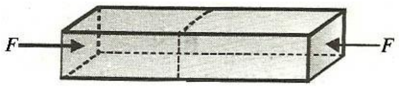
9.MECHANICAL PROPERTIES OF SOLIDS

Single Correct Answer Type

1. The velocity of small ball of mass M and density $d_1 =$ when dropped a container filled with glycerine becomes constant after some time. If the density glycerine is d_2, the viscous force acting on ball is
a) $\frac{Md_1g}{d_2}$ b) $Mg\left(1-\frac{d_2}{d_1}\right)$ c) $\frac{M(d_1 + d_2)}{g}$ d) $M\, d_1 d_2$
2. A marble of mass x and diameter $2r$ is gently released in a tall cylinder containing honey. If the marble displaces mass $y(< x)$ of the liquid, then the terminal velocity is proportional to
a) $x+y$ b) $x-y$ c) $\frac{x+y}{r}$ d) $\frac{x-y}{r}$
3. Work W is required to form a bubble of volume V from a given solution. What amount of work is required to be done to form a bubble of volume $2V$?
a) W b) $2W$ c) $2^{1/3}\,W$ d) $4^{1/3}\,W$
4. The density of water at the surface of ocean is ρ. If the bulk modulus of water is B, then the density of ocean water at depth, when the pressure is αP_0 and p_0 is the atmospheric pressure, is
a) $\frac{pB}{B-(\alpha-1)p_0}$ b) $\frac{pB}{B+(\alpha-1)p_0}$ c) $\frac{pB}{B-\alpha p_0}$ d) $\frac{pB}{B+\alpha p_0}$
5. Two soap bubbles, one of radius 50 mm and the other of radius 80 mm, are brought in contact so that they have a common interface. The radius of the curvature of the common interface is
a) 0.003 m b) 0.133 m c) 1.2 m d) 8.9 m
6. A long elastic spring is stretched by 2 cm and its potential energy is U. If the spring is stretched by 10 cm, the P.E., will be
a) 5 U b) 25 U c) $U/5$ d) $U/20$
7. Two rods of different materials having coefficients of linear expansion α_1 and α_2 and Young's moduli, Y_1 and 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 rods. If $\alpha_1/\alpha_2 = 2/3$, then the thermal stresses developed in the two rods are equal, provided Y_1/Y_2 is equal to
a) 2:3 b) 1:1 c) 3:2 d) 4:9
8. Two parallel wires each of length 10 cm are 0.5 cm apart. A film of water is formed between them. If surface tension of water is 0.072 N/m, then the work done in increasing the distance between the wires by 1 mm is
a) 1.44×10^{-5} J b) 1.72×10^{-5} J c) 1.44×10^{-4} J d) 1.72×10^{-4} J
9. In the figure shown, forces of equal magnitude are applied to the two ends of a uniform rod. Consider A as the cross-sectional area of the rod. For this situation, mark out the incorrect statements



a) The rod is in compressive stress
b) The numerical value of stress developed in the rod is equal to F/A
c) The stress is defined as internal force developed at any cross section per unit area
d) None of the above
10. A small but heavy block of mass 10 kg is attached to a wire 0.3 m long. Its breaking stress is $4.8 \times 10^7\ \mathrm{N/m^2}$. The area of the cross section of the wire is $10^{-6}\ \mathrm{m^2}$. The maximum angular velocity with which the block can be rotated in the horizontal circle is
a) 4 rad/s b) 8 rad/s c) 10 rad/s d) 32 rad/s
11. A solid sphere of radius R, made up 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 is
a) $\frac{Mg}{AK}$ b) $\frac{Mg}{3AK}$ c) $\frac{3Mg}{AK}$ d) $\frac{Mg}{2AK}$

12. A ring is cut from a platinum tube 8.5 cm internal and 8.7 cm external diameter. It is supported horizontally from the pan of a balance, so that it comes in contact with the water in a glass vessel. If an extra 3.103 g.f. is required to pull it away from water, the surface tension of water is
a) 72 dyn/cm b) 70.80 dyn/cm c) 63.35 dyn/cm d) 60 dyn/cm

13. A number of droplets, each of radius r, combine to form a drop of radius R. If T is the surface tension, the rise in temperature will be
a) $\frac{2T}{r}$ b) $\frac{3T}{R}$ c) $2T\left[\frac{1}{r}-\frac{1}{R}\right]$ d) $3T\left[\frac{1}{r}-\frac{1}{R}\right]$

14. The length of a needle floating on water is 2.5 cm. The minimum force in addition to its weight needed to lift the needle above the surface of water will be (surface tension of water is 0.072 N/m)
a) 3.6×10^{-3} N b) 10^{-2} N c) 9×10^{-4} N d) 6×10^{-4} N

15. The ratio of diameters of two wires of same material is n: 1. The length of each wire is 4 m. On applying the same load, the increases in the length of the thin wire will be ($n > 1$)
a) n^2 times b) n times c) $2n$ times d) $(2n + 1)$ times

16. A glass rod of radius 1 mm is inserted symmetrically into a glass capillary tube with inside radius 2 mm. Then the whole arrangement is brought in contact of the surface of water. Surface tension of water is 7×10^{-2} N/m. To what height will the water rise in the capillary? ($\theta = 0°$)
a) 1.4 cm b) 4.2 cm c) 2.1 cm d) 6.8 cm

17. Two soap bubbles of radii a and b combine to form a single bubble of radius c. If P is the external pressure, then the surface tension of the soap solution is
a) $\frac{P\,(c^3+a^3+b^3)}{4\,(a^2+b^2-c^2)}$ b) $\frac{P\,(c^3-a^3-b^3)}{4\,(a^2+b^2-c^2)}$ c) $Pc^3 - 4a^2 - 4b^2$ d) $Pc^2 - 2a^2 - 3b^2$

18. A straw 6 cm long floats on water. The water film on one side has surface tension of 50 dyn/cm. On the other slide, camphor reduces the surface tension to 40 dyn/cm. The resultant force acting on the straw is
a) $(50 \times 6 - 40 \times 6)$ dyn b) 10 dyn
c) $\left(\frac{50}{6}-\frac{40}{6}\right)$ dyn d) 90 dyn

19. In the previous question, the force of attraction between the plates is
(Here h represents the height to which the liquid rises)
a) $\frac{l\rho g}{2}h^2$ b) $\frac{l\rho g}{2}h$ c) $\frac{l\rho g}{2}$ d) $\frac{l\rho g}{2h}$

20. Neglecting the density of air, the terminal velocity obtained by a raindrop of radius 0.3 mm falling through the air of viscosity 1.8×10^{-5} N/m^2 will be
a) 10.9 m/s b) 8.3 m/s c) 9.2 m/s d) 7.6 m/s

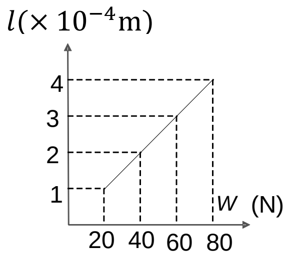
21. The angle of contact between glass and water is 0° and water (surface tension 70 dyn/cm) rises in a glass capillary up to 6 cm. Another liquid of surface tension 140 dyn/cm, angle of contact 60° and relative density 2 will rise in the same capillary up to
a) 12 cm b) 24 cm c) 3 cm d) 6 cm

22. The edges of an aluminium cube are 10 cm long. One face of the cube is firmly fixed to a vertical wall. A mass of 100 kg is then attached to the opposite face of the cube. Shear modulus of aluminium is 25×10^9 Pa, the vertical deflection in the face to which mass is attached is
a) 4×10^{-4}m b) 4×10^{7}m c) 25×10^{-6}m d) 6×10^{-7}m

23. A glass rod of diameter $d = 2$ mm is inserted symmetrically into a glass capillary tube of radius $r = 2$ mm. Then the whole arrangement is vertically dipped into liquid having surface tension 0.072 N/m. The height to which liquid will rise on capillary is (Take g $= 10$ m/s^2, $p_{\text{liq}} = 1000$ kg/m^3. Assume contact angle to be zero of capillary tube to be long enough)
a) 1.44 cm b) 6 cm c) 4.86 cm d) None of these

24. When a certain weight is suspended from a long uniform wire, its length increases by 1 cm. If the same weight is suspended from another wire of the same material and length but having a diameter half of the first one, the increases in length will be
a) 0.5 cm b) 2 cm c) 4 cm d) 8 cm

25. The adjacent graph shows the extension (l) of a wire of length 1m suspended from the top of a roof at one end and with a load Wconnected to the other end. If the cross-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} Nm^{-2} b) 2×10^{-11} Nm^{-2} c) 3×10^{12} Nm^{-2} d) 2×10^{13} Nm^{-2}

26. Consider vertical parallel of semi-circular cross section dipped in a liquid. Assume that the wetting of the tube is complete. The force of surface tension on the flat part and on curved part of the tube are in the ratio
a) $2:\pi$ b) $1:\pi$ c) $3:\pi$ d) $2.7:\pi$

27. In the previous question, the net force exerted by fluid on moving plate is
a) 0.6 N backwards b) 0.6 N forwards c) 0.2 N backwards d) 0.2 N backwards

28. A drop of liquid of density ρ is floating half-immersed in a liquid of density d. If ρ is the surface tension the diameter of the drop of the liquid is
a) $\sqrt{\dfrac{\sigma}{g\,(2\rho - d)}}$ b) $\sqrt{\dfrac{2\sigma}{g\,(2\rho - d)}}$ c) $\sqrt{\dfrac{6\sigma}{g\,(2\rho - d)}}$ d) $\sqrt{\dfrac{12\,\sigma}{g\,(2\rho - d)}}$

29. A copper bar of length L and area of cross section A is placed in a chamber at atmospheric pressure. If the chamber is evacuated, the percentage change in its volume will be (compressibility of copper is 8×10^{-12} m^2/N and 1 atm $= 10^5$ N/m)
a) 8×10^{-7} b) 8×10^{-5} c) 1.25×10^{-4} d) 1.25×10^{-5}

30. What amount of work is done in increasing the length of a wire through unity?
a) $\dfrac{YL}{2A}$ b) $\dfrac{YL^2}{2A}$ c) $\dfrac{YA}{2L}$ d) $\dfrac{YL}{A}$

31. A wire of cross section A is stretched horizontally between two clamps located $2l$ m apart. A weight W kg is suspended from the mid-point of the wire. If the mid-point sags vertically through a distance $x < 1$ the strain produced is
a) $\dfrac{2x^2}{l^2}$ b) $\dfrac{x^2}{l^2}$ c) $\dfrac{x^2}{2l^2}$ d) None of these

32. Two wires of the same length and same material but radii in the ratio of 1:2 are stretched by unequal forces to produce equal elongation. The ratio of the two forces is
a) 1:1 b) 1:2 c) 1:3 d) 1:4

33. A drop of water of volume V is pressed between the two glass placed so as to spread to an area A. If T is the surface tension, the normal foce required to separate the glass plates is
a) $\dfrac{TA^2}{V}$ b) $\dfrac{2TA^2}{V}$ c) $\dfrac{4TA^2}{V}$ d) $\dfrac{TA^2}{2V}$

