PHYS 203

Ch. 1

Equilibrium and Elasticity

Chapter 1

Chapter One

Equilibrium and Elasticity

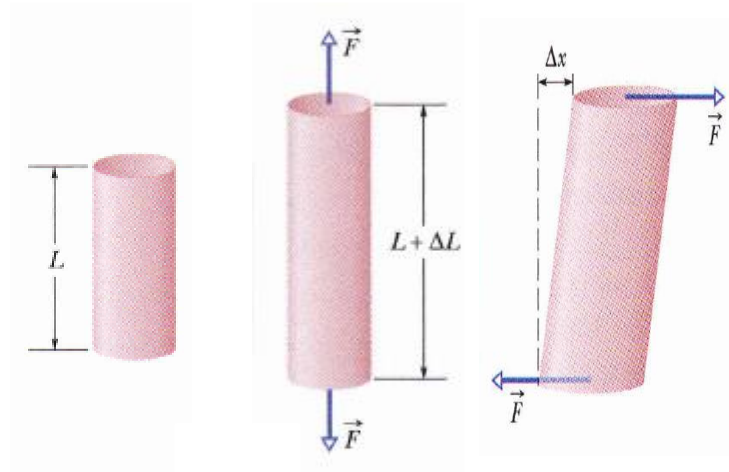
- ***Elasticity***

Elasticity

Elasticity

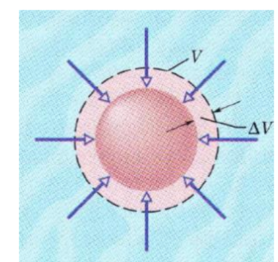
stress produces a **strain**

tensile stress
shearing stress
hydraulic stress



stress and strain are proportional to each other.

stress = modulus × strain.

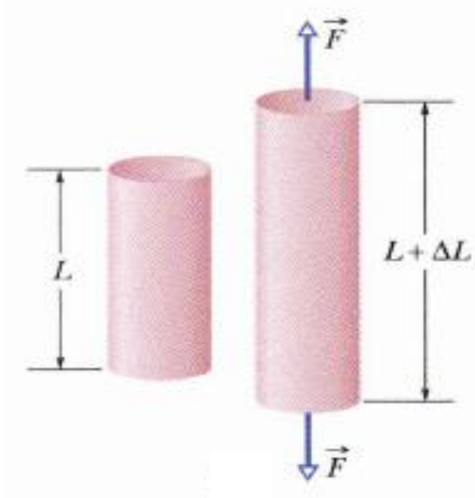


The constant of proportionality is called a **modulus of elasticity**.

Elasticity

Tension and Compression

$$\frac{F}{A} = E\frac{\Delta L}{L}.$$



The stress on the object is defined as F/A

where F is the magnitude of the force applied perpendicularly
A is the area

The strain dimensionless quantity $\Delta L/L$, the fractional change in a length

E is the modulus for tensile and compressive stresses is called the **Young's modulus**

Elasticity

Example 1:

One end of a steel rod of radius 9.5 mm and length 81 cm is held. A force of 62 kN applied perpendicularly to the end face. If Young's modulus of steel is 2×10^{11} N/m^2, the stress on the rod is:

Solution:

(B)

(A) 1.4×10^8 N/m^2
(B) 2.2×10^8 N/m^2
(C) 3.5×10^8 N/m^2
(D) 4.7×10^8 N/m^2

Elasticity

Example 2:

Referring to Example 1, the elongation of the steel rod is:

Solution:

(C)

(A) 0.33 mm
(B) 0.53 mm
(C) 0.89 mm
(D) 1.02 mm

Elasticity

Example 3:

Referring to Example 1, the strain on the steel rod is:

Solution:

(A)

(A) 1.1×10^{-3} N/m^2
(B) 2.4×10^{-3} N/m^2
(C) 3.5×10^{-3} N/m^2
(D) 4.8×10^{-3} N/m^2

Elasticity

Example 4:

A vertical 4 m long iron rod stretches 1 mm when a mass of 225 kg is hung from its lower end. If Young's modulus of iron is 1.764×10^{11} N/m^2, the cross-sectional area of the rod is:

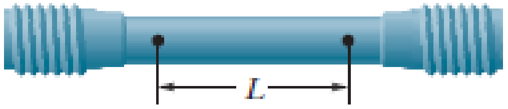
Solution:

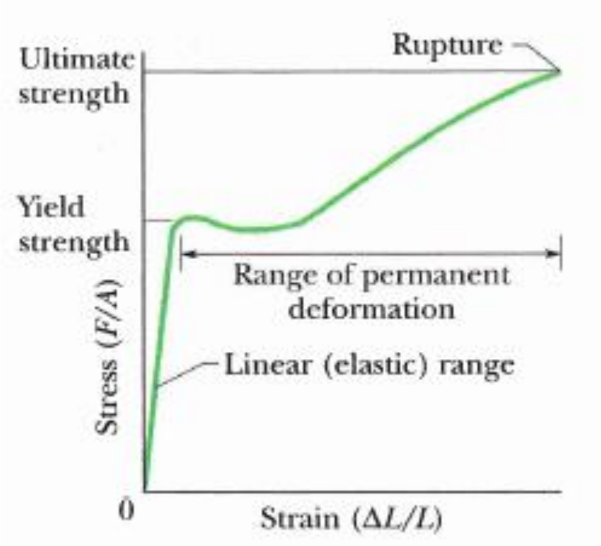
(B)

