CHAPTER 09

Mechanical Properties of Solids

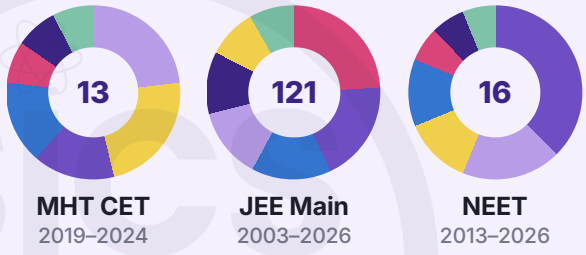
MHT CET · JEE · NEET Physics

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EXAM WEIGHTAGE



	CET	JEE	NEET
Young's Modulus & Elongation	2 (15%)	23 (19%)	6 (38%)
Wire Combinations & Special Cases	1 (8%)	29 (24%)	1 (6%)
Elastic Behaviour, Stress & Strain	3 (23%)	16 (13%)	3 (19%)
Bulk Modulus & Compressibility	2 (15%)	18 (15%)	2 (12%)
Thermal Stress & Breaking Stress	1 (8%)	14 (12%)	1 (6%)
Elastic Potential Energy	3 (23%)	11 (9%)	2 (12%)
Shear Modulus & Poisson's Ratio	1 (8%)	10 (8%)	1 (6%)

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01 CONCEPT Elastic Behaviour, Stress & Strain

IN ONE LINE

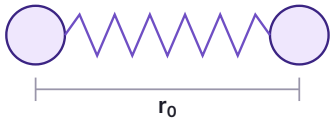
A deforming force produces **stress** and **strain**; within the elastic limit the body returns to its original shape and stress $\propto$ strain.

9.1.1 States of matter and solids

- Solid: definite shape and volume. Liquid: definite volume only. Gas: neither.
- Crystalline solids have a regular pattern and a sharp melting point; amorphous solids (glass) have neither.

9.1.2 Elasticity and plasticity

- **Elasticity**: a body tends to regain its original shape and size when the deforming force is removed.
- **Plasticity**: it does not regain them.
- Nearly perfectly elastic: quartz fibre, phosphor bronze.
- Nearly perfectly plastic: paraffin wax, wet clay.



Molecules behave as if joined by springs

- Reason: deforming a solid changes the distance between molecules, and intermolecular forces pull them back.
- **Elastic limit**: the largest deforming force up to which a body fully recovers.
- **Elastic fatigue**: temporary loss of elastic strength under repeated loading. Bridges become unsafe; spring balances read wrongly.
- **Elastic after-effect**: the delay in regaining the original state.

9.1.3 Which is more elastic?

- Same force, less deformation: more elastic.
- Steel is more elastic than rubber; water is more elastic than air.
- Solids > liquids > gases in bulk modulus.

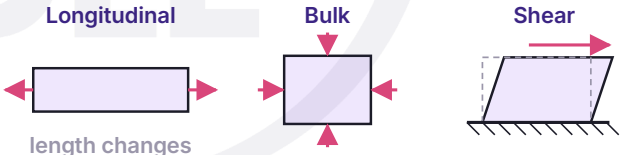
9.1.4 What changes elasticity

- Hammering and rolling: elasticity increases.
- Annealing: elasticity decreases.
- Rise in temperature: elasticity decreases (invar steel hardly changes).
- Impurities can raise or lower it.

9.1.5 Stress

$$\text{Stress} = \frac{F}{A}$$

- Restoring force per unit area. It balances the applied force at equilibrium.
- Unit N m^{-2} (pascal). Dimensions $[ML^{-1}T^{-2}]$.



The three kinds of stress

- **Longitudinal**: force along the length, on the cross-section. Tensile if length grows, compressive if it falls.
- **Bulk**: normal force at all points; equal to the change in pressure. Occurs in solids, liquids and gases.
- **Shear**: tangential force on a face; only shape changes.

Pressure	Stress
always normal to the area	normal or tangential
always compressive	compressive or tensile

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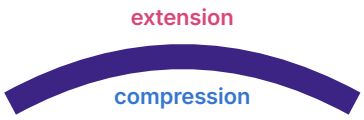
9.1.6 Strain

$$\text{Longitudinal strain} = \frac{\Delta l}{L}$$

$$\text{Volumetric strain} = \frac{\Delta V}{V}$$

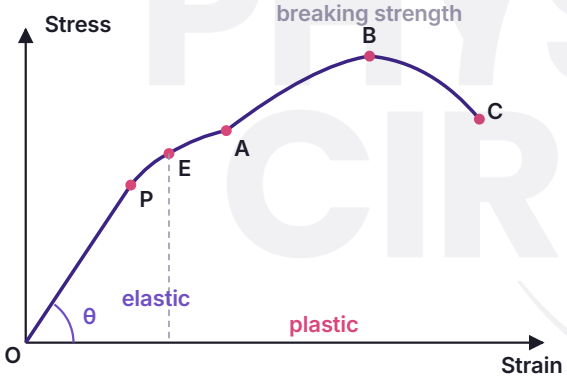
$$\text{Shearing strain } \varphi = \frac{x}{L}$$

- Change in configuration divided by the original: no unit, no dimensions.
- A bent beam has both extension and compression.



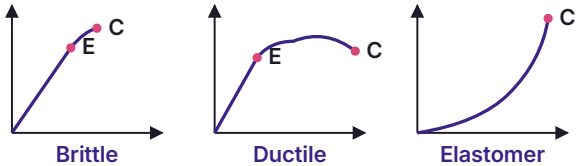
Outer layer stretched, inner layer compressed

9.1.7 Stress-strain curve



Load on a metal wire

- **O to P**: straight line, Hooke's law holds. Slope = Y = tan θ.
- **P to E**: not straight, but the wire still recovers. E is the elastic limit or yield point.
- **E to A**: permanent set; the wire does not recover.
- **A to B**: small increase in stress gives a large strain. B is the breaking strength.
- **B to C**: the wire flows and breaks at C.