34. Two vertical parallel glass plates are partially submerged in water. The distance between the plates is d and the length is l. Assume that the water between the plates does not reach the upper edges of the plates and that the wetting is complete. The water will rise to height ($\rho =$ density of water and $\sigma =$ surface tension of water)
a) $\dfrac{2\sigma}{\rho g d}$ b) $\dfrac{\sigma}{2\rho g d}$ c) $\dfrac{4\sigma}{\rho g d}$ d) $\dfrac{5\sigma}{\rho g d}$

35. Bulk modulus of water is 2×10^9 N/m^2. The change in pressure required to increase the density of water by 0.1% is
a) 2×10^9 N/m^2 b) 2×10^8 N/m^2 c) 2×10^6 N/m^2 d) 2×10^4 N/m^2

36. The elastic limit of an elevator cable is $2 \times 10^9\ \mathrm{N/m^2}$. The maximum upward acceleration that an elevator of mass 2×10^3 kg can have when supported by a cable whose cross-sectional area is $10^{-4}\ \mathrm{m^2}$, provided the stress in cable would not exceed half of the elastic limit would be

a) $10\ \mathrm{m/s^2}$ b) $50\ \mathrm{m/s^2}$
c) $40\ \mathrm{m/s^2}$ d) Not possible to move up

37. Two glass plates are separated by water. If surface tension of water is 75 dyn/cm and the area of each plate wetted by water is $8\ \mathrm{cm^2}$ and the distance between the plates is 0.12 mm, then the force applied to separate the two plates is

a) 10^2 dyn b) 10^4 dyn c) 10^5 dyn d) 10^6 dyn

38. If the work done by stretching a wire by 1 mm is 2 J, the work necessary for stretching another wire of the same material but with the radius of cross section and half the length by 1 mm is

a) $\frac{1}{4}$J b) 4 J c) 8 J d) 16 J

39. A capillary tube is attached horizontally to a constant pressure head arrangement. If the radius of the capillary tube is increased by 10%, then the rate of flow of the liquid shall change nearly by

a) +10% b) 46% c) −10% d) −40%

40. The pressure of a medium is changed from 1.01×10^5 Pa to 1.165×10^5 Pa and change in volume is 10% keeping temperature constant. The Bulk modulus of the medium is

a) 204.8×10^5Pa b) 102.4×10^5Pa c) 51.2×10^5Pa d) 1.55×10^5Pa

41. Two wires of the same material and same mass are stretched by the same force. Their lengths are in the ratio 2:3. Their elongations are in the ratio

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

42. Two identical wires of iron and copper with their Young's modulus in the ratio 3: 1 are suspended at same level. They are to be loaded so as to have the same extension and hence level. Ratio of the weight is

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

43. Maximum excess pressure inside a thin-walled steel tube of radius r and thickness Δr ($\ll r$), so that the tube would not rupture would be (breaking stress of steel is $\sigma_{\max}$)

a) $\sigma_{\max} \times \frac{r}{\Delta r}$ b) $\sigma_{\max} \times \frac{\Delta r}{r}$ c) $\sigma_{\max}$ d) $\sigma_{\max} \times \frac{\Delta 2r}{r}$

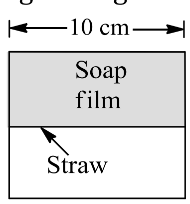
44. Two long metallic strips are joined together by two rivets each of radius 2 mm. Each rivet can withstand a maximum shearing stress of $1.5 \times 10^9\ \mathrm{N/m^2}$. Assuming that each rivet shares the stretching load equally, the maximum tensile force the strip can exert without rupture is

a) 1.88×10^4 N b) 3.8×10^4 N c) 6×10^7 N d) 3×10^4 N

45. A material has normal density ρ and bulk modulus K. The increase in the density of the material when it is subjected to an external pressure P from all sides is

a) $P/\rho K$ b) $K/\rho P$ c) $\rho P/K$ d) $\rho K/P$

46. A soap film of surface tension 3×10^{-2} formed in a rectangular frame can support a straw as shown in the figure. If $g = 10\ \mathrm{m/s^2}$, the mass of the straw is



a) 0.006 g b) 0.06 g c) 0.6 g d) 6 g

47. A wire is suspended vertically from a rigid support. When loaded with a steel weight in air. The wire extends by 16 cm. When the weight is completely immersed in water, the extension is reduced to 14 cm. The relative density of the material of the weight is

a) $2\ \mathrm{g/cm^3}$ b) $6\ \mathrm{g/cm^3}$ c) $8\ \mathrm{g/cm^3}$ d) $16\ \mathrm{g/cm^3}$

48. A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1 m and its cross-sectional area is $4.9 \times 10^{-7}\ \mathrm{m^2}$. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency 140 rad $\mathrm{s^{-1}}$. If the Young's modulus of

the material of the wire is $n \times 10^9$ $\mathrm{Nm^{-2}}$, the value of n is

a) 4 b) 2 c) 4.5 d) 5

49. A large number of droplets, each of radius a, coalesce to form a bigger drop of radius b. Assume that the energy released in the process is converted into the kinetic energy of the drop. The velocity of the drop is ($\sigma =$ surface tension, $\rho =$ density)

a) $\left[\frac{\sigma}{\rho}\left(\frac{1}{a}-\frac{1}{b}\right)\right]^{1/2}$ b) $\left[\frac{2\sigma}{\rho}\left(\frac{1}{a}-\frac{1}{b}\right)\right]^{1/2}$ c) $\left[\frac{3\sigma}{\rho}\left(\frac{1}{a}-\frac{1}{b}\right)\right]^{1/2}$ d) $\left[\frac{6\sigma}{\rho}\left(\frac{1}{a}-\frac{1}{b}\right)\right]^{1/2}$

50. Young's modulus of brass and steel are 10×10^{10} N/m and 2×10^{11} $\mathrm{N/m^2}$, respectively. A brass wire and a steel wire of the same length are extended by 1 mm under the same force. The radii of the brass and steel wires are R_B and R_S, respectively. Then

a) $R_s = \sqrt{2}\,R_B$ b) $R_s = \frac{R_B}{\sqrt{2}}$ c) $R_s = 4R_B$ d) $R_s = \frac{R_B}{4}$

51. A water drop is divided into eight equal droplets. The pressure difference between inner and outer sides of the big drop

a) Will be the same as for smaller droplet

b) Will be half of that for smaller droplet

c) Will be one-fourth of that for smaller droplet

d) Will be twice of that for smaller droplet

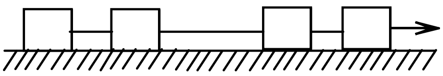
52. Between a plate of area 100 $\mathrm{cm^2}$ and another plate of area 100 $\mathrm{m^2}$ there is a 1 mm, thick layer of water, if the coefficient of viscosity of water is 0.01 paise, then the force required to move the smaller plate with a velocity 10 cm/s with reference to large plate is

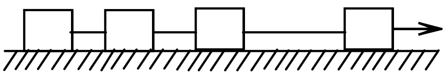
a) 100 dyn b) 10^4 dyn c) 10^6 dyn d) 10^9 dyn

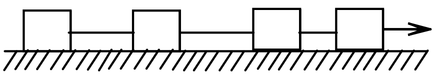
53. A river 10 m deep is flowing at 5 m/s. The shearing stress between horizontal layers of the river is ($\eta = 10^{-3}$ SI units)

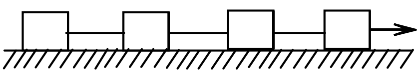
a) 10^{-3} $\mathrm{N/m^2}$ b) 0.8×10^{-3} $\mathrm{N/m^2}$ c) 0.5×10^{-3} $\mathrm{N/m^2}$ d) 1 $\mathrm{N/m^2}$

54. Each of the pictures shows four objects tied together with rubber bands being pulled to the right across a horizontal frictionless surface by a horizontal force F. All the objects have the same mass; all the rubber bands obey Hooke's law and have the same equilibrium length and the same force constant. Which of these pictures is drawn most correctly?

a) 

b) 

c) 

d) 

55. A massive stone pillar 20 m high and of uniform cross section rests on a rigid base and supports a vertical load of 5.0×10^5 N at its upper end. If the compressive stress in the pillar is not exceed 16×10^6 N/m, what is the minimum cross-sectional area of the pillar? (Density of the stone $= 2.5 \times 10^3$ $\mathrm{kg/m^3}$ take g $=$ 10 N/kg)

a) 0.15 $\mathrm{m^2}$ b) 0.25 $\mathrm{m^2}$ c) 0.35 $\mathrm{m^2}$ d) 0.45 $\mathrm{m^2}$

56. Young's modulus of rubber is 10^4 $\mathrm{N/m^2}$ and area of cross section is 2 $\mathrm{cm^{-2}}$. If force of 2×10^5 dyn is applied along its length, then its initial l becomes

a) $3l$ b) $4l$ c) $2l$ d) None of these

57. A 20-cm-long capillary tube is dipped in water. The water rises up to 8 cm. If the entire arrangement is put in a freely falling elevator, the length of water column in the capillary tube will be

a) 20 cm b) 4 cm c) 10 cm d) 8 cm

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

a) $\frac{0.1}{4Y}\,\rho L^2$ g b) $\frac{1}{2Y}\,\rho L^2$ g c) $\frac{\rho L^2 g}{Y}$ d) $\frac{\rho Lg}{Y}$

59. Two wires of the same material and length are stretched by the same force. Their masses are in the ratio 3: 2. Their elongations are in the ratio

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

60. The length of a steel cylinder is kept constant by applying pressure at its two ends. When the temperature of rod is increased by 100°C from its initial temperature, the increase in pressure to be applied at its ends is
($Y_{\text{steel}} = 2 \times 10^{11} \text{N/m}^2, \alpha_{\text{steel}} = 11 \times 10^{-6}/°\text{C}, 1 \text{ atm} = 10^5 \text{ N/m}^2$)
a) 22×10^7 atm b) 2.2×10^3 atm c) Zero d) 4.3×10^3 atm

61. A spherical liquid drop of radius R is divided into eight equal droplets. If the surface tension is T, then the work done in this process will be
a) $2\pi R^2T$ b) $3\pi R^2T$ c) $4\pi R^2T$ d) $2\pi RT^2$

62. A vessel, whose bottom has round holes with diameter 0.1 mm, is filled with water. The maximum height up to which water can be filled without leakage is
a) 100 cm b) 75 cm c) 50 cm d) 30 cm

63. A steel wire is stretched by 1 kg wt. If the radius of the wire is doubled, its Young's modulus will
a) Remain unchanged b) Become half c) Become double d) Become four times

64. The length of a wire is increased by 1 mm on the application of a given load. In a wire of the same material, but of length and radius twice that of the first, on application of the same load, extension is
a) 0.25 mm b) 0.5 mm c) 2 mm d) 4 mm

65. Two wires of the same material have lengths in the ratio 1: 2 and their radii are in the ratio $1:\sqrt{2}$. If they are stretched by applying equal forces, the increase in their lengths will be in the ratio
a) $\sqrt{2} : 2$ b) $2:\sqrt{2}$ c) 1: 1 d) 1: 2

66. When the tension in a metal wire is T_1, its length is l_1. When the tension is T_2, its length is l_2. The natural length of wire is
a) $\frac{T_2}{T_1}(l_1 + l_2)$ b) $T_1 l_1 + \text{i}_2 l_2$ c) $\frac{l_1T_2 - l_2T_1}{T_2 - T_1}$ d) $\frac{l_1T_2 + l_2T_1}{T_2 + T_1}$

