

PICK PREP

LEARN • THINK • GROW

**NEET
PHYSICS
ESSENTIALS**

MECHANICAL PROPERTIES OF SOLIDS



UNDERSTAND
THE PHYSICS



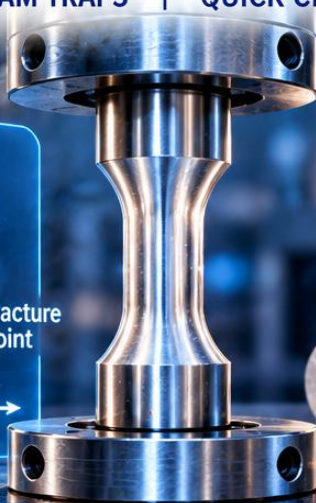
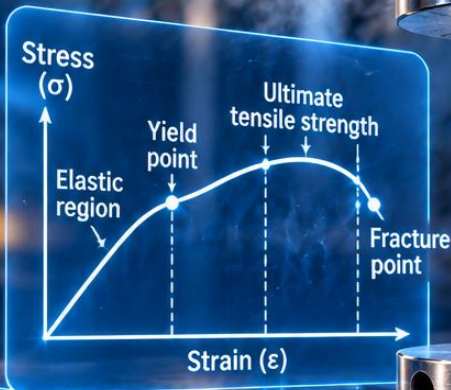
RECOGNIZE
THE PATTERN



SOLVE WITH
CONFIDENCE

NEET PHYSICS ESSENTIALS CONCEPT SUMMARY

KEY CONCEPTS | FORMULAS | RECOGNITION CUES
MISCONCEPTIONS | EXAM TRAPS | QUICK CHECKS



SAME PHYSICS.
A HIGHER SCORE.

1. Chapter Introduction

Mechanical Properties of Solids studies how solids respond when forces, pressure, or temperature changes alter their length, volume, or shape. The chapter links stress, strain, elastic moduli, material behaviour, elastic energy, elastic wires, and thermal effects.

2. Chapter in One View

- Loading produces deformation.
- Stress = internal loading per unit area.
- Strain = relative deformation.
- Elastic moduli = resistance to elastic deformation.
- Identify loading: pulling, compression, shear, pressure, heating.
- Identify change: length, volume, shape, transverse dimension.
- Choose required quantity: stress, strain, extension, volume change, energy.
- Select model: Young's, bulk, shear, spring, thermal.
- Check validity conditions, units, signs.
- Ensure answer makes physical sense.

3. Must-Know Concepts

- **Elasticity:** recovery after unloading.
- **Plastic deformation:** permanent change.
- **Stress:** internal force per unit area (Pa).
- **Strain:** relative deformation, dimensionless.
- **Normal stress:** tensile/compressive.
- **Shear stress:** tangential, sliding layers.
- **Uniform pressure:** volume change.
- **Hooke's law:** valid in proportional region.
- **Young's modulus:** axial length deformation.
- **Bulk modulus:** volume change.
- **Shear modulus:** shape change.
- **Poisson's ratio:** lateral vs longitudinal strain.
- **Elastic energy:** area under force–extension graph.
- **Wire as spring:** effective spring constant.
- **Thermal expansion:** depends on freedom/restraint.

4. Key Formulas

Stress: $\sigma = \frac{F_{\perp}}{A}$

Meaning Normal force per unit area.

Use when Normal loading and cross-sectional area are known.

Condition Use the normal component of force for normal stress;
shear stress is separate.

Exam trap Stress is not total force. Smaller area means greater
stress for the same normal force.

Longitudinal strain: $\varepsilon = \frac{\Delta L}{L}$

Meaning Normal force per unit area.

Use when Normal loading and cross-sectional area are known.

Condition Use the normal component of force for normal stress;
shear stress is separate.

Exam trap Stress is not total force. Smaller area means greater
stress for the same normal force.

Volumetric strain: $\varepsilon_v = \frac{\Delta V}{V}$

Meaning Volume change relative to original volume.