Curve shape tells the type of material

Type	Behaviour	Example
brittle	breaks just after the elastic limit	glass, cast iron
ductile	long plastic range, drawn into wires	mild steel
elastomer	large strain, no plastic range	rubber

9.1.8 Hooke's law

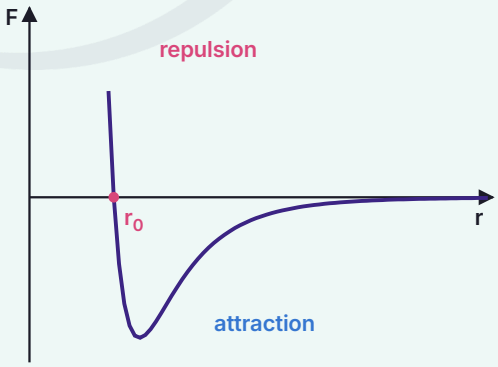
$$\text{Stress} \propto \text{strain}, \quad E = \frac{\text{stress}}{\text{strain}}$$

- Holds within the limit of proportionality.
- E depends on the material and the type of deformation, and falls with temperature.
- E does not depend on the dimensions of the body.
- E has the unit and dimensions of stress.

Modulus	Stress type	Exists in
Young's Y	longitudinal	solids
Bulk K	volume	solids, liquids, gases
Rigidity η	shear	solids

JEE · NEET Corner

Interatomic force



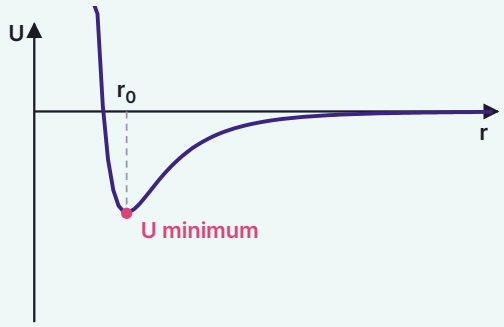
Force between two atoms: zero at r_0

- Electrical in origin; acts at distances of about 10^{-10} m.
- $r > r_0$: attraction. $r < r_0$: repulsion, rising very fast.

$$F = -\frac{dU}{dr}$$

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Potential energy curve



U is least at r_0: stable equilibrium

$$U = \frac{A}{r^{12}} - \frac{B}{r^6}$$

- The first term is repulsion, the second attraction.

Intermolecular force

$$F = -\frac{a}{r^7} + \frac{b}{r^9}$$

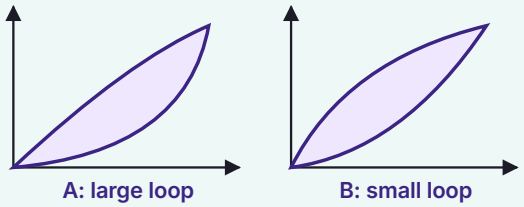
- Van der Waals forces: weaker than interatomic forces by 50 to 100 times.
- They depend on the distance and also on the orientation of the molecules.

Interatomic force constant

$$k = Y\, r_0$$

- Unit N m^{-1}. Atoms in length l of a wire: N = $l \div r_0$.

Elastic hysteresis



Area of the loop = energy lost per unit volume

- Strain lags behind stress on loading and unloading.
- Car tyres: small loop (B), less heating. Shock absorbers: large loop (A).

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Solved Examples 01 Elastic Behaviour, Stress & Strain

SOLVED 1 MHT CET 2019 · 2 May · Shift 1

Two identical wires of substances P and Q are subjected to equal stretching force along the length. If the elongation of Q is more than that of P, then

(a) both P and Q are equally elastic
(b) P is more elastic than Q
(c) P is plastic and Q is elastic
(d) Q is more elastic than P

STEP 1 Same force on identical wires: elongation $\propto$ one over Y
STEP 2 Smaller elongation means larger Y
STEP 3 **P is more elastic than Q**

Answer: **(b)**

SOLVED 2 JEE Main 2024 · 1 Feb · Shift 1

With rise in temperature, the Young's modulus of elasticity:

(a) changes erratically
(b) increases
(c) decreases
(d) remains unchanged

STEP 1 Intermolecular forces weaken as temperature rises
STEP 2 The same strain now needs less stress
STEP 3 Y **decreases**

Answer: **(c)**

SOLVED 3 JEE Main 2024 · 27 Jan · Shift 2

Assertion (A): The property of a body by virtue of which it tends to regain its original shape when the external force is removed is elasticity. Reason (R): The restoring force depends upon the bonded inter-atomic and inter-molecular forces of the solid.