67. In the previous question, the work done in spraying is
a) $999E$ b) $99E$ c) $9E$ d) E

68. The breaking stress for a substance is 10^6 N/m^2. What length of the wire of this substance should be suspended vertically so that the wire breaks under its own weight? (Given : density of material of the wire $= 4 \times 10^3$ kg/m^3 and $\text{g} = 10$ m/s^2)
a) 10 m b) 15 m c) 25 m d) 34 m

69. If in the above question, the Young's modulus of the material is Y, the value of extension x is
a) $\left(\frac{Wl}{YA}\right)^{1/3}$ b) $\left(\frac{YA}{Wl}\right)^{1/3}$ c) $\frac{1}{l}\left[\frac{WA}{Y}\right]^{1/3}$ d) $l\left[\frac{W}{YA}\right]^{1/3}$

70. A wire of length L and radius r is fixed at one end. When a stretching force F is applied at free end, the elongation in the wire is l. When another wire of same material but of length $2L$ and radius $2r$, also fixed at one end is stretched by a force $2F$ applied at free end, then elongation in the second wire will be
a) $\ell/2$ b) ℓ c) 2ℓ d) $\ell/4$

71. The lower end of a capillary tube is at a depth of 12 cm and water rises 3 cm in it. The mouth pressure required to blow an air bubble at the lower end will be x cm of water column, where x is
a) 12 b) 15 c) 3 d) 9

72. A cube with a mass = 20 g wettable water floats on the surface of water. Each face of the cube is $\alpha = 3$ cm long. Surface tension of water is 70 dyn/cm. The distance of the lower face of the cube from the surface of water is ($\text{g} = 980$ cm/s^2)
a) 2.3 cm b) 4.6 cm c) 9.7 cm d) 12.7 cm

73. A loop of 6.28 cm long thread is put gently on a soap film in a wire loop. The film is pricked with a needle inside the soap film enclosed by the thread. If the surface tension of soap solution is 0.030 N/m, then the tension in the thread is
a) 1×10^{-4} N b) 2×10^{-4} N c) 3×10^{-4} N d) 4×10^{-4} N

74. On applying a stress of x N/m^2, the length of wire of some material gets doubled. Value of Young's modulus for the material of and wire in N/m^2, is (assume Hooke's law to be valid and go for approx.

results)

a) x b) $2x$

c) $x/2$ d) Insufficient information

75. A nylon rope 2 cm in diameter has a breaking strength of 1.5×10^5 N. The breaking strength of a similar rope 1 cm in diameter is

a) 0.375×10^5 N b) 2×10^5 N c) 6×10^5 N d) 9×10^4 N

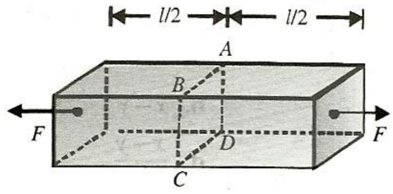
76. A thin square plate of side 5 cm is suspended vertically from a balance so that lower side just dips into water with side to surface. When the plate is clean ($\theta = 0°$), it appears to weight 0.044 N. But when the plate is greasy ($\theta = 180°$), it appears to weight 0.03 N. The surface tension of water is

a) 3.5×10^{-2} N/m b) 7.0×10^{-2} N/m c) 14.0×10^{-2} N/m d) 1.08 N/m

77. Two wires of the same material and length but diameters in the ratio 1: 2 are stretched by the same force. The potential energy per unit volume for the two wires when stretched will be in the ratio

a) 16:1 b) 4 :1 c) 2:1 d) 1:1

78. Two equal and opposite point forces are applied at mid-points of the ends of a rod of square cross section, as shown. Consider the dotted section $ABCD$. If the rod is cut across this cross section, the force exerted by the right part of the rod on left part across this cross section is



a) Acting at point passing through cross section $ABCD$

b) Acting at a point but not passing through the centre of cross section $ABCD$

c) Uniformly distributed across the cross section $ABCD$

d) Non-uniformly distributed across the cross section $ABCD$

79. If T is surface tension of soap solution, the amount of work done in blowing a soap bubble from a diameter D to a diameter $2D$ is

a) $2\pi D^2T$ b) $4\pi D^2T$ c) $6\pi D^2T$ d) $8\pi D^2T$

80. Two vertical parallel glass plates are partially submerged in water. The distance between the plates is d and the length is l. Assume that the water between the plates does not reach the upper edges of the plates and that the wetting is complete, if water is replaced by another liquid of surface tension 2σ, then the force F of attraction between two plates would become

a) $2F$ b) $4F$ c) $8F$ d) $16F$

81. A hollow sphere has a small hole in it. On lowering the sphere in a tank of water, it is observed that water enters into the hollow sphere at a depth of 40 cm below the surface. Surface tension of water is 7×10^{-2} N/m. The diameter of the hole is

a) $\frac{1}{28}$ mm b) $\frac{1}{21}$ mm c) $\frac{1}{14}$ mm d) $\frac{1}{7}$ mm

82. The dimensions of four wires of the same material are given below. In which wire the increase in the length will be maximum?

a) Length 100 cm, diameter 1 mm b) Length 200 cm, diameter 2 mm

c) Length 300 cm, diameter 3 mm d) Length 50 cm, diameter 0.5 mm

83. When the load on a wire is slowly increased from 3 to 5 kg wt, the elongation increases from 0.61 to 1.02 mm. The work done during the extension of wire is

a) 0.16 J b) 0.016 J c) 1. 6 J d) 16 J

84. When a weight of 5 kg is suspended from a copper wire of length 30 m and diameter 0.5 mm, the length of the wire increases by 2.4 cm. If the diameter is doubled, the extension produced is

a) 1.2 cm b) 0.6 c) 0.3 cm d) 0.15 cm

85. Water rises to a height h in a capillary tube of cross-sectional area A. The height to which water will rise in a capillary tube of cross-sectional area $4A$ will be

a) h b) $h/2$ c) $h/4$ d) $4h$

86. Two bars A and B of circular cross section, same volume and made of the same material, are subjected to tension. If the diameter of A is half that of B and if the force applied to both the rod is the same and it is in the elastic limit, the ratio of extension of A to that of B will be

a) 16 b) 8 c) 4 d) 2

87. A ball falling in a lake of depth 200 m shows a decrease of 0.1% in its volume at the bottom. The bulk modulus of the elasticity of the material of the ball is (take $g = 10\ m/s^2$)

a) $10^9\ N/m^2$ b) $2 \times 10^9\ N/m^2$ c) $3 \times 10^9\ N/m^2$ d) $4 \times 10^9\ N/m^2$

88. A 5 kg rod of square cross section 5 cm on a side and 1 m long is pulled along a smooth horizontal surface by a force applied at one end. The rod has a constant acceleration of $2\ m/s^2$. Determine the elongation in the rod. (Young's modulus of the material of the rod is $5 \times 10^3\ N/m^9$)

a) Zero, as for elongation to be there, equal and opposite forces must act on the rod

b) Non-zero but cannot be determine from the given situation

c) 0.4 μm

d) 16 μm

89. A piece of copper wire has twice the radius of a piece of steel wire. Young's modulus for steel is twice that of the copper. One end of the copper wire is joined to one end of the steel wire so that both can be subjected to the same longitudinal force. By what fraction of its length will the steel have stretched when the length of the copper has increased by 1%?

a) 1% b) 2% c) 2.5% d) 3%

90. A wire is stretched 1 mm by a force of 1 kN. How far would a wire of the same material and length but of four times that diameter be stretched by the same force?

a) $\frac{1}{2}$ mm b) $\frac{1}{4}$ mm c) $\frac{1}{8}$ mm d) $\frac{1}{16}$ mm

91. A paper disc of radius R from which a hole of radius r is cut out is floating in a liquid of the surface tension S. The force on the disc due to the surface tension is

a) $S \times 2\pi R$ b) $S \times 2\pi r$ c) $S \times 2\pi(R - r)$ d) $S \times 2\pi(R + r)$

92. The space between two large horizontal metal plates, 6 cm apart, is filled with a liquid of viscosity $0.8\ N/m^2$. A thin plate of surface area $0.01\ m^2$ is moved parallel to the length of the plate such that the plate is at a distance of 2 m from one of the plates and 4 cm from the other. If the plate moves with a constant speed of 1 m/s, then

a) The layer of the fluid, which is having the maximum velocity, is lying mid-way between the plates

b) The layers of the fluid, which is in contact with the moving plate, is having the maximum velocity

c) The layer of the fluid, which is in contact with the moving plate and is on the side of farther plate, is moving with the maximum velocity

d) The layer of the fluid, which is in contact with the moving plant and is on the side of nearer plate, is moving with the maximum velocity

93. A rubber rope of length 8 m is hung from the ceiling of a room. What is the increase in length of rope due to its own weight? (Given : Young's modulus of elasticity of rubber = 5 × 106 N/m and density of rubber $= 1.5 \times 10^3\ kg/m^3$. Take $g = 10\ m/s^2$)

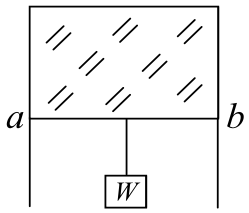
a) 1.5 mm b) 6 mm c) 24 mm d) 96 mm

94. A student performs an experiment to determine the Young's modulus of a wire, exactly 2 m long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of $\pm 0.05\ mm$ at a load of exactly 1.0 kg. The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of $\pm 0.01 mm$. Take $g = 9.8\ m/s^2$ (exact). The Young's modulus obtained from the reading is

a) $(2.0 \pm 0.3) \times 10^{11} N/m^2$ b) $(2.0 \pm 0.2) \times 10^{11} N/m^2$

c) $(2.0 \pm 0.1) \times 10^{11} N/m^2$ d) $(2.0 \pm 0.05) \times 10^{11} N/m^2$

95. A film of soap solution is trapped between a vertical frame and a light wire ab of length 0.1 m. If $g = 10\ m/s^2$, then the load W that should be suspended from the wire to keep it in equilibrium is



a) 0.2 g b) 0.3 g c) 0.4 g d) 0.5 g

96. An elastic material of Young's modulus Y is subjected to a stress S. The elastic energy stored per unit volume of the material is

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

97. A glass rod of radius r_1 is inserted symmetrically into a vertical capillary tube of radius r_2 such that theie lower ends are at the same level. The arrangement is now dipped in water. The height to which water will rise into the tube will be ($\sigma =$ surface tension of water, $\rho =$ density of water)

a) $\frac{2\sigma}{(r_2 - r_1)\rho g}$ b) $\frac{\sigma}{(r_2 - r_1)\rho g}$ c) $\frac{2\sigma}{(r_2 + r_1)\rho g}$ d) $\frac{2\sigma}{(r_2^2 + r_1^2)\rho g}$

