CHAPTER 9

MECHANICAL PROPERTIES OF SOLIDS

FACT/DEFINITION TYPE QUESTIONS

1. The property of a body by virtue of which it tends to regain its original size and shape when the applied force is removed is called
(a) elasticity (b) plasticity
(c) rigidity (d) compressibility

2. Which of the following materials is most elastic?
(a) Steel (b) Rubber
(c) Copper (d) Glass

3. When forces are applied on a body such that it is still in static equilibrium, then the extent to which the body gets deformed, depends on
(a) nature of the material
(b) magnitude of deforming force
(c) Both (a) & (b)
(d) None of these

4. The restoring force per unit area is known as
(a) strain (b) elasticity
(c) stress (d) plasticity

5. In magnitude hydraulic stress is equal to
(a) hydraulic force (b) hydraulic pressure
(c) restoring force (d) hydraulic strain

6. Substances which can be stretched to cause large strains are called
(a) brittle (b) ductile
(c) plastic (d) elastomer

7. Shearing stress change _______ of the body.
(a) length (b) breadth
(c) shape (d) volume

8. The reason for the change in shape of a regular body is
(a) volume stress (b) shearing strain
(c) longitudinal strain (d) metallic strain

9. Shearing strain is expressed by
(a) angle of shear (b) angle of twist
(c) decrease in volume (d) increase in volume

10. Which of the following substance has the lowest elasticity?
(a) Steel (b) Copper
(c) Rubber (d) wood

11. Which of the following affects the elasticity of a substance?
(a) Hammering and annealing
(b) Change in temperature
(c) Impurity in substance
(d) All of the above

12. Which of the following is not a type of stress?
(a) Tensile stress (b) Compressive stsress
(c) Hydraulic stress (d) None of these

13. If the load is increased beyond the _______ point, the strain increases rapidly for even a small change in the stress.
(a) elastic point (b) yield point
(c) plastic point (d) fracture point

14. What is the phenomenon of temporary delay in regaining the original configuration by an elastic body, after the removel of a deforming force?
(a) Elastic fatigue (b) Elasticity
(c) Plasticity (d) Elastic after effect

15. Which of the following types of stress causes no chang in shape?
(a) Compressive stress (b) Hydraulic stress
(c) Shearing stress (d) None of these

16. Which of the following elastic moduli is used to describe the elastic behaviour of object as they respond to the deforming forces acting on them?
(a) Young's modulus (b) Shear modulus
(c) Bulk modulus (d) All of these

17. If a mass M produces an elongation of ΔL in a wire of radius r and length L, then the young's modulus of the material of the wire is given by

(a) $Y = \dfrac{Mg}{(\pi r^2 \times \Delta L)}$ (b) $Y = \dfrac{Mg \times \Delta L}{(\pi r^2 \times L)}$

(c) $Y = \dfrac{Mg \times L}{(\pi r^2 \times \Delta L)}$ (d) $Y = \dfrac{M \times \Delta L}{(\pi r^2 \times L)}$

18. Which is relevant only for solids?
(a) Young's modulus (b) Shear modulus
(c) Bulk modulus (d) Both (a) & (b)

19. When a fluid compresses an object, then the Hooke's law is expressed as

(a) $F = kV$ (b) $P = \dfrac{\Delta V}{V}$

(c) $P = B\left(\dfrac{\Delta V}{V}\right)$ (d) $F = B\left(\dfrac{\Delta V}{V}\right)$

20. Which of the following is the correct relation? Y = Young's modulus & G = modulus of rigidity?
(a) $Y < G$ (b) $Y > G$
(c) $Y = G$ (d) None of these

21. The expression of force constant for a spring following Hooke's law is given by

(a) $k = \frac{ya}{\ell}$ (b) $k = \frac{ya}{\Delta\ell}$

(c) $k = \frac{ya\,\Delta\ell}{\ell}$ (d) $k = \frac{ya\,\ell}{\Delta\ell}$

22. How is modulus of rigidity related to young's modulus?

(a) $Y = \frac{G}{3}$ (b) $G = \frac{Y}{3}$

(c) $G = Y$ (d) $G = \frac{Y}{2}$

23. For an equal stretching force F, the young's modulus (Y_s) for steel and rubber (Y_r) are related as

(a) $Y_s = Y_r$ (b) $Y_s < Y_r$

(c) $Y_s > Yr$ (d) $Y_s \geq Y_r$

24. A 2 m long rod of radius 1 cm which is fixed from one end is given a twist of 0.8 radians. The shear strain developed will be

(a) 0.002 (b) 0.004 (c) 0.008 (d) 0.016

25. The isothermal bulk modulus of a gas at atmospheric pressure is

(a) 1 mm of Hg (b) 13.6 mm of Hg

(c) 1.013×10^5 N/m^2 (d) 2.026×10^5 N/m^2

26. Hooke's law states that

(a) stress is directly proportional to strain

(b) stress is inversely proportional to strain

(c) stress is equal to strain

(d) stress and strain are independent of each other

27. The ratio of stress and strain is called

(a) elastic limit (b) plastic deformation

(c) modulus of elasticity (d) tensile strength

28. The ratio of tensile stress to the longitudinal strain is defined as

(a) modulus of elasticity (b) Yong's modulus

(c) bulk modulus (d) None of these

29. The correct increasing order of coefficient of elasticity of Copper, Steel, Glass and Rubber is

(a) Steel, Rubber, Copper, Glass

(b) Rubber, Copper, Glass, Steel

(c) Rubber, Glass, Steel, Copper

(d) Rubber, Glass, Copper, Steel

30. If the length of a wire is reduced to half, then it can hold the

(a) half load (b) same load

(c) double load (d) one fourth load

31. The ratio of shearing stress to the corresponding shearing strain is called

(a) bulk modulus (b) Young's modulus

(c) modulus of rigidity (d) None of these

32. The Young's modulus of a perfectly rigid body is

(a) unity

(b) zero

(c) infinity

(d) some finite non-zero constant

33. The only elastic modulus that applies to fluids is

(a) Young's modulus (b) modulus of rigidity

(c) bulk modulus (d) shear modulus

34. The reciprocal of the bulk modulus is called

(a) modulus of rigidity (b) volume stress

(c) volume strain (d) compressibility

35. Modulus of rigidity of a liquid is

(a) constant (b) infinite

(c) zero (d) cannot be predicted

36. According to Hook's law of elasticity, if stress is increased, then the ratio of stress to strain

(a) becomes zero (b) remains constant

(c) decreases (d) increases

STATEMENT TYPE QUESTIONS

37. Which of the following statements are correct ?

I. Elastic fatigue is the property by virtue of which behavior becomes less elastic under the action of repeated alternating deforming forces.

II. Elasticity is the property due to which the body regains its original configuration, when deforming forces are removed.