Use when Pressure or loading changes the body's volume.

Meaning Volume change relative to original volume.

Condition Use original volume V ; compression gives $\Delta V < 0$.

Exam trap Do not confuse ΔV with $\Delta V/V$.

Young's modulus: $Y = \frac{FL}{A\Delta L}$

Meaning Resistance to axial elastic deformation.

Use when A wire or rod is stretched/compressed along its length.

Condition Uniform member and appropriate linear-elastic conditions.

Exam trap Do not use blindly after the material leaves the proportional region.

Bulk modulus: $K = -\frac{\Delta P}{\Delta V/V}$

Meaning Resistance to volume change under pressure.

Use when Pressure change produces a small volume change.

Condition The minus sign gives positive K for ordinary compression.

Exam trap ΔP is pressure change, not necessarily absolute pressure.

Shear modulus: $G = \frac{\tau}{\gamma}$, $\tau = \frac{F_{\parallel}}{A}$, $\gamma \approx \frac{\Delta x}{h}$

Meaning	Resistance to shape change by sliding.
Use when	A tangential force shifts the top of a block while the base is fixed.
Condition	For small deformation, $\gamma \approx \tan \theta \approx \theta$ in radians.
Exam trap	Do not choose modulus by object shape; choose it by the deformation.

Poisson's ratio: $\nu = -\frac{\epsilon_{\text{lateral}}}{\epsilon_{\text{longitudinal}}}$

Meaning	Connects transverse and axial deformation.
Use when	Length and diameter/width changes are both given or required.
Condition	The strains have opposite signs in ordinary tensile stretching.
Exam trap	Keep the negative sign in the definition.

Relations among elastic constants:

$$Y = 2G(1 + \nu), Y = 3K(1 - 2\nu), Y = \frac{9KG}{3K + G}$$

Meaning	Connects Young's, bulk, and shear moduli and Poisson's ratio.
Use when	Two relevant constants are given and another is required.
Condition	For isotropic, linear-elastic materials.

Exam trap Check material assumptions before using these relations.

Extension of wire: $\Delta L = \frac{FL}{AY}$

Meaning Predicts the extension of a uniform wire under axial force.

Use when F, L, A, and Y are known.

Condition Small deformation and linear-elastic response.

Exam trap Convert area and length into compatible SI units.

Elastic energy in spring: $U = \frac{1}{2}kx^2 = \frac{1}{2}Fx = \frac{F^2}{2k}$

Meaning Recoverable work stored in an ideal spring.

Use when An ideal spring changes extension by x within its elastic range.

Condition Force rises linearly from zero to final force.

Exam trap Do not use final force × full extension when force varies.

Elastic energy in wire: $U = \frac{F^2L}{2AY} = \frac{F^2L}{2AY} = \frac{AY(\Delta L)^2}{2L}$

Meaning Total recoverable elastic energy in a stretched wire.

Use when The wire is uniformly and elastically stretched.

Condition	Linear-elastic deformation.
Exam trap	Total energy is not the same as energy density.

Energy density: $u = \frac{1}{2} \sigma \varepsilon = \frac{\sigma^2}{2Y} = \frac{1}{2} Y \varepsilon^2$

Meaning	Elastic energy stored per unit volume.
Use when	Uniaxial linear-elastic deformation.
Condition	Use the corresponding linear-elastic stress–strain relation.
Exam trap	Check whether the question asks total energy U or energy density u.

Wire as spring: $k = \frac{AY}{L}$

Meaning	Effective spring constant of an elastic wire.
Use when	A wire behaves elastically under axial extension.
Condition	Uniform cross-section and linear-elastic response.
Exam trap	Larger area increases k; larger length decreases k.

Series/parallel wires:

$$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2}, \quad k_{eq} = k_1 + k_2$$

Meaning	Equivalent spring constant of connected elastic elements.
Use when	Identify physical connection first: end-to-end or side-by-side.
Condition	Ideal elastic elements.
Exam trap	Series uses reciprocals; parallel uses direct addition.