(A) 6×10^5 m^2
(B) 5×10^5 m^2
(C) 4×10^5 m^2
(D) 3×10^5 m^2

Elasticity

In a steel test specimen





Some Elastic Properties of Selected Materials of Engineering Interest

Material	Density ρ (kg/m^3)	Young's Modulus E (10^9 N/m^2)	Ultimate Strength S_u (10^6 N/m^2)	Yield Strength S_y (10^6 N/m^2)
Steel[a]	7860	200	400	250
Aluminum	2710	70	110	95
Glass	2190	65	50[b]	—
Concrete[c]	2320	30	40[b]	—
Wood[d]	525	13	50[b]	—
Bone	1900	9[b]	170[b]	—
Polystyrene	1050	3	48	—

Elasticity

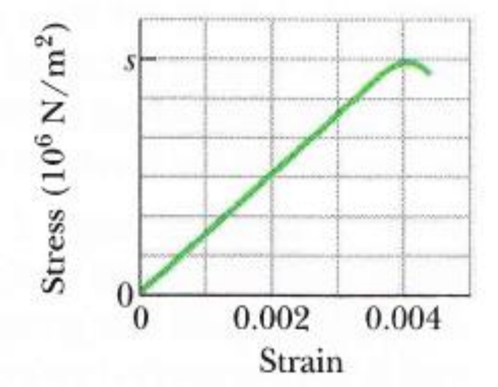
Example 5:

In the given graph if s is equal to 300, then Young's modulus is:

Solution:

(C)

(A) $25 \times 10^9\ N/m^2$
(B) $50 \times 10^9\ N/m^2$
(C) $75 \times 10^9\ N/m^2$
(D) $90 \times 10^9\ N/m^2$



Elasticity

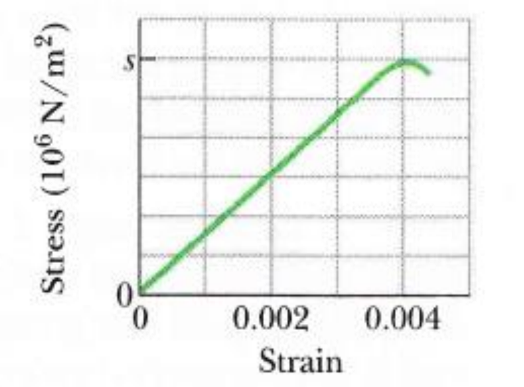
Example 6:

Referring to Example 5, the Yield strength for the material is:

Solution:

(D)

(A) $3 \times 10^5\ N/m^2$
(B) $3 \times 10^6\ N/m^2$
(C) $3 \times 10^7\ N/m^2$
(D) $3 \times 10^8\ N/m^2$



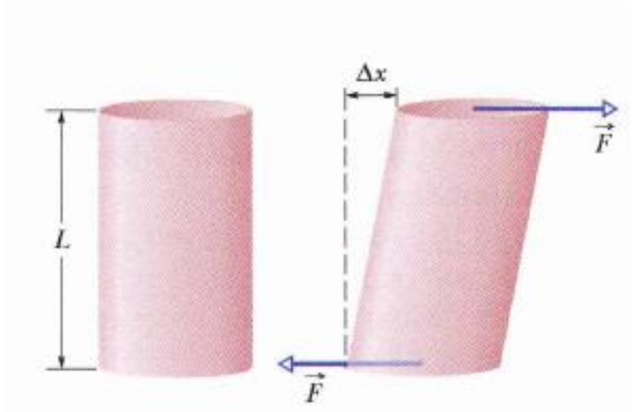
Elasticity

Shearing

The strain is the dimensionless ratio $\Delta x/L$

The corresponding modulus, which is given the symbol G, is called the **shear modulus.**

$$\frac{F}{A} = G\,\frac{\Delta x}{L}.$$



Example 7:

A horizontal aluminum rod 4.8 cm in diameter projects 5.3 cm from a wall. A 1200 kg object is suspended from the end of the rod. Neglecting the rod's mass, the shear stress on the rod is:

Solution:

(A)

(A) $6.5021 \times 10^6\ N/m^2$
(B) $4.1899 \times 10^6\ N/m^2$
(C) $3.8500 \times 10^6\ N/m^2$
(D) $2.6870 \times 10^6\ N/m^2$

Elasticity

Example 8:

Referring to Example 7, if the shear modulus of aluminum is 3.0×10^{10} N/m^2, the vertical deflection of the end of the rod is:

Solution:

(B)

(A) 0.36×10^{-5} m
(B) 1.15×10^{-5} m
(C) 2.67×10^{-5} m
(D) 3.35×10^{-5} m

Elasticity

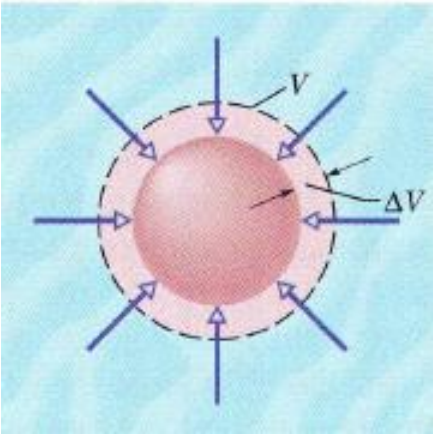
Hydraulic Stress

The stress is the fluid pressure p on the object, pressure is a force per unit area.

The strain is $\Delta V/V$, where V is the original volume of the specimen and ΔV is the absolute value of the change in volume.

The corresponding modulus, with symbol B, is called the **bulk modulus** of the material.

$$p = B\,\frac{\Delta V}{V}.$$



Elasticity

Example 9:

The Bulk modulus of sea-water is 2.2×10^9 Pa and its density is 1.025×10^3 kg/m^3. If the pressure of a sea-water with mass of 1.025×10^3 kg at a depth of 5 km is 5.0×10^7 Pa, then the change in its volume is:

Solution:

(C)

(A) 0.096 m^3
(B) 0.062 m^3
(C) 0.023 m^3
(D) 0.002 m^3