III. Plasticity is the property due to which the regain in original shape is delayed after the removal of deforming forces.

(a) I and II (b) II and III

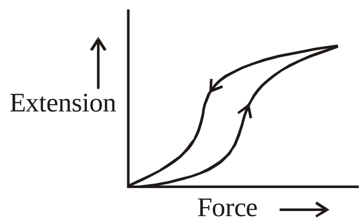
(c) I and III (d) I, II and III

38. The diagram shows a force - extension graph for a rubber band. Consider the following statements :

I. It will be easier to compress this rubber than expand it

II. Rubber does not return to its original length after it is stretched

III. The rubber band will get heated if it is stretched and released



Which of these can be deduced from the graph?

(a) III only (b) II and III

(c) I and III (d) I only

39. Which of the following statements is/are true?

I. Stress is not a vector quantity

II. Deforming force in one direction can produce strains in other directions also.

(a) I only (b) II only

(c) Both I and II (d) None of these

40. Which of the following is/are correct statement(s) about shearing strain?

I Shearing strain is produced by applying normal force.

II Shearing strain = tan θ

(a) I only (b) II only
(c) Both I and II (d) None of these

41. Consider the following statements and select the correct statements from the following.

I. A material which stretches to a lesser exent for a load is more elastic

II. A material which undergoes compression is most elastic

III. A material which stretches to greater extent is more elastic

(a) I and II (b) II and III
(c) I and III (d) I, II and III

42. Which of the following statements is/are true?

I. Water is more elastic than air

II. Modulus of elasticity is more for steel than that of copper.

III. Young's modulus of elasticity for a perfectly rigid body is infinte

(a) I only (b) II only
(c) I and II only (d) I, II and III

43. Consider the following statements and select the correct option.

I. Young's modulus for a perfectly rigid body is zero

II. Rubber is less elastic than steel

III. Bulk modulus is relevant for solids, liquids and gases

IV. The young's modulus and shear modulus are relevant for solids

(a) I only (b) II only
(c) III and IV (d) I, II, III and IV

44. Which of the following statements is/are wrong ?

I. Hollow shaft is much stronger than a solid rod of same length and same mass.

II. Reciprocal of bulk modulus of elasticity is called compressibility.

III. It is difficult to twist a long rod as compared to small rod.

(a) I and II (b) II and III
(c) III only (d) I only

45. Which of the following is/are false?

I Normal stress = force/area

II Young's modulus = $\frac{\text{force} \times \text{change in length}}{\text{area} \times \text{original length}}$

(a) I only (b) II only
(c) Both I and II (d) None of these

46. Select the correct statement(s) from the following.

I. Modulus of rigidity for a liquid is zero

II. Young's modulus of a material decreases with rise in temperature

III. Poisson's ratio is unitless

(a) I only (b) II only
(c) I and II (d) I, II and III

MATCHING TYPE QUESTIONS

47. Match the column - I and Column - II.

	Column I		**Column II**
(A)	Mud	(1)	Elastic
(B)	Steel	(2)	Elastomer
(C)	Rubber	(3)	Plastic
(D)	Copper	(4)	Compressible

(a) (A)→(2), (B)→(3), (C)→(4), (D)→(1)
(b) (A)→(3), (B)→(1), (C)→(2), (D)→(1)
(c) (A)→(1), (B)→(2), (C)→(3), (D)→(4)
(d) (A)→(2), (B)→ (1), (C)→(3), (D)→(4)

48.

	Column I		**Column II**
(A)	Young's modulus of elasticity	(1)	Rubber
(B)	Hooke's law	(2)	Solids
(C)	Hydraulic stress	(3)	Sraight line
(D)	Elastomers	(4)	Solids, liquids & gases

(a) (A)→(2), (B)→(3), (C)→(4), (D)→(1)
(b) (A)→(4), (B)→(2), (C)→(3), (D)→(1)
(c) (A)→(1), (B)→(2), (C)→(3), (D)→(4)
(d) (A)→(2), (B)→ (1), (C)→(3), (D)→(4)

49.

	Column -I		**Column-II**
(A)	Equal force acting perpendicular to each point on a spherical surface	(1)	Balance the net weight to be supported
(B)	Cross-sectional area of the rope used in giant structures	(2)	Higher modulus of elasticity
(C)	Steel in structural designs	(3)	Reduction in volume without change in shape
(D)	Stress-strain curve	(4)	Inversely depends on the yeild strength

(a) (A) → (4); (B) → (1, 3); (C) → (2) ; (D) → (1)
(b) (A) → (3); (B) → (1, 2); (C) → (4) ; (D) → (3, 4)
(c) (A) → (2); (B) → (1) ; (C) → (4) ; (D) → (3)
(d) (A) → (3); B → (1, 4) ; (C) → (2) ; (D) → (2)

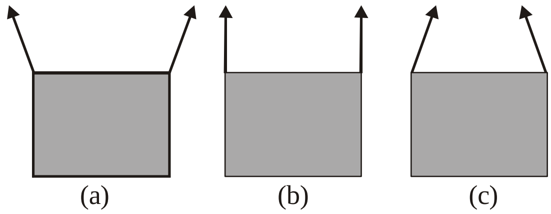
50. A copper wire ($Y = 10^{11}$ N/m^2) of length 8 m and steel wire ($Y = 2 \times 10^{11}$ N/m^2) of length 4 m each of 0.5 cm^2 cross-section are fastened end to end and stretched with a tension of 500 N.

	Column-I		**Column-II**
(A)	Elongation in copper wire in mm	(1)	0.25
(B)	Elongation in steel wire in mm	(2)	1.0
(C)	Total elongation in mm	(3)	0.8
(D)	Elastic potential energy of the system in joules	(4)	$\frac{1}{4}$ th the elongation in copper wire

(a) (A)→(3), (B)→(4), (C)→(2), (D)→(1)
(b) (A)→(4), (B)→(2), (C)→(3), (D)→(1)
(c) (A)→(1), (B)→(2), (C)→(3), (D)→(4)
(d) (A)→(2), (B)→ (1), (C)→(3), (D)→(4)

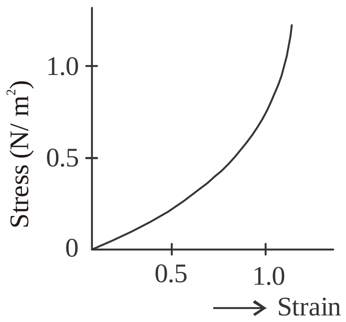
DIAGRAM TYPE QUESTIONS

51. A rectangular frame is to be suspended symmetrically by two strings of equal length on two supports . It can be done in one of the following three ways



