Module # 2

“MECHANICAL PROPERTIES”

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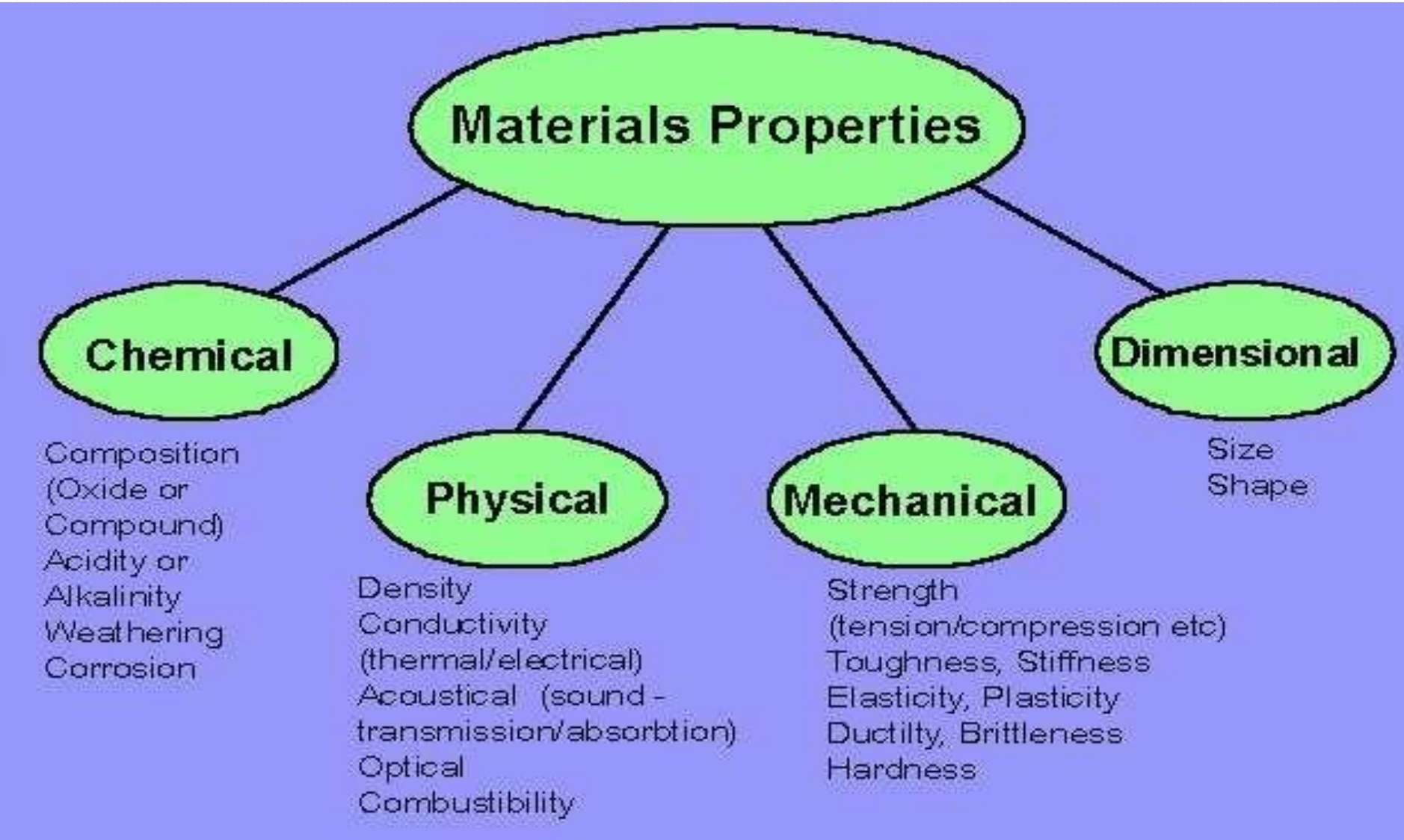
MS- Structural Engineering

INTRODUCTION:

- The practical application of engineering materials

  in manufacturing engineering depends upon a thorough knowledge of their particular properties under a wide range of conditions.
- The term ***"property"*** is a qualitative or quantitative measure of response of materials to externally imposed conditions like forces and temperatures.
- However,the range of properties found in different classes of materials is very large.

Classification of material property:



MECHANICAL PROPERTIES:

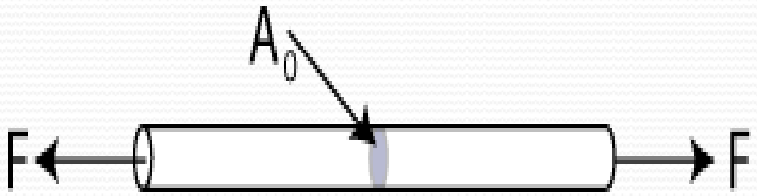
- The properties of material that determine its behaviour under applied forces are known as mechanical properties.
- They are usually related to the elastic and plastic behaviour of the material.
- These properties are expressed as functions of stress-strain,etc.
- A sound knowledge of mechanical properties of materials provides the basis for predicting behaviour of materials under different load conditions and designing the components out of them.

