Mechanical Properties Of Dental Material Lect 5&6

By:

Prof. Dr. Mohammed M A

Ashur university college

Mechanical Properties

Mechanical properties: describe the ability of the material to resist forces and their effects on the bodies.

One of the most important properties of dental material is the ability to withstand the various mechanical forces placed during their use.

Stress: is the force per unit area induced in a body in response to some externally applied force.

The unit of stress is the unit of force {Newton (N)} divided by a unit of area, and is commonly expressed as Pascal (1 Pa = 1 N/m2 = 1 MN/mm2).

$$\text{Stress } (\sigma) = \frac{\text{Force}}{\text{Unit area}}$$

Types of Stress

1. *Compressive stress:* It results from two sets of forces directed toward each other in the same straight line or when one surface is constrained and the other is subjected to a force directed toward the constraint.



Types of Stress

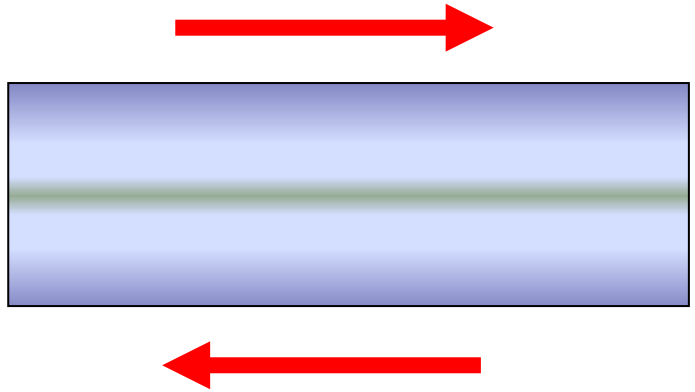
2. *Tensile stress:* it results from two sets of forces directed away from each other in the same straight line or when one end is constrained and the other end is subjected to a force directed away from the constraint.



Types of Stress

3. Shear stress: **Shear is the result of two sets of forces directed parallel to each other (not along the same straight line) which is applied to one part of the body in one direction, and the rest is being pushed in the opposite direction. The result is sliding of the molecules over each other.**



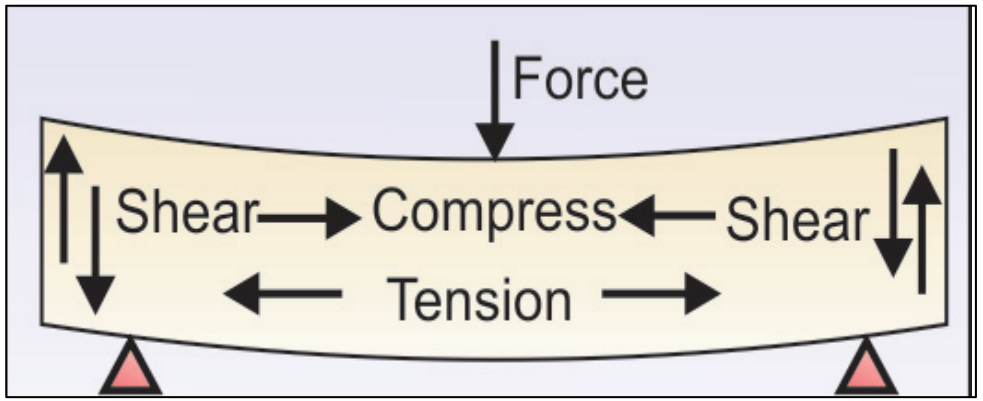


Types of Stress

4. ***Flexural (bending) stress:*** ***results from an applied bending moment.***

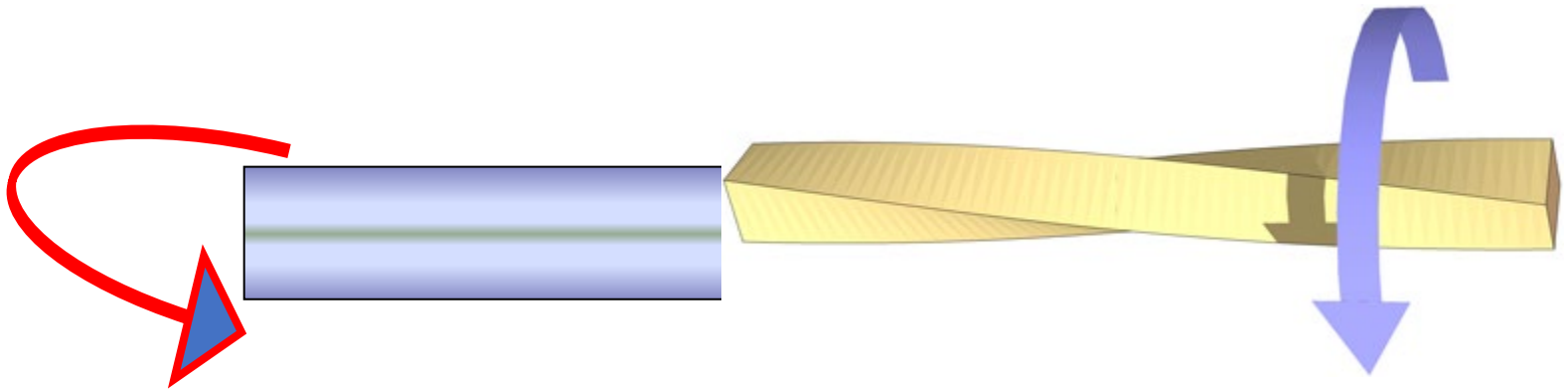
Usually, three types of stresses occur at the same time If a piece of metal is being bending it will exhibit tensile stress on the outer surface, compressive on the inner and shear stress in the middle.





Types of Stress

5. *Torsion stress:* results from the twisting of a body



Strain

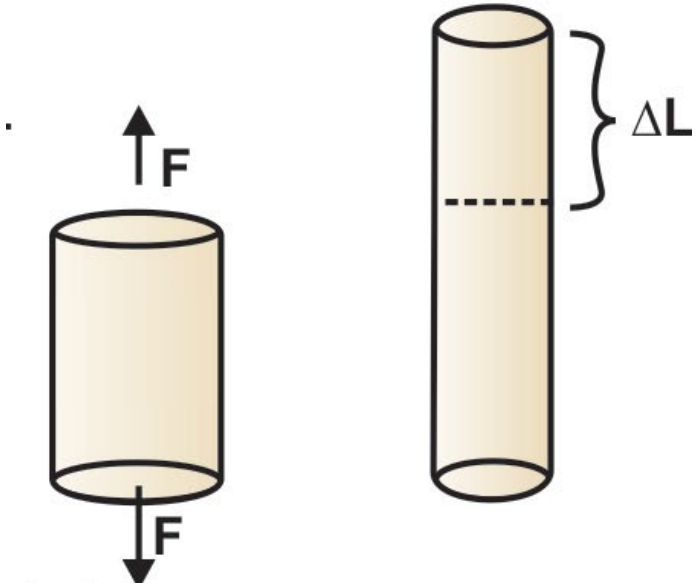
When external force or load is applied to a material the phenomena of strain occurs; i.e. the change in the dimensions of the material.

Strain: **is the change in length (dimension) or deformation per unit length (dimension) caused by externally applied force. Strain is denoted as 'ε'. It has no unit of measurement.**

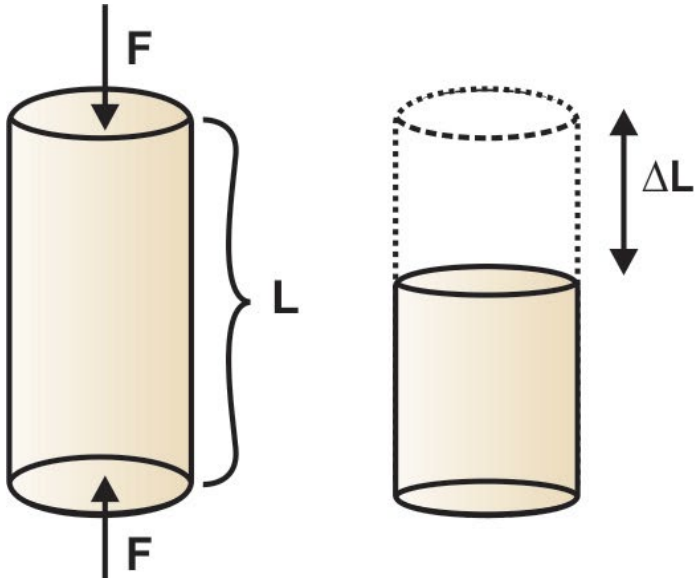
$$\text{Strain} = \frac{\text{Change in length } (\Delta L)}{\text{Original length } (Lo)} = \frac{L - Lo}{Lo} = \frac{\Delta L}{Lo}$$

