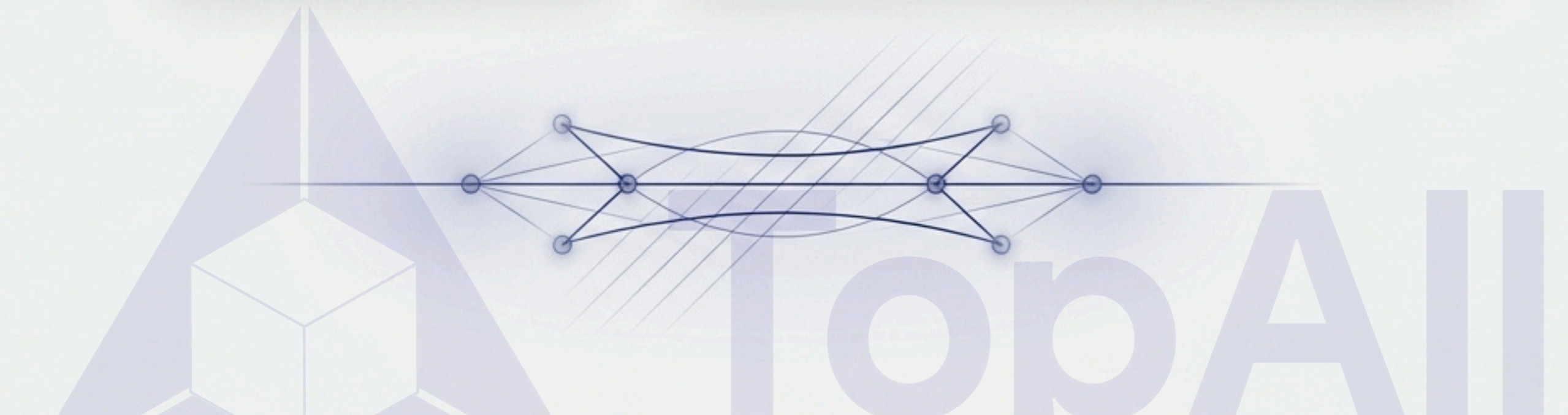


[Class 11 Physics]

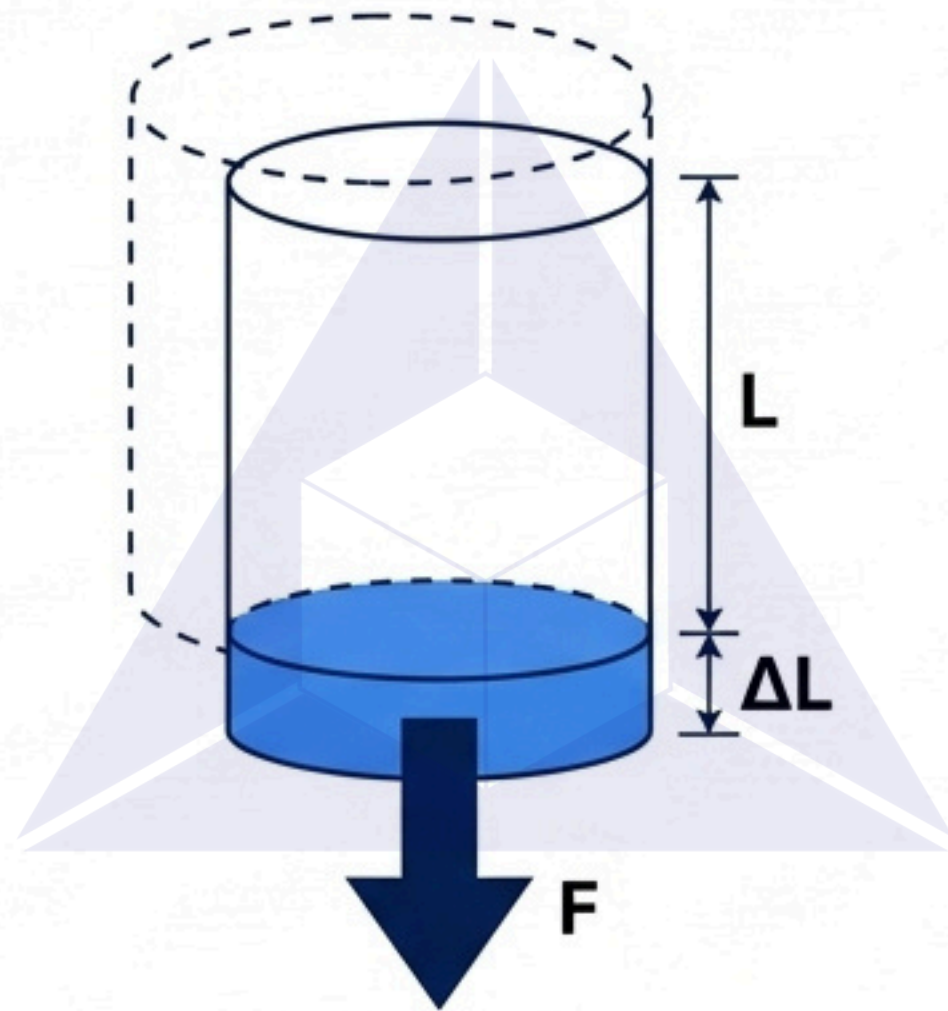
[Chapter 8: Mechanical Properties]



Young's Modulus

Measuring the Elasticity and Stiffness of Solids

What is Young's Modulus?