STRESS AND STRAIN

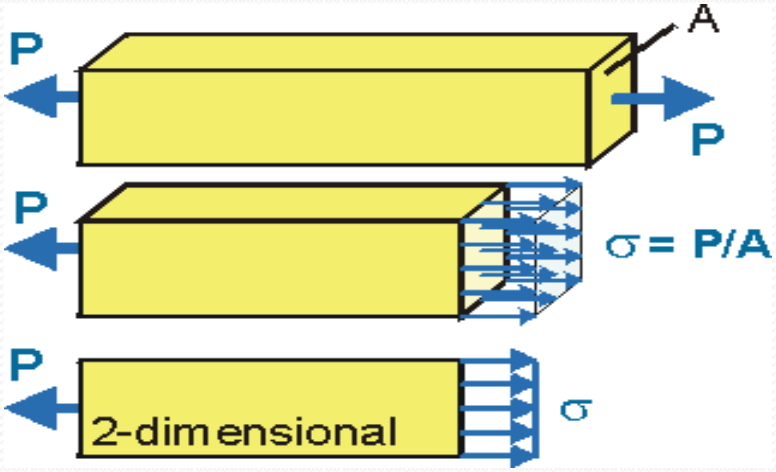
- Experience shows that any material subjected to a load may either deform, yield or break, depending upon the
  - The Magnitude of load
  - Nature of the material
  - Cross sectional dime.

CONTI..

- The sum total of all the elementary interatomic forces or internal resistances which the material is called upon to exert to counteract the applied load is called stress.
- Mathematically, the stress is expressed as force divided by cross-sectional area.

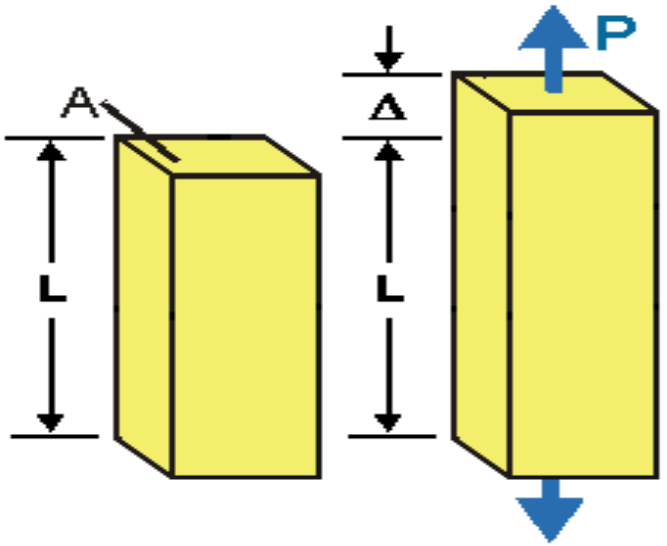


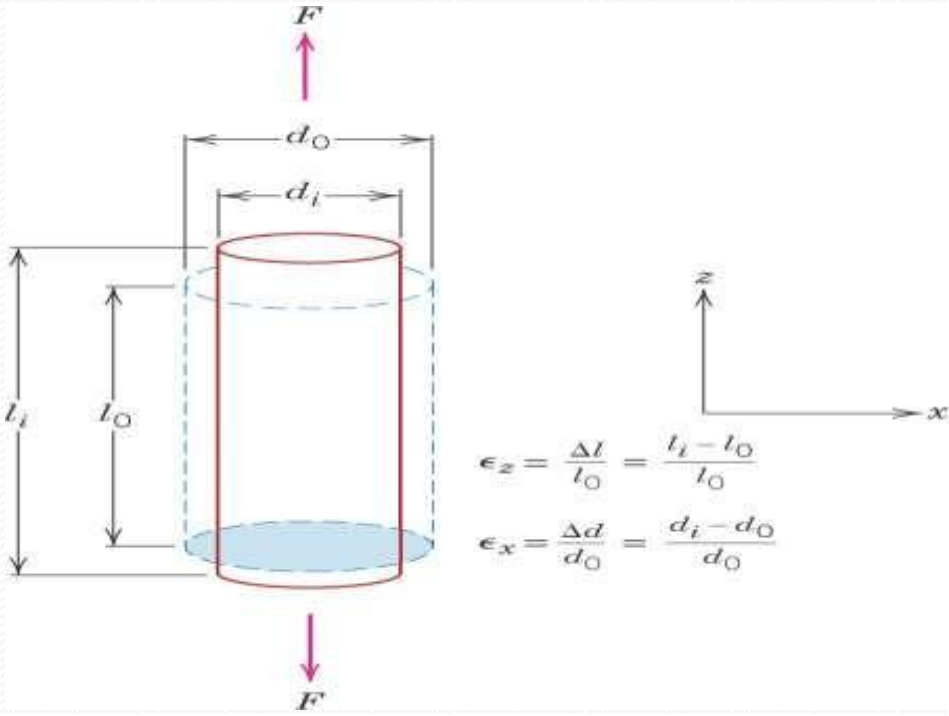
$$\text{Stress, } \sigma = \frac{\text{Force}}{\text{Cross-Sectional Area}} = \frac{F}{A_0}$$



CONTI…

- Strain is the dimensional response given by material against mechanical loading/Deformation produced per unit length.
- Mathematically Strain is change in length divided by original length.





STRENGTH

- The strength of a material is its capacity to withstand destruction under the actionof external loads.
- It determines the ability of a material to withstand stress without failure.
- The maximum stress that any material will withstand before destruction is called ultimatestrength.

Tensile Strength

This is the maximum conventional stress that can be sustained by the material.
It is the ultimate strength in tension and corresponds to the maximum load in a tension test.
It is measured by the highest point on the conventional stress-strain curve. In engineering tension tests this strength provides the basic design information on the materials.
The tensile strength of a material is the maximum amount of tensile stress that it can be subjected to before failure.

