fig. 1 Examples of beams.

- The area of the section (S) called the straight section or normal section of the beam.
- The curve (C) called the middle fiber of the beam.

5. Validity domain of material resistance:

• Hypothesis of small deformations: Deformations due to loads are negligible compared to the dimensions of the components studied.

• Navier-Bernoulli hypothesis (plane sections hypothesis): the straight sections remain flat and normal to the average fiber during deformation.

• Saint Venant hypothesis: The stresses (and consequently the deformations linked to them by Hooke's law), in a region far from the points of application of a system of forces, depend only on the general resultant and the resulting moment of this system of forces.

These simplifying hypotheses lead to approximate solutions, which generally allow a good approximation of the behavior of structures subjected to different types of loads.

6. Kinds of charge and liaisons:

6.1 Liaisons: There are three types of liaisons between beam and supports are following:

- **Moving -articulation support: (sphere or cylinder or roller)**

  The simple support (fig 2.) introduces a single reaction unknown into the study of the beam.

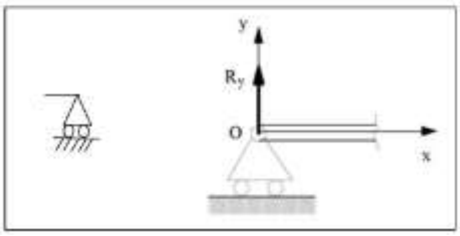


Fig 2. Simple support.

- **fixed -articulation support:**

  The articulation is allow rotating at the end of beam and introduces two reactions unknowns, by projection on two directions of the plane average as show in figure 3.

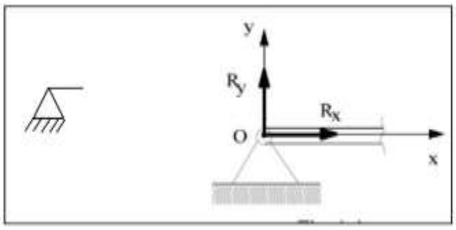


Fig 3. Fixed articulation support.

➢ fixed support:

- This support contacting the beam to a part considered as fixed, this type of support therefore introduces three reactions unknowns, the two projections of R on two axes of the mean plane and the intensity of the Moment M perpendicular to the mean plane. such as in figure 4.

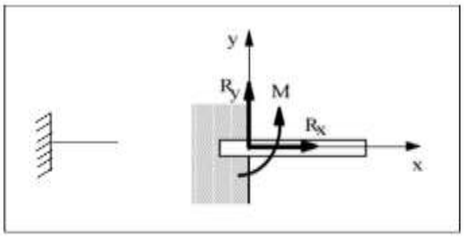
- 

Fig 4. Fixed support

7. Types of charges (loads):

The Loads applied to the beam may consist of a concentrated load (load applied at a point as in fig 5.a), uniform load (fig 5.b), uniformly varying load (fig 5.b), or an applied couple or moment (fig 5.d). These loads shown in the following figures 5.

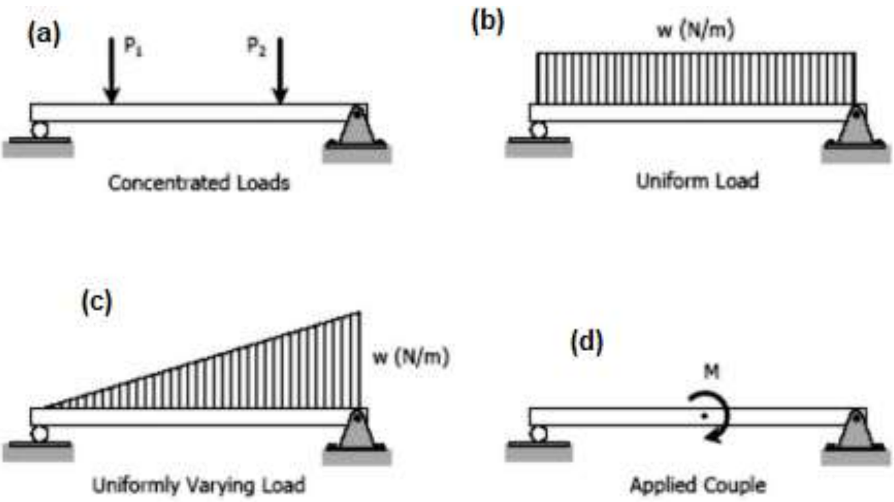


Fig 5. Kinds of loads of beam

8. Conditions for Equilibrium system:

The first condition for equilibrium is that the forces along each coordinate axis add to zero. From Newton’s law, we know that the following relations apply as:

$$\sum \vec{F} = \vec{0} \Rightarrow \begin{cases} \sum Fx = 0 \\ \sum Fy = 0 \\ \sum Fz = 0 \end{cases}$$