98. The surface energy of a liquid drop is E. It is sprayed into 1000 equal droplets. Then its surface energy becomes

a) $1000E$ b) $100E$ c) $10E$ d) E

99. A steel wire of length 4.7 m and cross-sectional area $3 \times 10^{-6} m^2$ stretches by the same amount as a copper wire of length 3.5 m and cross-sectional area of 4×10^{-6} m^2 under a given load. The ratio of Young's modulus of steel to that of copper is

a) 1.8 b) 3.6 c) 0.6 d) 8.7

100. Water rises to a height of 10 cm in a capillary tube and mercury falls to a depth of 3.42 cm in the same capillary tube. If the density of mercury is 13.6 g/c. c. and the angles of contact for mercury and water are 135° and 0°, respectively, the ratio of surface tension for water and mercury is

a) 1: 0.15 b) 1: 3 c) 1: 6.5 d) 1.5: 1

101. One end of uniform wire of length L and of weight W is attached rigidly to a point in the roof and a weight W_1 is suspended from its lower end. If s is the area of cross section of the wire, the stress in the wire at a height $(3L/4)$ from its lower end is

a) $\frac{W_1}{s}$ b) $\left[W_1 + \frac{W}{4}\right] s$ c) $\left[W_1 + \frac{3W}{4}\right] /s$ d) $\frac{W_1 + W}{s}$

102. A long wire hangs vertically with its upper end clamped. A torque of 8 Nm applied to the free end twists it through 45°. The potential energy of the twisted wire is

a) π J b) $\frac{\pi}{2}$ J c) $\frac{\pi}{4}$ J d) $\frac{\pi}{8}$ J

103. A copper wire and a steel wire of the same cross-sectional area and length are joined end-to-end (at one end). Equal and opposite longitudinal forces are applied to the free ends giving a total elongation of l. Then the two wires will have

a) Same stress and same strain b) Same stress and different strains
c) Different stresses and same strain d) Different stresses and different strains

104. A wire can sustain the weight of 20 kg before breaking. If the wire is cut into two equal parts, each part can sustain a weight of

a) 10 kg b) 20 kg c) 40 kg d) 35 kg

105. A ball rises to the surface of a liquid with constant velocity. The density of the liquid is four time the density of the material of the ball. The frictional force of the liquid on the rising ball is greater than the weight of the ball by a factor of

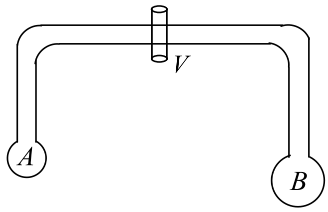
a) 2 b) 3 c) 4 d) 6

106. A small metal ball of diameter 4 mm and density 10.5 g/cm^3 in dropped in glycerine of density 10.5 g/cm^3. The ball attains a terminal velocity of 8/cm/sec. The coefficient of viscosity of glycerine is

a) 4.9 poise b) 9.8 poise c) 98 poise d) 980 poise

107. The value V in the bent tube is initially kept closed. Two soap bubbles A (smaller) and B (larger) are

formed at the two open ends of the tube. V is now opened and air can flow freely between the bubbles



a) There will be change in the size of the bubbles
b) The bubbles will become of equal size
c) A will become smaller and B will become larger
d) The sizes of A and B will be interchanged

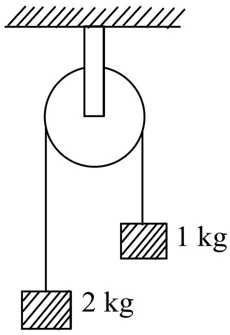
108. The extension in a string obeying Hooke's law is x. The speed of sound in the stretched string is v. If the extension in the string is increased to 1.5 x, the speed of sound will be
a) 1.22 v b) 0.61 v c) 1.50 v d) 0.75 v

109. A cube is shifted to a depth of 100 m is a lake. The change in volume is 0.1%. The bulk modulus of the material is nearly
a) 10 Pa b) 10^4 Pa c) 10^7 Pa d) 10^9 Pa

110. Two soap bubbles of different radii are in communication with each other. Then
a) Air follows from the larger bubble into smaller bubble till both bubbles acquire same size
b) Air follows from the smaller bubble into larger bubble and the larger bubble grows in size with decrease in size of the smaller bubble
c) Air does not flow but the sizes of the bubbles changes
d) Sizes of the bubbles remain unchanged

111. Water rises to a height of 2 cm in a capillary tube. If the tube is tilted 60° from the vertical, water will rise in the tube to a length of
a) 4.0 cm b) 2.0 cm
c) 1.0 cm d) Water will not rise at all

112. Two blocks of masses 1 kg and 2 kg are connected by a metal wire going over a smooth pulley as shown in the figure. The breaking stress of the metal is $(40/3\pi) \times 10^6$ N/m^2. If $g = 10$ m/s^2, then what should be the minimum radius of the wire used if it is not to break?



a) 0.5 mm b) 1 mm c) 1.5 mm d) 2 mm

113. A uniform cylindrical wire is subjected to a longitudinal tensile stress of 5×10^7 N/m^2. Young's modulus of the material of the wire is 2×10^{11} N/m^2. The volume change in the wire is 0.02%. The factional change in the radius is
a) 0.25×10^{-4} b) 0.5×10^{-4} c) 1.0×10^{-4} d) 1.5×10^{-4}

114. A sphere of brass released in a long liquid column attains a terminal speed v_0. If the terminal speed is attained by a sphere of marble of the same radius and released in the same liquid is $n\, v_0$, then the value of n will be (Given: The specific gravities of brass, marble and liquid are 8.5, 2.5 and 0.8, respectively)
a) $\frac{5}{17}$ b) $\frac{17}{77}$ c) $\frac{11}{31}$ d) $\frac{17}{5}$

115. A spherical ball falls through viscous medium with terminal velocity v. If this ball is replaced by another ball of the same mass but half the radius, then the terminal velocity will be (neglect the effect of buoyancy)
a) v b) $2v$ c) $4v$ d) $8v$

116. A solid sphere falls with a terminal velocity of 20 m/s in air. If it is allowed to fall in vacuum,
   a) Terminal velocity will be 20 m/s
   b) Terminal velocity will be less than 20 m/s
   c) Terminal velocity will be greater than 20 m/s
   d) No terminal velocity will be attained

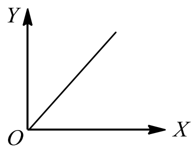
Multiple Correct Answers Type

117. When a capillary tube is dipped in a liquid, the liquid rises to a height h in the tube. The free liquid surface inside the tube is hemispherical in shape. The tube is now pushed down so that height of the tube outside the liquid is less than h. Then
   a) The liquid will come out of the tube like in a small fountain
   b) The liquid will ooze out of the tube slowly
   c) The liquid will fill the tube but not come out of its upper end
   d) The free liquid surface inside the tube will not be hemispherical
118. Choose the correct statements from the following:
   a) Steel is more elastic than rubber
   b) The stretching of a coil spring is determined by the Young's modulus of the wire of the spring
   c) The frequency of a tuning fork is determined by the shear modulus of the material of the fork
   d) When a material is subjected to a tensile (stretching) stress the restoring forces are caused by interatomic attraction
119. Which of the following are correct?
   a) For a small deformation of a material, the ratio (stress/stain) decreases
   b) For a large deformation of a material, the ratio (stress/strain) decreases
   c) Two wires made of different materials, having the same diameter and length are connected end to end. A force is applied. This stretches their combined length by 2 mm. Now, the strain is same in both the wire but stress is different
   d) None of these is correct
120. Two wires A and B have the same cross section and are made of the same material, but the length of wire A is twice that of B. Then, for a given load
   a) The extension of A will be twice that of B
   b) The extensions of A and B will be equal
   c) The strain in A will be half that in B
   d) The strains in A and B will be equal
121. If a liquid rises to the same height in two capillaries of the same material at the same temperature, then
   a) The weight of liquid in both capillaries must be equal
   b) The radius of meniscus must be equal
   c) The capillaries must be cylindrical and vertical
   d) The hydrostatic pressure at the base of capillaries must be same
122. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied?
   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
123. When a body of mass M is attached to lower end of a wire (of length L) whose upper end is fixed, then the elongation of the wire is l. In this situation, mark out the correct statement(s)
   a) Loss in gravitational potential energy of M is Mgl
   b) Elastic potential energy stored in the wire is $\frac{Mgl}{2}$
   c) Elastic potential energy stored in the wire is Mgl
   d) Elastic potential energy stored in the wire is $\frac{Mgl}{3}$

124. A light rod of length 2 m is suspended from the ceiling horizontally by means of two vertical wires of equal length tied to its ends. One of the wires is made of steel and is of cross section 0.1 cm^2. The other wire is a brass of cross section 0.2 cm^2. A weight is suspended from a certain point of the rod such that equal stress are produced in both the wires. Which of the following are correct?
a) The ratio of tension in the steel and brass wires is 0.5
b) The load is suspended at a distance of 400/3 cm from the steel wire
c) Both a and b are correct
d) Neither a nor b is correct

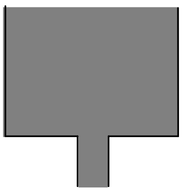
125. A metal wire of length L, area of cross-section A and Young's modulus Y is stretched by a variable from F such that F is always slightly greater than the elastic forces of resistance in the wire. When the elongation of the wire is l
a) The work done by F is $\frac{YAl^2}{L}$
b) The work done by F is $\frac{YAl^2}{2L}$
c) The elastic potential energy stored in the wire is F is $\frac{YAl^2}{2L}$
d) Heat is produced during the elongation S

126. A student performs an experiment for the determination of Young's modulus of the material of a wire. He obtains the following graph from his readings. The quantities on X and Y-axis may be respectively



a) Weight suspended and increase in length
b) Stress applied and strain developed
c) Stress applied and increase in length
d) Strain produced and weight suspended

127. A tank of large base area is filled with water up to a height of 5 m. A hole of 2 cm^2 cross section in the bottom allows the water to drain out in continuous streams. For this situation, mark out the correct statement(s) (take $\rho_{\text{water}} = 1000\ \mathrm{kg/m^3}, \mathrm{g} = 10\ \mathrm{m/s^2}$)

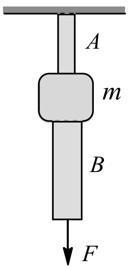


a) The cross-sectional area of the emerging stream of water decreases as it falls down
b) The cross-sectional area of the emerging stream of water increases as it falls down
c) At a distance of 5 m below the bottom of the tank, the cross-sectional area of the stream is 1.414 cm^2
d) At a distance of 5 m below the bottom of the tank, the cross-sectional area of the stream is 2.86 cm^2

128. A metal wire of length L is suspended vertically from a rigid support. When a body of mass M is attached to the lower end of wire, the elongation of the wire is l.
a) The loss in gravitational potential energy of mass M is Mgl.
b) The elastic potential energy stored in the wire is Mgl
c) The elastic potential energy storied in the wire is $\frac{1}{2}Mgl$
d) Heat produced is $\frac{1}{2}Mgl$

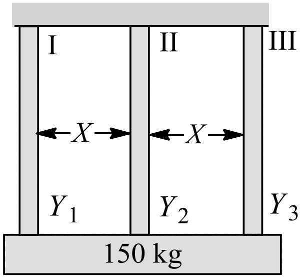
129. If n drops of a liquid, each with surface energy E, join to form a single drop, then
a) Some energy will be released in the process
b) Some energy will be released in the process
c) The energy released or absorbed will be $E(n - n^{2/3})$
d) The energy released or absorbed will be $nE(2^{2/3} - 1)$