Strain

- **Strain under tensile stress is an elongation in the direction of loading**



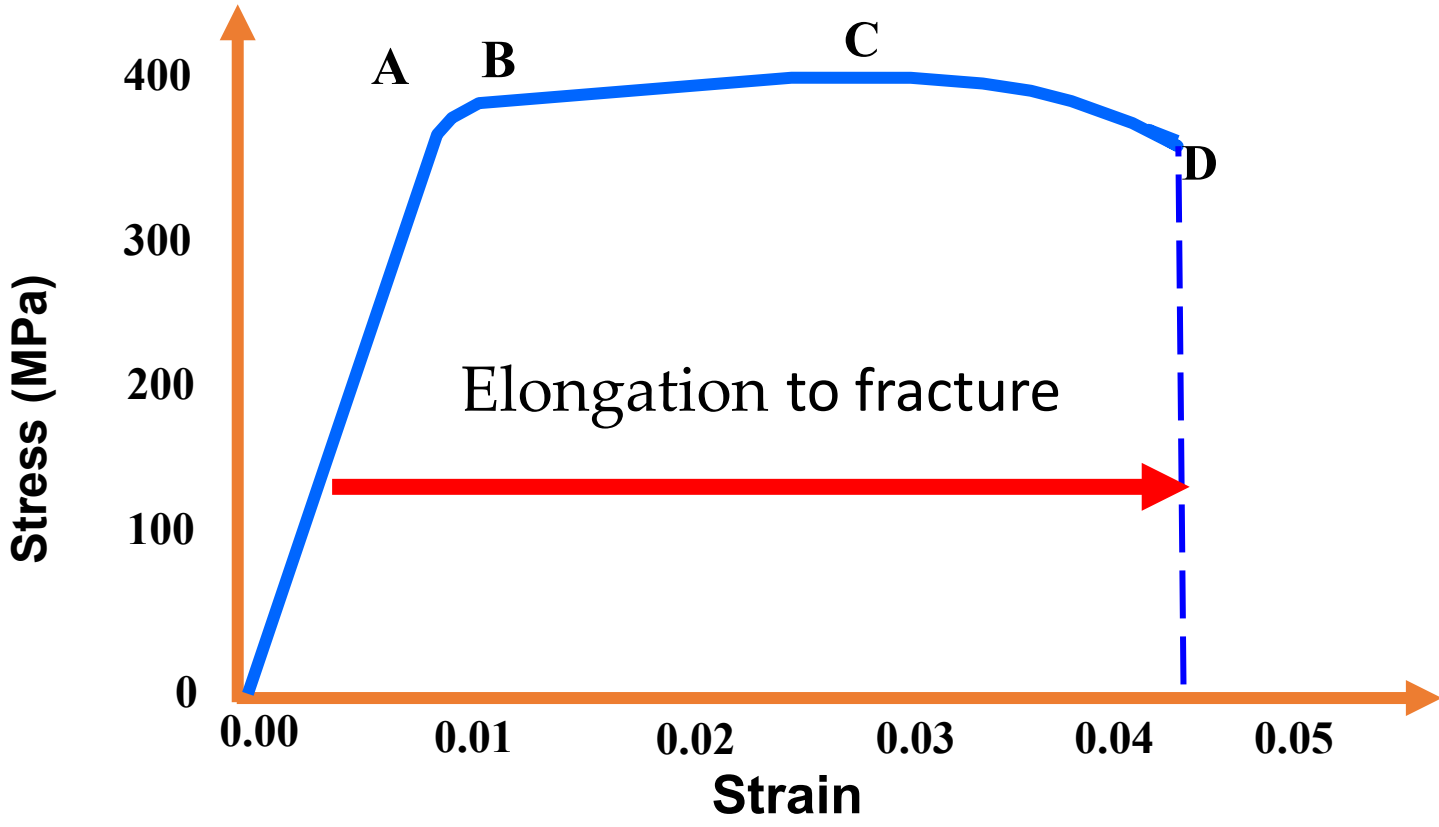
- **Strain under compression is shortening of the body in the direction of loading**



Elongation

"The deformation that results from the application of a tensile force is elongation". An alloy with high percent of elongation can be bent or adjusted without danger of fracture.

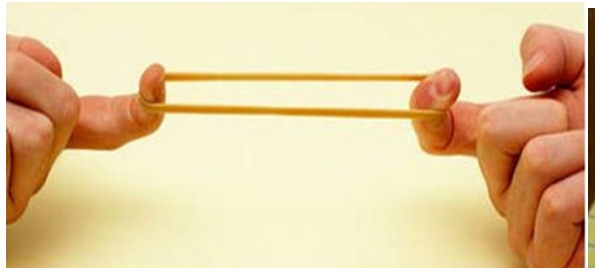
$$\text{Elongation} = \frac{\text{Increase in length}}{\text{Original length}} \times 100$$



Types of Strain

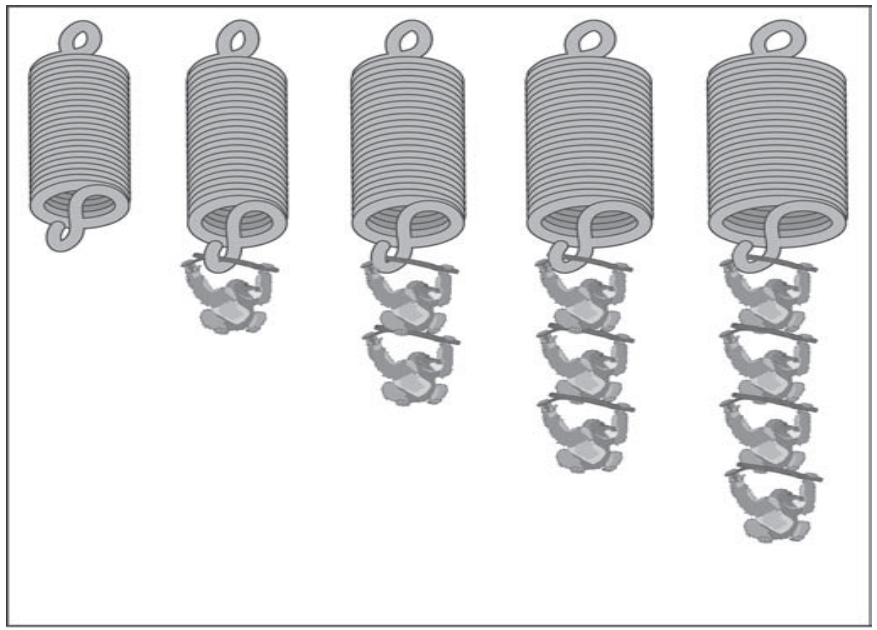
1. **Temporary of elastic or recoverable strain:** the material is returned to its original length after removal of the applied force.

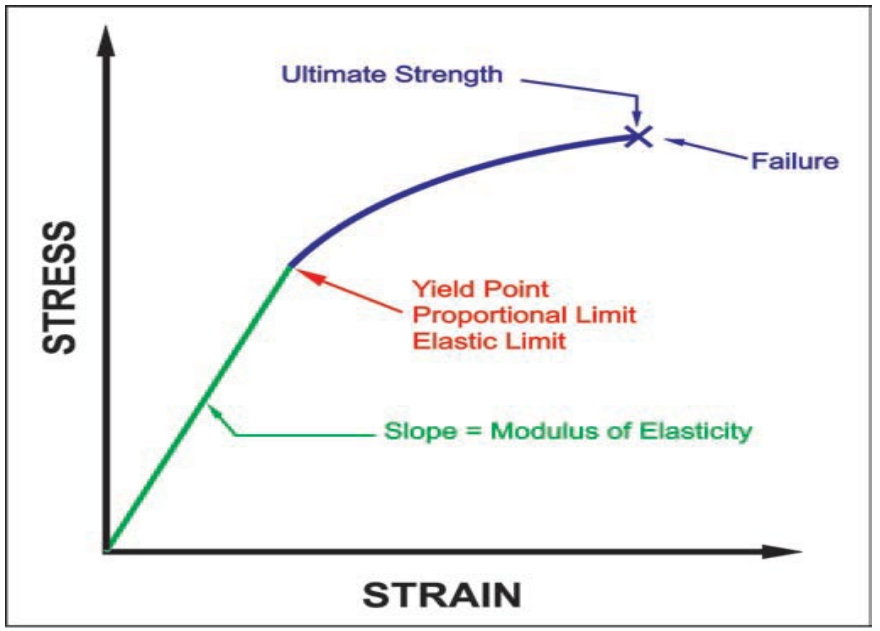
2. **Permanent or plastic or unrecoverable strain:** the material is not returned to its original length after removal of the applied force. The material may remain deformed.





Stress – Strain curve

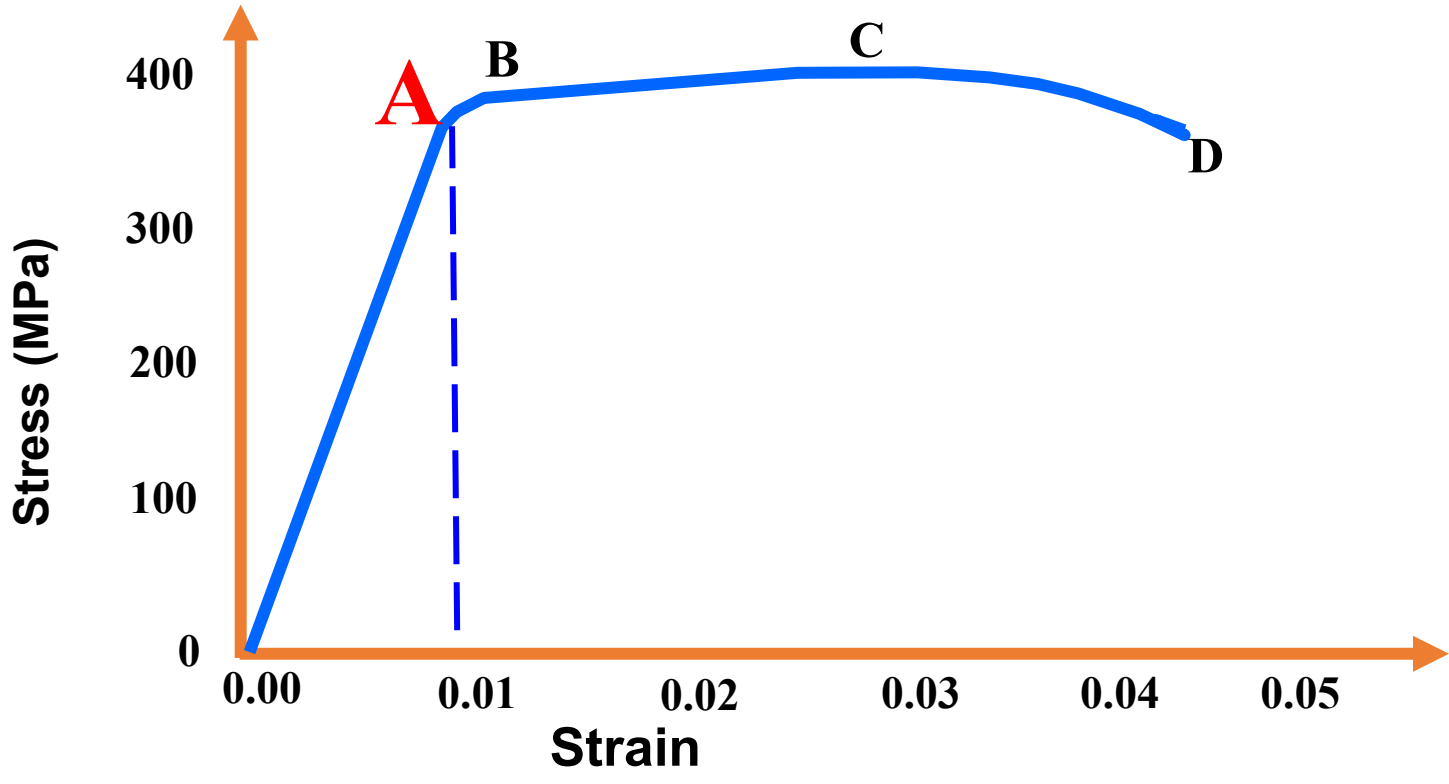




A convenient means of comparing the mechanical properties of materials is to apply various forces to material to determine the corresponding values of stress and strain. A plot of the corresponding values of stress and strain is referred to as “s-s curve”.

