10 Mechanical Properties of Solids

JEE-Main

T1 Strain, Stress, Young's Modulus of Elasticity

1. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R) **[27 Jan, 2024 (Shift-II)]**

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:

(*a*) (A) is false but (R) is true
(*b*) (A) is true but (R) is false
(*c*) Both (A) and (R) are true and (R) is the correct explanation (A)
(*d*) Both (A) and (R) are true but (R) is not the correct explanation of (A)

2. 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. **[29 Jan, 2024 (Shift-II)]**

(*a*) 3 times (*b*) 3/2 times (*c*) 4 times (*d*) 2 times

3. Two metallic wires P and Q have same volume and are made up of same material. If their area of cross sections are in the ratio 4 : 1 and force F_1 is applied to P, an extension of Δl is produced. The force which is required to produce same extension in Q is F_2.

[29 Jan, 2024 (Shift-II)]

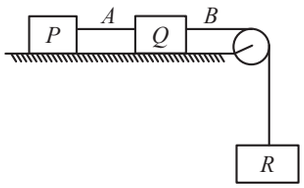
The value of $\frac{F_1}{F_2}$ is: _____ .

4. Young's modules 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 modules will be: **[30 Jan, 2024 (Shift-I)]**

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

5. Each of three blocks *P*, *Q* and *R* shown in figure has a mass of 3 kg. Each of the wire *A* and *B* has cross-sectional area 0.005 cm^2 and Young's modulus 2×10^{11} N m^{-2}. Neglecting friction, the longitudinal strain on wire *B* is _____ $\times 10^{-4}$.

(Take $g = 10$ m/s^2) **[30 Jan, 2024 (Shift-I)]**



6. A solid circular disc of mass 50 kg rolls along a horizontal floor so that its center of mass has a speed of 0.4 m/s. The absolute value of work done on the disc to stop it is _____ J.

[31 Jan, 2024 (Shift-I)]

7. One end of a metal wire is fixed to a ceiling and a load of 2 kg hangs from the other end. A similar wire is attached to the bottom of the load and another load of 1 kg hangs from this lower wire. Then the ratio of longitudinal strain of upper wire to that of the lower wire will be ___.

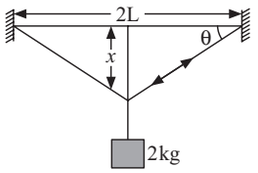
[Area of cross section of wire 0.005 cm^2, $Y = 2 \times 10^{11}$ Nm^{-2} and $g = 10$ ms^{-2}] **[1 Feb, 2024 (Shift-II)]**

8. An elastic spring under tension of 3 *N* has a length *a*. Its length is *b* under tension 2 *N*. For its length $(3a - 2b)$, the value of tension will be _____ *N*. **[04 April, 2024 (Shift-I)]**

9. The density and breaking stress of a wire are 6×10^4 kg/m^3 and 1.2×10^8 N/m^2 respectively. The wire is suspended from a rigid support on a planet where acceleration due to gravity is $1^{rd}/3$ of the value on the surface of earth. The maximum length of the wire with breaking is _____ *m* (take, $g = 10$ m/s^2) **[05 April, 2024 (Shift-I)]**

10. A wire of cross sectional area *A*, modulus of elasticity 2×10^{11} Nm^{-2} and length 2 m is stretched between two vertical rigid supports. When a mass of 2 kg is suspended at the middle it sags lower from its original position making angle $\theta = 1/100$ radian on the points of support. The value of *A* is _____ $\times 10^{-4}$ m^2 (consider $x << L$).

(given : $g = 10$ m/s^2) **[06 April, 2024 (Shift-II)]**



11. Two persons pull a wire towards themselves. Each person exerts a force of 200 N on the wire. Young's modulus of the material of wire is 1×10^{11} N m^{-2}. Original length of the wire is 2 m and the area of cross section is 2 cm^2. The wire will extend in length by _____ μm. **[09 April, 2024 (Shift-I)]**

12. A 100 *m* long wire having cross-sectional area $6.25 \times 10^{-4} m^2$ and Young's modulus is $10^{10}\ Nm^{-2}$ is subjected to a load of 250 *N*, then the elongation in the wire will be: **[24 Jan, 2023 (Shift-I)]**

(*a*) 6.25×10^{-3} m (*b*) 4×10^{-4} m

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

13. 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 **[24 Jan, 2023 (Shift-II)]**