Thermal expansion: $\Delta L = \alpha L \Delta T$

Meaning	Change in length due to temperature change.
Use when	The body is free to expand or contract.
Condition	Small temperature range with stated α .
Exam trap	Does not calculate thermal stress for a fully restrained rod.

Thermal stress (restraint): $\sigma = Y\alpha\Delta T$ $|F| = AY\alpha|\Delta T|$

Meaning	Stress/force when natural thermal length change is fully prevented.
Use when	Both ends are fixed and expansion/contraction is completely restrained.
Condition	Uniform temperature change and linear-elastic behaviour. Heating gives compression; cooling gives tension.

Do not use free-expansion displacement as the final outcome when movement is prevented.

Exam trap

5. Formula Selection Guide

See this situation Think this model Use this relation

Force normal to area; asks loading per area Normal stress $\sigma = \frac{F_{\perp}}{A}$

Length changes relative to original length Longitudinal strain $\varepsilon = \frac{\Delta L}{L}$

Uniform pressure changes volume Bulk modulus $K = -\frac{\Delta P}{\Delta V/V}$

Top layer shifts sideways Shear modulus $G = \frac{\tau}{\gamma}$

Axial force changes wire length Young's modulus $Y = \frac{FL}{A\Delta L}$

Diameter changes when wire is stretched Poisson's ratio $\nu = -\frac{\varepsilon_{lat}}{\varepsilon_{long}}$

Force changes during extension Work / elastic energy Area under F-x graph

Elastic wire behaves like a spring Wire spring constant $k = \frac{AY}{L}$

See this situation	Think this model	Use this relation
Wires end-to-end	Series	$\frac{1}{k_{eq}} = \sum \frac{1}{k_i}$
Wires side-by-side	Parallel	$k_{eq} = \sum k_i$
Heated rod free to move	Thermal expansion	$\Delta L = \alpha L \Delta T$
Heated rod fully fixed	Thermal stress	$\sigma = Y \alpha \Delta T$

6. When to Use / When Not to Use

- **Hooke's law and elastic moduli:** Use only in valid elastic range.
- **Elastic energy:** Use area under F–x graph if force varies.
- **Thermal deformation:** Free → expansion; restrained → stress develops.

7. Common Misconceptions

- Easy to deform ≠ less elastic.
- Elastic ≠ always proportional.
- Same force ≠ same stress.
- Same extension ≠ same strain.
- Young's modulus ≠ for all deformations.
- Wire stretched → also lateral contraction.

8. Exam Traps

- Stress $\neq$ force; strain $\neq$ extension.
- Wrong dimensions in strain.
- Confusing proportional limit vs elastic limit.
- Hooke's law outside valid range.
- Missing signs in bulk modulus/Poisson's ratio.
- Wrong work formula for variable force.
- Mixing total energy vs energy density.
- Series vs parallel spring mix-up.
- Using free expansion for restrained rods.