(a) (A) is false, (R) is true
(b) Both true, (R) does not explain (A)
(c) Both true, (R) explains (A)
(d) (A) is true, (R) is false

STEP 1 (A) is the definition of elasticity: true
STEP 2 The restoring force comes from the spring-like bonds between molecules: true
STEP 3 This force is why the body returns, so **(R) explains (A)**

Answer: **(c)**

SOLVED 4 MHT CET 2020 · 16 Oct · Shift 2

Two wires A and B are stretched by the same load. The radius of wire A is double the radius of wire B. The stress on the wire B as compared to the stress on the wire A is

(a) half
(b) equal
(c) twice
(d) four times

STEP 1 Stress = $\frac{F}{\pi r^2}$, so with the same F, stress $\propto \frac{1}{r^2}$
STEP 2 $\frac{\text{stress}_B}{\text{stress}_A} = \left(\frac{r_A}{r_B}\right)^2 = 2^2$
STEP 3 Stress on B is **four times**

Answer: **(d)**

SOLVED 5 MHT CET 2020 · 16 Oct · Shift 2

Two wires of different materials have same length L and same diameter d. The second wire is connected at the end of the first wire and forms one single wire of double the length. This wire is subjected to stretching force F. The two wires have

(a) different stress but same strain
(b) different stress and different strain
(c) same stress but different strain
(d) same stress and same strain

STEP 1 In series both carry the same F over the same area: same stress
STEP 2 Strain = stress ÷ Y, and Y differs
STEP 3 **Same stress but different strain**

Answer: **(c)**

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Solved Examples 01 Elastic Behaviour, Stress & Strain (contd.)

SOLVED 6 NEET 2023

A wire suspended from the ceiling is stretched by a weight W attached at its free end. The longitudinal stress at any point of cross-sectional area A of the wire is:

(a) $\frac{W}{A}$ (b) $\frac{W}{2A}$
(c) Zero (d) $\frac{2W}{A}$

STEP 1 Light wire: tension is W at every point
STEP 2 Stress = tension ÷ area
STEP 3 Stress = $\frac{W}{A}$

Answer: **(a)**

SOLVED 7 JEE Main 2017

A man grows into a giant such that his linear dimensions increase by a factor of 9. Assuming that his density remains the same, the stress in the leg will change by a factor of:

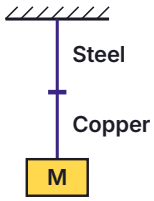
(a) $\frac{1}{81}$ (b) 9
(c) $\frac{1}{9}$ (d) 81

STEP 1 Weight $\propto$ volume $\propto 9^3$; leg area $\propto 9^2$
STEP 2 Stress = weight ÷ area $\propto 9^3 \div 9^2$
STEP 3 Stress changes by a factor of **9**

Answer: **(b)**

SOLVED 8 JEE Main 2022 · 30 Jul · Shift 2

A block of mass M is attached to a wire. The upper part of the wire is steel and the lower part copper. Both parts have the same area of cross section. Neglecting the mass of the wires, the ratio of longitudinal strain in steel and copper is: ($Y_{steel} = 2 \times 10^{11}$ N m^{-2}, $Y_{copper} = 1.5 \times 10^{11}$ N m^{-2})



(a) $\frac{3}{5}$ (b) $\frac{4}{5}$
(c) $\frac{4}{3}$ (d) $\frac{3}{4}$

STEP 1 Same force, same area: same stress in both
STEP 2 Strain = stress ÷ Y, so strain $\propto$ one over Y
STEP 3 $\frac{\text{strain}_s}{\text{strain}_c} = \frac{1.5}{2} = \frac{3}{4}$

Answer: **(d)**

SOLVED 9 NEET 2019

The stress-strain curves are drawn for two different materials X and Y. The ultimate strength point and the fracture point are close to each other for X but far apart for Y. Materials X and Y are likely to be (respectively),

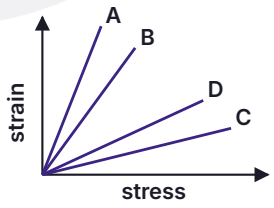
(a) Plastic and ductile (b) Ductile and brittle
(c) Brittle and ductile (d) Brittle and plastic

STEP 1 Points close: the material breaks soon after the elastic limit: brittle
STEP 2 Points far apart: long plastic range: ductile
STEP 3 **X brittle, Y ductile**

Answer: **(c)**

SOLVED 10 JEE Main 2026 · 23 Jan · Shift 1

The strain-stress plot for materials A, B, C and D is shown in the figure. Which material has the largest Young's modulus?



(a) B (b) A
(c) D (d) C

STEP 1 The slope of this plot is $\frac{\text{strain}}{\text{stress}} = \frac{1}{Y}$
STEP 2 Largest Y means the smallest slope
STEP 3 Line C has the smallest slope: **C**

Answer: **(d)**

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MECHANICAL PROPERTIES
OF SOLIDS

LEVEL 1 · EASY

Topic-wise Previous Year Questions

MHT CET · NEET · JEE Main

60	16	7
questions	concepts	topics

CONTENTS

01	Elastic Behaviour, Stress & Strain	Q 1–11	11 Qs
02	Young's Modulus & Elongation	Q 12–32	21 Qs
03	Wire Combinations & Special Cases	Q 33–33	1 Qs
04	Thermal Stress & Breaking Stress	Q 34–38	5 Qs
05	Elastic Potential Energy	Q 39–46	8 Qs
06	Bulk Modulus & Compressibility	Q 47–53	7 Qs
07	Shear Modulus & Poisson's Ratio	Q 54–60	7 Qs
	Answer key		

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TOPIC 01

Elastic Behaviour, Stress & Strain

11 PYQs · Easy 11 · Medium 0 · Difficult 0 | MHT CET 2 · NEET 2 · JEE 7

Concepts covered: Elasticity, plasticity & elastic limit (4) · Stress (4) · Strain (1) · Stress-strain curve & materials (2)

LEVEL 1 · EASY 11 questions

◆ Elasticity, plasticity & elastic limit 4 Qs

1. Two identical wires of substances 'P' and 'Q' are subjected to equal stretching force along the length. If the elongation of 'Q' is more than that of 'P', then
MHT CET 2019 · 2 MAY · SHIFT 1
(a) both P and Q are equally elastic
(b) P is more elastic than Q
(c) P is plastic and Q is elastic
(d) Q is more elastic than P