(*a*) Both *A* and *R* are correct but *R* is NOT the correct explanation of *A*

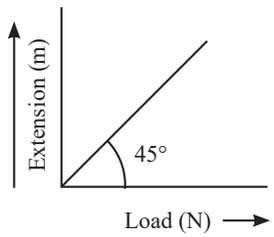
(*b*) *A* is not correct but *R* is correct

(*c*) Both *A* and *R* are correct and *R* is the correct explanation of *A*

(*d*) *A* is correct but *R* is not correct

14. As shown in the figure, in an experiment to determine Young's modulus of a wire, the extension-load curve is plotted. The curve is a straight line passing through the origin and makes an angle of 45º with the load axis. The length of the wire is 62.8 cm and its diameter is 4 mm. The Young's modulus is found to be $x \times 10^4\ Nm^{-2}$.

The value of *x* is_____ **[25 Jan, 2023 (Shift-I)]**



15. A force is applied to a steel wire 'A', rigidly clamped at one end. As a result elongation in the wire is 0.2 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) **[30 Jan, 2023 (Shift-II)]**

(*a*) 6.06×10^{-2} mm (*b*) 2.77×10^{-2} mm

(*c*) 3.0×10^{-2} mm (*d*) 6.9×10^{-2} mm

16. Under the same load, wire A having length 5.0 m and cross section $2.5 \times 10^{-5}\ m^2$ stretches uniformly by the same amount as another wire *B* of length 6.0 m and a cross section of $3.0 \times 10^{-5}\ m^2$ stretches. The ratio of the Young's modulus of wire *A* to that of wire *B* will be: **[31 Jan, 2023 (Shift-II)]**

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

17. The Young's modulus of a steel wire of length 6 *m* and cross-sectional area 3 mm^2, is $2 \times 11^{11}\ N/m^2$. The wire is suspended from its support on a given planet. A block of mass 4 *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 m/s^2) **[1 Feb, 2023 (Shift-II)]**

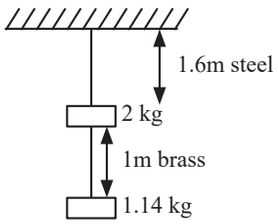
(*a*) 1 *cm* (*b*) 1 *mm* (*c*) 0.1 *mm* (*d*) 0.1 *cm*

18. A steel rod has a radius of 20 mm and a length of 20m. A force of 62.8 kN stretches it along its length. Young's modulus of steel is $2.0 \times 10^{11}\ N/m^2$. The longitudinal strain produced in the wire is ____ $\times 10^{-5}$ **[06 April, 2023 (Shift-I)]**

19. 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 $7 \times 10^5\ Nm^{-2}$. The value of mass *m* is _____ kg.

(Take, g = 9.8 ms^{-2} and $\pi = \frac{22}{7}$) **[6 April, 2023 (Shift-II)]**

20. Two wires each of radius 0.2 cm and negligible mass, one made of steel and other made of brass are loaded as shown in the figure. The elongation of the steel wire is ___ $\times 10^{-6}$ m. [Young's modulus for steel = $2 \times 10^{11}\ Nm^{-2}$ and g = 10 ms^{-2}] **[10 April, 2023 (Shift-I)]**



21. 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]

[10 April, 2023 (Shift-II)]

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

22. The length of wire becomes l_1 and l_2 when 100 N and 120 N tensions are applied respectively. If $10\ l_2 = 11\ l_1$, the natural length of wire will be $\frac{1}{x} l_1$. Here the value of *x* is _____. **[11 April, 2023 (Shift-I)]**

23. 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*L*' and radius '2*r*' is pulled by a force '2*f*' Then the increase in its length will be : **[15 April, 2023 (Shift-I)]**

(*a*) 2ℓ (*b*) ℓ (*c*) 4ℓ (*d*) $\ell/2$

24. 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 _____ms^{-2}. (Take acceleration due to gravity on the surface of earth = 10 ms^{-2}) **[26 June, 2022 (Shift-I)]**

25. A wire of length *L* is hanging from a fixed support. The length changes to L_1 and L_2 when masses 1kg and 2kg are suspended respectively from its free end. Then the value of *L* is equal to:

[29 June, 2022 (Shift-I)]

(*a*) $\sqrt{L_1 L_2}$ (*b*) $\frac{L_1 + L_2}{2}$

(*c*) $2L_1 - L_2$ (*d*) $3L_1 - 2L_2$

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 5cm. Another wire of the same material of length 4*L* and radius 4*r* pulled by a force 4*F* under same conditions. The increase in length of this wire is _____ cm. **[25 July, 2022 (Shift-I)]**