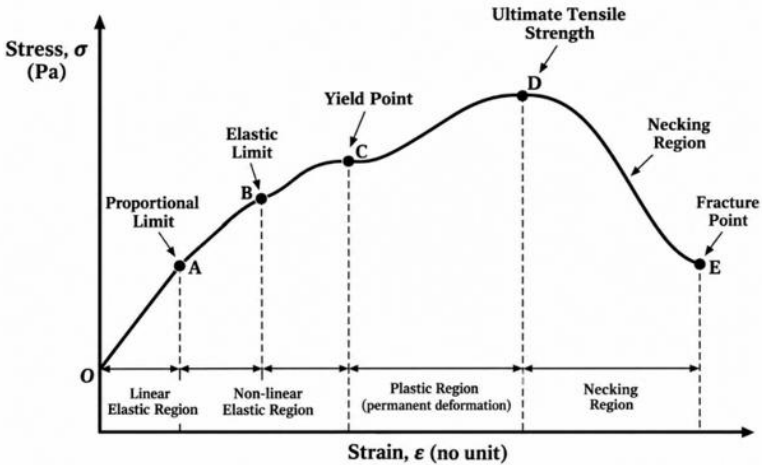
9. See This $\rightarrow$ Think This

- Returns after unloading $\rightarrow$ Elastic.
- Permanent deformation $\rightarrow$ Plastic.
- Force $\perp$ section $\rightarrow$ Normal stress.
- Layers slide $\rightarrow$ Shear stress.
- Length change $\rightarrow$ Young's modulus.
- Volume change $\rightarrow$ Bulk modulus.
- Shape change $\rightarrow$ Shear modulus.
- Max stress $\rightarrow$ Ultimate tensile strength.

- Local area ↓ → Necking.
- Variable force → Area under $F-x$.
- End-to-end wires → Series.
- Side-by-side wires → Parallel.
- Heated rod free → Expansion.
- Heated rod fixed → Thermal stress.

10. Stress–Strain Curve

- **Proportional limit:** stress $\propto$ strain ends.
- **Elastic limit:** recovery boundary.
- **Yielding:** large deformation begins.
- **Plastic region:** permanent deformation.
- **Ultimate tensile strength:** max stress.
- **Necking:** local area reduction.
- **Fracture:** specimen breaks.
- **Energy:** area under curve = work per unit volume.



11. Material Properties

Property	Recognize by
Strength	Withstands large stress
Ductility	Can be drawn into wire
Malleability	Can be made into sheets
Brittleness	Breaks with little deformation
Toughness	Absorbs energy before breaking
Resilience	Stores/releases elastic energy
Hardness	Resists indentation/scratch
Fatigue	Weakens under repeated loading

Property Recognize by

Creep Slow deformation under sustained load

12. Quick Checks

- Stress? → Force/area.
- Strain unit? → None.
- Same force, smaller area → Stress ↑.
- Length change → Young's modulus.
- Volume change → Bulk modulus.
- Sliding deformation → Shear modulus.
- Elastic limit → Recovery boundary.
- Variable force work → Area under F-x.
- Spring energy → $U = \frac{1}{2}kx^2$.
- Wire-making → Ductility.
- Sheet-making → Malleability.
- End-to-end wires → Series.
- Side-by-side wires → Parallel.
- Heated rod fixed → Thermal stress.

13. Mini Exam Reasoning

- Axial extension: $\Delta L = FL/(AY)$.
- Sideways push: $G = \tau/\gamma$.
- Heated rod fixed: $\sigma = Y\alpha\Delta T$.
- Spring stretched: $U = \frac{1}{2}kx^2$.

14. Before You Calculate

- Identify asked quantity.
- Choose correct deformation model.
- Use original dimensions.
- Convert to SI units.
- Check signs.
- Verify validity conditions.
- Estimate magnitude/unit sanity.

15. One-Minute Recall

- Stress = F/A ; strain = $\Delta L/L$.
- Elasticity = recovery; proportionality = stress $\propto$ strain.
- Length $\rightarrow$ Young's; volume $\rightarrow$ bulk; shape $\rightarrow$ shear.
- Poisson's ratio = lateral/longitudinal strain.
- Stress-strain story: proportional $\rightarrow$ elastic limit $\rightarrow$ yield $\rightarrow$ plastic $\rightarrow$ ultimate $\rightarrow$ necking $\rightarrow$ fracture.

- Spring energy = $\frac{1}{2}kx^2$.
- Wire spring constant = AY/L .
- Series vs parallel wires.
- Free thermal expansion vs restrained stress.

Go Deeper with the Complete Concept Book

This website concept summary supports rapid understanding, formula selection and revision. The complete NEET Physics Essentials Concept Book provides fuller concept development, detailed derivations, microquestions, solved examples and integrated problem-solving.

COMPLETE CONCEPT BOOK

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Confidence