130. Two wire A and B have equal lengths and are made of the same material, but the diameter of A is twice that of wire B. Then, for a given load
    a) The extension of B will be four times that of A
    b) The extension of A and B will be equal
    c) The strain in B is four times that in A
    d) The strains in A and B will be equal
131. Choose the correct alternatives
    a) For most material, the modulus of rigidity (η) is equal to one third of their Young's modulus.
    b) A deforming force in one direction can produce strain in other directions also.
    c) Stress is a vector quantity, since stress = force/area, where, force is a vector quantity.
    d) A material which stretches less for a given load is more elastic.
132. In the previous question
    a) Young's modulus of A is twice that of B
    b) Young's modulus is the same for both A and B
    c) A can withstand a greater load before breaking than B
    d) A and B will withstand the same load before breaking
133. The wires A and B shown in figure, are made of the same material and have radii r_A and r_B respectively. A block of mass m is connected between them. When a force F is mg/3, one of the wires breaks.



    a) A will break before B if $r_A < r_B$
    b) A will break before B if $r_A = r_B$
    c) Either A or B will break if $r_A = 2r_B$
    d) The length of A and B must be known to decide which wire will break
134. Which of the following are correct?
    a) The product of bulk modulus of elasticity and compressibility is 1
    b) A rope 1 cm in diameter breaks if the tension in it exceeds 500 N. The maximum tension that may be given to a similar rope of diameter 2 cm is 2000 N
    c) Both a and are correct
    d) Neither a nor b is correct
135. Viscous force is somewhat like friction as it opposes, the motion and is non-conservation but not exactly so, because
    a) It is velocity dependent while friction is not
    b) It is velocity independent while frication is
    c) It is temperature dependent while friction is not
    d) It is independent of area is like surface tension while friction is dependent
136. A metal wire length L, cross-sectional area A and Young's modulus Y is stretched by a variable force F. F is varying in such a way that F is always slightly greater than the elastic forces of resistance in the wire. When the elongation in the wire is l, up to this instant
    a) The work done by F is $\frac{YAl^2}{2L}$
    b) The work done by F is $\frac{YAl^2}{L}$
    c) The elastic potential energy stored in wire is $\frac{YAl^2}{2L}$
    d) No energy is lost during elongation
137. A heavy block of mass 150 kg hangs with the help of three vertical wires of equal length and equal cross-

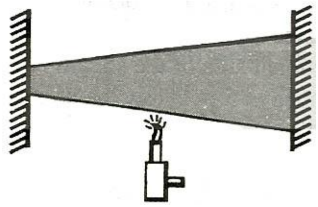
sectional area as shown in the figure



Wire is attached to the mid-point (centre of mass) of block. Take $Y_2 = 2Y_1$. For this arrangement mark out the correct statement(s)

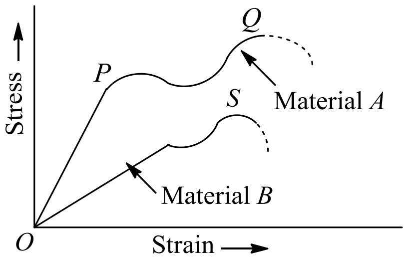
a) The wire I and III should have same Young's modulus
b) Tension in I and III would be always equal
c) Tension in I and III would be different
d) Tension in II is 75 g

138. A rod is made of uniform material and has non-uniform cross section. It is fixed at both the ends as shown and heated at mid-section. Which of the following statements are not correct?



a) Force of compression in the rod will be maximum at mid-section
b) Compressive stress in the rod will be maximum at left end
c) Since rod in fixed at both the ends, its length will remain unchanged. Hence, no strain will be induced in it
d) None of the above

139. The figure shows the stress-strain graphs for materials A and B. From the graph it follows that



a) Material A has a higher Young's modulus
b) Material B is more ductile
c) Material A can withstand greater stress
d) Material A can withstand greater stress

140. Excess pressure can be $(2T/R)$ for

a) Spherical drop
b) Spherical meniscus
c) Cylindrical bubble in air
d) Spherical bubble in water

141. Which of the following statements are correct?

a) The Young's modulus, strain energy
b) The Young's modulus of rubber is less than that of steel
c) The stretching of a coil is related by its Young's modulus
d) The stretching of a coil is related by its shear

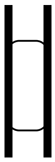
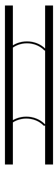
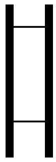
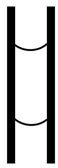
142. Which of the following are correct?

a) The shear modulus of a liquid is infinite
b) Bulk modulus of a perfectly rigid body is infinity
c) According to Hooke's law, the ratio of the stress and strain remains constant

d) None of the above

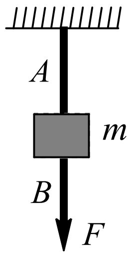
143. Four rods A, B, C and D of the same length and material but of different radii $r, r\sqrt{2}, r\sqrt{3}$ and $2r$, respectively, are held between two rigid walls. The temperature of all rods is increased through the same range. If the rods do not bend, then
a) The stress in the rods A, B, C and D is in the ratio $1:2:3:4$
b) The forces on them exerted by the wall are in the ratio $1:2:3:4$
c) The energy stored in the rods due to elasticity is in the ratio $1:2:3:4$
d) It is independent of area like surface tension while friction depends

144. A uniform plank is resting over a smooth horizontal floor and is pulled by applying a horizontal force at its one end. Which of the following statements are not correct?
a) Stress developed in plank material is maximum at the end at which force is applied and decrease linearly to zero at the other end
b) A uniform tensile stress is developed in the plank material
c) Since plank is pulled at one end only, plank starts to accelerate along direction of the force. Hence, no stress is developed in the plank material
d) None of the above

145. A vertical glass capillary tube, open at both ends, contains some water. Which of the following shapes may not be taken by the water in the tube?
a)  b)  c)  d) 

146. Two rods of different materials having coefficients of thermal expansionand 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
a) 2:3 b) 1:1 c) 3:2 d) 4:9

147. A composite rod consists of a steel rod of length 25 cm and area $2A$ and a copper rod of length 50 cm and area A. The composite rod is subjected to an axial load F. If the Young's moduli of steel and copper are in the ratio 2:1, then
a) The extension produced in copper rod will be more
b) The extension in copper and steel parts will be in the ratio 1:2
c) The stress applied to copper rod will be more
d) No extension will be produced in the steel rod

148. The wires A and B shown in the figure are made of the same material and have radii r_A and r_B, respectively. The block between them has a mass m. When the force F is mg/3, one of the wires breaks. Then


a) A will break before B if $r_A = r_B$
b) A will break before B if $r_A < 2r_B$
c) Either A or B may break if $r_A = 2r_B$
d) The lengths of A and B must be known to predict which wire will break

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 149 to 148. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

149

Statement 1: Young's modulus for a perfectly plastic body is zero.

Statement 2: For a perfectly plastic body, restoring force is zero.

150

Statement 1: Force constant $k = \frac{YA}{l}, where\ Y$ is Young's modulus, A is area and l is original length of the given spring.

Statement 2: Force constant in the case of a given spring is called spring constant.

151

Statement 1: Bulk modulus of elasticity (K) represents incompressibility of the material

Statement 2: Bulk modulus of elasticity is proportional to change in pressure

152

Statement 1: Steel is more elastic than rubber

Statement 2: Under given deforming force, steel is deformed less than rubber

153

Statement 1: Ductile metals are used to prepare thin wires.

Statement 2: In the stress-strain curve of ductile metals, the length between the points representing elastic limit and breaking point is very small.

154

Statement 1: Glassy solids have sharp melting point

Statement 2: The bonds between the atoms of glassy solids get broken at the same temperature

155

Statement 1: The stretching of a coil is determined by its shear modulus

Statement 2: Shear modulus change only shape of a body keeping its dimensions unchanged

156

Statement 1: A small drop of mercury is spherical but bigger drops are oval in shape

Statement 2: Surface tension of liquid decreases with increase in temperature

157

Statement 1: Two identical solid balls, one of ivory and the other of wet-clay are dropped from the same height on the floor. Both the balls will rise to same height after bouncing

Statement 2: Ivory and wet-clay have same elasticity

158

Statement 1: A hollow shaft is found to be stronger than a solid shaft made of same material

Statement 2: The torque required to produce a given twist in hollow cylinder is greater than that required to twist a solid cylinder of same size and material

159

Statement 1: The bridges are declared unsafe after a long use.

Statement 2: The bridges lose their elastic strength with time.

160

Statement 1: Stress is the internal force per unit area of a body

Statement 2: Rubber is less elastic than steel

161

Statement 1: An object from a greater height reaches a steady terminal velocity

Statement 2: The viscous forces on a body depends upon its velocity. The greater the velocity the greater is the viscous force

162

Statement 1: Finer the capillary, greater is the height to which the liquid rises in the tube

Statement 2: This is in accordance with the ascent formula

163

Statement 1: The restoring force $F$and a stretched string for extension x is related to potential energy Uas, $F = -\frac{dU}{dx}$

Statement 2: $F = -kx \ and \ U = \frac{1}{2}kx^2$, where k is a spring constant for the given stretched string.

164

Statement 1: Small liquid drops assume spherical shape

Statement 2: Due to surface tension liquid drops tend to have minimum surface area

165

Statement 1: Smaller drops of liquid resist deforming forces better than the larger drops

Statement 2: Excess pressure inside a drop is directly proportional to its surface area

166

Statement 1: Spring balances show correct readings even after they had been used for a long time interval

Statement 2: On using for long time, spring balances losses its elastic strength

167

Statement 1: Droplets of liquid are usually more spherical in shape than large drops of the same liquid

Statement 2: Force of surface tension predominates the force of gravity in case of small drops

168

Statement 1: Dust particles generally settle down in a closed room

Statement 2: The terminal velocity is inversely proportional to the square of their radii

169

Statement 1: The unit of stress is same as that of pressure.

Statement 2: Stress has the same meaning as that pressure.

170

Statement 1: A needle placed carefully on the surface of water may float, whereas the ball of the same material will always sink

Statement 2: The buoyancy of an object depends both on the material and shape of the object

171

Statement 1: While blowing a soap bubble, to increase the size of soap babble, we have to increase the air pressure within the soap bubble

Statement 2: To increase the size of soap bubble, more air has to be pushed into the bubble

172

Statement 1: Surface tension has the same units as force gradient

Statement 2: Surface tension is the force gradient along the surface of liquid

173

Statement 1: More is the cohesive force, more is the surface tension

Statement 2: More cohesive force leads to more shrinking of liquid surface

174

Statement 1: Two identical springs of steel and copper are equally stretched. More work will be done on steel than copper.

Statement 2: Steel is more elastic than copper.

175

Statement 1: A raindrop after failing through some height attains a constant velocity

Statement 2: At constant velocity, the viscous drag is just equal to its weight

176

Statement 1: Spraying of water causes cooling

Statement 2: For an isolated system, surface energy increase on the expense of internal energy

177

Statement 1: A solid shaft is found to be stronger, than a hollow shaft of same material.

Statement 2: The torque required to produce a given twist in solid cylinder is smaller than that required to twist a hollow cylinder of the same size and material.