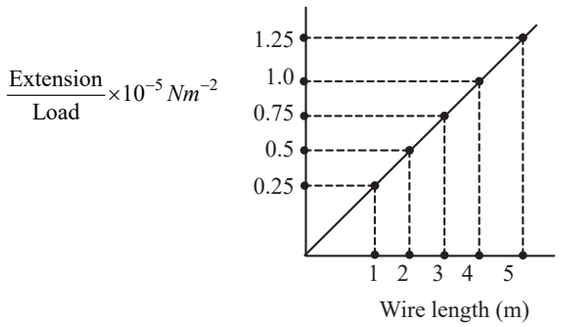
27. A uniform heavy rod of mass 20 kg, cross sectional area 0.4 m^2 and length 20 m is hanging from a fixed support. Neglecting the lateral contraction, the elongation in the rod due to its own weight is $x \times 10^{-9}$ m. The value of x is _____: (Given. Young's modulus $Y = 2 \times 10^{11}$ Nm^{-2} and $g = 10$ ms^{-2}) **[26 July, 2022 (Shift-II)]**

28. The area of cross section of the rope used to lift a load by a crane is 2.5×10^{-4} 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}) **[26 July, 2022 (Shift-II)]**

(*a*) 6.25×10^{-4} m^2 (*b*) 10×10^{-4} m^2

(*c*) 1×10^{-4} m^2 (*d*) 1.67×10^{-4} m^2

29. In an experiment to determine the Young's modulus, steel wires of five different lengths (1, 2, 3, 4, and 5m) but of same cross section (2 mm^2) were taken and curves between extension and load were obtained. The slope (extension / load) of the curves were plotted with the wire length and the following graph is obtained. If the Young's modulus of given steel wires is $x \times 10^{11}$ Nm^{-2}, then the value of x is _____. **[27 July, 2022 (Shift-II)]**



30. 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 = 2×10^{11} N/m^2) **[28 July, 2022 (Shift-I)]**

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

31. A string of area of cross – section 4 mm^2 and length 0.5 m is connected with a rigid body of mass 2 kg. The body is rotated in a vertical circular path of radius 0.5 m. The body acquires a speed of 5 m/s at the bottom of the circular path. Strain produced in the string when the body is at bottom of the circle is _____ $\times 10^{-5}$.

(use Young's modulus 10^{11}N /m^2 and $g = 10$ m/s^2) **[28 July, 2022 (Shift-II)]**

32. 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 wire will: **[29 July, 2022 (Shift-I)]**

(A) remain same

(B) become 8 times its initial value

(C) become $\frac{1}{4}^{th}$ of its initial value

(D) become 4 times its initial value

(*a*) 2×10^{-9} m (*b*) 5×10^{-10} m

(*c*) 4×10^{-8} m (*d*) 5×10^{-8} m

33. If *Y, K* and η are the value of Young's moduls, bulk modulus of rigidity of any material respectively. Choose the correct relation for these parameters **[24 Feb, 2021 (Shift-I)]**

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

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

34. 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. **[24 Feb, 2021 (Shift-II)]**

35. The length of metallic wire is ℓ_1 when tension in it is T_1. It is ℓ_2 when the tension is T_2. The original length of the wire will be: **[26 Feb, 2021 (Shift-II)]**

(*a*) $\frac{T_2\ell_1 + T_1\ell_2}{T_1 + T_2}$ (*b*) $\frac{T_1\ell_1 - T_2\ell_2}{T_2 - T_1}$

(*c*) $\frac{T_2\ell_1 - T_1\ell_2}{T_2 - T_1}$ (*d*) $\frac{\ell_1 + \ell_2}{2}$

36. Two separate wires *A* and *B* are stretched by 2 mm and 4 mm respectively, when they are subjected to a force of 2*N*. Assume that both the wires are made up of same material and the radius of wire *B* is 4 times that of the radius of wire *A*. The length of the wires *A* and *B* are in the ratio of *a* : *b*. Then *a*/*b* can be expressed as 1/*x* where *x* is _____. **[18 March, 2021 (Shift-I)]**

37. The value of tension in a long thin metal wire has been changed from T_1 to T_2. The lengths of the metal wire at two different values of tension T_1 and T_2 are ℓ_1 and ℓ_2 respectively. The actual length of the metal wire is: **[20 July, 2021 (Shift-I)]**