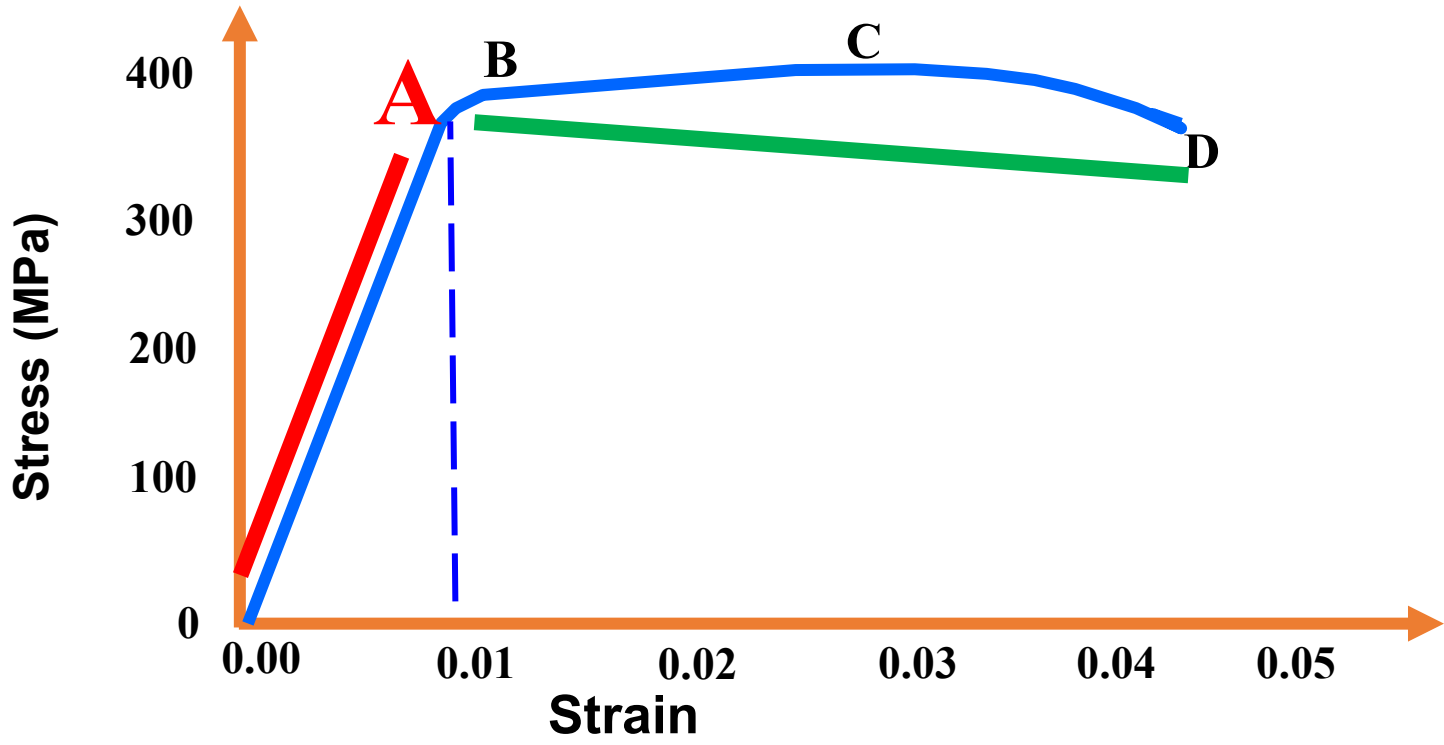
Proportional limit

- **Proportional limit : the greatest stress that a material will sustain without a deviation from the proportionality of stress to strain.**



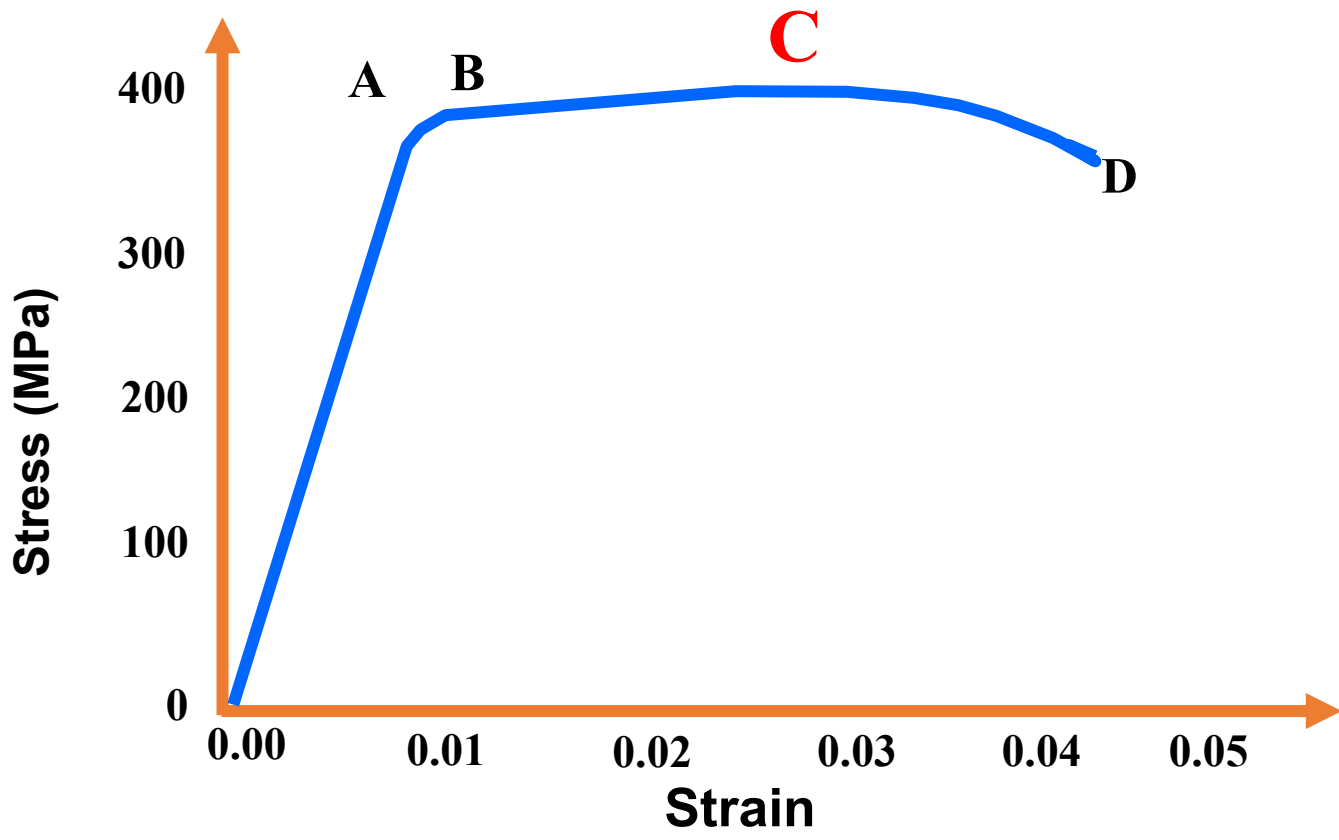
Elastic limit: The greatest stress to which the material can be subjected such that it will return to its original shape and dimension when the stress is removed (maximum stress that a material will sustain without permanent deformation).

- The region before the proportional limit is called the "elastic region".
- The region beyond this proportional limit is called as "plastic region" .