Tensile Strength

There are three typical definitions of tensile strength.
Yield strength
The stress at which material strain changes from elastic deformation to plastic deformation, causing it to deform permanently is known as yield strength.
Ultimate strength
The maximum stress a material can withstand is known as ultimate strength.
Breaking strength
The strength co-ordinate on the stress-strain curve at the point of rupture is known as breaking strength.

Tensile Strength

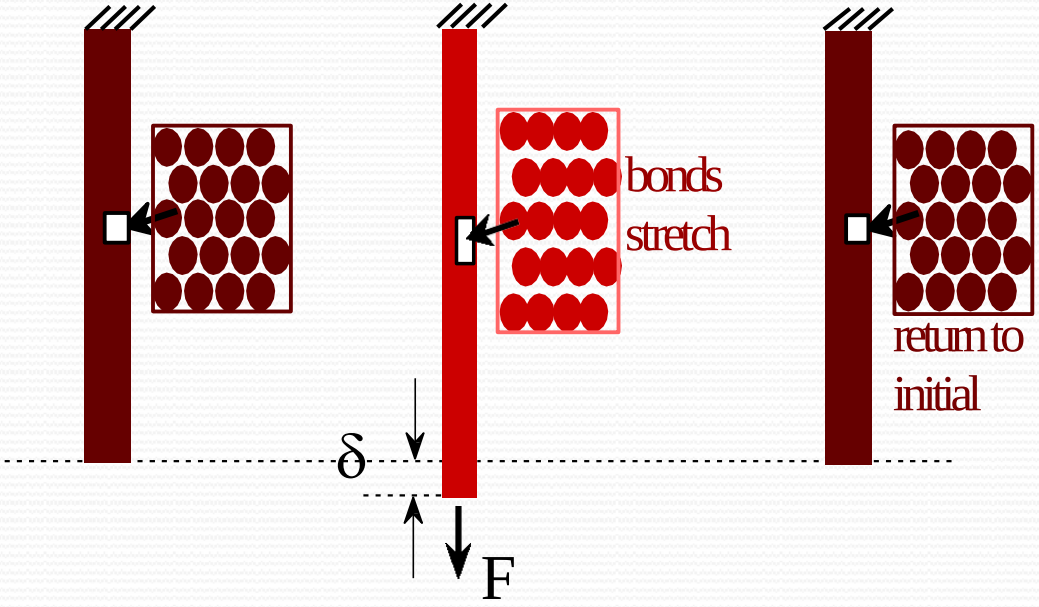
In ductile materials the load drops after the ultimate load because of necking. This indicates the beginning of plastic instability.

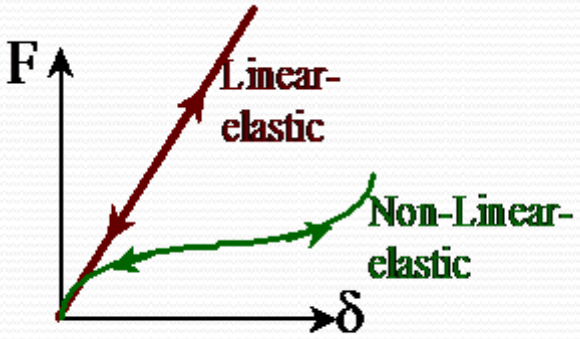
In brittle materials, the ultimate tensile strength is a logical basis for working stresses. Like yield strength, it is used with a factor of safety.

Material	Tensile Strength kg/mm^2
Alloy steel	60 -70
Mild Steel	42
Grey CI	19
White CI	47
Aluminum alloy	47

ELASTICITY:

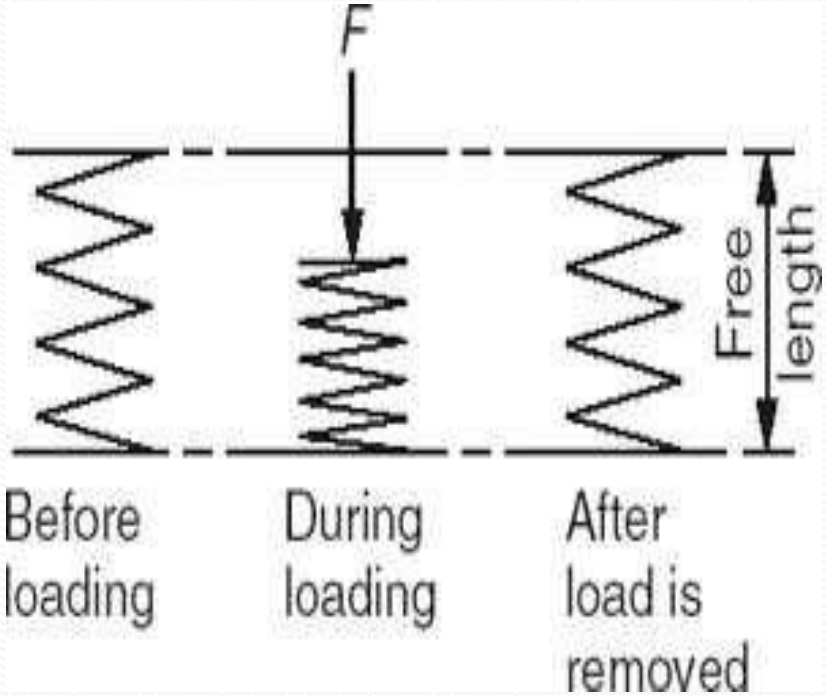
- The property of material by virtue of which deformation caused by applied load disappears upon removal of load.
- Elasticity of a material is the power of coming back to its original position after deformation when the stress or load is removed.