(*a*) $\frac{T_1\ell_2 - T_2\ell_1}{T_1 - T_2}$ (*b*) $\sqrt{T_1T_2\ell_1\ell_2}$

(*c*) $\frac{\ell_1 + \ell_2}{2}$ (*d*) $\frac{T_1\ell_1 - T_2\ell_2}{T_1 - T_2}$

38. The length of a metal wire is ℓ_1, when the tension in it is T_1 and is ℓ_2 when the tension is T_2. The natural length of the wire is: **[20 July, 2021 (Shift-II)]**

(*a*) $\sqrt{\ell_1\ell_2}$ (*b*) $\frac{\ell_1 + \ell_2}{2}$

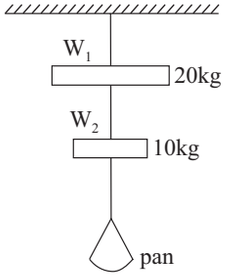
(*c*) $\frac{\ell_1T_2 - \ell_2T_1}{T_2 - T_1}$ (*d*) $\frac{\ell_1T_2 + \ell_2T_1}{T_2 + T_1}$

39. Two wires of same length and radius are joined end to end and loaded. The Young's modulii of the materials of the two wires are Y_1 and Y_2. The combination behaves as a single wire then its Young's modulus is: **[25 July, 2021 (Shift-I)]**

(*a*) $Y = \frac{Y_1Y_2}{2(Y_1 + Y_2)}$ (*b*) $Y = \frac{2Y_1Y_2}{3(Y_1 + Y_2)}$

(*c*) $Y = \frac{Y_1Y_2}{Y_1 + Y_2}$ (*d*) $Y = \frac{2Y_1Y_2}{Y_1 + Y_2}$

40. Wires W_1 and W_2 are made of same material having the breaking stress of 1.25×10^9 N /m^2 . W_1 and W_2 have cross-sectional area of 8×10^{-7} m^2 and 4×10^{-7} m^2, respectively. Masses of 20 kg and 10 kg hang from them as shown in the figure. The maximum mass that can be placed in the pan without breaking the wires is ____ kg. (Use $g = 10$ m/s^2) **[27 Aug, 2021 (Shift-II)]**



41. A uniform heavy rod of weight 10 kg ms^{-2}, cross-sectional area 100 cm^2 and length 20 cm is hanging from a fixed support. Young modulus of the material of the rod is 2×10^{11} Nm^{-2}. Neglecting the lateral contraction, find the elongation of rod due to its own weight:
[31 Aug, 2021 (Shift-I)]

42. Four identical hollow cylindrical columns of mild steel support a big structure of mass 50×10^3 kg, The inner and outer radii of each column are 50 cm and 100 cm respectively. Assuming uniform local distribution, calculate the compression strain of each column.
[31 Aug, 2021 (Shift-II)]
[Use $Y = 2.0 \times 10^{11}$ Pa, $g = 9.8$ m/s^2]
(*a*) 3.60×10^{-8} (*b*) 2.60×10^{-7}
(*c*) 1.87×10^{-3} (*d*) 7.07×10^{-4}

43. Speed of a transverse wave on a straight wire (mass 6.0 g, length 60 cm and area of cross- section 1.0 mm^2) is 90 ms^{-1}. If the young's modulus of wire is 16×10^{11} Nm^{-2}, the extension of wire over its natural length is:
[7 Jan, 2020 (Shift-I)]
(*a*) 0.03 mm (*b*) 0.01 mm
(*c*) 0.02 mm (*d*) 0.04 mm

44. A rod of length L at room temperature and uniform area of cross section A, is made of a metal having coefficient of linear expansion $\alpha/^oC$. It is observed that an external compressive force F, is applied on each of its ends, prevents any change in the length of the rod, when it temperature rises by ΔT K. Young's modulus, Y, for this metal is:
[9 Jan, 2019 (Shift-I)]

(*a*) $\frac{F}{A\alpha\Delta T}$ (*b*) $\frac{F}{A\alpha(\Delta T - 273)}$

(*c*) $\frac{F}{2A\alpha\Delta T}$ (*d*) $\frac{2F}{A\alpha\Delta T}$

45. A load of mass M kg is suspended from a steel wire of length 2 m and radius 1.0 mm in Searle's apparatus experiment. The increase in length produced in the wire is 4.0 mm. Now the load is fully immersed in a liquid of relative density 2. The relative density of the material of load is 8. The new value of increase in length of the steel wire is:
[12 Jan, 2019 (Shift-II)]
(*a*) 3.0 mm (*b*) 4.0 mm (*c*) 5.0 mm (*d*) zero