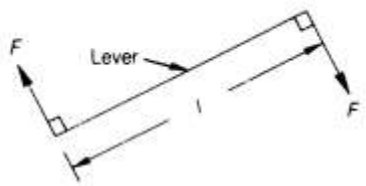
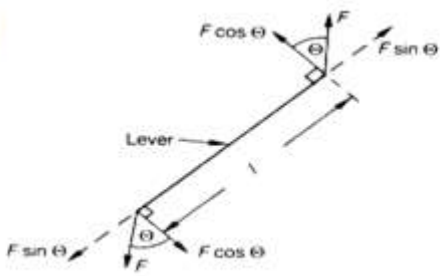
The second condition of equilibrium is that the resultant of all applied moments, including bending and twisting moments must be zero.

$$\sum \vec{M}_p(\vec{F}) = \vec{0}$$

The two equilibrium conditions used to determine support reactions and internal forces on cross-sections of structural members.

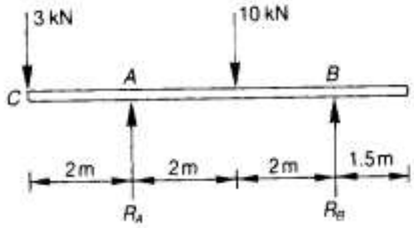
- **Couples**

A couple can be described as the moment produced by two equal and opposite forces acting together, as shown in Figure 6 where,

F = force (N) L = lever length (m) the moment at the couple (clockwise-couple) **M = F x L** (N.m)	**(a)** 
For the counter-clockwise couple of M = F COS θ x 1 The components of force F sin θ will simply place the lever in tension, and will not cause a moment.	**(b)** 

Example:

Determine the values of the reactions of R_A, and R_B, for the simply supported beam shown.



Solution

Taking moments about B:

$$\sum \vec{M}_B(\vec{F}) = \vec{0}$$

Clockwise couples = counter-clockwise couples

R_A x 4 = 3 x 6+10 x 2 =18 + 20

⇒ R_A = 9.5 kN

Resolving forces vertically:

$$\sum Fy = 0$$

R_A+R_B = 3+10

or

R_B = 13 - 9.5 = 3.5 kN

9. Engineering Materials:

Materials used in engineering applications may be classified into the following groups:

(a) ferrous metals and alloys; such as iron, steel, cast steel, alloy steel, and cast iron.

(b) Non-ferrous metals and alloys; such as aluminum and its alloys, copper and its alloys (brass & bronze), nickel and nickel alloys, and zinc and zinc alloys,

(c) Mon-metals; such as wood, leather, and ivory,

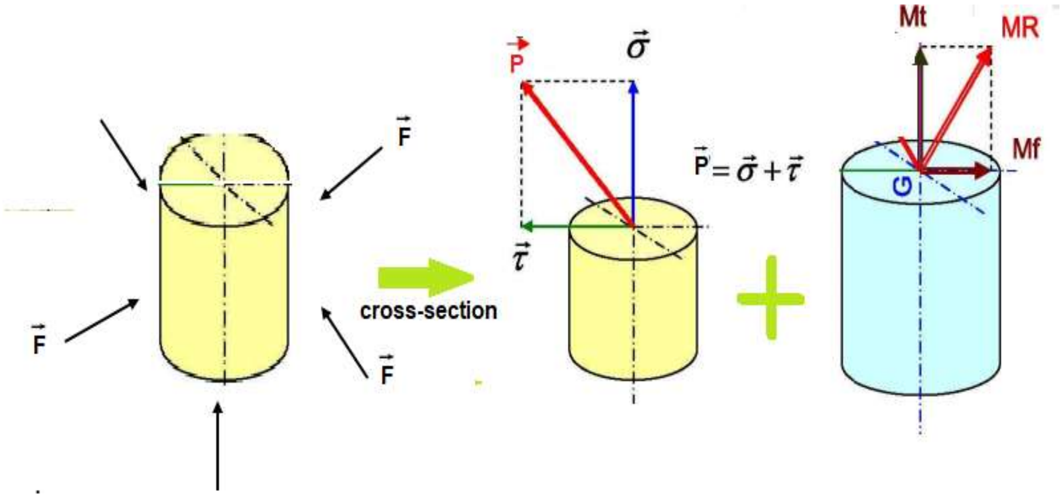
(d) Polymers: such as polyethylene, epoxy, and phenolic.