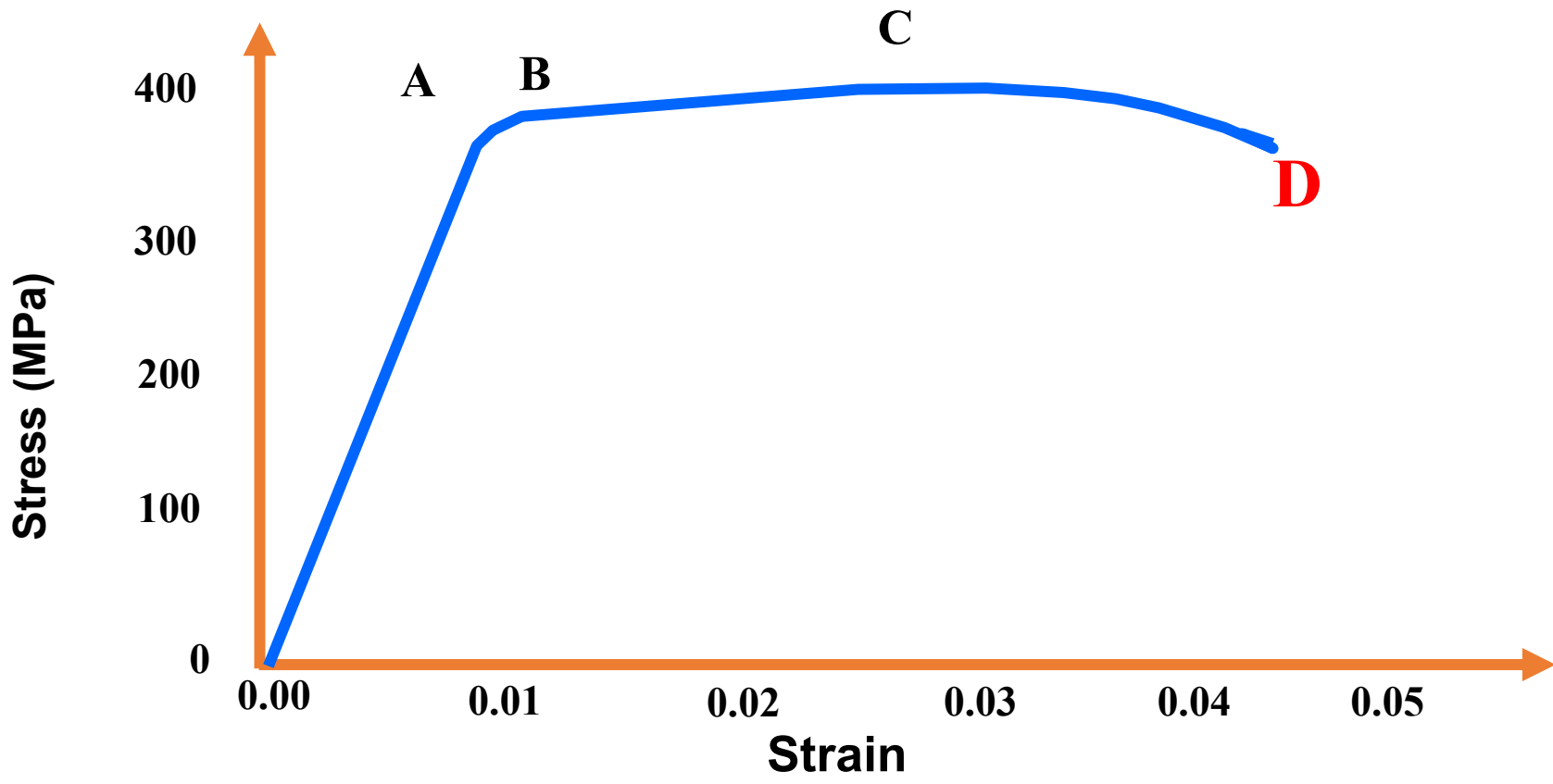
Elastic limit deals only with the elasticity of the material, but proportional limit deals with proportionality stress and strain. Theoretically, the values will be same.

<u>Ultimate stress:</u> is the maximum stress that a material can withstand before failure. (point C)



Fracture stress :The stress at which the material fractures(D).

A material does not necessarily fracture at the point at which the maximum stress occurs.

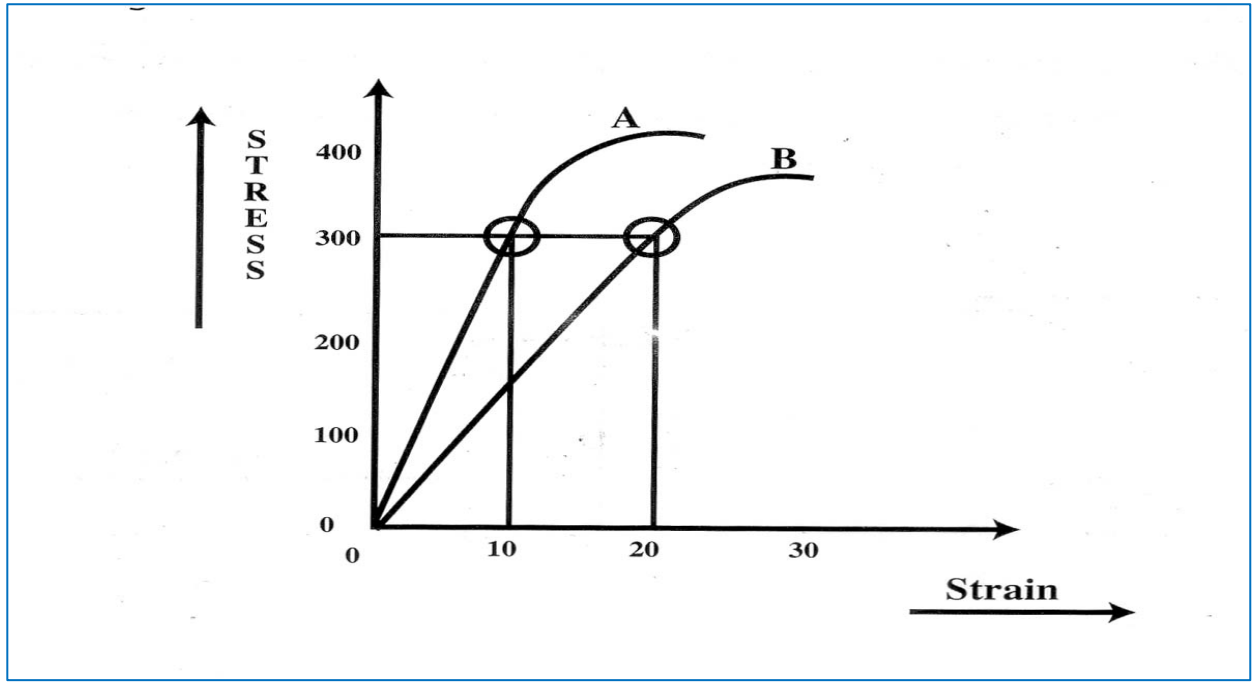


Modulus of elasticity or elastic modulus

“The term elastic modulus represents the relative stiffness or rigidity of the material within the elastic range”.

If any stress value equal to or less than the proportional limit is divided by its corresponding strain value, a constant of proportionality will result.

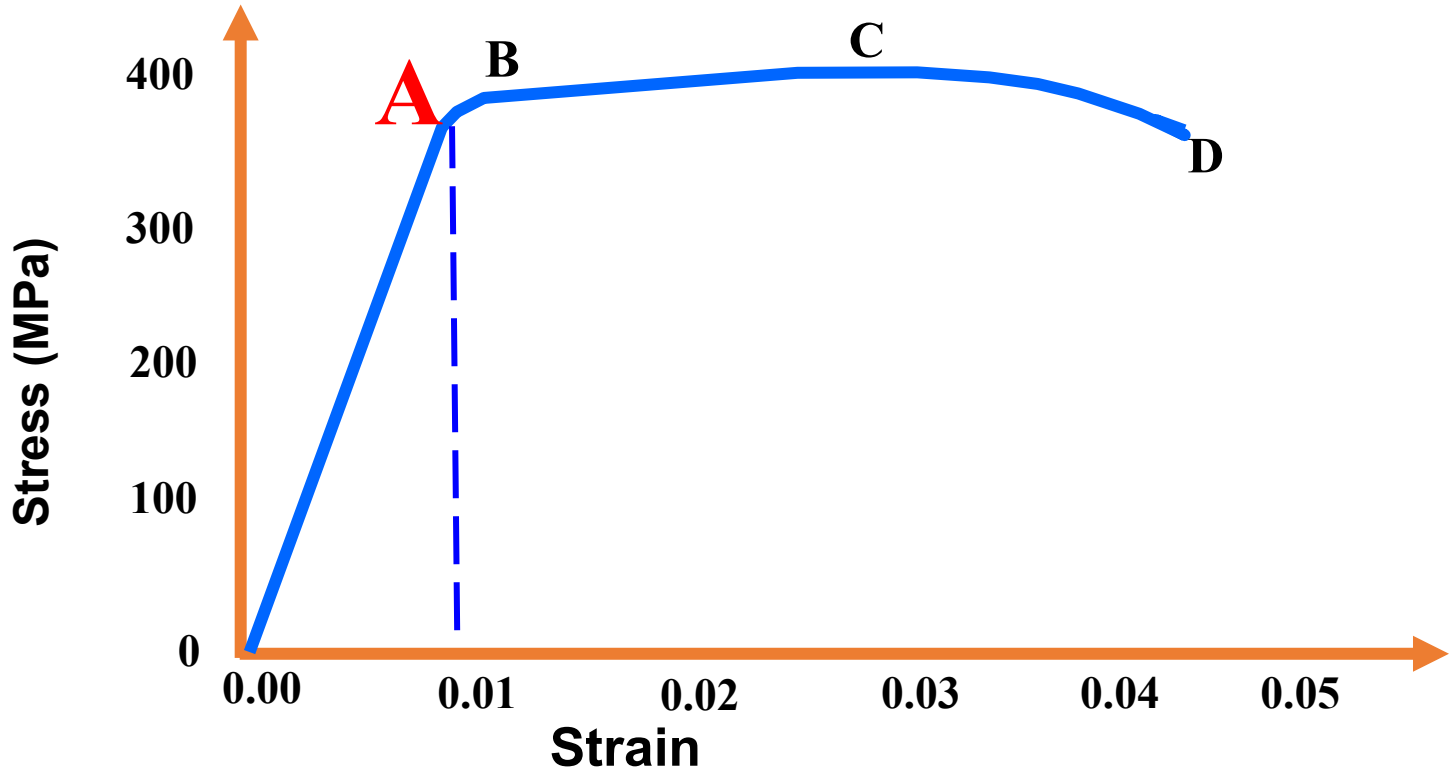
Modulus of elasticity = Stress / Strain



Flexibility

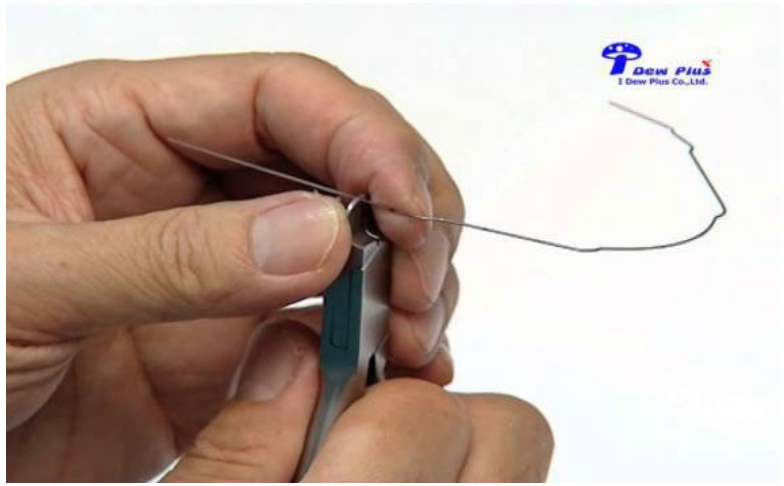
Flexibility: **The higher strain which occurs when the material is stressed to its proportional limit (the amount of strain up to the elastic limit), So that flexibility is the total amount of elastic strain in a material.**