46. A steel wire having a radius of 2.0 mm, carrying a load of 4 kg, is hanging from a ceiling. Given that $g = 3.1\ \pi$ ms^{-2}, what will be the tensile stress that would be developed in the wire?
[8 April, 2019 (Shift-I)]
(*a*) 4.8×10^6 Nm^{-2} (*b*) 5.2×10^6 Nm^{-2}
(*c*) 6.2×10^6 Nm^{-2} (*d*) 3.1×10^6 Nm^{-2}

47. Young's moduli of two wires A and B in the ratio 7 : 4. Wire A is 2 m long and has radius R. Wire B is 1.5 m long and has radius 2 mm. If the two wires stretch by the same length for a given load, then the value of R is close to
[8 April, 2019 (Shift-II)]
(*a*) 1.9 mm (*b*) 1.7 mm
(*c*) 1.5 mm (*d*) 1.3 mm

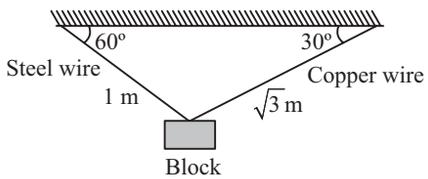
48. A boy's catapult is made of rubber cord which is 42 cm long, with 6 mm diameter of cross-section and of negligible mass. The boy keeps a stone weighing 0.02 kg on it and stretches the cord by 20 cm by applying a constant force. When released, the stone flies off with a velocity of 20 ms^{-1}. Neglect the change in the area of cross-section of the cord while stretched. The Young's modulus of rubber is closest to:
[8 April, 2019 (Shift-I)]
(*a*) 10^4 Nm^{-2} (*b*) 10^8 Nm^{-2}
(*c*) 10^6 Nm^{-2} (*d*) 10^3 Nm^{-2}

49. In an experiment, brass and steel wires of length 1 m each with areas of cross section 1 mm^2 are used. The wires are connected in series and one end of the combined wire is connected to a rigid support and other end is subjected to elongation. The stress required to produce a net elongation of 0.2 mm is:
[10 April, 2019 (Shift-II)]
(Given, the Young's Modulus for steel and brass are respectively, 120×10^9 N/m^2 and 60×10^9 N/m^2)
(*a*) 0.2×10^6 N/m^2 (*b*) 4.0×10^6 N/m^2
(*c*) 1.8×10^6 N/m^2 (*d*) 1.2×10^6 N/m^2

50. 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?
[10 April, 2019 (Shift-II)]
(*a*) 1.16 mm (*b*) 0.90 mm (*c*) 1.36 mm (*d*) 1.00 mm

51. A uniform cylindrical rod of length L and radius r, is made from a material whose Young's modulus of Elasticity equals Y. When this rod is heated by temperature T and simultaneously subjected to a net longitudinal compressional force F, its length remains unchanged. The coefficient of volume expansion, of the material of the rod, is (nearly) equals to:
[12 April, 2019 (Shift-II)]
(*a*) $9F/(\pi r^2 YT)$ (*b*) $F/(3\pi r^2 YT)$
(*c*) $3F/(\pi r^2 YT)$ (*d*) $6F/(\pi r^2 YT)$

52. A block of weight 100 N is suspended by copper and steel wires of same cross sectional area 0.5 cm^2 and, length $\sqrt{3}$ m and 1 m, respectively. Their other ends are fixed on a ceiling as shown in figure. The angles subtended by copper and steel wires with ceiling are 30° and 60°, respectively. If elongation in copper wire is (Δl_C) and elongation in steel wire is (Δl_S), then the ratio $\frac{\Delta \ell_C}{\Delta \ell_S}$ is _____. [Young's modulus for copper and steel are 1×10^{11} N/m^2 and 2×10^{11} N/m^2 respectively] **[JEE Adv, 2019]**



T2 Bulk Modulus, Shear Modulus, Elasticity Potential Energy

53. Match List-I with List-II:

	List-I		List-II
(A)	A force that restores an elastic body of unit area to its original state	(I)	Bulk modulus
(B)	Two equal and opposite forces parallel to opposite faces	(II)	Young's modulus
(C)	Forces perpendicular everywhere to the surface per unit area same everywhere	(III)	Stress
(D)	Two equal and opposite forces perpendicular to opposite faces	(IV)	Shear modulus

Choose the correct answer from the options given below:

[05 April, 2024 (Shift-II)]

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

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

[30 Jan, 2023 (Shift-I)]

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

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

55. A certain pressure '*P*' is applied to 1 litre of water and 2 litre of a liquid separately. Water gets compressed to 0.01% whereas the liquid gets compressed to 0.03%. The ratio of Bulk modulus of water to that of the liquid is $\frac{3}{x}$. The value of *x* is_____.