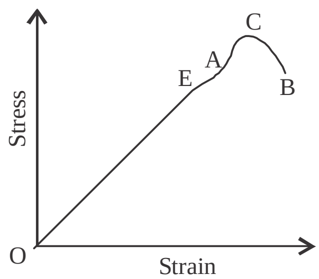
The tension in the strings will be
(a) the same in all cases
(b) least in (a)
(c) least in (b)
(d) least in (c)

52. The graph given is a stress-strain curve for



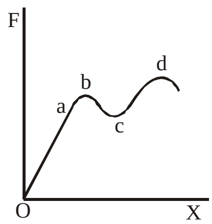
(a) elastic objects (b) plastics
(c) elastomers (d) None of these

53. For the given graph, Hooke's law is obeyed in the region



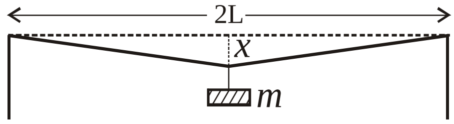
(a) OA (b) C
(c) OE (d) OB

54. The diagram shown below represents the applied forces per unit area with the corresponding change X (per unit length) produced in a thin wire of uniform cross section in the curve shown. The region in which the wire behaves like a liquid is



(a) ab (b) bc
(c) cd (d) Oa

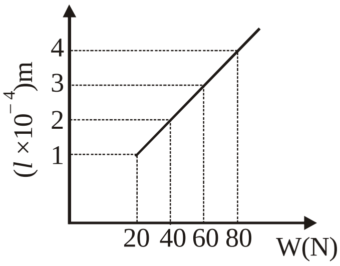
55. A mild steel wire of length 2L and cross-sectional area A is stretched, well within elastic limit, horizontally between two pillars. A mass m is suspended from the mid point of the wire. Strain in the wire is



(a) $\frac{x^2}{2L}$ (b) $\frac{x}{L}$

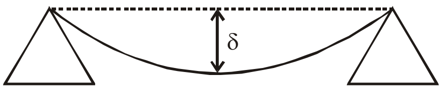
(c) $\frac{x^2}{L}$ (d) $\frac{x^2}{2L}$

56. The adjacent graph shows the extension (Δl) of a wire of length 1m suspended from the top of a roof at one end with a load W connected to the other end. if the corss-sectional area of the wire is 10^{-6}m^2, calculate the Young's modulus of the material of the wire



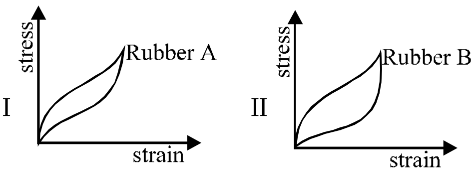
(a) 2×10^{11} N/m^2 (b) 2×10^{-11} N/m^2
(c) 2×10^{-12} N/m^2 (d) 2×10^{-13} N/m^2

57. A beam of metal supported at the two edges is loaded at the centre. The depression at the centre is proportional to



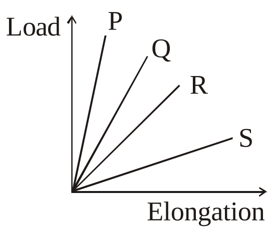
(a) Y^2 (b) Y (c) 1/Y (d) $1/Y^2$

58. Two different types of rubber are found to have the stress-strain curve as shown :
I. To absorb vibrations one would prefer rubber A
II. For manufacturing car tyre one would prefer B



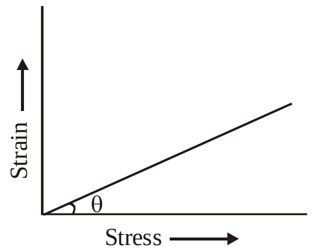
(a) I, II are true (b) I is true, II is false
(c) I is false, II is true (d) I, II are false

59. The load versus elongation graph for four wires is shown. The thinnest wire is



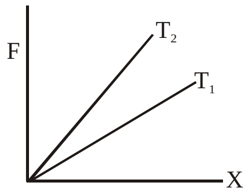
(a) *P* (b) *Q* (c) *R* (d) *S*

60. The value of tan (90° – θ) in the graph gives



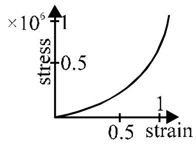
(a) Young's modulus of elasticity
(b) compressibility
(c) shear strain
(d) tensile strength

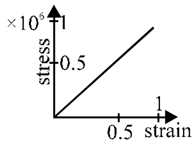
61. The diagram below shows the change in the length X of a thin uniform wire caused by the application of stress F at two different temperatures T_1 and T_2. The variation shown suggests that

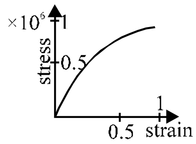


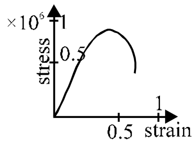
(a) $T_1 > T_2$
(b) $T_1 < T_2$
(c) $T_2 > T_1$
(d) $T_1 \geq T_2$

62. Stress vs strain curve for the elastic tissue of the aorta, the large tube (vessel) carrying blood from the heart, will be : [stress is proportional to square of the strain for the elastic tissue of the aorta]

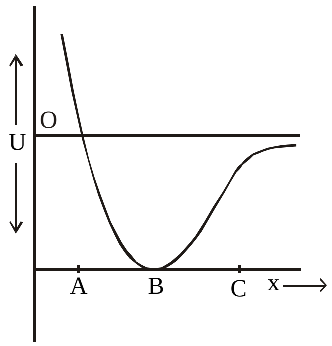
(a) 

(b) 

(c) 

(d) 

63. The potential energy U between two atoms in a diatomic molecules as a function of the distance x between atoms has been shown in the figure. The atoms are



(a) attracted when x lies between A and B and are repelled when x lies between B and C
(b) attracted when x lies between B and C and are repelled when x lies between A and B
(c) are attracted when they reach B from C
(d) are repelled when they reach B from A

ASSERTION- REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

64. **Assertion:** Solids are least compressible and gases are most compressible.
Reason: solids have definite shape and volume but gases do not have either definite shape or definite volume.

65. **Assertion:** Rubber is more elastic than lead
Reason: If same load is attached to lead and rubber, then the strain produced is much less in rubber than in lead.

66. **Assertion:** Hollow shaft is found to be stronger than a solid shaft made of same equal material.
Reason: Torque required to produce a given twist in hollow cylinder is greater than that required to twist a solid cylinder of same length and material.

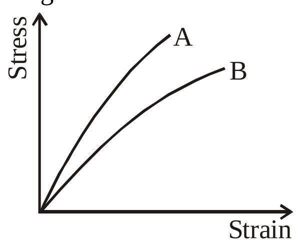
67. **Assertion :** Bulk modulus of elasticity (k) represents incompressibility of the material.
Reason : Bulk modulus of elasticity is proportional to change in pressure.

68. **Assertion :** Stress is the internal force per unit area of a body.
Reason : Rubber is less elastic than steel.