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

178. Match the following:

Column-I		Column- II	
(A)	Longitudinal stress	(p)	Volume changes
(B)	Shear stress	(q)	Shape changes
(C)	Volume changes	(r)	Volume does not change
(D)	Tensile stress	(s)	Shape does not change

CODES :

	A	**B**	**C**	**D**
a)	A,d	a,c	b,c	b,c
b)	a,c	a,d	b,d	b,c
c)	b,d	b,c	a,c	a,d
d)	a,d	b,c	a,d	a,d

179. A glass plate of length 10 cm breadth 4 cm and thickness 0.4 cm weighs 20 g in air. It is held vertically with long side horizontal and half the plate immersed in water. What will be its apparent weight? Surface tension of water = 70 J dyn/cm

Column-I		Column- II	
(A)	Buoyant force due to liquid	(p)	20 gf
(B)	Force due to surface tension	(q)	8 gf
(C)	Apparent weight of the plate	(r)	1.5 gf
		(s)	13.5 gf

CODES :

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

180. With regard to dependence of quantities given in Columns I and II, match the following:

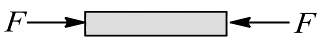
Column-I		Column- II	
(A)	Young's modulus of a substance	(p)	Depends on temperature
(B)	Bulk modulus of a substance	(q)	Depends on length
(C)	Modulus of rigidity of a substance	(r)	Depends on area of cross-section
(D)	Volume of a substance	(s)	Depends on the nature of material

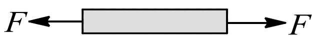
CODES :

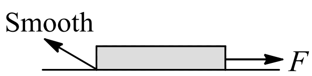
	A	B	C	D
a)	A,d	a,c	b,c	b,c
b)	a,c	a,d	b,d	b,c
c)	b,d	b,c	a,c	a,d
d)	a,d	a,d	a,d	a,b,c

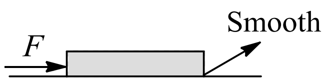
181. In Column I, a uniform bar of uniform cross-sectional area under the application of forces is shown in the figure and in Column II, some effects/phenomena are given. Match the entries of Column I with the entries of Column II

Column-I

(A) 

(B) 

(C) 

(D) 

Column- II

(p) Uniform stresses developed in the rod

(q) Non-uniform stresses developed in the rod

(r) Compressive stress developed

(s) Tensile stresses developed

CODES :

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

182. Match the following:

	Column-I		Column- II
(A)	Splitting of bigger drop into small droplets	(p)	Temperature increases
(B)	Formation of bigger drop from small droplets	(q)	Temperature decreases
(C)	Spraying of liquid	(r)	Surface energy increases
		(s)	Surface energy decreases

CODES :

	A	**B**	**C**	**D**
a)	B,c	a,d	b,c	
b)	a,d	a,c	b,c	
c)	a,c	a,d	b,d	
d)	b,d	b,c	a,c	

183. Consider a wire of length l, cross-sectional area A and Young's modulus Y and match Column I with Column II:

	Column-I		Column- II
(A)	If the wire is pulled at its ends by equal and opposite forces of magnitude F so that it undergoes an elongation x, according to Hooke's law, $F\ kx$, where (k) of the wire will depend on	(p)	Young's modulus Y
(B)	Let us suspend the wire vertically from a rigid support and attach a mass m at its lower end. If the mass is slightly pulled down and released, it executes S.H.M. of a time period that will depend on	(q)	Elongation (x)
(C)	If the given wire is fixed between two r. Length (l) rigid supports and its temperature is increased thermal stress that develops in the rod will depend on	(r)	Length (l)
(D)	Work done in stretching the wire to a section length $l + x$ will depend on	(s)	Area of cross-section (A)

CODES :

	A	**B**	**C**	**D**
a)	A,c,d	a,c,d	a	a,b,c,d
b)	a	a,c,d	a,b,c,d	a,c,d
c)	a,c,d	a	a,c,d	a,b,c,d
d)	a,c,d	a,b,c,d	a	a,c,d

Linked Comprehension Type

This section contain(s) 20 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 184 to -184

A body's catapult is made of rubber cord 42 cm long and 6 mm in diameter. The boy keeps a stone weighing 0.02 kg on it and stretches the cord by 20 cm. When released, the stone files off with a velocity of 20 ms^{-1}. Neglect the change in the cross-section of the cord in stretched.

184. The stress in the rubber cord is

a) 1.8×10^6 Nm^{-2} b) 1.4×10^6 Nm^{-2} c) 2.4×10^5 Nm^{-2} d) 1.8×10^5 Nm^{-2}

Paragraph for Question Nos. 185 to - 185

A structure steel rod has a radius of 10 mm and length of 1.0 m. A 100 kN force stretches it along its length. Young's modulus of structural steel is 2×10^{11} Nm^{-2}.

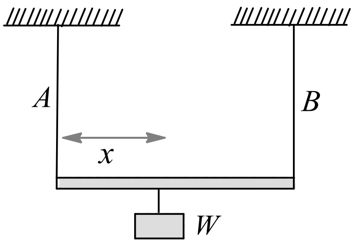
185. The elongation in the wire is

a) 1.59 mm b) 3.18 mm c) 2.38 mm d) 0.79 mm

Paragraph for Question Nos. 186 to - 186

A light rod of length $L = 2$ m is suspended horizontally from the ceiling by two wires A and B of equal lengths. The wire A is made of steel with the area of cross section $A_s = 1 \times 10^{-5}$ m^2, while the wire B is made of brass of cross-sectional area $A_b = 2 \times 10^{-5} m^2$. A weight W is suspended at a distance x from the wire A as shown in the figure

Take, Young's modulus of steel and brass as $Y_s = 2 \times 10^{11}$ Nm^{-2} and $Y_b = 1 \times 10^{11}$ Nm^{-2}



186. Determine the value of x so that equal stresses are produced in each wire

a) 1.33 m b) 2.5 m c) 3.6 m d) 2.1 m

Paragraph for Question Nos. 187 to - 187

A lead sphere of 1.0 mm diameter and relative density 11.20 attains a terminal velocity of 0.7 cm/s in a liquid of relative density 1.26

187. Determine the coefficient of dynamic viscosity of the liquid

a) 0.45 N/m^2 b) 0.85 N/m^2 c) 0.56 N/m^2 d) 0.77 N/m^2

Paragraph for Question Nos. 188 to - 188

A long capillary tube of radius 0.2 mm is placed vertically inside a beaker of water

188. If the surface tension of water is 7.2×10^{-2} N/m and the angle of contact between glass and water is zero, then determine the height of the water column in the tube

a) 3 cm b) 9 cm c) 7 cm d) 5 cm

Paragraph for Question Nos. 189 to - 189

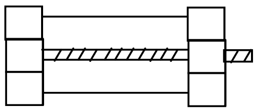
An oil of relative density 0.9 and viscosity 0.12 kg/ms flows through a 2.5 cm diameter pipe with a pressure drop of $38.4\ \mathrm{kN/m^2}$ in a length of 30 m. Determine

189. The discharge

a) $2.16 \times 10^{-4}\ \mathrm{m^3/s}$ b) $2.9 \times 10^{-3}\ \mathrm{m^3/s}$ c) $1 \times 10^{-4}\ \mathrm{m^3/s}$ d) $2 \times 10^{-4}\ \mathrm{m^3/s}$

Paragraph for Question Nos. 190 to - 190

A steel bolt of cross-sectional area $A_b = 5 \times 10^{-5}\ \mathrm{m^2}$ is passed through a cylindrical tube made of aluminium. Cross-sectional area of the tube material is $A_t = 10^{-4}\ \mathrm{m^2}$ and its length is $l = 50$ cm. The bolt is just taut so that there is no stress in the bolt and temperature of the assembly increases through $\Delta\theta = 10°$C. Given, coefficient of linear thermal expansion of steel, $\alpha_b = 10^{-5}/°\mathrm{C}$



Young's modulus of steel $Y_b = 2 \times 10^{11}\ \mathrm{N/m^2}$
Young's modulus of Al, $Y_t = 10^{11}\ \mathrm{N/m^2}$, coefficient of linear thermal expansion of Al $\alpha_t = 2 \times 10^{-5}/°\mathrm{C}$

190. The compressive strain in tube is

a) 10^{-4} b) 5×10^{-5} c) 2×10^{-3} d) 10^{-6}

Paragraph for Question Nos. 191 to - 191

According to Hooke's law, within the elastic limit stress/strain = constant. This constant depends on the type of strain or the type of force acting. Tensile stress might result in compressional or elongative strain; however, a tangential stress can only cause a shearing strain. After crossing the elastic limit, the material undergoes elongation and beyond a stage beaks. All modulus of elasticity are basically constants for the materials under stress

191. Two wires of the same material have length and radius (l, r) and $\left(2l, \frac{r}{2}\right)$. The ratio of their Young's modulus is

a) 1:2 b) 2:3 c) 2:1 d) 1:1

Paragraph for Question Nos. 192 to - 192

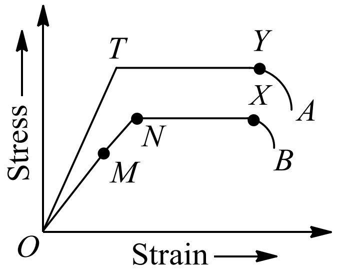
Molecular forces exist between the molecules of a liquid in a container. The molecules on the surface have unequal force leading to a tension on the surface. If this is not compensated by a force, the equilibrium of the liquid will be a difficult task. This leads to an excess pressure on the surface. The nature of the meniscus can inform us of the direction of the excess pressure. The angle of contact of the liquid decided by the forces between the molecules, air and container can make angle of contact

192. The direction of the excess pressure in the meniscus of a liquid of angle of contact $2\pi/3$ is

a) Upward
b) Downward
c) Horizontal
d) Cannot be determined

Paragraph for Question Nos. 193 to - 193

Materials get deformed when force is applied. Some of them regain their status when the applied force is removed. They are termed as elastic. Those of which not regaining are called plastic. There may be delay in the regaining in some materials. They are said to have got elastic aftereffect, since they have gone beyond the elastic limit. Repeated application and removal of force leads to fatigueness in the material. Fatigued materials may break at any point time and so are avoided
The stress strain graph for two materials A and B is shown in the following figure:

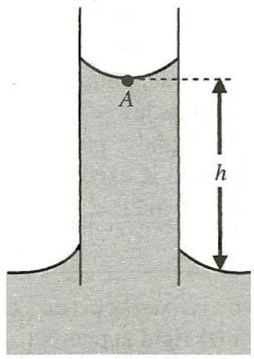


193. If the intensity of A and B is E_A and E_B, respectively, then

a) $E_A = E_B$
b) $E_A > E_B$
c) $E_A < E_B$
d) $E_A \ll E_B$

Paragraph for Question Nos. 194 to - 194

The figure shows a capillary tube of radius r dipped into water. The atmospheric pressure is P_0 and the capillary rise of water is h. s is the surface tension for water-glass