It measures the fundamental resistance of a solid material to linear deformation (either stretching or compressing).

The ratio of tensile or compressive stress to longitudinal strain.

Exam Takeaway: Young's modulus applies **ONLY** to solid materials undergoing linear deformation.

The Fundamental Ratio

[SI Unit: Pascal (Pa)]

σ : Tensile or
Compressive Stress
(Restoring force per
unit area)

$$Y = \frac{\sigma}{\epsilon}$$

ϵ : Longitudinal Strain
(Fractional change in
length)



Key Idea: Because strain (ϵ) is a dimensionless ratio, Young's Modulus (Y) inherits the exact same unit as stress (σ).



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The Expanded Equation

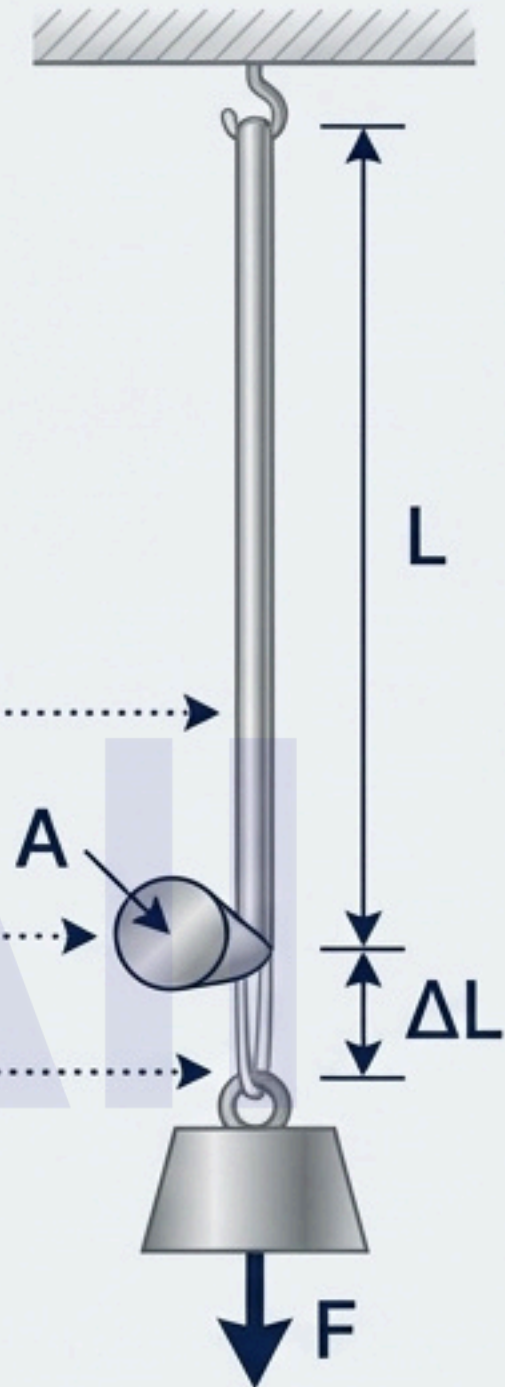
$$Y = \frac{F \cdot L}{A \cdot \Delta L}$$

Applied Force (N)

Original Length (m)

Cross-sectional Area (m²)

Change in length /
Elongation (m)



Exam Takeaway: For a given material (Y) and force (F), elongation (ΔL) is directly proportional to length (L) and inversely proportional to area (A).

Interpreting the Modulus

High Young's Modulus



-  **Trait:** Stiff Material.
- **Meaning:** Requires a massive force (F) to produce even a tiny change in length (ΔL).
- **Context:** Ideal for structural engineering.

Low Young's Modulus



-  **Trait:** Soft / Pliant Material.
- **Meaning:** Requires very little force to stretch or compress.
- **Context:** Biological tissues, everyday polymers.

Think of Y as a measure of how 'stubborn' a material is against changing its length.

Material Benchmarks

How common materials rank by stiffness (Data from Table 8.1)

High Stiffness (Metals)

- Steel (Highest)
- Copper
- Brass
- Aluminium

Require massive force to stretch.

Moderate Stiffness

- Glass
- Concrete

Low Stiffness

- Wood
- Bone
- Polystyrene

Deform more easily under load.

Notice how **Steel** towers over Aluminium. This is exactly why steel is the primary choice for heavy-duty structural engineering and cranes.

The Elasticity Paradox



The Myth: Rubber stretches a lot, so it must be highly elastic.



The Physics Truth: Elasticity is the tendency to *resist* deformation and regain original shape. Steel stretches far less than rubber for the same load, meaning it has a much higher restoring force.

Conclusion: In Physics, Steel > Rubber in elasticity.

Chapter Recap: Young's Modulus

Quick Recap

- ✓ Measures resistance to linear stretching/compression.
- ✓ $Y = \text{Stress} / \text{Strain}$
- ✓ Expanded: $Y = (F \cdot L) / (A \cdot \Delta L)$
- ✓ Unit: Pascal (Pa)

⚠ Exam Memory Cues

Higher Y = Stiffer material (harder to stretch).

THE TRAP: High elasticity means high **resistance** to stretching. Remember that **Steel** is more elastic than highly stretchable everyday materials.



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