69. **Assertion :** Young's modulus for a perfectly plastic body is zero.
Reason : For a perfectly plastic body, restoring force is zero.

70. **Assertion :** Identical springs of steel and copper are equally stretched. More work will be done on the steel spring
Reason : Steel is more elastic than copper.

71. **Assertion :** The stress-strain graphs are shown in the figure for two materials A and B are shown in figure. Young's modulus of A is greater than that of B.



Reason : The Young's modules for small strain is,

$$Y = \frac{\text{stress}}{\text{strain}} = \text{slope of linear portion, of graph; and slope of}$$

A is more than slope that of B.

72. **Assertion :** Strain causes the stress in an elastic body.
Reason : An elastic rubber is more plastic in nature.

73. **Assertion:** Girders are given I shape.
Reason: To bear more pressure, depth is increased as per $P = h\rho g$

CRITICALTHINKING TYPE QUESTIONS

74. If the ratio of radii of two wires of same material is 2 : 1 and ratio of their lengths is 4 : 1, then the ratio of the normal forces that will produce the same extension in the length of two wires is
(a) $2:1$ (b) $4:1$
(c) $1:4$ (d) $1:1$

75. A and B are two wires. The radius of A is twice that of B. They are stretched by the same load. Then the stress on B is
(a) equal to that on A (b) four times that on A
(c) twice that on A (d) half that on A

76. An iron bar of length ℓ cm and cross section A cm^2 is pulled by a force of F dynes from ends so as to produce an elongation $\Delta\ell$ cm. Which of the following statement is correct ?
(a) Elongation is inversely proportional to length
(b) Elongation is directly proportional to cross section A
(c) Elongation is inversely proportional to cross-section
(d) Elongation is directly proportional to Young's modulus

77. Two wires of equal lengths are made of the same material. Wire A has a diameter that is twice as that of wire B. If identical weights are suspended from the ends of these wires, the increase in length is
(a) four times for wire A as for wire B
(b) twice for wire A as for wire B
(c) half for wire A as for wire B
(d) one-fourth for wire A as for wire B

78. A steel ring of radius r and cross-section area 'A' is fitted on to a wooden disc of radius R(R > r). If Young's modulus be E, then the force with which the steel ring is expanded is
(a) $AE\dfrac{R}{r}$ (b) $AE\left(\dfrac{R-r}{r}\right)$
(c) $\dfrac{E}{A}\left(\dfrac{R-r}{A}\right)$ (d) $\dfrac{Er}{AR}$

79. If a spring extends by x on loading, then the energy stored by the spring is (if T is tension in the spring and k is spring constant)
(a) $\dfrac{T^2}{2x}$ (b) $\dfrac{T^2}{2k}$ (c) $\dfrac{2x}{T^2}$ (d) $\dfrac{2T^2}{k}$

80. A steel wire of length 'L' at 40°C is suspended from the ceiling and then a mass 'm' is hung from its free end. The wire is cooled down from 40°C to 30°C to regain its original length 'L'. The coefficient of linear thermal expansion of the steel is 10^{-5}/° C, Young's modulus of steel is 10^{11} N/m^2 and radius of the wire is 1 mm. Assume that L >>diameter of the wire. Then the value of 'm' in kg is nearly
(a) 1 (b) 2 (c) 3 (d) 5

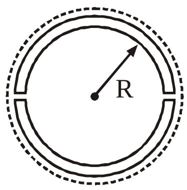
81. When a pressure of 100 atmosphere is applied on a spherical ball, then its volume reduces to 0.01%. The bulk modulus of the material of the rubber in dyne/cm^2 is
(a) 10×10^{12} (b) 100×10^{12}
(c) 1×10^{12} (d) 10×10^{12}

82. From a steel wire of density ρ is suspended a brass block of density ρ_b. The extension of steel wire comes to e. If the brass block is now fully immersed in a liquid of density ρ_l, the extension becomes e'. The ratio $\dfrac{e}{e'}$ will be
(a) $\dfrac{\rho_b}{\rho_b-\rho_l}$ (b) $\dfrac{\rho_b-\rho_l}{\rho_b}$
(c) $\dfrac{\rho_b-\rho}{\rho_l-\rho}$ (d) $\dfrac{\rho_l}{\rho_b-\rho_l}$

83. An iron rod of length 2m and cross-sectional area of 50 mm^2 stretched by 0.5 mm, when a mass of 250 kg is hung from its lower end. Young's modulus of iron rod is
(a) 19.6×10^{20} N / m^2 (b) 19.6×10^{18} N / m^2
(c) 19.6×10^{10} N / m^2 (d) 19.6×10^{15} N / m^2

84. What per cent of length of wire increases by applying a stress of 1 kg weight/mm^2 on it?
(Y = 1 × 10^{11} N/m^2 and 1 kg weight = 9.8 newton)
(a) 0.0067% (b) 0.0098%
(c) 0.0088% (d) 0.0078%

85. A wooden wheel of radius R is made of two semicircular parts (see figure). The two parts are held together by a ring made of a metal strip of cross-sectional area S and length L. L is slightly less than $2\pi R$. To fit the ring on the wheel, it is heated so that its temperature rises by ΔT and it just steps over the wheel. As it cools down to surrounding temperature, it presses the semicircular parts together. If the coefficient of linear expansion of the metal is α and its Young's modulus is Y, the force that one part of the wheel applies on the other part is



(a) $2\pi SY\alpha\Delta T$ (b) $SY\alpha\Delta T$
(c) $\pi SY\alpha\Delta T$ (d) $2SY\alpha\Delta T$

86. The extension in a string obeying Hooke's law is x. The speed of sound in the stretched string is v. If the extension in the string is increased to 1.5 x, the speed of sound will be
(a) 1.22 v (b) 0.61 v (c) 1.50 v (d) 0.75 v

87. An elevator cable is to have a maximum stress of 7 x 10^7 N/m^2 to allow for appropriate safety factors. Its maximum upward acceleratiom is 1.5 m/s^2. If the cable has to support the total weight of 2000 kg of a loaded elevator, the area of cross–section of the cable should be
(a) 3.28 cm^2 (b) 2.38 cm^2
(c) 0.328 cm^2 (d) 8.23 cm^2

88. A steel wire is suspended vertically from a rigid support. When loaded with a weight in air, it extends by ℓ_a and when the weight is immersed completely in water, the extension is reduced to ℓ_w. Then the relative density of material of the weight is

(a) ℓ_a / ℓ_w (b) $\frac{\ell_a}{\ell_a - \ell_w}$

(c) $\ell_w / (\ell_a - \ell_w)$ (d) ℓ_w / ℓ_a

89. If a rubber ball is taken at the depth of 200 m in a pool, its volume decreases by 0.1%. If the density of the water is 1×10^3 kg/m^3 and g = 10m/s^2, then the volume elasticity in N/m^2 will be

