VIVEKANANDA COLLEGE

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NAAC ACCREDITED 'A' GRADE

Topic: Mechanical Properties of Materials

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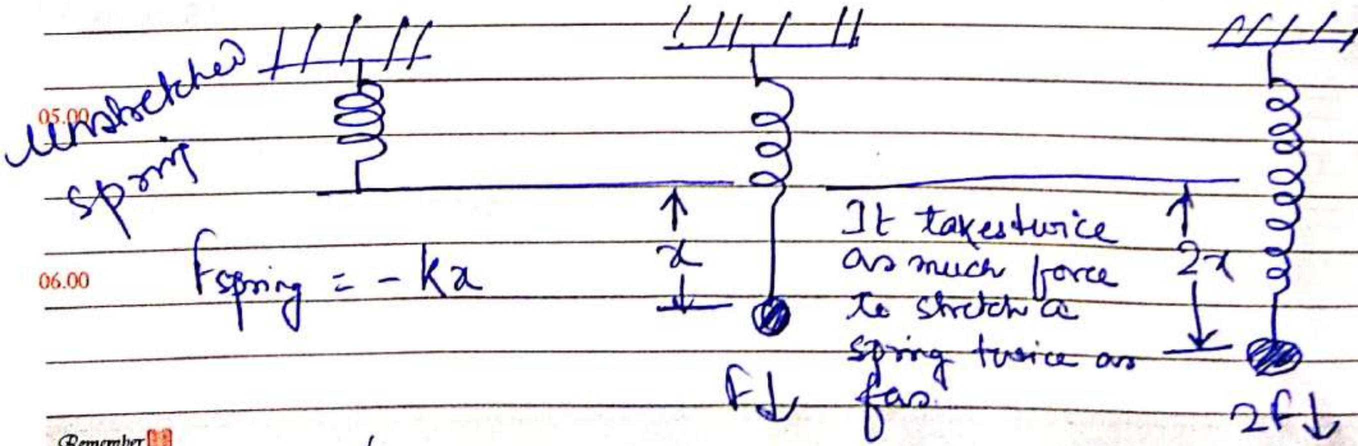
CC-3

Applied Physics

Mechanical properties of materials

Hooke's law is a principle of physics that states that the force needed to extend or compress a spring by some distance is proportional to that distance. Hooke sought to demonstrate the relationship between the forces applied to a spring and its elasticity.
This can be expressed mathematically as $F = -kx$, where F is the force applied to the spring (either in the form of stress or strain). X is the displacement of the spring with a negative value demonstrating that the displacement of the spring once it is stretched and K is the spring constant and details just how stiff it is.

Hooke's law is the first classical example of an explanation of elasticity - which is the property of an object or material which causes it to be restored to its original shape after distortion. This ability to return to a normal shape after experiencing distortion can be referred to as restoring force.
This restoring force is proportional to the amount of stretch.



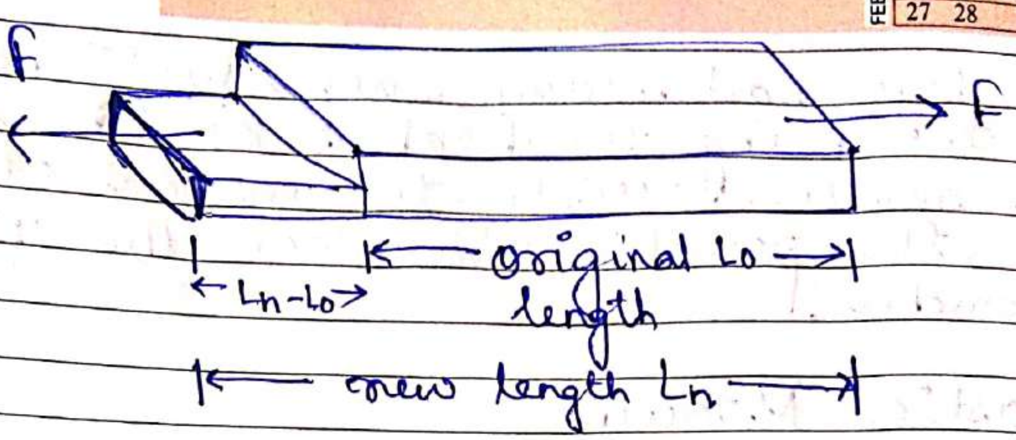
This law had many important practical application with one being the creation of a balance wheel, which made possible the creation of the mechanical clock, the portable timepiece, the spring scale and manometer.