2. With rise in temperature, the Young's modulus of elasticity:
JEE MAIN 2024 · 1 FEB · SHIFT 1
(a) changes erratically (b) increases
(c) decreases (d) remains unchanged

3. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The property of body, by virtue of which it tends to regain its original shape when the external force is removed, is Elasticity.
Reason (R): The restoring force depends upon the bonded inter atomic and inter molecular force of solid.
In the light of the above statements, choose the correct answer from the options given below:
JEE MAIN 2024 · 27 JAN · SHIFT 2
(a) (A) is false but (R) is true
(b) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(c) Both (A) and (R) are true and (R) is the correct explanation of (A)
(d) (A) is true but (R) is false

4. Given below are two statements: one is labelled as Assertion A and the other is labelled as Reason R
Assertion A: Steel is used in the construction of buildings and bridges.
Reason R: Steel is more elastic and its elastic limit is high.
In the light of above statements, choose the most appropriate answer from the options given below
JEE MAIN 2023 · 24 JAN · SHIFT 2
(a) Both A and R are correct and R is the correct explanation of A
(b) A is correct but R is not correct
(c) Both A and R are correct but R is NOT the correct explanation of A
(d) A is not correct but R is correct

◆ Stress 4 Qs

5. Two wires A and B are stretched by the same load. The radius of wire A is double the radius of wire B. The stress on the wire B as compared to the stress on the wire A is
MHT CET 2020 · 16 OCT · SHIFT 2
(a) half (b) equal
(c) twice (d) four times

6. Let a wire be suspended from the ceiling (rigid support) and stretched by a weight W attached at its free end. The longitudinal stress at any point of cross-sectional area A of the wire is:
NEET 2023
(a) W/A (b) $W/2A$ (c) Zero (d) $2W/A$

7. A steel wire having a radius of 2.0 mm, carrying a load of 4 kg, is hanging from a ceiling. Given that g = 3.1π ms^{-2}, what will be the tensile stress that would be developed in the wire?
JEE MAIN 2019 · 8 APR · SHIFT 1
(a) 3.1×10^6 Nm^{-2} (b) 6.2×10^6 Nm^{-2}
(c) 4.8×10^6 Nm^{-2} (d) 5.2×10^6 Nm^{-2}

8. A metal block of mass m is suspended from a rigid support through a metal wire of diameter 14 mm. The tensile stress developed in the wire under equilibrium state is 7×10^5Nm^{-2}. The value of mass m is _____ kg. (Take, g = 9.8 ms^{-2} and $\pi = \frac{22}{7}$)
JEE MAIN 2023 · 6 APR · SHIFT 2 *(Numerical)*

◆ Strain 1 Q

9. A steel rod has a radius of 20 mm and a length of 2.0 m. A force of 62.8 kN stretches it along its length. Young's modulus of steel is 2.0×10^{11} N/m^2. The longitudinal strain produced in the wire is _____ $\times 10^{-5}$
JEE MAIN 2023 · 6 APR · SHIFT 1 *(Numerical)*

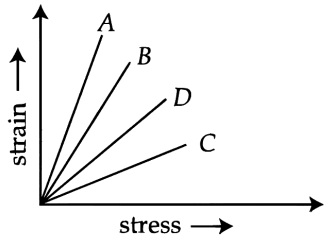
◆ Stress-strain curve & materials 2 Qs

10. The stress-strain curves are drawn for two different materials X and Y. It is observed that the ultimate strength point and the fracture point are close to each other for material X but are far apart for material Y.
We can say that materials X and Y are likely to be (respectively),
NEET 2019
(a) Plastic and ductile (b) Ductile and brittle
(c) Brittle and ductile (d) Brittle and plastic

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11. The strain-stress plot for materials A, B, C and D is shown in the figure. Which material has the largest Young's modulus?

JEE MAIN 2026 · 23 JAN · SHIFT 1



(a) B (b) A (c) D (d) C

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TOPIC 02

Young's Modulus & Elongation

21 PYQs · Easy 21 · Medium 0 · Difficult 0 | MHT CET 1 · NEET 3 · JEE 17

Concepts covered: Young's modulus & its nature (8) · Elongation: wires of the same material (8) · Comparing different materials (5)

LEVEL 1 · EASY 21 questions

◆ Young's modulus & its nature 8 Qs

12. A wire of length L, area of cross section A is hanging from a fixed support. The length of the wire changed to L_1 when mass M is suspended from its free end. The expression for Young's modulus is:

NEET 2020 · PHASE 1

(a) $\frac{Mg(L_1-L)}{AL}$ (b) $\frac{MgL}{AL_1}$
(c) $\frac{MgL}{A(L_1-L)}$ (d) $\frac{MgL_1}{AL}$

13. The Young's modulus of steel wire of radius r and length L is Y.
If the radius r and length L of the wire are doubled then the value of Y

JEE MAIN 2026 · 5 APR · SHIFT 1

(a) increases by two times
(b) reduces by half
(c) remains unchanged
(d) becomes one fourth

14. A 3 m long wire of radius 3 mm shows an extension of 0.1 mm when loaded vertically by a mass of 50 kg in an experiment to determine Young's modulus. The value of Young's modulus of the wire as per this experiment is $P \times 10^{11}\ \text{Nm}^{-2}$, where the value of P is: (Take $g = 3\pi\ \text{m/s}^2$)

JEE MAIN 2025 · 8 APR · SHIFT 2

(a) 2.5 (b) 25 (c) 10 (d) 5

15. Young's modulus of material of a wire of length 'L' and cross-sectional area A is Y. If the length of the wire is doubled and cross-sectional area is halved then Young's modulus will be:

JEE MAIN 2024 · 30 JAN · SHIFT 1

(a) 4 Y (b) 2 Y (c) $\frac{Y}{4}$ (d) Y

16. For a solid rod, the Young's modulus of elasticity is $3.2 \times 10^{11}\text{Nm}^{-2}$ and density is $8 \times 10^3\ \text{kg m}^{-3}$. The velocity of longitudinal wave in the rod will be.