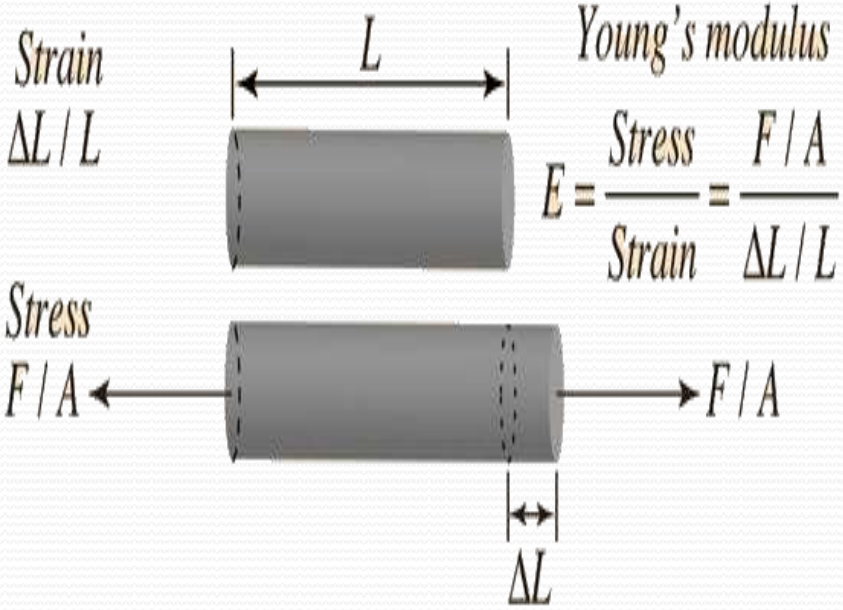




Elastic means reversible.

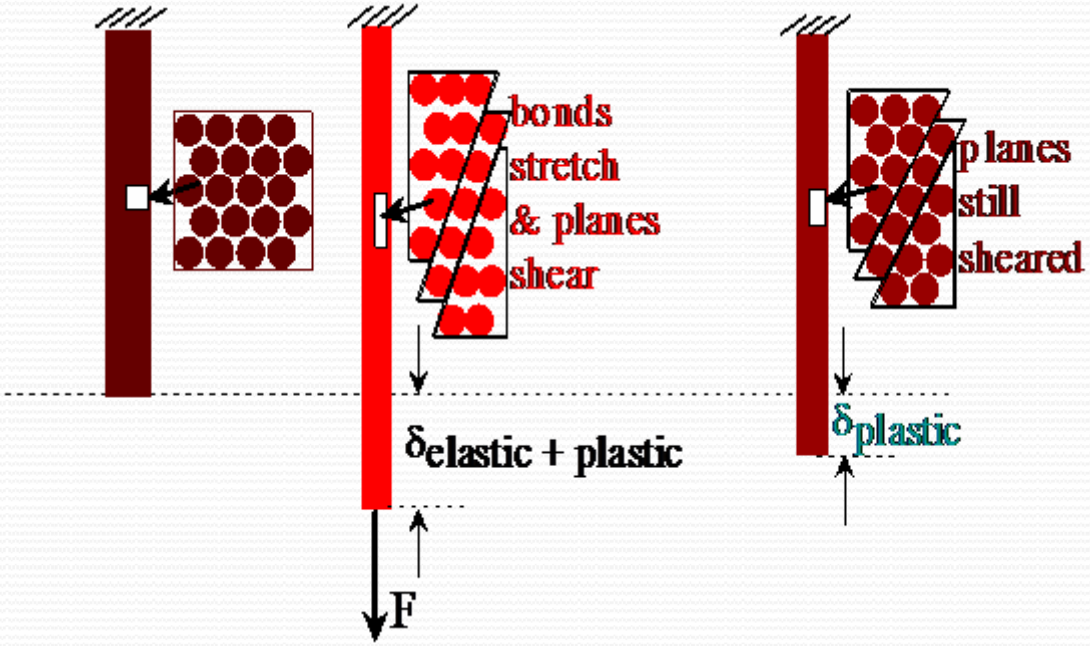
CONTI..

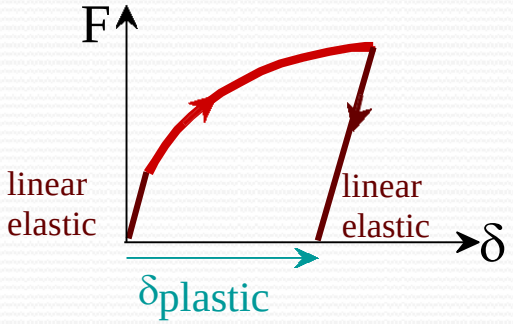

F
Free length
Before loading
During loading
After load is removed


Strain
ΔL / L
L
Young's modulus
E = Stress / Strain = F / A / ΔL / L
Stress
F / A
F / A
ΔL

PLASTICITY:

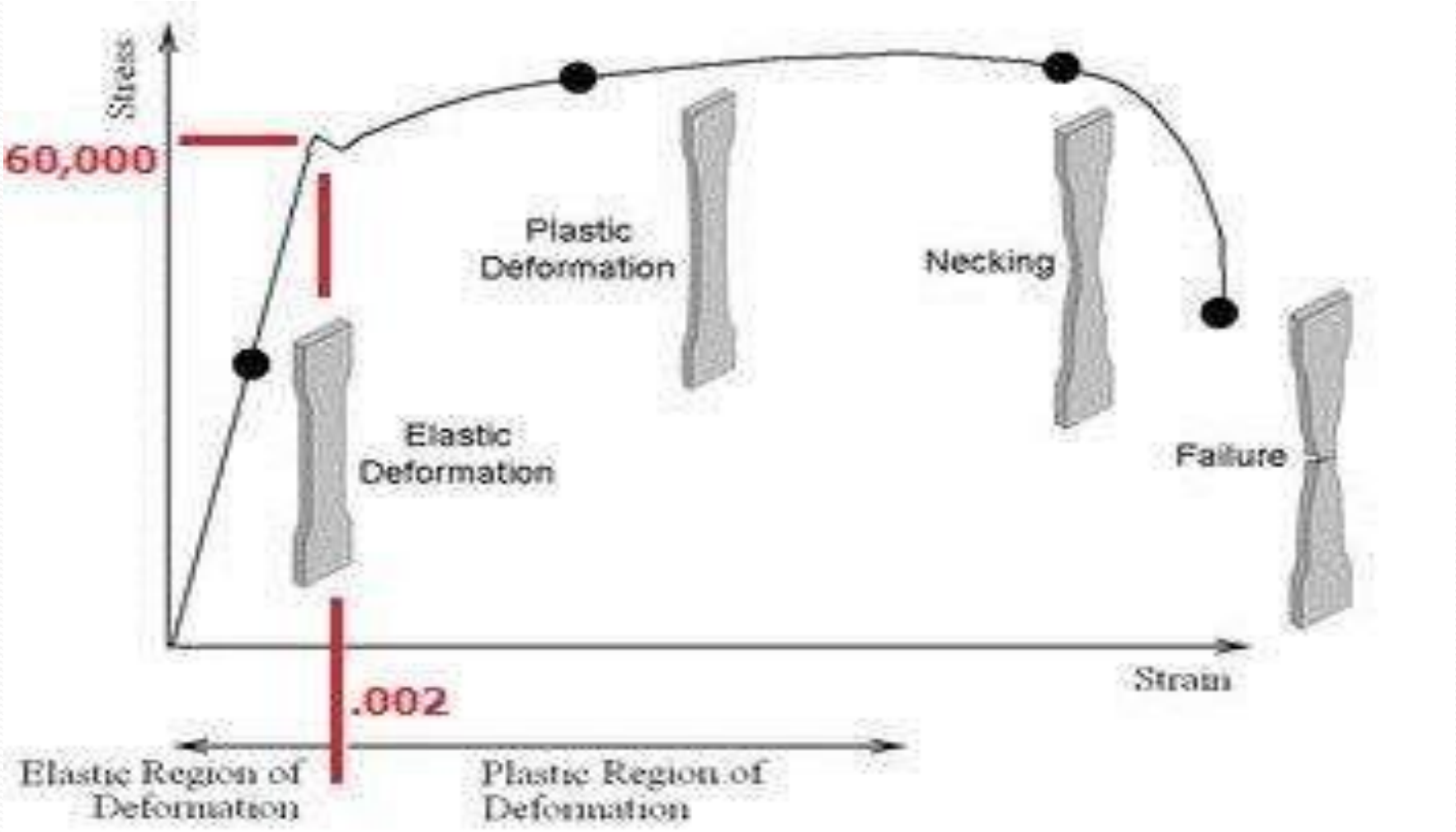
- The plasticity of a material is its ability to undergo some degree of permanent deformation without rupture or failure.
- Plastic deformation will take only after the elastic limit is exceeded.
- It increases with increase in temperature.





Plastic means permanent.

STRESS STRAIN CURVE SHOWS ELASTICITY AND PLASTICITY FOR MATERIALS:



STIFFNESS:

- The resistance of a material to elastic deformation or deflection is called stiffness or rigidity.
- A material which suffers slight deformation under load has a high degree of stiffness or rigidity.
- E.g. Steel beam is more stiffer or more rigid than aluminium beam.

DUCTILITY:

- It is the property of a material which enables it to draw out into thin wires.
- E.g., Mild steel is a ductile material.
- The percent elongation and the reduction in area in tension is often used as emperical measures of ductility.