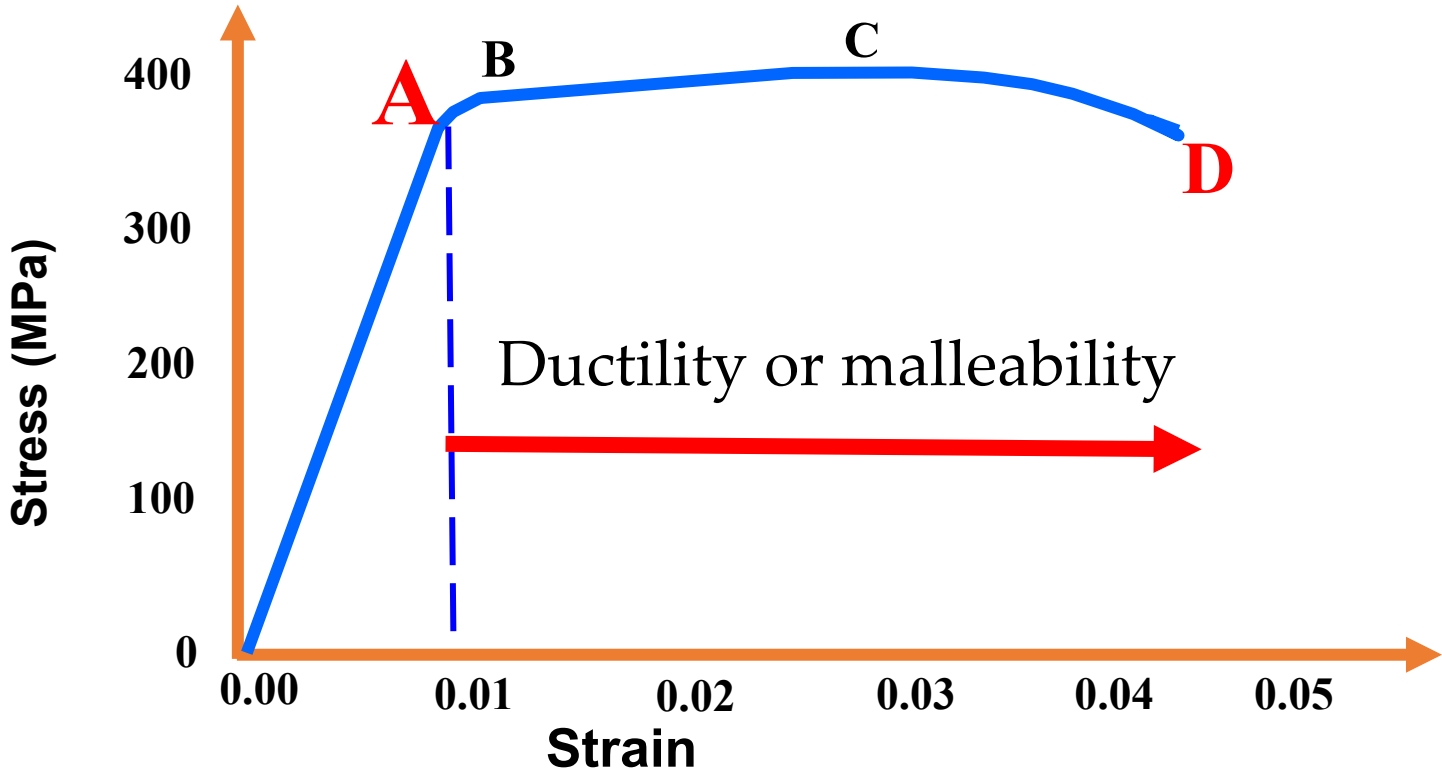




Ductility and malleability

Ductility: It is the ability of the material to withstand permanent deformation under tensile stress without fracture; it depends on plasticity and tensile strength. It's the ability of the material to be drawn into a fine wire. Examples: gold: most ductile.





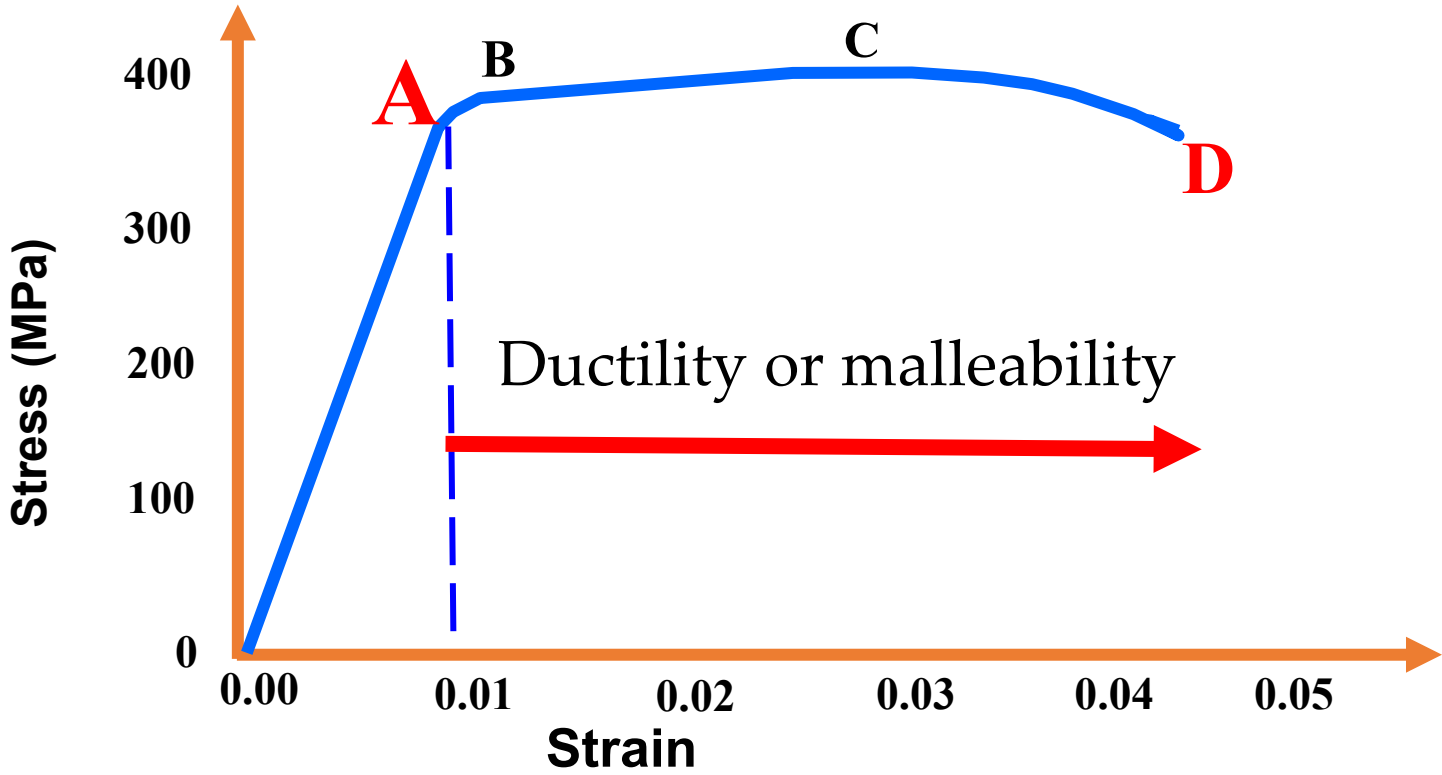
Ductility and malleability

Malleability: **It is the ability of the material to withstand permanent deformation under compressive stress** without fracture. It's the ability of the material to be drawn into a sheet. Examples: gold: most malleable.

Elastic strain = flexibility.