JEE MAIN 2023 · 31 JAN · SHIFT 2

(a) $3.65 \times 10^3\ \text{ms}^{-1}$ (b) $6.32 \times 10^3\ \text{ms}^{-1}$
(c) $18.96 \times 10^3\ \text{ms}^{-1}$ (d) $145.75 \times 10^3\ \text{ms}^{-1}$

17. A 100 m long wire having cross-sectional area $6.25 \times 10^{-4}\ \text{m}^2$ and Young's modulus is $10^{10}\ \text{Nm}^{-2}$ is subjected to a load of 250 N, then the elongation in the wire will be:

JEE MAIN 2023 · 24 JAN · SHIFT 1

(a) 6.25×10^{-6} m (b) 4×10^{-3} m
(c) 4×10^{-4} m (d) 6.25×10^{-3} m

18. If the length of a wire is made double and radius is halved of its respective values. Then, the Young's modulus of the material of the wire will:

JEE MAIN 2022 · 29 JUL · SHIFT 1

(a) remain same
(b) become 8 times its initial value
(c) become $\frac{1}{4}$ of its initial value
(d) become 4 times its initial value

19. The force required to stretch a wire of cross-section 1 cm^2 to double its length will be: (Given Young's modulus of the wire $= 2 \times 10^{11}\ \text{N/m}^2$)

JEE MAIN 2022 · 28 JUL · SHIFT 1

(a) 1×10^7 N (b) 1.5×10^7 N
(c) 2×10^7 N (d) 2.5×10^7 N

◆ Elongation: wires of the same material 8 Qs

20. A wire of length L and radius r is rigidly fixed at one end. On stretching the other end of the wire with a force F, the increase in length is l. If another wire of the same material but double the length and radius is stretched with a force $2F$, then increase in length is

MHT CET 2019 · 3 MAY · SHIFT 1

(a) $\frac{l}{4}$ (b) $2l$ (c) $\frac{l}{2}$ (d) l

21. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied?

NEET 2013

(a) length = 200 cm, diameter = 2 mm
(b) length = 300 cm, diameter = 3 mm
(c) length = 50 cm, diameter = 0.5 mm
(d) length = 100 cm, diameter = 1 mm

22. Two wires A and B are made of same material having ratio of lengths $\frac{L_A}{L_B} = \frac{1}{3}$ and their diameters ratio $\frac{d_A}{d_B} = 2$. If both the wires are stretched using same force, what would be the ratio of their respective elongations?

JEE MAIN 2025 · 7 APR · SHIFT 1

(a) 3 : 4 (b) 1 : 12 (c) 1 : 3 (d) 1 : 6

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23. A wire of length L and radius r is clamped at one end. If its other end is pulled by a force F, its length increases by l. If the radius of the wire and the applied force both are reduced to half of their original values keeping original length constant, the increase in length will become:

JEE MAIN 2024 · 29 JAN · SHIFT 2

(a) 2 times (b) 4 times
(c) 3 times (d) $\frac{3}{2}$ times

24. A wire of length ' L ' and radius ' r ' is clamped rigidly at one end. When the other end of the wire is pulled by a force f, its length increases by ' l '. Another wire of same material of length ' $2\,\mathrm{L}$ ' and radius ' $2r$ ' is pulled by a force ' $2f$ '. Then the increase in its length will be:

JEE MAIN 2023 · 15 APR · SHIFT 1

(a) $2l$ (b) $4l$ (c) l (d) $l/2$

25. A force is applied to a steel wire 'A', rigidly clamped at one end. As a result elongation in the wire is $0.2\ \mathrm{mm}$. If same force is applied to another steel wire ' B ' of double the length and a diameter 2.4 times that of the wire ' A ', the elongation in the wire ' B ' will be (wires having uniform circular cross sections)

JEE MAIN 2023 · 30 JAN · SHIFT 2

(a) $6.9 \times 10^{-2}\ \mathrm{mm}$ (b) $6.06 \times 10^{-2}\ \mathrm{mm}$
(c) $2.77 \times 10^{-2}\ \mathrm{mm}$ (d) $3.0 \times 10^{-2}\ \mathrm{mm}$

26. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force F, its length increases by $5\ \mathrm{cm}$. Another wire of the same material of length 4L and radius 4r is pulled by a force 4F under same conditions. The increase in length of this wire is _____ cm.

JEE MAIN 2022 · 25 JUL · SHIFT 1 *(Numerical)*

27. A uniform metallic wire is elongated by 0.04 m when subjected to a linear force F. The elongation, if its length and diameter is doubled and subjected to the same force will be _____ cm.