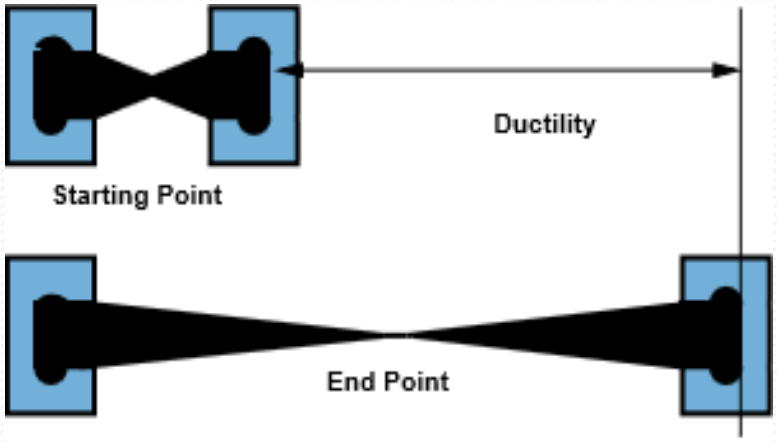
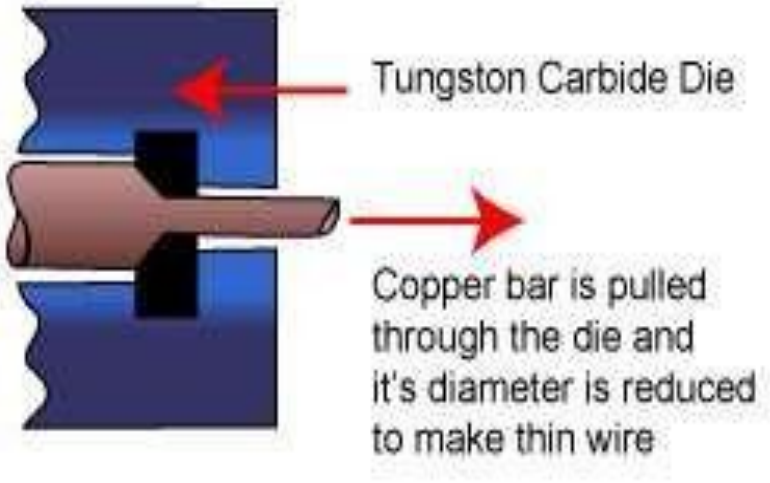
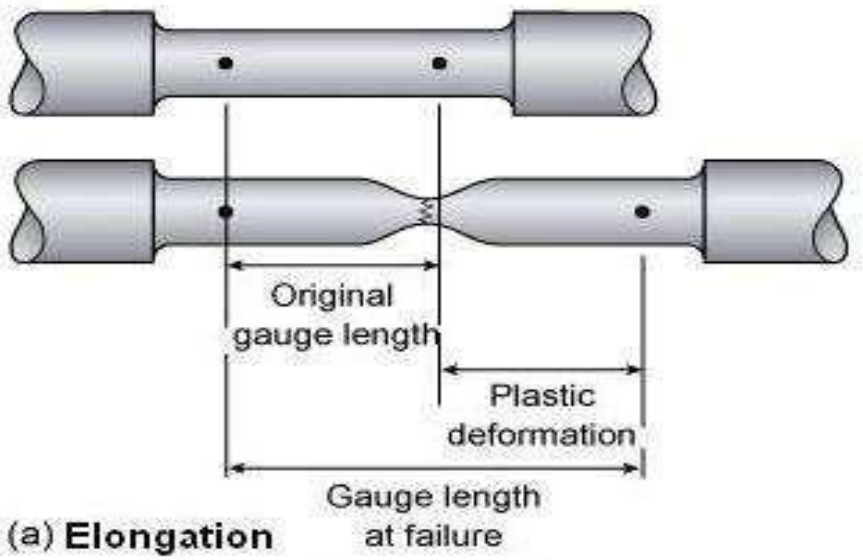
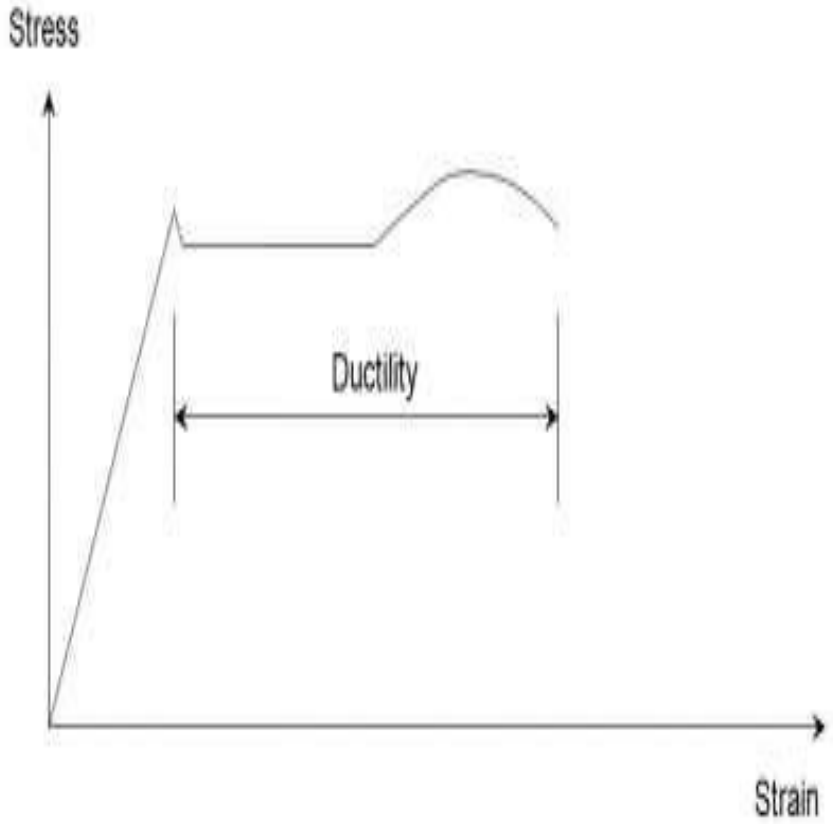


Figure 23:2: Ductility Test




Original
gauge length
Plastic
deformation
Gauge length
at failure
(a) Elongation
Original diameter d
Reduction in
diameter
Diameter at failure
(b) Reduction in Area

Ductility


Stress
Ductility
Strain

Malleability:

- Malleability of a material is its ability to be flattened into thin sheets without cracking by hot or cold working.
- E.g Lead can be readily rolled and hammered into thin sheets but can be drawn into wire.

