Ashur University college

Biomedical Engineering Department

Mechanics of Materials

Third year

Presented by Ali Hussein ATAIWI

-BMER311-Mechanics of Materials I (Th.: 2 Hrs., Tut.: 1, Prac.)

Mechanical properties of materials, simple one and two dimensions' mechanical and thermal stresses and strains; statically determinate and indeterminate bars; beams and structures: (shear force and bending moment diagrams); elastic strain energy; impact; springs, deflections of beams.

1-1 References:

1. Introduction to Mechanics of Solid, by: E. Popov
2. Elements of Strength of Materials, by: Timoshenko
3. Strength of Materials, by: Singer
4. Mechanics of Materials by: Ferdinand P. Beer, E. Russell Johnston, Jr. and John T. De Wolf, Third Edition.

1-2 UNITS:

	British	Metric	S.I. (System International)
1- Force (1 N = 4.448 lb)	lb(lebra), kip, Ton 1 kip = 1000 lb 1 ton = 2240 lb	g(gram), kg 1 kg = 1000 g 1 Ton = 1000 kg	N(Newton), kN 1 kN = 1000 N 1 kg = 10 N
2- Length (1 in = 2.54 cm)	In (inch), ft 1 ft = 12 in	mm, cm, m 1 cm = 10 mm 1 m = 100 cm 1 m =1000 mm	mm, cm, m 1 cm = 10 mm 1 m = 100 cm 1 m =1000 mm
3-Stress (=Force/Area) kPa = 6.894 psi	psi (lb/in^2) ksi (kip/in^2)	Pa[Pascal] (N/m^2), kPa, MPa, GPa MPa[Mega Pascal] = 10^6 Pa (N/mm^2) GPa[Giga Pascal] = 10^9 Pa (kN/mm^2)	

Best units used in these lectures: mm or in. [length], N or Pa (lb) [Force], MPa(N/mm^2), psi (lb/in^2) [Stress]

1-3 Definition: Strength of Materials

The study of **Strength of Materials** (or Mechanics of Materials) is the study of behavior of solid bodies under load. The way in which they react to applied forces, the deflections resulting and the stresses and the strain set up within the bodies, are all considered in attempt to provide sufficient knowledge to enable any component to be designed such that will not fail within its service life.

1-4 Forces in Strength of Materials:

There are several types of forces that act on solid bodies. These consist of forces applied to the mass of the body and to the surface of the body, forces at restraints, and internal forces.
In Figure 1 we show a general three dimensional body with forces depicted acting on its surface and on its mass.

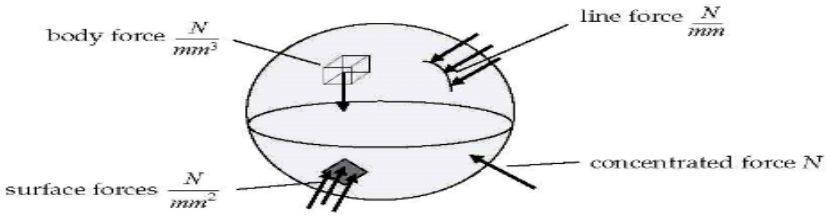


Figure 1

1-5 Objectives

Strength of Materials answers two questions:

Is the material strong enough?

Is the material stiff enough?

- ❑ **If the material is not strong enough, your design will break.**
- ❑ **If the material isn't stiff enough, your design probably won't function the way it's intended to.**

- ❖ **The main objective of the study of strength of materials (or mechanics of materials) is to provide the engineer with methods of analyzing various machines and structural members.**
- ❖ **Design and analysis of a given structure involve the determination of *stresses* and *deformation***

Lecture - 1 (Introduction)

Classification of Materials:

A. Elastic Material

If material undergoes deformation on external loading and the deformation disappear on removal the load. Example – steel and rubber

B. Plastic Material

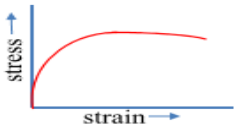
If material undergoes deformation on external loading and the deformation does not disappear at all on removal load. Example – lead and gold

C. Elastic-plastic Material

If material undergoes deformation on external loading and the deformation disappear partially on removal of the load. Hence, a permanent deformation remain even after removal of the load in elasto-plastic material.

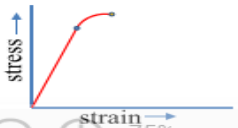
D. Ductile Material

Material can undergo large deformation before failure. In other word, a material which can be drawn into wires is known as ductile material. Example – Aluminium, copper, magnesium, etc. An advantage of ductility is that visible distortion may occur if the loads become too large, thus providing an opportunity to take remedial action before an actual fracture occurs.



E. Brittle Material

A material in which no deformation take place when external load is applied and it fails by rupture. In other word, materials that fail in tension at relatively low values of strain known as brittle materials. Example – concrete, cast-iron, glass, ceramic materials.



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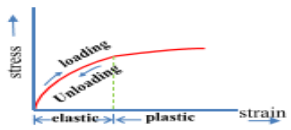
Lecture - 1 (Introduction)

Mechanical Properties of Materials:

A. **Hardness**: The hardness of a material is a measure of its resistance to penetration by an identer. It is also measure of strength and often has the units of stress. The identer is fabricated to a hard material and the shape of tip may conical, soberical or pyramidal.

B. **Elasticity**: Is the property of a material by virtue of which it returns to its original dimension during unloading.

C. **Plasticity**: Is the property of a material by virtue of which permanent deformation of the material take place after removal of load.



D. **Ductility**: Is the property of a material by virtue of which it can be drawn into wires before rupture. It is measured by the percentage of elongation and percentage of reduction of area of a test piece before rupture. Ductile materials are capable of absorbing large amount of energy prior to fracture. With increasing carbon content, steel become less ductile but has a higher yield stress and higher ultimate stress.

E. **Brittleness** : Lack of ductility is brittleness.

F. **Toughness** : The property of a metal by virtue of which it can be bent, twisted or stretched under a high stress before rupture is called toughness.

G. **Malleability** : The property of a metal by virtue of which it can be beaten or rolled into their sheets without rupture is called malleability.

H. **Strength**: It is the ability of a material to resist the action of external force without breaking. The tensile strength, compressive strength and shear strength represents the strength of a material.

1-6 Design Considerations

Safety

Economy

Design of engineering systems is usually a trade-off between maximizing safety and minimizing cost.

1-7 Typical Approach to an Engineering Solution

– Identify the problem
– State the objective
– Develop alternative solutions
– Evaluate the alternatives, and
– Use the best alternative