JEE MAIN 2021 · 24 FEB · SHIFT 2 *(Numerical)*

◆ Comparing different materials 5 Qs

28. The Young's modulus of steel is twice that of brass. Two wires of same length and of same area of cross section, one of steel and another of brass are suspended from the same roof. If we want the lower ends of the wires to be at the same level, then the weights added to the steel and brass wires must be in the ratio of

AIPMT 2015

(a) 4: 1 (b) 1: 1 (c) 1: 2 (d) 2: 1

29. Young's moduli of the material of wires A and B are in the ratio of $1:4$, while its area of cross sections are in the ratio of $1:3$. If the same amount of load is applied to both the wires, the amount of elongation produced in the wires A and B will be in the ratio of
[Assume length of wires A and B are same]

JEE MAIN 2023 · 10 APR · SHIFT 2

(a) 1: 12 (b) 1: 36 (c) 12: 1 (d) 36: 1

30. The Young's modulus of a steel wire of length $6\ \mathrm{m}$ and cross-sectional area $3\ \mathrm{mm}^2$, is $2 \times 10^{11}\ \mathrm{N/m^2}$. The wire is suspended from its support on a given planet. A block of mass $4\ \mathrm{kg}$ is attached to the free end of the wire. The acceleration due to gravity on the planet is $\frac{1}{4}$ of its value on the earth. The elongation of wire is (Take g on the earth $= 10\ \mathrm{m/s^2}$):

JEE MAIN 2023 · 1 FEB · SHIFT 2

(a) 0.1 cm (b) 1 cm (c) 0.1 mm (d) 1 mm

31. Under the same load, wire A having length $5.0\ \mathrm{m}$ and cross section $2.5 \times 10^{-5}\ \mathrm{m^2}$ stretches uniformly by the same amount as another wire B of length $6.0\ \mathrm{m}$ and a cross section of $3.0 \times 10^{-5}\ \mathrm{m^2}$ stretches. The ratio of the Young's modulus of wire A to that of wire B will be:

JEE MAIN 2023 · 31 JAN · SHIFT 2

(a) 1 : 2 (b) 1 : 4 (c) 1 : 1 (d) 1 : 10

32. The elongation of a wire on the surface of the earth is 10^{-4} m. The same wire of same dimensions is elongated by 6×10^{-5} m on another planet. The acceleration due to gravity on the planet will be _____ $\mathrm{ms^{-2}}$. (Take acceleration due to gravity on the surface of earth = 10 $\mathrm{ms^{-2}}$)

JEE MAIN 2022 · 26 JUN · SHIFT 1 *(Numerical)*

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TOPIC 03

Wire Combinations & Special Cases

1 PYQs · Easy 1 · Medium 0 · Difficult 0 | MHT CET 0 · NEET 0 · JEE 1

Concepts covered: Own weight, pulleys & sag (1)

LEVEL 1 · EASY 1 questions

33. Two persons pull a wire towards themselves. Each person exerts a force of $200\ \mathrm{N}$ on the wire. Young's modulus of the material of wire is $1 \times 10^{11}\ \mathrm{N\,m^{-2}}$. Original length of the wire is $2\ \mathrm{m}$ and the area of cross section is $2\ \mathrm{cm}^2$. The wire will extend in length by _____ μm.

JEE MAIN 2024 · 9 APR · SHIFT 1 *(Numerical)*

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TOPIC 04

Thermal Stress & Breaking Stress

5 PYQs · Easy 5 · Medium 0 · Difficult 0 | MHT CET 0 · NEET 1 · JEE 4

Concepts covered: Thermal stress (3) · Breaking stress & maximum load (2)

LEVEL 1 · EASY 5 questions

◆ Thermal stress 3 Qs

34. A metallic bar of Young's modulus, $0.5 \times 10^{11}\ \mathrm{N\,m^{-2}}$ and coefficient of linear thermal expansion $10^{-5}{}^{\circ}\mathrm{C}^{-1}$, length $1\ \mathrm{m}$ and area of cross-section $10^{-3}\ \mathrm{m}^2$ is heated from $0^{\circ}\mathrm{C}$ to $100^{\circ}\mathrm{C}$ without expansion or bending. The compressive force developed in it is:

NEET 2024

(a) $5 \times 10^3\ \mathrm{N}$ (b) $50 \times 10^3\ \mathrm{N}$
(c) $100 \times 10^3\ \mathrm{N}$ (d) $2 \times 10^3\ \mathrm{N}$

35. The pressure that has to be applied to the ends of a steel wire of length $10\ cm$ to keep its length constant when its temperature is raised by $100^{\circ}C$ is: (For steel Young's modulus is $2 \times 10^{11}\ Nm^{-2}$ and coefficient of thermal expansion is $1.1 \times 10^{-5}\ K^{-1}$)

JEE MAIN 2014

(a) $2.2 \times 10^8\ Pa$ (b) $2.2 \times 10^9\ Pa$
(c) $2.2 \times 10^7\ Pa$ (d) $2.2 \times 10^6\ Pa$

36. A steel rod with $\mathrm{y} = 2.0 \times 10^{11}\ \mathrm{Nm^{-2}}$ and $\alpha = 10^{-5}\ {}^{\circ}\mathrm{C}^{-1}$ of length 4 m and area of cross-section 10 cm^2 is heated from 0° C to 400°C without being allowed to extend. The tension produced in the rod is $\mathrm{x} \times 10^5$ N where the value of x is _____.

JEE MAIN 2021 · 1 SEP · SHIFT 2 *(Numerical)*

◆ Breaking stress & maximum load 2 Qs

37. The area of cross section of the rope used to lift a load by a crane is $2.5 \times 10^{-4}\ \mathrm{m}^2$. The maximum lifting capacity of the crane is 10 metric tons. To increase the lifting capacity of the crane to 25 metric tons, the required area of cross section of the rope should be: (take $g = 10\ ms^{-2}$)

JEE MAIN 2022 · 26 JUL · SHIFT 2

(a) $6.25 \times 10^{-4}\ \mathrm{m}^2$ (b) $10 \times 10^{-4}\ \mathrm{m}^2$
(c) $1 \times 10^{-4}\ \mathrm{m}^2$ (d) $1.67 \times 10^{-4}\ \mathrm{m}^2$

38. The elastic limit of brass is 379 MPa. What should be the minimum diameter of a brass rod if it is to support a 400 N load without exceeding its elastic limit?