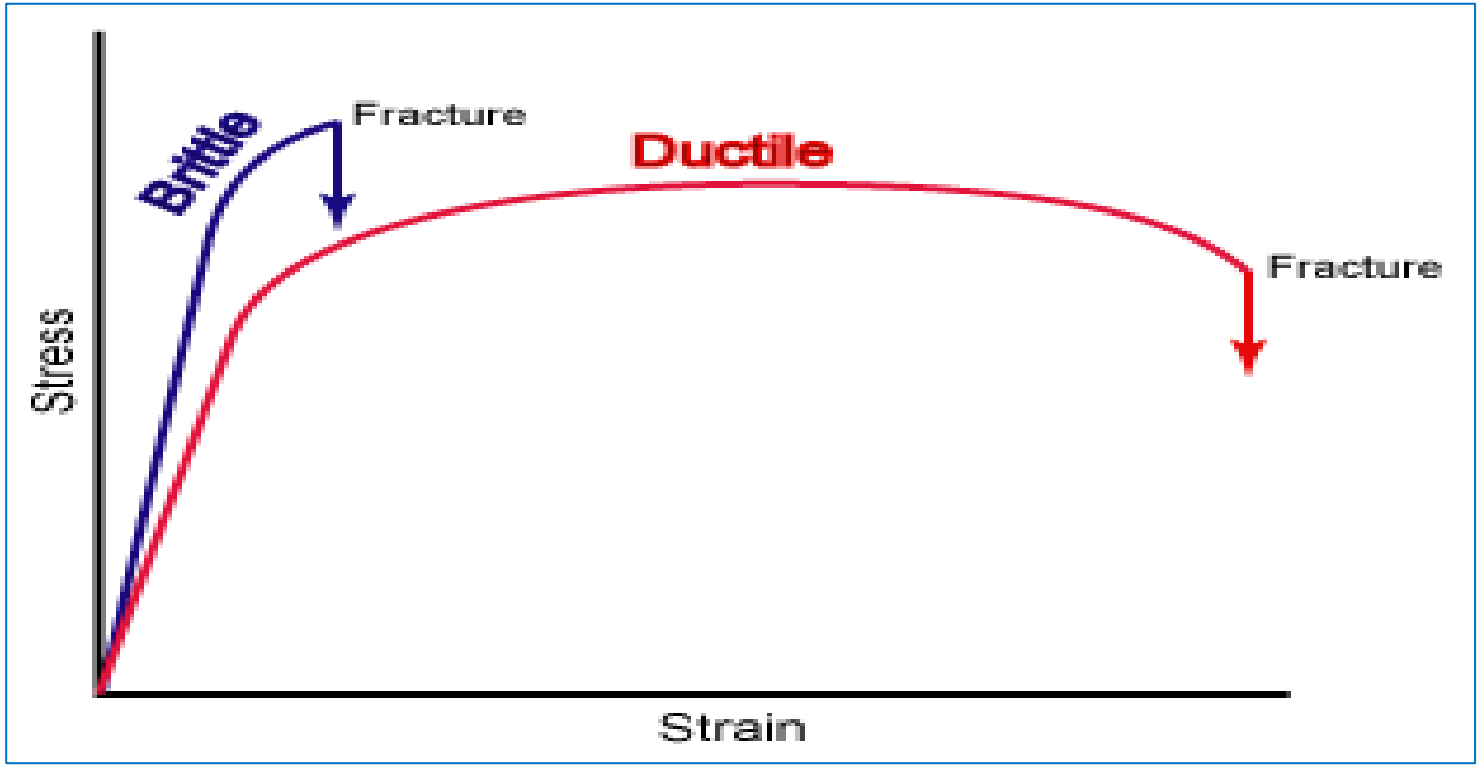
Plastic strain = ductility or malleability.





Brittleness

Brittleness: **It is the opposite of ductility; it requires lack of plasticity.**

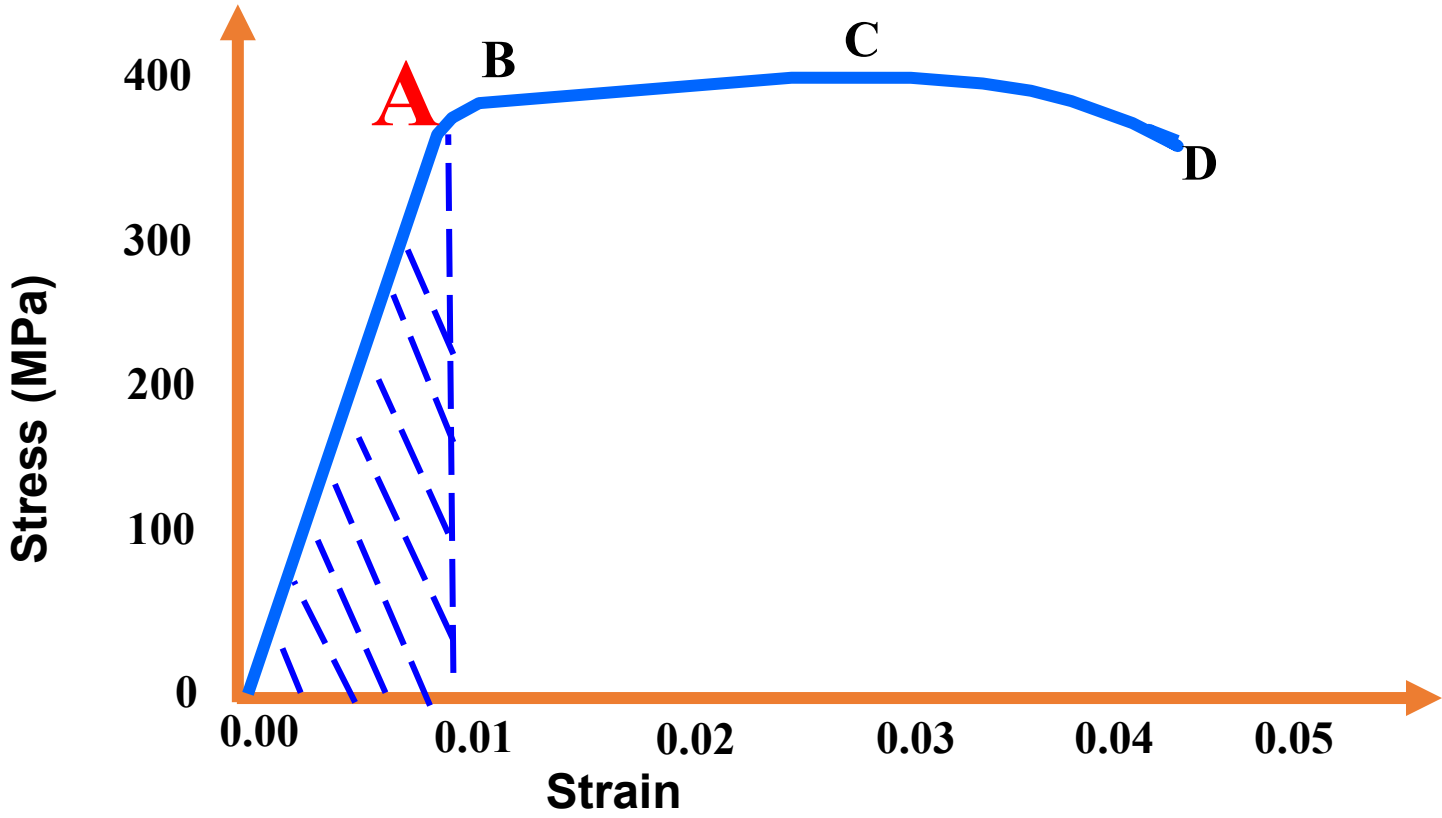




Resilience

Resilience: **The amount of energy absorbed by a structure when it is stressed within the proportional limit. Or it is the energy needed to deform the material to its proportional limit.**