Comparision of ductility and malleability

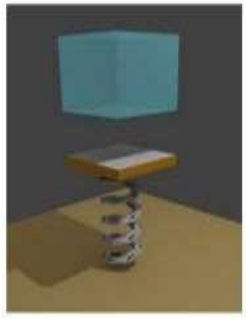
- Ductility and Malleability are frequently used interchangeably many times.
- Ductility is ***tensile quality, while*** malleability is ***compressive quality.***

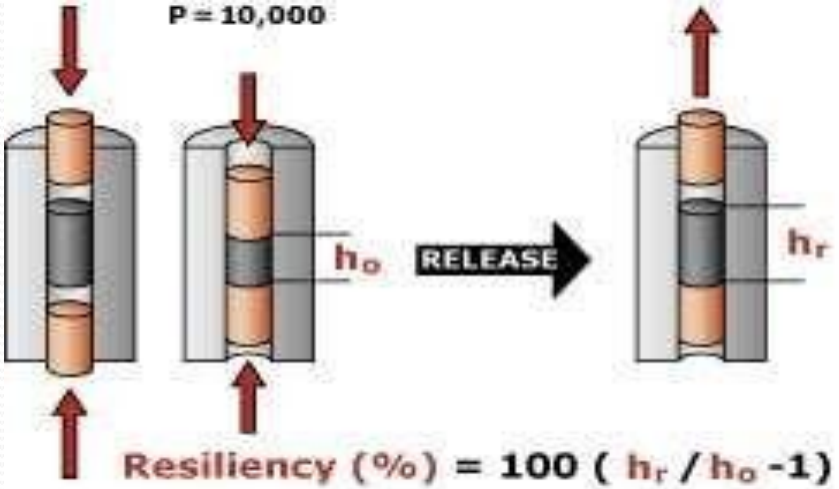
RESILIENCE:

- It is the capacity of a material to absorb energy elastically.
- The maximum energy which can be stored in a body upto elastic limit is called the ***proof resilience, and*** the proof resilience per unit volume is called ***modulus of resilience***.
- The quantity gives capacity of the material to bear shocks and vibrations.

Resilience

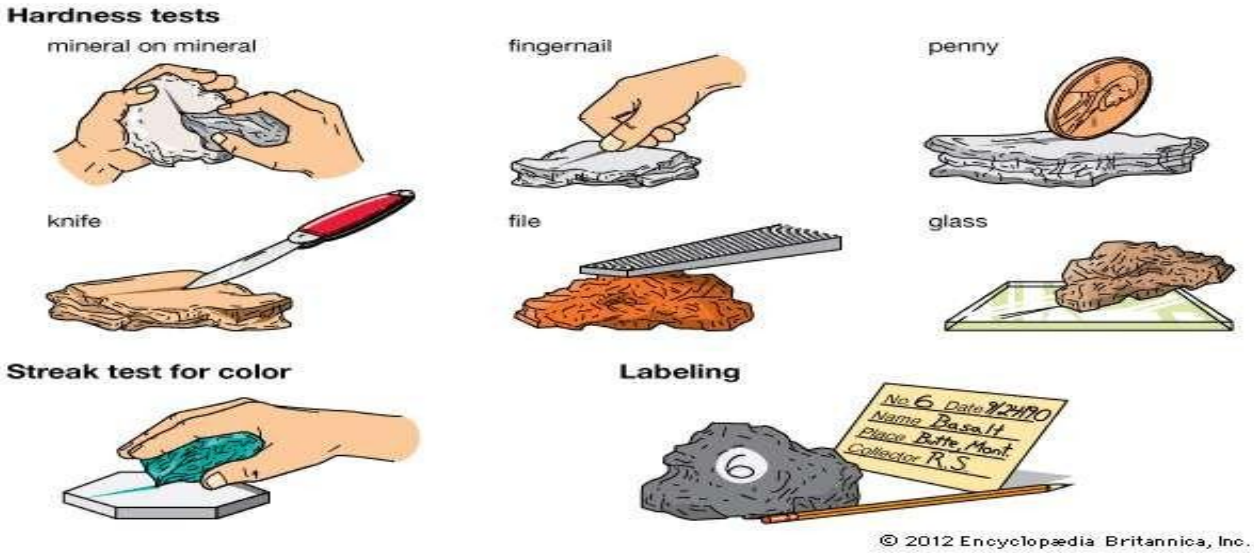
- It is the property of a material to absorb energy and to resist shock and impact loads. It is measured by the amount of energy absorbed per unit volume within elastic limit. This property is essential for spring materials.