JEE MAIN 2019 · 10 APR · SHIFT 2

(a) 1.16 mm (b) 1.36 mm (c) 1.00 mm (d) 0.90 mm

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TOPIC 05

Elastic Potential Energy

8 PYQs · Easy 8 · Medium 0 · Difficult 0 | MHT CET 2 · NEET 2 · JEE 4

Concepts covered: Work done & energy stored (5) · Energy density (3)

LEVEL 1 · EASY 8 questions

◆ Work done & energy stored 5 Qs

39. A metal rod has length, cross-sectional area and Young's modulus as L, A and Y, respectively. If the elongation in the rod produced is ℓ, then work done is proportional to

MHT CET 2020 · 19 OCT · SHIFT 2

(a) ℓ^4 (b) ℓ (c) ℓ^3 (d) ℓ^2

40. A wire of length ' L ' and area of cross section ' A ' is made of material of Young's modulus ' r . It is stretched by an amount ' x '. The work done in stretching the wire is

MHT CET 2019 · 2 MAY · SHIFT 2

(a) $\frac{Yx^2A}{2L}$ (b) $\frac{2Yx^2A}{L}$ (c) $\frac{Y\times A}{2L}$ (d) $\frac{Yx^2A}{2}$

41. When a block of mass M is suspended by a long wire of length L, the length of the wire becomes (L + l). The elastic potential energy stored in the extended wire is:

NEET 2019

(a) Mgl (b) mgL (c) $\frac{1}{2}$ Mgl (d) $\frac{1}{2}$ MgL

42. A wire fixed at the upper end stretches by length l by applying a force F. The work done in stretching is

AIEEE 2004

(a) $2Fl$ (b) Fl (c) $\frac{F}{2l}$ (d) $\frac{Fl}{2}$

43. A wire suspended vertically from one of its ends is stretched by attaching a weight of $200N$ to the lower end. The weight stretches the wire by $1\ mm$. Then the elastic energy stored in the wire is

AIEEE 2003

(a) $0.2\ J$ (b) $10\ J$ (c) $20\ J$ (d) $0.1\ J$

◆ Energy density 3 Qs

44. The amount of elastic potential energy per unit volume (in SI unit) of a steel wire of length $100\ \text{cm}$ to stretch it by $1\ \text{mm}$ is (if Young's modulus of the wire $= 2.0 \times 10^{11}\text{Nm}^{-2}$):

NEET 2023

(a) 10^{11} (b) 10^{17} (c) 10^{7} (d) 10^{5}

45. An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10}\ \text{N/m}^2$ undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is:

JEE MAIN 2023 · 8 APR · SHIFT 1

(a) 5600 (b) 2800 (c) 11200 (d) 8400

46. If S is stress and Y is young's modulus of material of a wire, the energy stored in the wire per unit volume is

AIEEE 2005

(a) $\frac{S^2}{2Y}$ (b) $2S^2Y$ (c) $\frac{S}{2Y}$ (d) $\frac{2Y}{S^2}$

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TOPIC 06

Bulk Modulus & Compressibility

7 PYQs · Easy 7 · Medium 0 · Difficult 0 | MHT CET 1 · NEET 0 · JEE 6

Concepts covered: Bulk modulus & compressibility (7)

LEVEL 1 · EASY 7 questions

47. The compressibility of water is $5 \times 10^{-10}\ \mathrm{m^2/N}$. Pressure of 15×10^6 Pa is applied on 100 mL volume of water. The change in the volume of water is

MHT CET 2020 · 19 OCT · SHIFT 2

(a) zero (b) 0.75 mL decrease
(c) 0.75 mL increase (d) 1.50 mL increase

48. The increase in the pressure required to decrease the volume (ΔV) of water is $6.3 \times 10^7\ \mathrm{N/m^2}$. The percentage decrease in the volume is ____.
(Bulk modulus of water $= 2.1 \times 10^9\ \mathrm{N/m^2}$.)

JEE MAIN 2026 · 4 APR · SHIFT 1

(a) 2 % (b) 3 % (c) 6 % (d) 4 %

49. Under isothermal condition, the pressure of a gas is given by $\mathrm{P} = a\,\mathrm{V}^{-3}$, where a is a constant and V is the volume of the gas. The bulk modulus at constant temperature is equal to

JEE MAIN 2023 · 13 APR · SHIFT 1

(a) $\frac{P}{2}$ (b) 2 P (c) 3 P (d) P

50. The bulk modulus of a liquid is $3 \times 10^{10}\ \mathrm{Nm^{-2}}$. The pressure required to reduce the volume of liquid by 2% is:

JEE MAIN 2022 · 24 JUN · SHIFT 1

(a) $3 \times 10^8\ \mathrm{Nm^{-2}}$ (b) $9 \times 10^8\ \mathrm{Nm^{-2}}$
(c) $6 \times 10^8\ \mathrm{Nm^{-2}}$ (d) $12 \times 10^8\ \mathrm{Nm^{-2}}$

51. The Bulk moduli of Ethanol, Mercury and water are given as 0.9, 25 and 2.2 respectively in units of $10^9\ \mathrm{Nm^{-2}}$. For a given value of pressure, the fractional compression in volume is $\frac{\Delta V}{V}$. Which of the following statements about $\frac{\Delta V}{V}$ for these three liquids is correct?