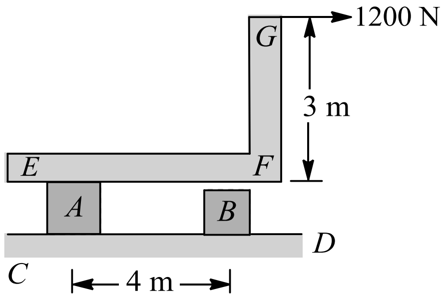


194. The pressure inside water at the point A (lowest point of the meniscus) is

a) P_0
b) $P_0 + \frac{2s}{r}$
c) $P_0 - \frac{2s}{r}$
d) $P_0 - \frac{4s}{r}$

Paragraph for Question Nos. 195 to - 195

In the figure shown, A and B are two short steel rods each of cross-sectional area 5 cm^2. The lower ends of A and B are welded to a fixed plate CD. The upper end of A is welded to the L-shaped piece EFG, which can slide without friction on upper end of B. A horizontal pull of 1200 N is exerted at G as shown. Neglect the weight of EFG



195. Mark out the correct statement(s)
    a) Shearing stress in A is zero
    b) Shearing stress in B is zero
    c) Shearing stress in both A and B is zero
    d) Shearing stress in both A and B is non-zero

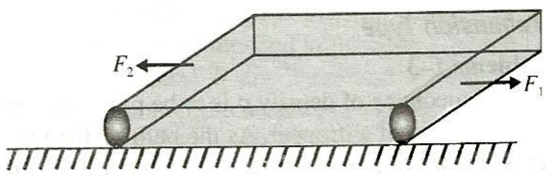
Paragraph for Question Nos. 196 to - 196

When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When the force becomes smaller than the weight of the drop, the drop gets detached from the dropper

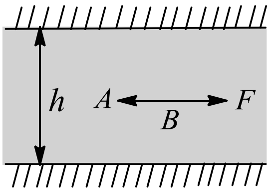
196. If the radius of the opening of the dropper is r, the vertical force due to the surface tension on the drop of radius R (assuming $r \ll R$) is
    a) $2\pi rT$ b) $2\pi RT$ c) $\frac{2\pi r^2 T}{R}$ d) $\frac{2\pi R^2 T}{r}$

Integer Answer Type

197. A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1 m and its cross-sectional area is 4.9×10^{-7} m^2. If the mass is pulled a little in the vertically downward direction and released, it performs simple harmonic motion of angular frequency 140 rad s^{-1}. If the Young's modulus of the material of the wire is $n \times 10^9$ Nm^{-2}, the value of n is
198. Two opposite forces $F_1 = 120$ N and $F_2 = 80$ N act on an elastic plank of modulus of elasticity $Y = 2 \times 10^{11}$ N/m^2 and length $l = 1$ m placed over a smooth horizontal surface. The cross-sectional area of the plank is $S = 0.5$ m^2. The change in length of the plank is $x \times 10^{-11}$ m. Find the value of x

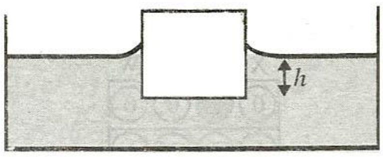


199. A thin plate AB of large area A is placed symmetrically in a small gap of height h filled with water of viscosity η_0 and the plate has a constant velocity v by applying a force F as shown in the figure. If the gap is filled with some other liquid of viscosity 0.75 η_0, at what minimum distance (in cm) from top wall should the plate be placed in the gap, so that the plate can again be pulled at the same constant velocity V, by applying the same force F? (Take $h = 20$ cm)

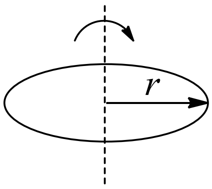


200. Steel wire of length 'L' at 40°C is suspended from the ceiling and then a mass 'm' hung from its free end. The wire is cooled down from 40°C to 30°C to regain its original length 'L'. The coefficient of linear thermal expansion of the steel is 10^{-5}/°C, Young's modulus of steel is $10^{11} N/m^2$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

201. A cube of side a and mass m just floats on the surface of water as shown in the figure. The surface tension and density of water are T and ρ_w, respectively. If angle of contact between cube and water surface is zero, find the distance h (in metres) between the lower face of cube and surface of the water
(Take $m = 1$ kg, $\mathrm{g} = 10\ \mathrm{m/s^2}$, $aT = \frac{10}{4}$ unit and $\rho_w a^2 \mathrm{g} = 10$ unit)



202. A ring of radius r made of wire of density ρ is rotated about a stationary vertical axis passing through its centre and perpendicular to the plane of the ring as shown in the figure. Determine the angular velocity (in rad/s) of ring at which the ring breaks. The wire breaks at tensile stress σ. Ignore gravity. Take $\sigma/\rho = 4$ and $r = 1$ m



203. A substance breaks down under a stress of 10^5 Pa. If the density of the wire is $2 \times 10^3\ \mathrm{kg/m^3}$, find the minimum length of the wire which will break under its own weight ($\mathrm{g} = 10\ \mathrm{m/s^2}$)

204. n drops of water, each of radius 2 mm, fall through air at a terminal velocity of 8 cm/s. If they coalesce to form a single drop, then the terminal velocity of the combined drop is 32 cm/s. The value of n is

205. The diameter of a gas bubbles formed at the bottom of a pond is $d = 4$ cm. When the bubble rises to the surface, its diameter tension of water $= T = 0.07\ \mathrm{N/m^{-1}}$

: ANSWER KEY :

1)	b	2)	d	3)	d	4)	a
5)	b	6)	b	7)	c	8)	a
9)	d	10)	a	11)	b	12)	a
13)	d	14)	a	15)	a	16)	a
17)	b	18)	a	19)	a	20)	a
21)	c	22)	b	23)	a	24)	c
25)	a	26)	a	27)	a	28)	d
29)	b	30)	c	31)	c	32)	d
33)	b	34)	a	35)	c	36)	c
37)	c	38)	d	39)	b	40)	d
41)	c	42)	c	43)	b	44)	b
45)	c	46)	c	47)	c	48)	a
49)	d	50)	b	51)	b	52)	a
53)	c	54)	b	55)	d	56)	c
57)	a	58)	b	59)	c	60)	b
61)	c	62)	d	63)	a	64)	b
65)	c	66)	c	67)	c	68)	c
69)	d	70)	b	71)	b	72)	a
73)	c	74)	a	75)	a	76)	b
77)	a	78)	c	79)	c	80)	b
81)	c	82)	d	83)	b	84)	b
85)	b	86)	a	87)	b	88)	c
89)	b	90)	d	91)	d	92)	b
93)	d	94)	b	95)	d	96)	b
97)	a	98)	c	99)	a	100)	c
101)	c	102)	a	103)	b	104)	b
105)	b	106)	b	107)	c	108)	a
109)	d	110)	b	111)	a	112)	b
113)	a	114)	b	115)	b	116)	d
1)	c,d	2)	a,d	3)	a,b	4)	a,d
5)	a,b	6)	a	7)	a,b	8)	a,b,c
9)	b,c,d	10)	a,b,c,d	11)	a,c	12)	a,c,d
13)	a,c	14)	a,c	15)	a,b,d	16)	b,c
17)	a,c	18)	a,b,c	19)	a,c	20)	a,c,d
21)	a,b,d	22)	a,c	23)	a,d	24)	a,b,c,d
25)	b,d	26)	a,b,c	27)	b,c	28)	b,c
29)	a,b,c	30)	c	31)	a,b,c	32)	a,b,c
1)	a	2)	b	3)	a	4)	a
5)	c	6)	d	7)	a	8)	c
9)	d	10)	a	11)	a	12)	b
13)	b	14)	a	15)	a	16)	a
17)	c	18)	e	19)	a	20)	c
21)	a	22)	c	23)	d	24)	a
25)	a	26)	a	27)	a	28)	a
29)	d	1)	d	2)	a	3)	d
	4)	b					
5)	a	6)	a	1)	b	2)	a
	3)	a	4)	d			
5)	c	6)	c	7)	b	8)	d
9)	a	10)	b	11)	c	12)	b
13)	c	1)	4	2)	1	3)	5
	4)	3					
5)	2	6)	2	7)	5	8)	8
9)	5						

: HINTS AND SOLUTIONS :

1 **(b)**

Since, ball gains the constant velocity

Therefore, net force on the ball = zero

$\Rightarrow$ Weight of the ball = Buoyancy force + Viscous force (F_v)

$\Rightarrow Mg = \frac{M}{d_1} \times d_2 \times g + F_v$

$\therefore F_v = Mg\left(1 - \frac{d_2}{d_1}\right)$

2 **(d)**

$v_0 = \frac{2}{9}\frac{r^2\,(\rho - \rho')g}{\eta}$

Now, $x = \frac{4}{3}\pi r^3 \rho$ or $\rho \propto \frac{x}{r^3}$

Similarly, $\rho' \propto \frac{y}{r^3}$

$\therefore v_0 \propto \frac{x\ -\ y}{r}$

3 **(d)**

$V \times \frac{4}{3}\pi R^3; 2V = \frac{4}{3}\pi R'^3; 2 \times \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R'^3;$

$R' = 2^{1/3} R$

$W'2 \times 4\pi\left[2^{1/3} R\right]^2\sigma = 2^{2/3} \times 2 \times 4\pi R^2\sigma$

$= 4^{1/3} W$

4 **(a)**

From the definition of bulk modulus $B = -\frac{dp}{dV/V}$

As we move from surface to placed where pressure changes to αp_0, let us assume volume changes by ΔV, then

$B = \frac{V\Delta p}{\Delta V} = \frac{V(\alpha\ - 1)p_0}{\Delta V}$

New volume, $V' = V - \Delta V = V\left[1 - \frac{(\alpha - 1)p_0}{B}\right]$

Density at the given depth, $\rho' = \rho\, V/V'$, where ρ is density at surface

$\rho' = \frac{\rho \times B}{B - (\alpha - 1)p_0}$

5 **(b)**

$\left[P_0 + \frac{4\sigma}{R_2}\right] - \left[P_0 + \frac{4\sigma}{R_1}\right] = \frac{4\sigma}{R}$

or $\frac{1}{R} = \frac{1}{R_2} - \frac{1}{R_1}$

or $R = \frac{R_1R_2}{R_1 - R_2} = \frac{50 \times 80}{30}\text{mm} = \frac{400}{3}$ mm

$= \frac{400}{3 \times 1000}\text{m} = \frac{4}{30}\text{m} = 0.133$ m

6 **(b)**

The elastic potential is energy $= \frac{1}{2}$ Stress $\times$ Strain

$= \frac{1}{2}Y(\text{strain})^2 = \frac{1}{2}Y\left(\frac{\Delta l}{L}\right)^2$

$\therefore \frac{U_2}{U_1} \propto \left(\frac{\Delta l_2}{\Delta l_1}\right)^2 = \left(\frac{10}{2}\right)^2$

$\frac{U_2}{U_1} = 25 \Rightarrow U_2 = 25\,U_1$

7 **(c)**

Thermal stress $= Y\alpha t$

In the given problem,

$Y\alpha\ =$ constant

$\frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{3}{2}$

8 **(a)**

As we increase the separation between the wires by 1 mm, the increase in surface area of the film is

$\Delta A = 2 \times 0.1 \times 10^{-3} = 2 \times 10^{-4}\ \text{m}^2$

(as there are two surfaces of film)

So, increase in surface energy, $\Delta U = S\Delta A = 1.44 \times 10^{-5}$J

Work done = ΔU

9 **(d)**

All of the statements are factual statements. Stress is defined as internal force developed in the system per unit cross-sectional area and is not defied as force applied per unit cross-section area, although in equilibrium, stress is numerically equal to applied force per unit area