Elastic Moduli

~~In the stress strain curve given below, the region within the elastic limit (region OA) is of importance to structural and manufacturing sectors since it describes the maximum~~

Young that describes the elastic properties of a solid undergoing tension or compression in only one direction as in the case of a metal rod that after being stretched or compressed lengthwise returns to its original length. Young's modulus is a measure of ability of a material to withstand changes in length when under lengthwise tension or compression. Sometimes refered to as the modulus of ~~rigidity~~ elasticity, Young's modulus is equal to the longitudinal stress divided by strain. Stress and strain may be described as follows in the case of a metal bar under tension.

If a metal bar of cross sectional area A is pulled by a force F at each end, the bar stretches from its original length L_0 to a new length L_n. The stress is the quotient of the tensile force divided by the cross sectional area or F/A. The strain or relative deformation is the change in length, $L_n - L_0$, divided by the original length, or $(L_n - L_0)/L_0$. Thus Young's modulus may be expressed mathematically as

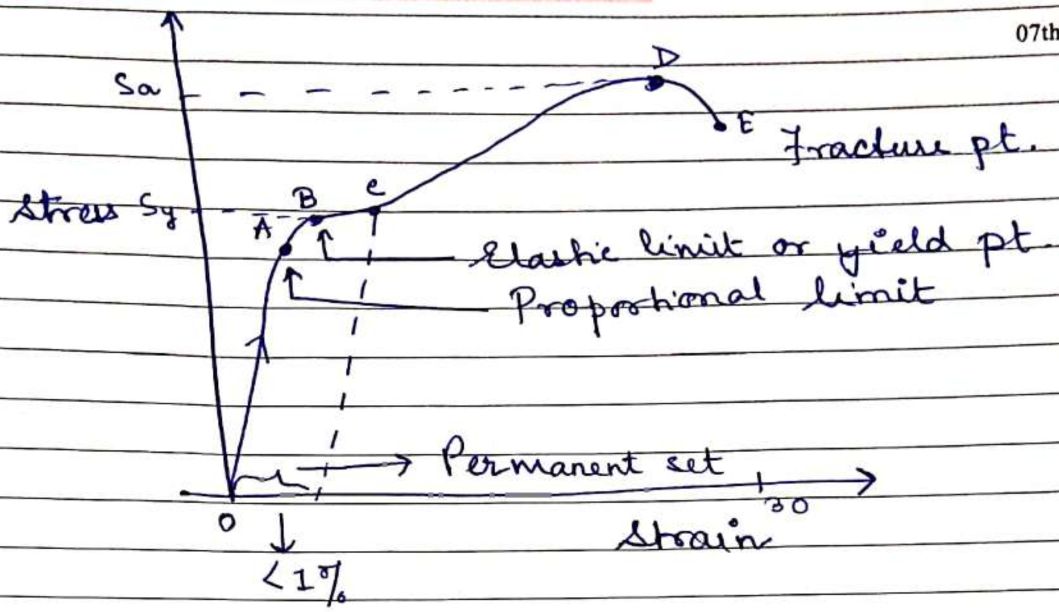


Young's modulus = Stress / strain

$$= \frac{F L_0}{A(L_n - L_0)}$$

The units of Young's modulus = N/m^2. The value of Young's modulus for Al is 1.0×10^7 psi or 7.0×10^{10} N/m^2. The value for steel is about three times greater which means that it takes three times as much force to stretch a steel bar the same amount as similar shaped Al. bar.

When a metal bar under tension is elongated, its width is slightly diminished. This lateral shrinkage constitutes a transverse strain that is equal to the change in the width divided by the original width. The ratio of the transverse strain to the longitudinal strain is called Poisson's ratio. The average value of Poisson's ratio for steels is 0.28 and for Al alloys 0.33.



Force exerted by stretched or contracted material

The Young's modulus of a material can be used to calculate the force it exerts under specific strain.

$F = \frac{EA\Delta L}{L_o}$ where F is the force exerted by the material when contracted or stretched by ΔL.

Hooke's law for a stretched wire can be derived from

$F = \left(\frac{EA}{L_o}\right)\Delta L = kx.$

$K = \frac{EA}{L_o}$ & $x = \Delta L$.