(a) 10^8 (b) 2×10^8
(c) 10^9 (d) 2×10^9

90. A uniform cube is subjected to volume compression. If each side is decreased by 1%, then bulk strain is

(a) 0.01 (b) 0.06
(c) 0.02 (d) 0.03

91. To break a wire, a force of 10^6 N/m^2 is required. If the density of the material is 3×10^3 kg/m^3, then the length of the wire which will break by its own weight will be

(a) 34m (b) 30m
(c) 300m (d) 3m

92. When a 4 kg mass is hung vertically on a light spring that obeys Hooke's law, the spring stretches by 2 cms. The work required to be done by an external agent in stretching this spring by 5 cms will be (g = 9.8 m/sec^2)

(a) 4.900 joule (b) 2.450 joule
(c) 0.495 joule (d) 0.245 joule

93. A rubber cord catapult has cross-sectional area 25 mm^2 and initial length of rubber cord is 10 cm. It is stretched to 5 cm and then released to project a missile of mass 5 gm. Taking $Y_{rubber} = 5 \times 10^8$ N/m^2. Velocity of projected missile is

(a) 20 ms^{-1} (b) 100 ms^{-1}
(c) 250 ms^{-1} (d) 200 ms^{-1}

94. 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 :

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

95. Copper of fixed volume 'V; is drawn into wire of length 'l'. When this wire is subjected to a constant force 'F', the extension produced in the wire is 'Δl'. Which of the following graphs is a straight line?

(a) Δl versus $\frac{1}{l}$ (b) Δl versus l^2

(c) Δl versus $\frac{1}{l^2}$ (d) Δl versus l

96. The approximate depth of an ocean is 2700 m. The compressibility of water is 45.4×10^{-11} Pa^{-1} and density of water is 10^3 kg/m^3.What fractional compression of water will be obtained at the bottom of the ocean ?

(a) 1.0×10^{-2} (b) 1.2×10^{-2}
(c) 1.4×10^{-2} (d) 0.8×10^{-2}

97. Consider four steel wires of dimensions given below (d = diameter and l = length) :

(a) l = 1m, d = 1mm (b) l = 2m, d = 2 mm
(c) l = 2m, d = 1mm (d) l = 1m, d = 2 mm

If same force is applied to all the wires then the elastic potential energy stored will be maximum in wire :

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

98. If in a wire of Young's modulus Y, longitudinal strain X is produced, then the value of potential energy stored in its unit volume will be

(a) YX^2 (b) $2YX^2$
(c) $Y^2 X/2$ (d) $YX^2/2$

99. A steel ring of radius r and cross sectional area A is fitted onto a wooden disc of radius R ($R > r$). If the Young's modulus of steel is Y, then the force with which the steel ring is expanded is

(a) $AY(R/r)$ (b) $AY(R-r)/r$
(c) $(Y/A)[(R-r)/r]$ (d) Yr/AR

100. For the same cross-sectional area and for a given load, the ratio of depressions for the beam of a square cross-section and circular cross-section is

(a) $3 : \pi$ (b) $\pi : 3$
(c) $1 : \pi$ (d) $\pi : 1$

101. The length of a metal is ℓ_1 when the tension in it is T_1 and is ℓ_2 when the tension is T_2. The original length of the wire is

(a) $\frac{\ell_1 + \ell_2}{2}$ (b) $\frac{\ell_1 T_2 + \ell_2 T_1}{T_1 + T_2}$

(c) $\frac{\ell_1 T_2 - \ell_2 T_1}{T_2 - T_1}$ (d) $\sqrt{T_1 T_2 \ell_1 \ell_2}$

102. A wire elongates by l mm when a load W is hanged from it. If the wire goes over a pulley and two weights W each are hung at the two ends, the elongation of the wire will be (in mm)

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

103. A thick rope of density ρ and length L is hung from a rigid support. The Young's modulus of the material of rope is Y. The increase in length of the rope due to its own weight is

(a) $(1/4)\rho g L^2/Y$ (b) $(1/2)\rho g L^2/Y$
(c) $\rho g L^2/Y$ (d) $\rho g L/Y$

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

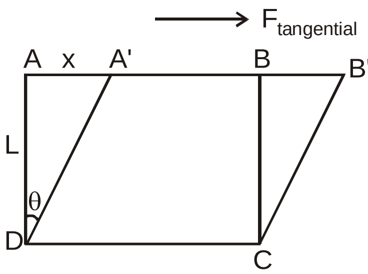
1. (a)

2. (a) Young's modulus of elasticity is highest for steel and Greater the young's modulus larger is its elasticity.

3. (c) The deformation of a body on application of a force depends on the nature of the material and the magnitude of the applied force.

4. (c) **5. (b)** **6. (d)** **7. (c)** **8. (b)**

9. (a) $\tan\theta = \frac{x}{L}$ = angle of shear = shearing strain



ABCD is the shape of body, before we apply tangential force and A′B′CD is the shape of body after applying tangential force.

10. (a)

11. (d) The hammering increases elasticity while annealing decreases it. The increase in temperature increases the elasticity while decrease in temperature decreases it. The impurity in the substance increases the elasticity.

12. (d) A cylinder stretched by two equal forces applied normal to its cross-sectional area, it experiences tensile stress; & if cylinder is compressed under the action of applied forces, the restoring force per unit area is known as compressive stress.
A body immersed in a fluid develops restoring force equal & opposite to the forces applied by fluid. This restoring force per unit area is hydraulic stress.

13. (b) Yield point is the point, beyond which the wire starts showing increase in strain without any increase in stress.

14. (d) Elastic after effect is defined as the temporary delay in regaining the original configuration by an elastic body after the removal of a deforming force.

15. (b) Hydraulic stress is relevant to volumetric strain, $\Delta V/V$, but there is no change in shape.

16. (d) The three elastic moduli viz young's modulus, shear modulus and bulk modulus are used to describe the elastic behavior of objects as they respond to deforming forces acting on them.

17. (c) Young's modulus $= \frac{\text{normal stress}}{\text{longitudinal strain}} = \frac{F/A}{\Delta L/L}$

$$= \frac{F \times L}{A \times \Delta L} = \frac{Mg \times L}{\pi r^2 \times \Delta L}$$

18. (d) Young's modulus $= \frac{\text{normal stress}}{\text{longitudinal stran}}$

Shear modulus $= \frac{\text{Tangential stress}}{\text{Shearing strain}}$

Longitudinal & shearing strains are possible only in solids.