JEE MAIN 2014 · 11 APR · SHIFT 1

(a) Ethanol > Water > Mercury
(b) Water > Ethanol > Mercury
(c) Mercury > Ethanol > Water
(d) Ethanol > Mercury > Water

52. The volume contraction of a solid copper cube of edge length 10 cm, when subjected to a hydraulic pressure of 7×10^6 Pa, would be _____ $\mathrm{mm^3}$.
(Given bulk modulus of copper $= 1.4 \times 10^{11}\ \mathrm{N\,m^{-2}}$)

JEE MAIN 2025 · 28 JAN · SHIFT 2 *(Numerical)*

53. The increase in pressure required to decrease the volume of a water sample by 0.2% is $\mathrm{P} \times 10^5\ \mathrm{Nm^{-2}}$. Bulk modulus of water is $2.15 \times 10^9\ \mathrm{Nm^{-2}}$. The value of P is _____.

JEE MAIN 2025 · 24 JAN · SHIFT 2 *(Numerical)*

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TOPIC 07

Shear Modulus & Poisson's Ratio

7 PYQs · Easy 7 · Medium 0 · Difficult 0 | MHT CET 1 · NEET 1 · JEE 5

Concepts covered: Shear modulus (2) · Poisson's ratio (2) · Relations between elastic constants (3)

LEVEL 1 · EASY 7 questions

◆ Shear modulus 2 Qs

54. A cube has side length 5 cm and modulus of rigidity $10^5\ \mathrm{N/m^2}$. The displacement produced by a force of 10 N in the upper face of cube is ____ mm.

JEE MAIN 2026 · 5 APR · SHIFT 1 *(Numerical)*

55. A square aluminum (shear modulus is $25 \times 10^9\ \mathrm{Nm^{-2}}$) slab of side 60 cm and thickness 15 cm is subjected to a shearing force (on its narrow face) of 18.0×10^4 N. The lower edge is riveted to the floor. The displacement of the upper edge is _____ μm.

JEE MAIN 2022 · 27 JUL · SHIFT 1 *(Numerical)*

◆ Poisson's ratio 2 Qs

56. For homogeneous isotropic material, which one of the following cannot be the value of Poisson's ratio?

MHT CET 2019 · 3 MAY · SHIFT 1

(a) 0.1 (b) – 1 (c) 0.5 (d) 0.8

57. Match List I with List II:

List I		List II	
A.	Young's Modulus	I.	$\frac{\Delta d}{\Delta L}\left(\frac{L}{d}\right)$
B.	Compressibility	II.	$\frac{FL}{A(\Delta L)}$
C.	Bulk Modulus	III.	$-\frac{1}{\Delta P}\left(\frac{\Delta V}{V}\right)$
D.	Poisson's Ratio	IV.	$-P\left(\frac{V}{\Delta V}\right)$

Choose the correct answer from the options given below:

NEET 2026

(a) A-IV, B-I, C-II, D-III
(b) A-III, B-II, C-I, D-IV
(c) A-I, B-IV, C-III, D-II
(d) A-II, B-III, C-IV, D-I

◆ Relations between elastic constants 3 Qs

58. Choose the correct relationship between Poisson ratio (σ), bulk modulus (K) and modulus of rigidity (η) of a given solid object:

JEE MAIN 2023 · 30 JAN · SHIFT 1

(a) $\sigma = \frac{3K+2\eta}{6K+2\eta}$ (b) $\sigma = \frac{3K-2\eta}{6K+2\eta}$
(c) $\sigma = \frac{6K+2\eta}{3K-2\eta}$ (d) $\sigma = \frac{6K-2\eta}{3K-2\eta}$

59. If Y, K and η are the values of Young's modulus, bulk modulus and modulus of rigidity of any material respectively. Choose the correct relation for these parameters.

JEE MAIN 2021 · 24 FEB · SHIFT 1

(a) $Y = \frac{9K\eta}{3K-\eta} N/m^2$ (b) $Y = \frac{9K\eta}{2\eta+3K} N/m^2$
(c) $\eta = \frac{3YK}{9K+Y} N/m^2$ (d) $K = \frac{Y\eta}{9\eta-3Y} N/m^2$

60. In materials like aluminium and copper, the correct order of magnitude of various elastic moduli is:

JEE MAIN 2014 · 9 APR · SHIFT 1

(a) Young's moduli < shear moduli < bulk moduli.
(b) Bulk moduli < shear moduli < Young's moduli.
(c) Shear moduli < Young's moduli < bulk moduli.
(d) Bulk moduli < Young's moduli < shear moduli

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ANSWER KEY

Shaded by level: **Easy**

01 Elastic Behaviour, Stress & Strain

1. (b)	2. (c)	3. (c)	4. (a)	5. (d)	6. (a)	7. (a)	8. 11	9. 25	10. (c)
11. (d)									

02 Young's Modulus & Elongation

12. (c)	13. (c)	14. (d)	15. (d)	16. (b)	17. (b)	18. (a)	19. (c)	20. (d)	21. (c)
22. (b)	23. (a)	24. (c)	25. (a)	26. 5	27. 2	28. (d)	29. (c)	30. (c)	31. (c)
32. 6									

03 Wire Combinations & Special Cases

33. 20									

04 Thermal Stress & Breaking Stress

34. (b)	35. (a)	36. 8	37. (a)	38. (a)					

05 Elastic Potential Energy

39. (d)	40. (a)	41. (c)	42. (d)	43. (d)	44. (d)	45. (a)	46. (a)		

06 Bulk Modulus & Compressibility

47. (b)	48. (b)	49. (c)	50. (c)	51. (a)	52. 50	53. 43			

07 Shear Modulus & Poisson's Ratio

54. 2	55. 48	56. (d)	57. (d)	58. (b)	59. (d)	60. (c)			

Note: *"Bonus" = no option is correct as the question is printed (dropped in the official key). Numerical questions show the numerical answer.*

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