[01 Feb 2023 (Shift-I)]

56. An aluminium rod with Young's modulus $Y = 7.0 \times 10^{10}\ N/m^2$ undergoes elastic strain of 0.04%. The energy per unit volume stored in the rod in SI unit is: **[8 April, 2023 (Shift-I)]**

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

57. The elastic potential energy stored in a steel wire of length 20 m stretched through 2 cm is 80 J. The cross sectional area of the wire is _____ mm^2.

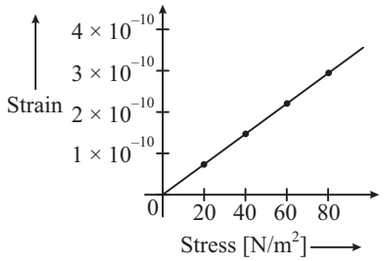
(Given, $y = 2.0 \times 10^{11}\ Nm^{-2}$) **[13 April, 2023 (Shift-I)]**

58. The bulk modulus of a liquid is $3 \times 10^{10} Nm^{-2}$. The pressure required to reduce the volume of liquid by 2% is: **[24 June, 2022 (Shift-I)]**

(*a*) $3 \times 10^8\ Nm^{-2}$ (*b*) $9 \times 10^8\ Nm^{-2}$

(*c*) $6 \times 10^8\ Nm^{-2}$ (*d*) $12 \times 10^8\ Nm^{-2}$

59. The elastic behaviour of material for linear stress and linear strain, is shown in the figure. The energy density for a linear strain of 5×10^{-4} is _____kJ/m^3. Assume that material is elastic upto the linear strain of 5×10^{-4}. **[26 June, 2022 (Shift-I)]**



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

[27 July, 2022 (Shift-I)]

61. The normal density of a material its ρ and its bulk modulus of elasticity is *K*. The magnitude of increase in density of material, when a pressure *P* is applied uniformly on all sides, will be :

[26 Feb, 2021 (Shift-I)]

(*a*) $\frac{K}{\rho P}$ (*b*) $\frac{PK}{\rho}$

(*c*) $\frac{\rho K}{P}$ (*d*) $\frac{\rho P}{K}$

62. An object is located at 2 km beneath the surface of the water. If the fractional compression $\frac{\Delta V}{V}$ is 1.36%, the ratio of hydraulic stress to the corresponding hydraulic strain will be [Given: density of water is $1000 kgm^{-3}$ and $g = 9.8\ ms^{-2}$.]

[17 March, 2021 (Shift-II)]

(*a*) $1.44 \times 10^7\ Nm^{-2}$ (*b*) $1.96\ 10^7\ Nm^{-2}$

(*c*) $2.26 \times 10^9\ Nm^{-2}$ (*d*) $1.44 \times 10^9\ Nm^{-2}$

63. A stone of mass 20 g is projected from a rubber catapult of length 0.1 m and area of cross section $10^{-6}\ m^2$ stretched by an amount 0.04 m. The velocity of the projected stone is _____ m /s. (Young's modulus of rubber = $0.5 \times 10^9\ N/m^2$) **[27 July, 2021 (Shift-I)]**

64. When a rubber ball is taken to a depth of _____m in deep sea, its volume decreases by 0.5%. (The bulk modulus of rubber = $9.8 \times 10^8\ Nm^{-2}$ and Density of sea water = $10^3\ kgm^{-3}$, $g = 9.8\ m/s^2$)

[31 Aug, 2021 (Shift-I)]

65. Two steel wires having same length are suspended from a ceiling under the same load. If the ratio of their energy stored per unit volume is 1 : 4, the ratio of their diameters is:

[9 Jan, 2020 (Shift-II)]