19. (c) When an object undergoes hydraulic compression due to a stress exerted by a surrounding liquid the Hooke's law takes the form $P = B(\Delta v/v)$

20. (b) Young's modulus $Y = 2G(1 - \sigma)$
G = modulus of rigidity and σ = poissons's ratio

21. (a) $Y = \frac{F}{A}.\frac{\ell}{\Delta\ell}$ or $\frac{F}{\Delta L} = \frac{YA}{\ell}$

Hence force constant $= \frac{F}{\Delta\ell} = \frac{YA}{\ell}$

22. (b) Modulus of rigidity is, generally less than that of young's modulus of a solid. For most of the solids, value of shear modulus is one-third of the young's modulus i.e.
G = Y/3.

23. (c) Young's modulus of steel is highest.

24. (b) $r\theta = L\phi \Rightarrow 10^{-2} \times 0.8 = 2 \times \phi \Rightarrow \phi = 0.004$

25. (c) Isothermal elasticity $K_1 = P = 1\text{atm} = 1.013 \times 10^5\ \text{N/m}^2$

26. (a) **27. (c)** **28. (b)**

29. (d) Elasticity is maximum for steel and minimum for rubber.

30. (b) **31. (c)**

32. (c) For a perfectly rigid body strain produced is zero for the given force applied, so
Y = stress/strain = ∞

33. (c) Bulk modulus = change in volume

34. (d) Compressibility $= \frac{1}{\text{Bulk modulus}}$

35. (c)

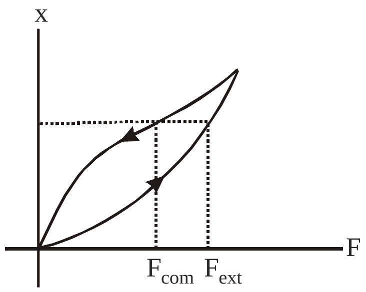
36. (b) The ratio of stress to strain is always constant. If stress is increased, strain will also increase so that their ratio remains constant.

STATEMENT TYPE QUESTIONS

37. **(d)**

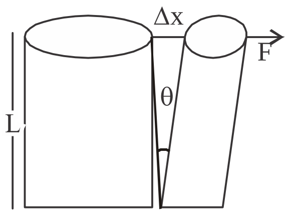
38. **(c)** From the figure, it is clear that

$F_{com} < F_{ext.}$



39. **(c)**

40. **(b)** Shearing strain $= \frac{\Delta x}{L} = \tan\theta$.



41. **(a)** A material for which strain is less for a given load is more elastic.

42. **(d)** **43.** **(b)** **44.** **(c)**

45. **(b)** Young's modulus $Y = \frac{\text{normal stress}}{\text{longitudinal strain}}$

$$= \frac{\frac{\text{force}}{\text{area}}}{\frac{\text{chage in length}}{\text{original length}}} = \frac{\text{Force} \times \text{original length}}{\text{Area} \times \text{change in length}}$$

46. **(d)**

MATCHING TYPE QUESTIONS

47. **(b)** (A)→(3), (B)→(1), (C)→(2), (D)→(1)

Mud is a completely plastic material.

Steel is perfect elastic.

Rubber is elastomer.

Copper is elastic.

48. **(a)** Young's modulus of elasticity exists only for solids. Hooke's law refers to a straight line on stress strain curve.

Hydraulic stress exists for all the three states, rubber is an elastomer.

49. **(d)** (A) → (3); B → (1, 4) ; (C) → (2) ; (D) → (2)

50. **(a)** (A)→(3), (B)→(4), (C)→(2), (D)→(1)

(A) $\Delta\ell_{copper} = \frac{F\ell}{AY} = \frac{500 \times 8}{0.5 \times 10^{-4} \times 10^{11}} = 0.8$ mm

(B) $\Delta\ell_{steel} = \frac{F\ell}{AY} = \frac{500 \times 4}{0.5 \times 10^{-4} \times 2 \times 10^{11}} = 0.2$ mm

(C) $\Delta\ell = \Delta\ell_{copper} + \Delta\ell_{steel} = 1.0$ mm

(D) $U = \left[\frac{e^2 Y_{copper}}{2} + \frac{e^2 Y_{steel}}{2}\right] \times \text{Vol} = 0.25$ J

DIAGRAM TYPE QUESTIONS

51. **(c)**

52. **(c)** The given graph does not obey Hooke's law. and there is no well defined plastic region. So the graph represents elastomers.

53. **(c)** Since OE is a straight line so, stress $\propto$ strain.

$\therefore$ Hooke's law is obeyed in the region OE of the graph.

54. **(b)** The wire starts behaving like a liquid at point b. It behaves like a viscous liquid in the region bc of the graph.

55. **(a)**

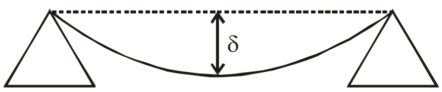
56. **(a)** From the graph $l = 10^{-4}$m, $F = 20$ N

$A = 10^{-6}\text{m}^2$, L = 1m

$$\therefore\ Y = \frac{FL}{Al} = \frac{20 \times 1}{10^{-6} \times 10^{-4}}$$

$$= 20 \times 10^{10} = 2 \times 10^{11}\ \text{N/m}^2$$

57. **(c)**



For a beam, the depression at the centre is given by,

$$\delta = \left(\frac{f\,L}{4Ybd^3}\right)$$

[f, L, b, d are constants for a particular beam]

i.e. $\delta \propto \frac{1}{Y}$

58. **(d)**

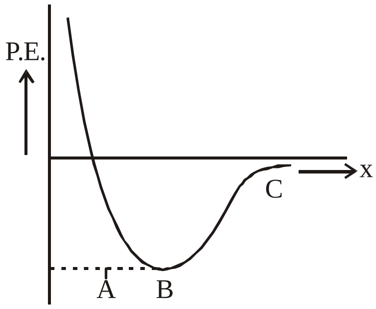
59. **(b)**

60. **(a)** $\tan(90° - \theta) = \frac{\text{stress}}{\text{strain}}$

61. **(a)** When same stress is applied at two different temperatures, the increase in length is more at higher temperature. Thus $T_1 > T_2$.

62. **(a)** As stress $\propto$ strain^2 hence graph (a) correctly dipicts.

63. **(b)** The atoms when brought from infinity are attracted due to interatomic electrostatic force of attraction. At point B, the potential energy is minimum and force of attraction is maximum. But if we bring atoms closer than x = B, force of repulsion between two nucleii starts and P.E. increases.



ASSERTION- REASON TYPE QUESTIONS

64. (b) The incompressibility of solids is primarily due to the tight coupling between the neighbouring atoms. Molecules in gases are very poorly coupled to their neighbours.

65. (d) Lead is more elastic than rubber because for same load strain produced is much less in lead than rubber.

66. (a) Torque required to produce a given twist in hollow cylinder is greater than solid cylinder thus both are true.

67. (a)

68. (b) Stress is defined as internal force (restoring force) per unit area of a body. Also, rubber is less elastic than steel, because restoring force is less for rubber than steel.