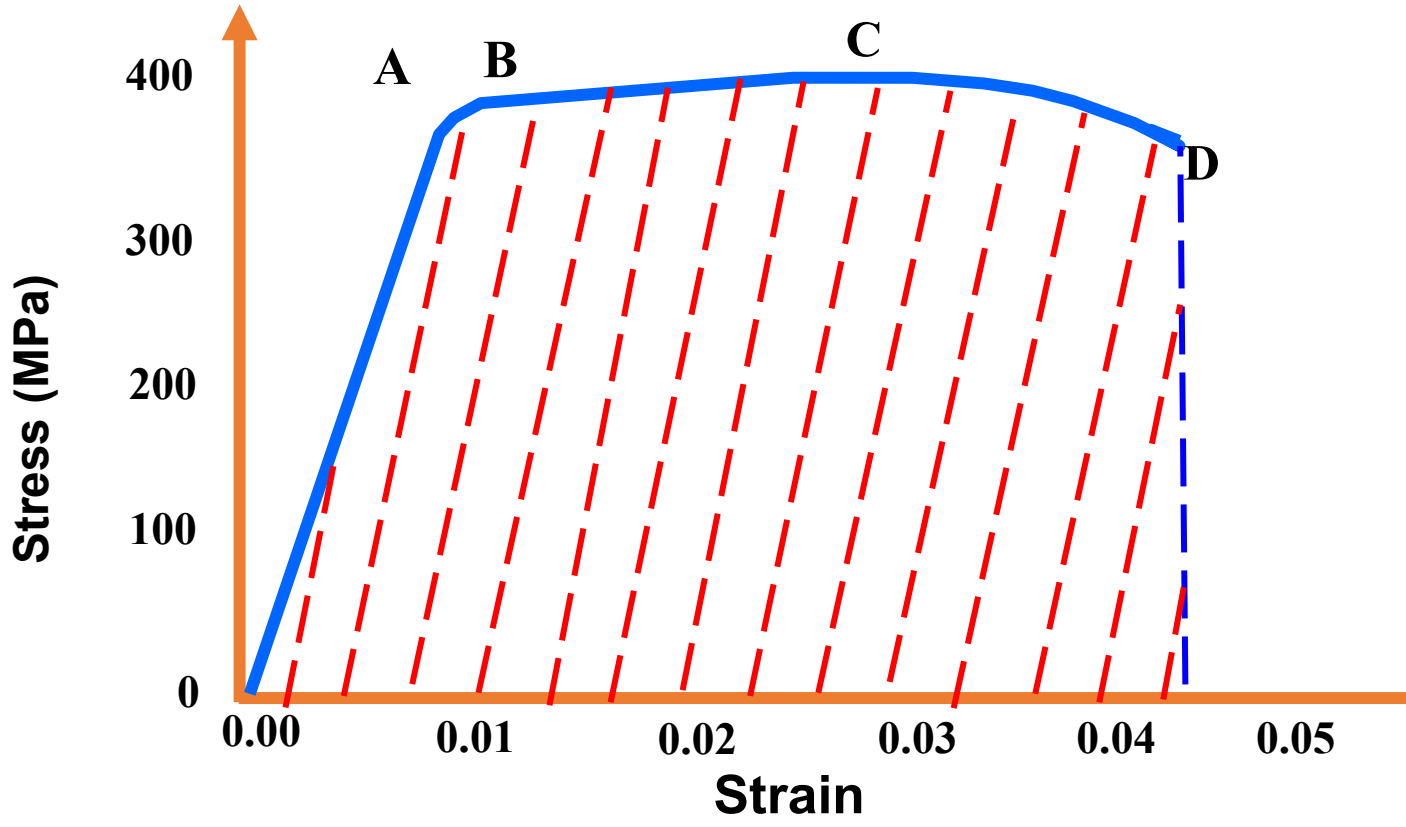


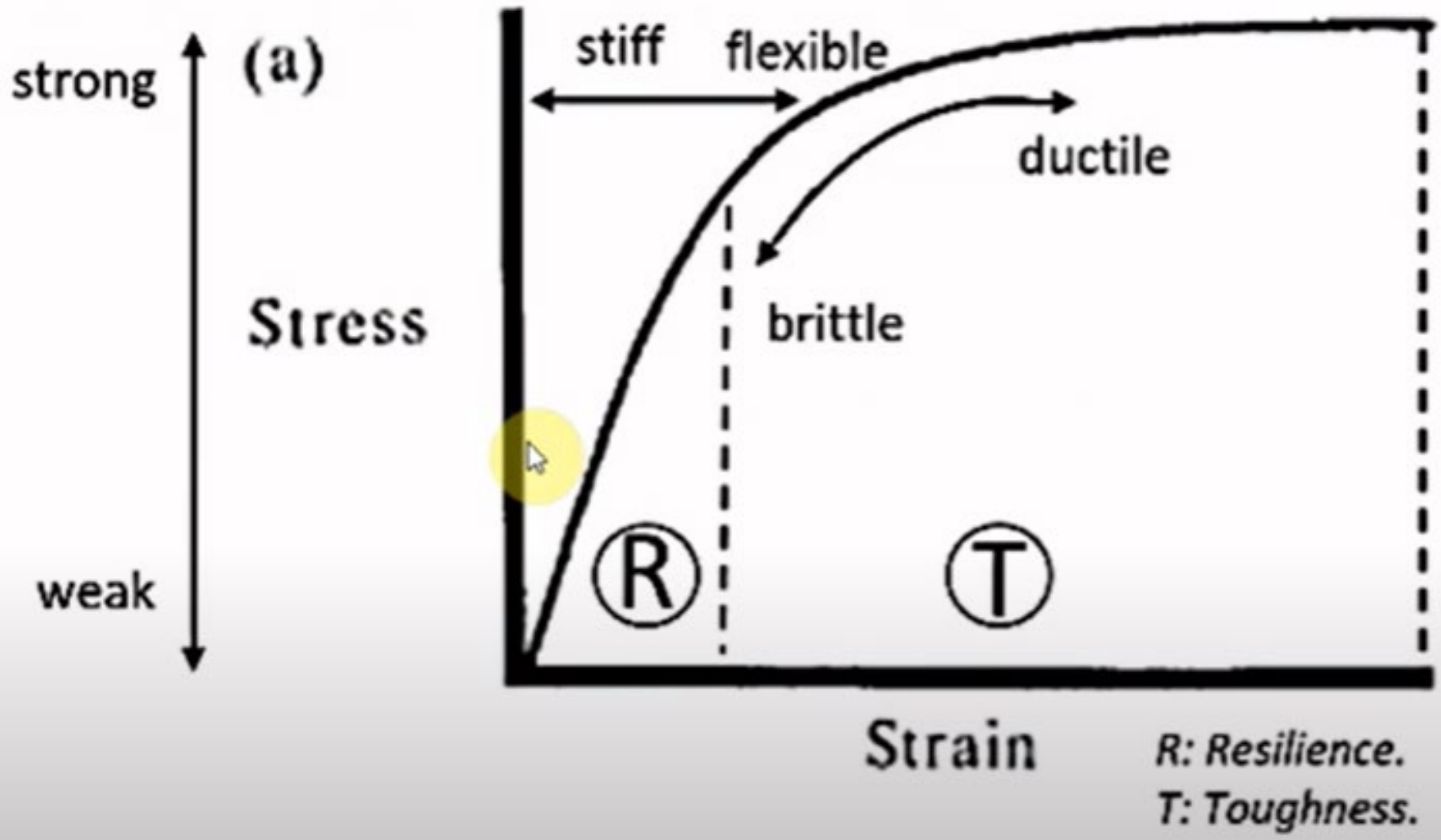


Toughness

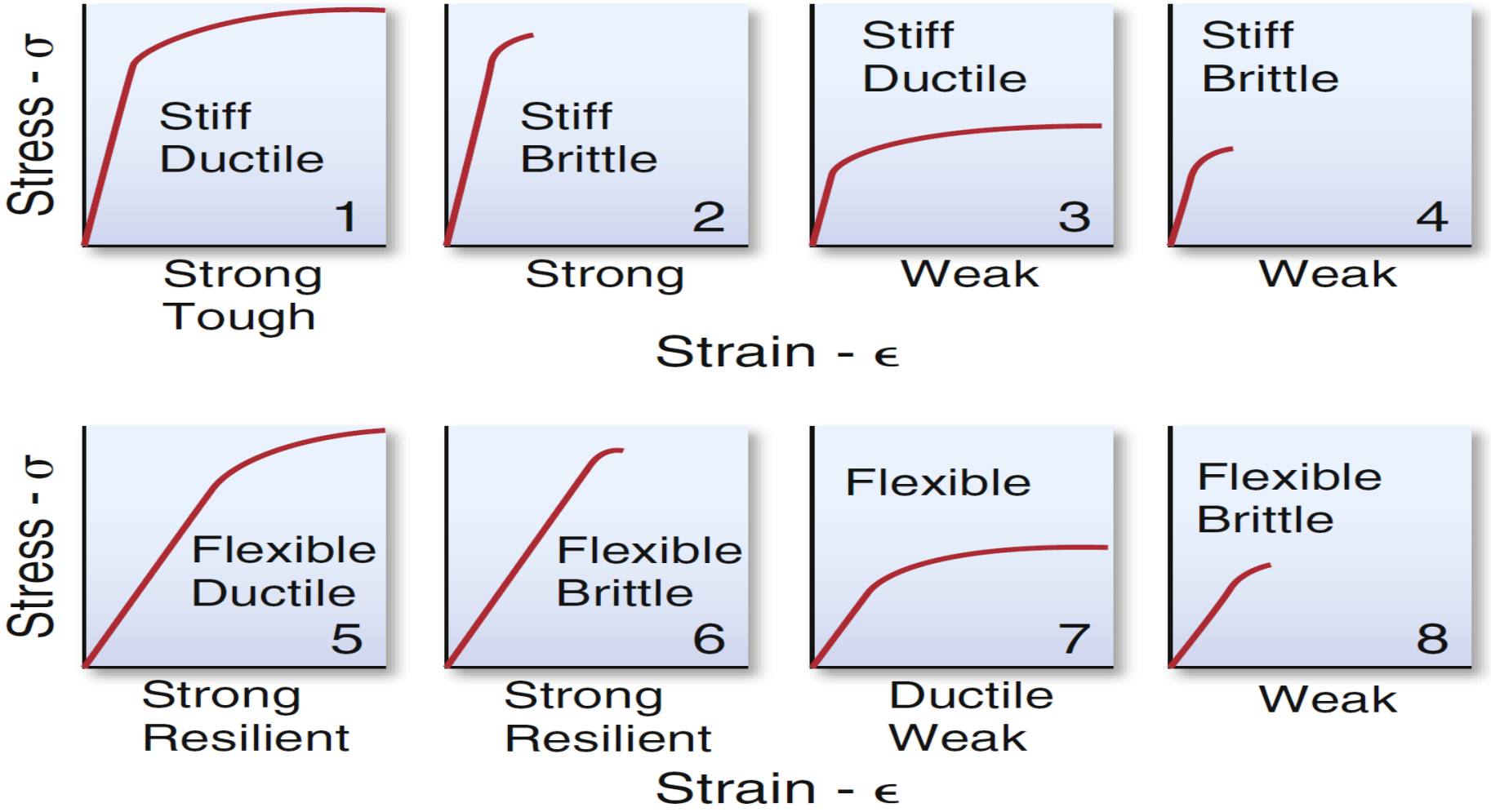
Toughness: It is the total work or energy required to break the material. It's the total area under the stress-strain curve. It requires strength and plasticity.






strong
(a)
weak
Stress
stiff
flexible
ductile
brittle
R
T
Strain
R: Resilience.
T: Toughness.