(*a*) 1 : 2 (*b*) $1 : \sqrt{2}$

(*c*) 2 : 1 (*d*) $\sqrt{2} : 1$

66. A cube of metal is subjected to a hydrostatic pressure of 4 GPa. The percentage change in the length of the side of the cube is close to (Given bulk modulus of metal, $B = 8 \times 10^{10}$ Pa)

[4 Sep, 2020 (Shift-II)]

(*a*) 0.6 (*b*) 20 (*c*) 1.67 (*d*) 5

JEE-Advanced

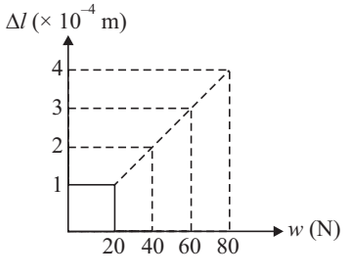
"Elastic Behaviour, Longitudinal Stress, Young Modulus"

Single Correct

1. One end of a horizontal thick copper wire of length $2L$ and radius $2R$ is welded to an end of another horizontal thin copper wire of length L and radius R. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is **C-48.69 W-48.19 UA-3.12 (JEE Adv. 2013)**

(a) 0.25 (b) 0.50 (c) 2.00 (d) 4.00

2. The adjacent graph shows the extension (Δl) of a wire of length 1m suspended from the top of a roof at one end and with a load w connected to the other end. If the cross-sectional area of the wire is 10^{-6} m^2, calculate from the graph the Young's modulus of the material of the wire. **(JEE Adv. 2003)**



(a) 2×10^{11} N/m^2 (b) 2×10^{-11} N/m^2

(c) 3×10^{12} N/m^2 (d) 2×10^{13} N/m^2

3. Two rods of different materials having coefficients of thermal expansion α_1, α_2 and Young's moduli Y_1, Y_2 respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of the rods. If $\alpha_1 : \alpha_2 = 2:3$, the thermal stresses developed in the two rods are equal provided $Y_1 : Y_2$ is equal to **(IIT-JEE 1989)**

(a) 2:3 (b) 1:1 (c) 3:2 (d) 4:9

4. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied? **(IIT-JEE 1981)**

(a) Length = 50 cm, diameter = 0.5 mm

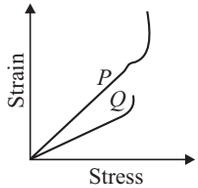
(b) Length = 100 cm, diameter = 1 mm

(c) Length = 200 cm, diameter = 2 mm

(d) Length = 300 cm, diameter = 3 mm

Multiple Correct

5. In plotting stress versus strain curves for two materials P and Q, a student by mistake puts strain on the Y-axis and stress on the X-axis as shown in the figure. Then the correct statement is/are **(JEE Adv. 2015)**



(a) P has more tensile strength than Q

(b) P is more ductile than Q

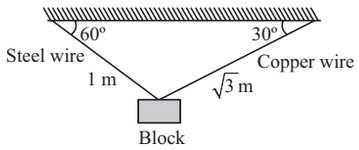
(c) P is more brittle than Q

(d) The Young's modulus of P is more than that of Q

Numerical Types/Integer Types

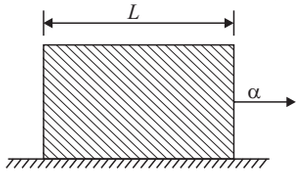
6. A block of weight 100 N is suspended by copper and steel wires of same cross sectional area 0.5 cm^2 and, length $\sqrt{3}$ m and 1 m, respectively. Their other ends are fixed on a ceiling as shown in figure. The angles subtended by copper and steel wires with ceiling are 30° and 60°, respectively. If elongation in copper wire is (Δl_c) and elongation in steel wire is (Δl_s), then the ratio $\frac{\Delta \ell_C}{\Delta \ell_S}$ is _____. [Young's modulus for copper and steel are 1×10^{11} N/m^2 and 2×10^{11} N/m^2 respectively]

C-34 W-48 UA-18 (JEE Adv. 2019)



Subjective

7. A uniform rod of length L and density ρ is being pulled along a smooth floor with a horizontal acceleration α (see figure).