69. (a) Young's modulus of a material, $Y = \frac{\text{stress}}{\text{strain}}$

Here, stress $= \frac{\text{restoring force}}{\text{area}}$

As restoring force is zero $\therefore\ Y = 0$.

70. (a) Work done $= \frac{1}{2} \times \text{Stress} \times \text{Strain} = \frac{1}{2} \times Y \times (\text{Strain})^2$.

Since, elasticity of steel is more than copper, hence more work has to be done in order to stretch the steel.

71. (d) **72. (a)**

73. (b) The most effective method to reduce depression in a beam of given length & material is to make depth of the beam large as compared to its breadth. But on increasing the depth too much, the beam bends. To check this buckling, a compromise between breadth & depth of a beam is made by using I-shaped girder.

CRITICALTHINKING TYPE QUESTIONS

74. (d) $Y = \frac{F\ell}{A\Delta\ell}; \Rightarrow \quad F = \frac{YA\Delta\ell}{\ell}$

$$\frac{F_1}{F_2} = \frac{A_1}{A_2} \times \frac{l_2}{l_1} = \frac{r_1^2}{r_2^2} \times \frac{l_2}{l_1} = \frac{4}{1} \times \frac{1}{4} = 1:1.$$

75. (b) Stress $= \frac{F}{A} = \frac{F}{\pi r^2}$

76. (c) According to Hooke's law

Stress $\propto$ strain i.e., $\frac{F}{A} \propto \frac{\Delta l}{l}$

$\Rightarrow$ For same F & l, $\Delta l \propto \frac{1}{A}$

77. (d) $l = \frac{FL}{AY} \Rightarrow l \propto \frac{1}{r^2}$ (F, L and Y are same)

$$\frac{l_A}{l_B} = \left(\frac{r_B}{r_A}\right)^2 = \left(\frac{r_B}{2r_B}\right)^2 = \frac{1}{4} \Rightarrow l_A = 4l_B$$

or $l_B = \frac{l_A}{4}$

78. (b) Initial length (circumference) of the ring = $2\pi r$

Final length (circumference) of the ring = $2\pi R$

Change in length = $2\pi R - 2\pi r$

$$\text{strain} = \frac{\text{change in length}}{\text{original length}} = \frac{2\pi(R-r)}{2\pi r} = \frac{R-r}{r}$$

Now Young's modulus $E = \frac{F/A}{l/L} = \frac{F/A}{(R-r)/r}$

$$\therefore\ F = AE\left(\frac{R-r}{r}\right)$$

79. (b) $U = \frac{F^2}{2K} = \frac{T^2}{2K}$

80. (c) We know that

$$Y = \frac{mg/A}{\Delta\ell/\ell} = \frac{mg\ell}{A\Delta\ell} \quad ....(1)$$

Also $\Delta\ell = \ell\,\alpha\,\Delta T$ ...(2)

From (1) and (2)

$$Y = \frac{mg\ell}{A\ell\,\alpha\,\Delta T} = \frac{mg}{A\,\alpha\,\Delta T}$$

$$\therefore\ m = \frac{YA\,\alpha\,\Delta T}{g} = \frac{10^{11} \times \pi(10^{-3})^2 \times 10^{-5} \times 10}{10} = \pi \approx 3$$

81. (c) Bulk modulus $K = \frac{P}{\frac{\Delta V}{V}} = \frac{100}{0.01/100} = 10^6$ atm

$= 10^{11}\ \text{N/m}^2 = 10^{12}\ \text{dyne/cm}^2$

82. (a) Weights without and with liquid proportional to ρ_b and $\rho_b - \rho_l$.

83. (c) $$Y = \frac{F/A}{\Delta\ell/\ell} = \frac{\frac{250 \times 9.8}{50 \times 10^{-6}}}{\frac{0.5 \times 10^{-3}}{2}}$$

$$= \frac{250 \times 9.8}{50 \times 10^{-6}} \times \frac{2}{0.5 \times 10^{-3}} \Rightarrow 19.6 \times 10^{10}\ \text{N/m}^2$$

84. (b) Stress = 1 kg wt/mm^2 = 9.8 N/mm^2

= 9.8 × 10^6 N/m^2.

$Y = 1\times10^{11}\,N/m^2, \quad \frac{\Delta\ell}{\ell}\times100 = ?$

$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{\text{Stress}}{\Delta\ell/\ell}$

$\therefore \frac{\Delta\ell}{\ell} = \frac{\text{Stress}}{Y} = \frac{9.8\times10^6}{1\times10^{11}}$

$\frac{\Delta\ell}{\ell}\times100 = 9.8\times10^{-11}\times100\times10^6$

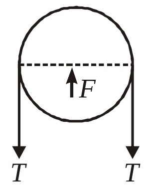
= 9.8 × 10^{-3} = 0.0098 %

85. (d) Elongation due to change in temperature,

$\Delta l = L\alpha\Delta T$

Which is compensated by elastic strain,
When temperature becomes normal, i.e.,

$\Delta l = \frac{TL}{YS}$



Thus, $\frac{TL}{YS} = L\alpha\Delta T$

$\Rightarrow T = VS\alpha\Delta T$

At equilibrium force exerted by one half on other,

$F = 2T = 2YS\alpha\Delta T$

86. (a) Speed of sound in a stretched string $v = \sqrt{\frac{T}{\mu}}$ …(i)

Where T is the tension in the string and μ is mass per unit length.

According to Hooke's law, $F \propto x \;\therefore\; T \propto x$ …(ii)

From (i) and (ii), $v \propto \sqrt{x} \;\therefore\; v' = \sqrt{1.5}\,v = 1.22v$

87. (a) Given, the breaking strength of cable $f_u = 7\times10^7$ N/m^2

The force carried by the cable,

$F = m(g+a)$

$= 2000(9.8+1.5) = 22600$ N

The area of cross-section, $A = \frac{F}{f_u} = \frac{22600}{7\times10^7}$

$= 3.28\times10^{-4}$ m^2.