(e) Ceramics: such as brick, glass, and china.

(f) Composites: such as plywood, concrete, and fiberglass.

One of the important duties of design engineers is to select the proper material with proper dimensions, which provide maximum safety and economy. Designers should be also concerned with other factors such as weight, size, and appearance.

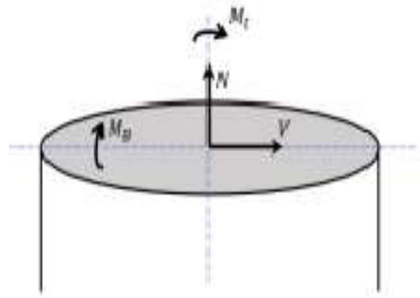
10. Stress



Fig, 7

There are four types of forces:

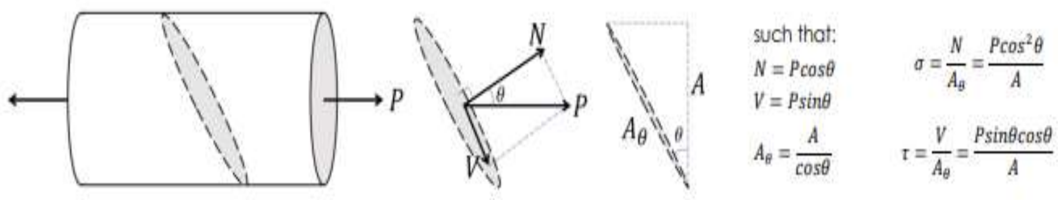
- Normal force (N) is perpendicular to the surface
- Shear force (V) is parallel to the surface
- Torsional moment (Mt) is about the axis normal (perpendicular) to the surface
- Bending moment (MB) is about the axis parallel to the surface



Stress measures the intensity of the force per given area:

- Normal stress (σ) results from the normal force N and/or bending moment M_B
- Shear stress (τ) results from shear stress V and/or torsional moment M

Stress can occur on oblique planes :



11. Strain:

• Strain is a measure of the material's response to stress and is expressed as a ratio to the change in length to the original length:

$$\varepsilon = \frac{\Delta L}{L_0}$$

Where elongation results in a positive strain, compression results in a negative strain.

Shear strain is based on the rotation of the object, measured in radians:

$$\gamma = \text{angle of deformation}$$

Modulus of Rigidity is similar to Young's Modulus but measures the ratio of shear stress to angle of deformation:

$$G = \tau / \gamma$$

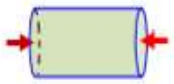
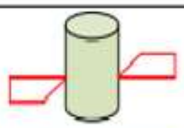
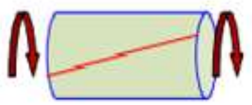
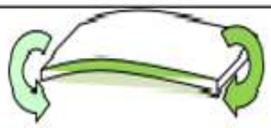
Young's Modulus defines the relationship between normal stress and lateral strain:

$$E = \sigma / \varepsilon$$

12. Basics types of deformation:

We can brief all the simple deformations in this table:

Table 1.1

type force	Deformation	Description	N	T	Mt	Mf
Normal force, Axial force, Thrust		The member is being stretched by the axial force and is in tension. The deformation is characterized by axial elongation.	1	0	0	0
Normal force, Axial force, Thrust		The member is being compressed by the axial force and is in compression. The deformation is characterized by axial shortening.	1	0	0	0
Shear force		The member is being sheared. The deformation is characterized by distorting a rectangle into a parallelogram.	0	1	0	0
Torque, Twist moment		The member is being twisted and is in torsion. The deformation is characterized by angle of twist.	0	0	1	0
Bending moment		The member is being bent and the deformation is characterized by a bent shape.	0	0	0	1