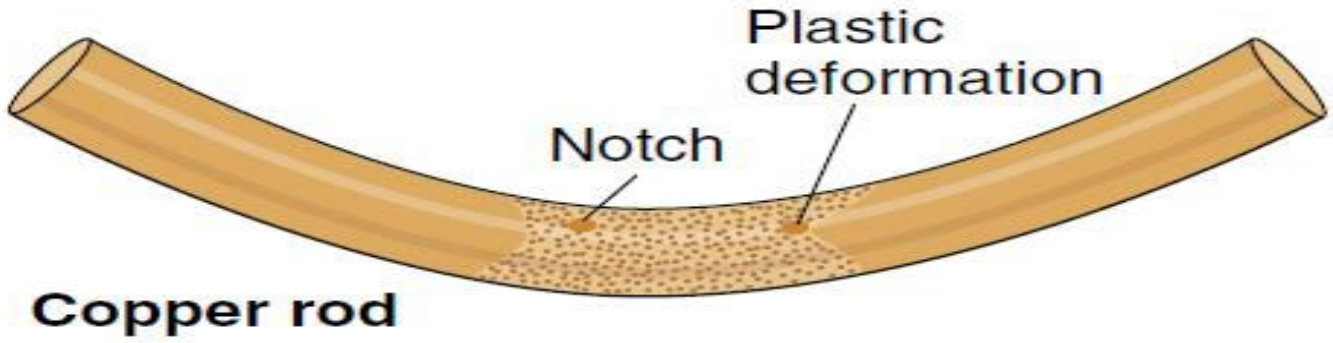
Properties and Stress-Strain Curves



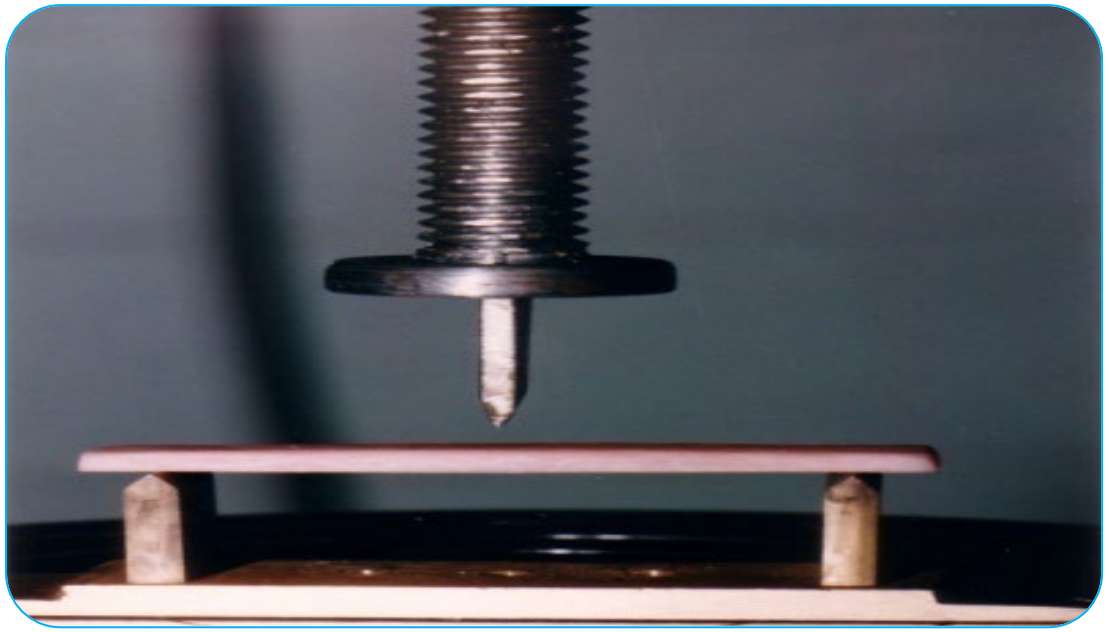
Strength: **is the measure of the resistance of the material to the externally applied force.**

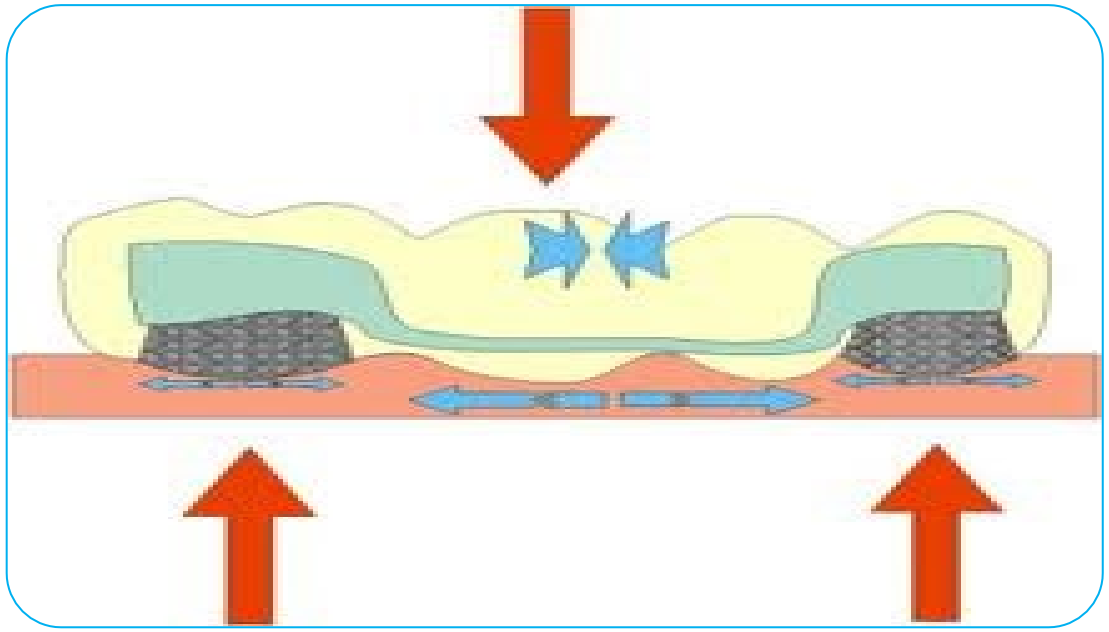
Fatigue: **is the fracture of a material when subjected to repeated (cyclic) small stresses below the Proportion limit.**





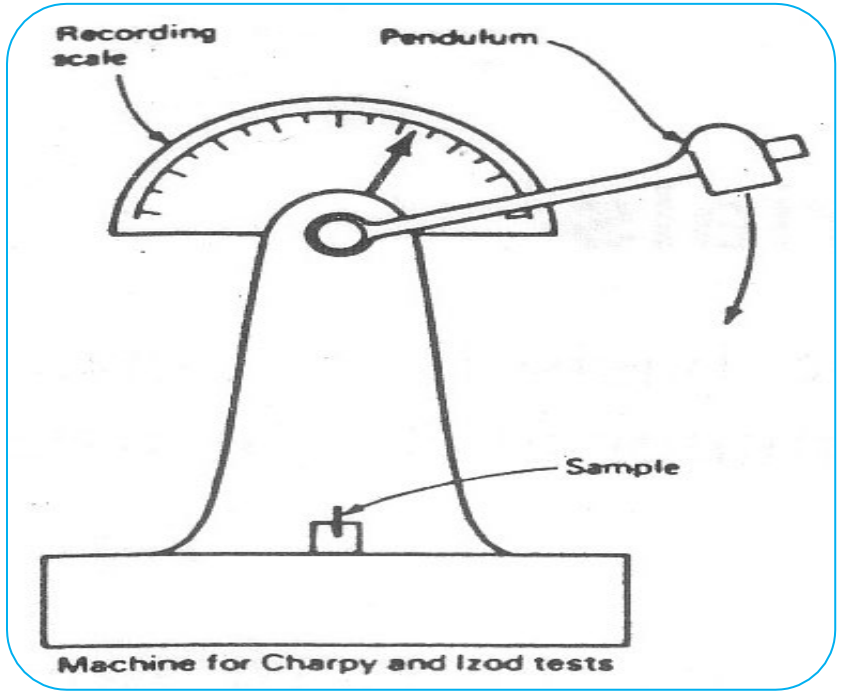
Transverse strength: It is the strength of the middle of a beam, which is supported only at its ends. It is important in dental bridges.



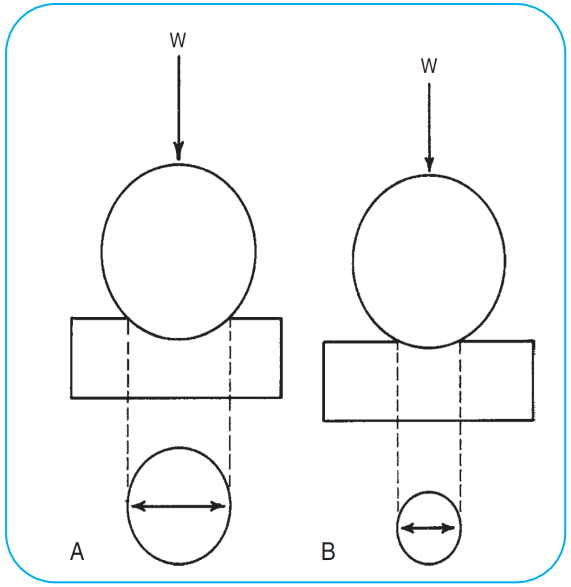


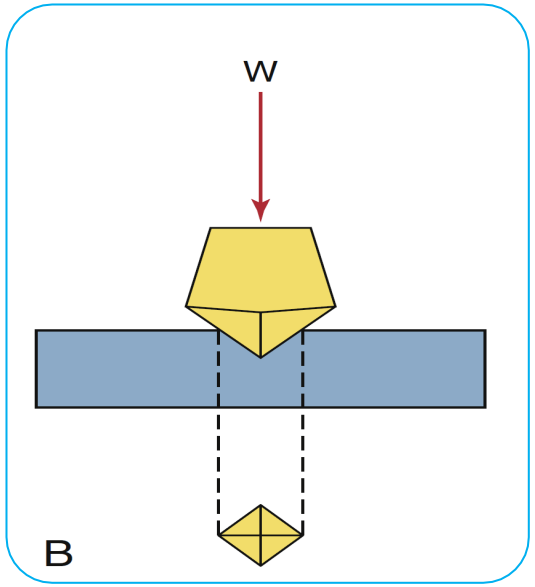
Impact strength: It is the ability of the material to break on sudden impact. Low impact strength means brittle material, like dropping of the denture.

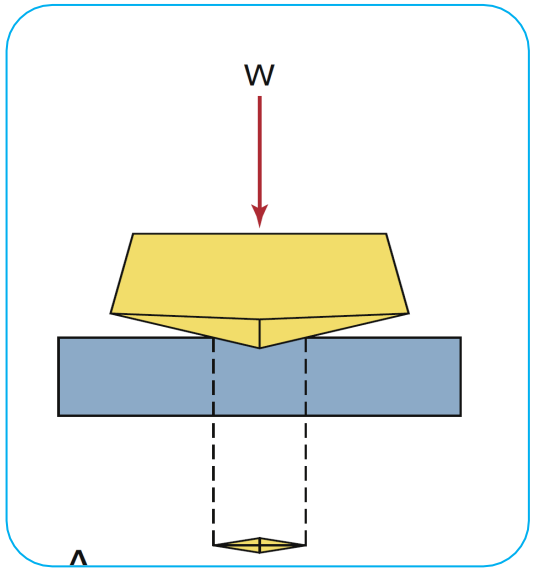




Hardness: It is the resistance of the material to deformation caused by penetrating or scratching the surface. It is done either by using steal ball (Brinell or Rocwell test) or using diamond (Vickers and Knoop test). The higher the number, the harder the material.







Thank you