The magnitude of the stress at the transverse cross-section through the mid-point of the rod is? **(IIT-JEE 1993)**

8. In Searle's experiment, which is used to find Young's modulus of elasticity, the diameter of the experimental wire is $D = 0.05$ cm (measured by a scale of least count 0.001 cm) and length is $L = 110$ cm (measured by a scale of least count 0.1 cm). A weight of 50 N causes an extension of $l = 0.125$ cm (measured by a micrometer of least count 0.001 cm). Find maximum possible error in the values of Young's modulus. Screw gauge and meter scale are free from error **(IIT-JEE 2004)**

"Pressure and Volumetric Strain, Bulk Modulus of Elasticity"

Single Correct

9. A given quantity of an ideal gas is at pressure p and absolute temperature T. The isothermal bulk modulus of the gas is **(IIT-JEE 1998)**

(a) 2/3 p (b) p (c) 3/2 p (d) 2p

10. The pressure of a medium is changed from $1.01 \times 10^5 Pa$ to $1.165 \times 10^5 Pa$ and change in volume is 10% keeping temperature constant. The bulk modulus of the medium is **(IIT-JEE 2005)**

(*a*) 204.8×10^5 Pa

(*b*) 102.4×10^5 Pa

(*c*) 51.2×10^5 Pa

(*d*) 1.55×10^5 Pa

11. When a block of iron floats in mercury at 0° C, fraction k_1 of its volume is submerged, while at the temperature 60° C, a fraction k_2 is seen to be submerged. If the coefficient of volume expansion of iron is γ_{Fe} and that of mercury is γ_{Hg}, then the ratio k_1/k_2 can be expressed as **(IIT-JEE 2001)**

(*a*) $(1 + 60\gamma_{Fe})/(1 + 60\gamma_{Hg})$

(*b*) $(1 - 60\gamma_{Fe})/(1 + 60\gamma_{Hg})$

(*c*) $(1 + 60\gamma_{Fe})/(1 - 60\gamma_{Hg})$

(*d*) $(1 + 60\gamma_{Hg})/(1 + 60\gamma_{Fe})$

Fill in the Blanks

12. A solid sphere of radius R made of a material of bulk modulus k is surrounded by a liquid in a cylindrical container. A massless piston of area A floats on the surface of the liquid. When a mass M is placed on the piston to compress the liquid the fractional change in the radius of the sphere, $\delta R/R$, is ..... **(IIT JEE 1998)**

13. A wire of length L and cross-sectional area A is made of a material of Young's modulus Y. If the wire is stretched by an amount x, the work done is _____. **(IIT-JEE 1987)**

Subjective

14. A thin rod of negligible mass and area of cross-section 4×10^{-6} m^2, suspended vertically from one end, has a length of 0.5 m at 100°C. The rod is cooled to 0°C, but prevented from contracting by attaching a mass at the lower end. Find **(IIT-JEE 1997)**

(*a*) This mass

(*b*) The energy stored in the rod, given for the rod. [Young's modulus = 10^{11} N/m^2, coefficient of linear expansion = 10^{-5} K^{-1} and g = 10 m/s^2].

ANSWER KEY

JEE-Main

1. (*c*)	**2.** (*d*)	**3.** [16]	**4.** (*c*)	**5.** [2]	**6.** [12]	**7.** [3]	**8.** [5]	**9.** [600]	**10.** [1]
11. [20]	**12.** (*d*)	**13.** (*c*)	**14.** [5]	**15.** (*d*)	**16.** (*b*)	**17.** (*c*)	**18.** [25]	**19.** [11]	**20.** [20]
21. (*b*)	**22.** [2]	**23.** (*b*)	**24.** [6]	**25.** (*c*)	**26.** [5]	**27.** [25]	**28.** (*a*)	**29.** [2]	**30.** (*a*)
31. [30]	**32.** (*a*)	**33.** (*b*)	**34.** [2]	**35.** (*c*)	**36.** [32]	**37.** (*a*)	**38.** (*c*)	**39.** (*d*)	**40.** [40]
41. (*b*)	**42.** (*b*)	**43.** (*a*)	**44.** (*a*)	**45.** (*a*)	**46.** (*d*)	**47.** (*b*)	**48.** (*c*)	**49.** (*)	**50.** (*a*)
51. (*c*)	**52.** [2]	**53.** (*c*)	**54.** (*a*)	**55.** [1]	**56.** (*a*)	**57.** [40]	**58.** (*c*)	**59.** [25]	**60.** [3]
61. (*d*)	**62.** (*d*)	**63.** [20]	**64.** [500]	**65.** (*d*)	**66.** (*c*)				

JEE-Advanced

1. (*c*)	**2.** (*a*)	**3.** (*c*)	**4.** (*a*)	**5.** (*a*, *b*)	**6.** [2]	**9.** (*b*)	**10.** (*d*)	**11.** (*a*)