88. (b) Let V be the volume of the load and ρ its relative density

So, $Y = \frac{FL}{A\ell_a} = \frac{V\rho g L}{A\ell_a}$ .....(1)

When the load is immersed in the liquid, then

$Y = \frac{F'L}{A\ell_w} = \frac{(V\rho g - V\times1\times g)L}{A\ell_w}$ ....(2)

(∵ Now net weight = weight – upthrust)

From eqs. (1) and (2), we get

$\frac{\rho}{\ell_a} = \frac{(\rho-1)}{\ell_w}$ or $\rho = \frac{\ell_a}{(\ell_a-\ell_w)}$

89. (d) $K = \frac{\Delta P}{\Delta V/V} = \frac{h\rho g}{\Delta V/V} = \frac{200\times10^3\times10}{0.1/100} = 2\times10^9$

90. (d) If side of the cube is L. then V = L^3 $\Rightarrow \frac{dV}{V} = 3\frac{dL}{L}$

∴ % change in volume = 3 × (% change in length)

= 3 × 1% = 3%

∴ Bulk strain $\frac{\Delta V}{V} = 0.03$

91. (a) $L = \frac{S}{dg} = \frac{10^6}{3\times10^3\times10} = \frac{100}{3} = 34\,m$

92. (b) $K = \frac{F}{x} = \frac{4\times9.8}{2\times10^{-2}} = 19.6\times10^2$

Work done = $\frac{1}{2}19.6\times10^2\times(0.05)^2 = 2.45\,J$

93. (c) Young's modulus of rubber, Y_{rubber}

$= \frac{F}{A}\times\frac{\ell}{\Delta\ell} \Rightarrow F = YA.\frac{\Delta\ell}{\ell}$

On putting the values from question,

$F = \frac{5\times10^8\times25\times10^{-6}\times5\times10^{-2}}{10\times10^{-2}}$

$= 25\times25\times10^{2-1} = 6250$N

kinetic energy = potential energy of rubber

$\frac{1}{2}mv^2 = \frac{1}{2}F\Delta\ell$

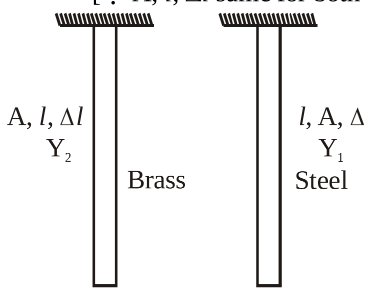
$v = \sqrt{\frac{F\Delta\ell}{m}} = \sqrt{\frac{6250\times5\times10^{-2}}{5\times10^{-3}}} = \sqrt{62500}$

= 25 × 10 = 250 m/s

94. (a) Young's modulus $Y = \frac{W}{A}.\frac{l}{\Delta l}$

$\frac{W_1}{Y_1} = \frac{W_2}{Y_2}$

[∵ A, l, Δl same for both brass and steel]



$\frac{W_1}{W_2} = \frac{Y_1}{Y_2} = 2$ [$Y_{steel}/Y_{brass} = 2$ given]

95. (b) As $Y = \dfrac{\frac{F}{A}}{\frac{\Delta l}{l}} \Rightarrow \Delta l = \dfrac{Fl}{AY}$

But $V = Al$ so $A = \dfrac{V}{l}$

Therefore $\Delta l = \dfrac{Fl^2}{VY} \propto l^2$

Hence graph of Δl versus l^2 will give a straight line.

96. (b) Compressibility of water,
$K = 45.4 \times 10^{-11}\ Pa^{-1}$
density of water $P = 10^3\ kg/m^3$
depth of ocean, h = 2700 m

We have to find $\dfrac{\Delta V}{V} = ?$

As we know, compressibility,

$K = \dfrac{1}{B} = \dfrac{(\Delta V/V)}{P}$ (P = Pgh)

So, $(\Delta V/V) = KPgh$
$= 45.4 \times 10^{-11} \times 10^3 \times 10 \times 2700 = 1.2258 \times 10^{-2}$

97. (c) We have, $U = \dfrac{F^2}{2k}$

where $k = \dfrac{Yl}{A} = \dfrac{Yl}{\frac{1}{4}\pi d^2}$

$\therefore\ U \propto \dfrac{d^2}{l}$

98. (d) $P.E. = \dfrac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$

or $(P.E./\text{volume}) = \dfrac{1}{2} \times (Y \times \text{strain})\ (\text{strain})$

$= \dfrac{1}{2} Y (\text{strain})^2 = \dfrac{1}{2} Y X^2$

99. (b) Let T be the tension in the ring, then

$$Y = \frac{T.2\pi r}{A.2\pi(R-r)} = \frac{Tr}{A(R-r)}$$

$$\therefore\ T = \frac{YA(R-r)}{r}$$

100. (a) $\delta = \dfrac{W\ell^3}{3YI}$, where W = load, ℓ = length of beam and I is geometrical moment of inertia for rectangular beam,

$I = \dfrac{bd^3}{12}$ where b = breadth and d = depth

For square beam $b = d$

$\therefore\ I_1 = \dfrac{b^4}{12}$

For a beam of circular cross-section, $I_2 = \left(\dfrac{\pi r^4}{4}\right)$

$\therefore\ \delta_1 = \dfrac{W\ell^3 \times 12}{3Yb^4} = \dfrac{4W\ell^3}{Yb^4}$

(for sq. cross section)

and $\delta_2 = \dfrac{W\ell^3}{3Y(\pi r^4/4)} = \dfrac{4W\ell^3}{3Y(\pi r^4)}$

(for circular cross-section)

Now $\dfrac{\delta_1}{\delta_2} = \dfrac{3\pi r^4}{b^4} = \dfrac{3\pi r^4}{(\pi r^2)^2} = \dfrac{3}{\pi}$

($\because b^2 = \pi r^2$ i.e., they have same cross-sectional area)

101. (c) If ℓ is the original length of wire, then change in length of first wire,

$\Delta\ell_1 = (\ell_1 - \ell)$

Change in length of second wire,

$\Delta\ell_2 = (\ell_2 - \ell)$

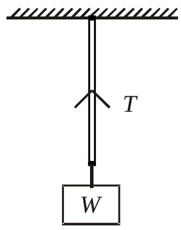
Now, $Y = \dfrac{T_1}{A} \times \dfrac{\ell}{\Delta\ell_1} = \dfrac{T_2}{A} \times \dfrac{\ell}{\Delta\ell_2}$

or $\dfrac{T_1}{\Delta\ell_1} = \dfrac{T_2}{\Delta\ell_2}$ or $\dfrac{T_1}{\ell_1 - \ell} = \dfrac{T_2}{\ell_2 - \ell}$

or $T_1\ell_2 - T_1\ell = T_2\ell_1 - \ell T_2$

or $\ell = \dfrac{T_2\ell_1 - T_1\ell_2}{T_2 - T_1}$

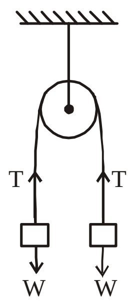
102. (a) Case (i)



At equilibrium, $T = W$

$Y = \dfrac{W/A}{\ell/L}$ .....(1)

Case (ii)



At equilibrium $T = W$

$\therefore Y = \dfrac{W/A}{\frac{\ell/2}{L/2}} \Rightarrow Y = \dfrac{W/A}{\ell/L}$

$\Rightarrow$ Elongation is the same.

103. (b) $\Delta\ell = \dfrac{F(L/2)}{AY} = \dfrac{(AL\rho g)(L/2)}{AY}$

$= \left(\dfrac{1}{2}\right)\rho g L^2/Y$