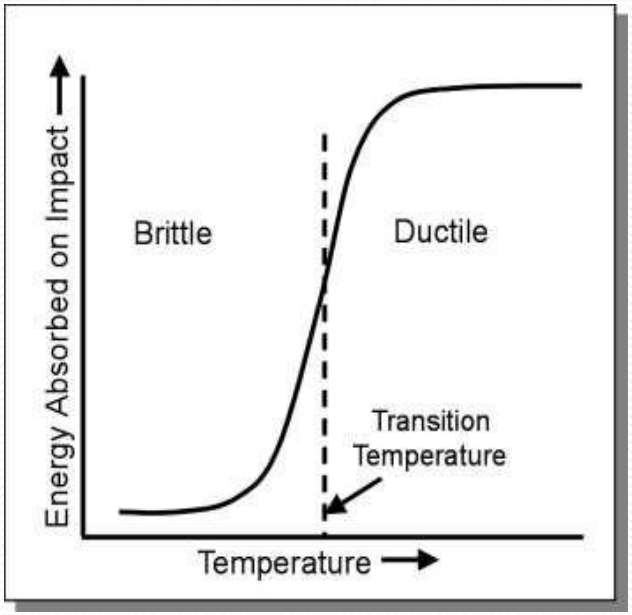
HARDNESS:

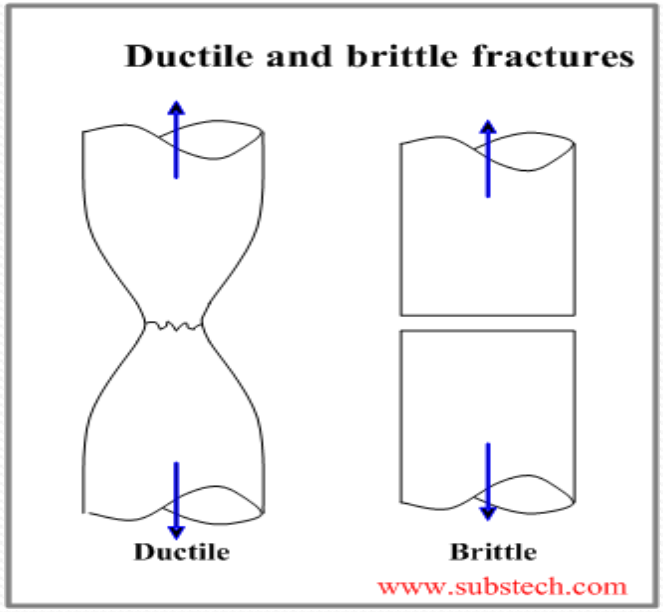
- Hardness is a fundamental property which is closely related to strength.
- Hardness is usually defined in terms of the ability of a material to resist to ***scratching, abrasion, cutting, identation,or penetration.***
- Methods used for determining hardness: Brinel, Rockwell ,Vickers.



BRITTLENESS:

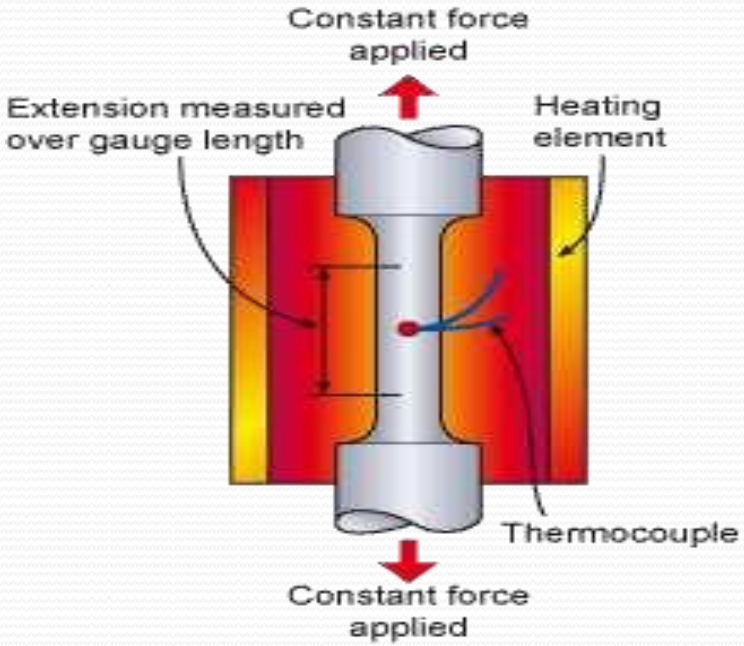
- It is the property of breaking without much permanent distortion.
- Non-Ductile material is considered to be brittle material.
- E.g, Glass, Cast iron,etc.





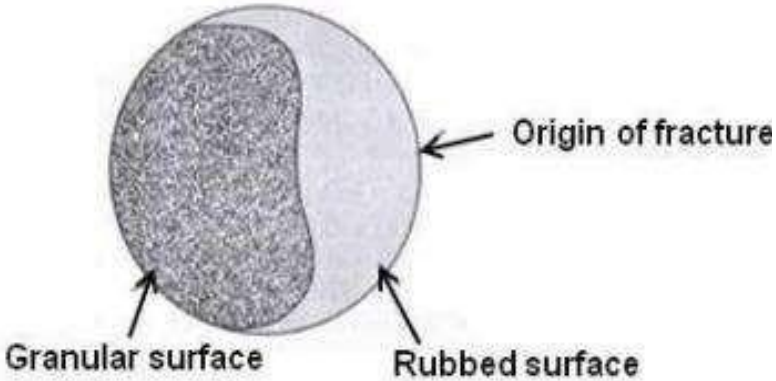
CREEP:

- The slow and progressive deformation of a material with time at constant stress is called creep.
- Depending on temperature, stresses even below the elastic limit can cause some permanent deformation.
- It is most generally defined as time-depndent strain occuring under stress.



FATIGUE:

- This phenomenon leads to fracture under repeated or fluctuating stress.
- Fatigue fractures are progressive beginning as minute cracks and grow under the action of fluctuating stress.
- Many components of high speed aero and turbine engines are of this type.



Surface of a Fatigue Fracture

THANK YOU