10 **(a)**

$mr\omega^2$ =Breaking stress $\times$ Cross-sectional area

$10 \times 0.3\ \omega^2 = 4.8 \times 10^7 \times 10^{-6} = 48$

or $\omega^2 = \frac{48}{3} = 16$ or $\omega = 4$ rad/s

11 **(b)**

Change in pressure due to placing of mass on prism is $\Delta p = \frac{Mg}{A}$

Form bulk modulus definition $K = \frac{-dp}{dV/V}$

$\left|\frac{dV}{V}\right| = \frac{\Delta p}{K} = \frac{Mg}{AK}$

From $V = \frac{4}{3}\pi r^3$

$\frac{dV}{V} = \frac{3dR}{R} \Rightarrow \frac{dR}{R} = \frac{1}{3}\frac{dV}{V} = \frac{Mg}{3AK}$

12 **(a)**

$\left[2\pi \times \frac{8.7}{2} + 2\pi \times \frac{8.5}{2}\right]\sigma = 3.97 \times 980$

or $\sigma = \frac{3.97 \times 980 \times 7}{22 \times 17.2}\text{dyn/cm}^1 = 72\ \text{dyn/cm}^1$

13 **(d)**

$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$ or $R^3 = nr^3$

Energy evolved $= (n \times 4\pi r^2 - 4\pi r^2)T$

Now, $\theta = \frac{Q}{V\rho S} = \frac{Q}{V} =$ (In C. G. S. system, $\rho =$ 1 and $\mathcal{S}$=1

$$\therefore\ \theta = \frac{[n \times 4\pi r^2 - 4\pi R^2]T}{\frac{4}{3}\pi R^3}$$

$$= \frac{3T\ [nr^2 - R^2]}{R^3}$$

$$= 3T\left[\frac{nr^2}{nr^3} - \frac{R^2}{R^3}\right] = 3T\left[\frac{1}{r} - \frac{1}{R}\right]$$

14 **(a)**

Surface tension force,

$$\mathrm{F} = S \times 2l = 0.072 \times 2 \times \frac{2.5}{100} = 3.6 \times\ 10^{-3}\ \mathrm{N}$$

15 **(a)**

$$Y = \frac{F/a}{\Delta l/l} = \frac{Fl}{a\Delta l}$$

or $Y = \frac{Fl \times 4}{\pi\, D^2 \times \Delta l}$ or $\Delta l \propto \frac{1}{D^2}$ or $\frac{\Delta l_2}{\Delta l_1} = \frac{D_1^2}{D_2^2} = \frac{n^2}{1}$

16 **(a)**

Let h be the height of water inside the capillary. Total upward force tending to pull water supports the weight of the water

$$T(2\pi r_1 + 2\pi r_2) = h\ (\pi r_2^2 - \pi r_1^2)\rho \mathrm{g}$$

$$\therefore\ h = \frac{2T}{(r_2 - r_1)\ \rho \mathrm{g}} = \frac{2 \times 7 \times 10^{-2}}{10^{-3}\ (10^3)(10)}$$

$$= 14 \times 10^{-3}\ \mathrm{m} = 1.4\ \mathrm{cm}$$

17 **(b)**

Assuming isothermal conditions,

$$\left(P + \frac{4\sigma}{a}\right)\left(\frac{4}{3}\pi a^3\right) + \left(P + \frac{4\sigma}{b}\right)\left(\frac{4}{3}\pi b^3\right)$$

$$= \left(P + \frac{4\sigma}{c}\right)\left(\frac{4}{3}\pi c^3\right)$$

or $P[a^3 + b^3 - c^3] = 4\sigma\ [c^2 - a^2 - b^2]$

or $\sigma = \frac{P\ (c^3 - a^3 - b^3)}{4\ (a^2 + b^2 - c^2)}$

18 **(a)**

$F = (\sigma_1 - \sigma_2)l$

19 **(a)**

Increase in P.E. $= hld\ \rho \mathrm{g}\left(\frac{h}{2}\right) = \frac{ld\rho \mathrm{g}}{2}h^2$

If F is the force of attraction between the plates, then

$$Fd = \frac{ld\rho \mathrm{g}}{2}h^2 \text{ or } F = \frac{l\rho \mathrm{g}}{2}h^2$$

20 **(a)**

The terminal velocity of the spherical raindrop of radius r is given by

$v_t = \frac{2r^2\rho \mathrm{g}}{\eta}$ where ρ is the density of water and η the viscosity of air

Substituting $r = 0.3\ \mathrm{mm} = 0.3 \times\ 10^{-3}\ \mathrm{m}, \rho =$ $10^3 \mathrm{kg/m^3}$

$\mathrm{g} = 9.8\ \mathrm{m/s^2}$ and $\eta\ = 1.8 \times 10^{-5}\ \mathrm{Ns/m^2}$

We get $v_t = \frac{2 \times (0.3)^2 \times 10^{-3} \times 9.8}{9 \times 1.8 \times 10^{-5}} = 10.9\ \mathrm{m/s}$

21 **(c)**

$$\frac{h_2}{h_1} = \frac{\sigma_2 \cos\theta_2}{\rho_2} \times \frac{\rho_1}{\sigma_1 \cos\theta_1}$$

or $\frac{h_1}{h_2} = \frac{140 \times \frac{1}{2}}{2} \times \frac{1}{70 \times 1}$ or $h_2 = \frac{h_1}{2} = \frac{6}{2}\mathrm{cm} = 3\ \mathrm{cm}$

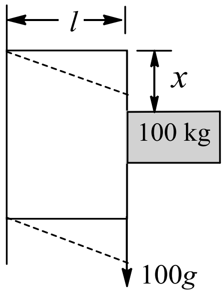
22 **(b)**

The situation is as shown in the figure. A force of 100g acts on farther face of cube as shown, due to which shear will develop

$$\eta = \frac{F/A}{x/l}$$

$$x = \frac{Fl}{A\eta} = \frac{100 \times 10 \times l}{l^2 \times\ 25 \times 10^9}$$

$$= 4\ \times 10^{-7}\mathrm{m}$$



23 **(a)**

Here, surface tension force support the weight of liquid

$$S \times 2\pi\left[r + \frac{d}{2}\right] = \left(r^2 - \frac{d^2}{4}\right)h\rho \mathrm{g}$$

$\Rightarrow\ h = 0.0144\ \mathrm{m} = 1.44\ \mathrm{cm}$

24 **(c)**

$$Y = \frac{Fl}{a\Delta l} \text{ or } \Delta l\ \propto \frac{1}{a}; \Delta l \propto \frac{1}{D^2}$$

$$\frac{\Delta l_2}{\Delta l_1} = \frac{D_1^2}{D_2^2} = 4 \text{ or } \Delta l_2 = 4\Delta l_1 = 4\ \mathrm{cm}$$

25 **(a)**

Extensions $\Delta l = \left(\frac{L}{YA}\right) \cdot W$

ie, graph is a straight line passing through origin (as shown in question also), the slope of which is $\frac{L}{YA}$

Slope= $\left(\frac{L}{YA}\right)$

$Y = \left(\frac{L}{A}\right)\left(\frac{1}{\text{slope}}\right)$

$= \left(\frac{1.0}{10^{-6}}\right)\frac{(80-20)}{(4-1) \times 10^{-4}}$

$= 2.0 \times 10^{11}\mathrm{Nm^{-2}}$

26 **(a)**

Effective length of flat part $= 2r$

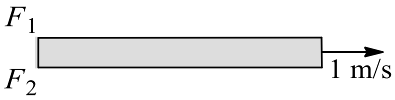
Effective length of curved part is πr

$F = \sigma l$

So, required ratio is $2:\pi$

27 **(a)**

The force experienced by the plate due to fluid is shown in the figure



F_1 is the force exerted by the layer in contact with plate on upper side and F_2 is the force exerted by the layer in contact with plate on lower side

$$F_1 = \eta A \times \frac{v}{4\text{ cm}} = 0.8 \times 0.01 \times \frac{1}{0.04} = 0.2\text{ N}$$

Where v is the velocity of layer in contact with plate

$$F_2 = \eta A \times \frac{v}{2\text{ cm}} = 0.8 \times 0.01 \times \frac{1}{0.02} = 0.2\text{ N} = 0.4\text{ N}$$

Total force, $F = F_1 + F_2 = 0.6$ N in backward direction

28 **(d)**

$$2\pi r\sigma + \frac{1}{2} \times \frac{4}{3}\pi r^3 d\mathrm{g} = \frac{4}{3}\pi r^3 \rho \mathrm{g}$$

or $2\pi r\sigma = \frac{\pi r^3 \mathrm{g}}{3}[4\rho - 2d]$ or $r^2 = \frac{3\times 2\pi\sigma}{\pi \mathrm{g}\,(2\rho - 2d)}$

or $r^2 = \frac{3\sigma}{\mathrm{g}(2\rho - d)}$ or $r = \sqrt{\frac{3\sigma}{\mathrm{g}\,(2\rho - d)}}$

Diameter $= 2r = \sqrt{\frac{12\sigma}{\mathrm{g}\,(2\rho - d)}}$

29 **(b)**

$$\frac{1}{K} = \frac{\Delta V/V}{\Delta P} \text{ or } \frac{\Delta V}{V} = \Delta P\left(\frac{1}{K}\right)$$

or $\frac{\Delta V}{V} \times 100 = 10^5 \times 8 \times 10^{-12} \times 100 = 8 \times 10^{-5}$

30 **(c)**

Work done $= \frac{1}{2} F \times$ Extension

$$= \frac{1}{2} \times \frac{YA}{L} \times 1 \qquad \left|\; Y = \frac{F \times L}{A \times 1}\right.$$

$$= \frac{YA}{2L} \qquad \left|\; F = \frac{YA}{L}\right.$$

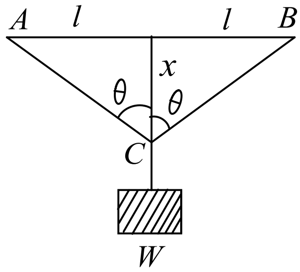
31 **(c)**

Here change in length is

$\Delta l = (AC + BC) - 2l$

$$= 2(l^2 + x^2)^{1/2} - 2l = 2l\left(1 + \frac{x^2}{l^2}\right)^{1/2}$$

$$= 2l\left(1 + \frac{1}{2}\frac{x^2}{l^2}\right) - 2l = \frac{x^2}{l}$$



$\therefore$ Strain $= \frac{\Delta l}{2l} = \frac{x^2}{2l^2}$

32 **(d)**

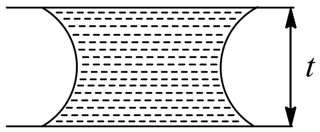
$$Y = \frac{Fl}{a\Delta l}$$

In the given problem, Y, l and Δl are constants

$\therefore F \propto a$

or $F \propto \pi r^2$ or $F \propto r^2$ or $\frac{F_1}{F_2} = \frac{r_1^2}{r_2^2} = \frac{1}{4}$

33 **(b)**



Pressure difference $= \frac{T}{R} = \frac{T}{t/2} = \frac{2T}{t}$

Force $= \frac{2T}{t}A$

But $V = At$ or $t = \frac{V}{A}$

$\therefore$ Force $= \frac{2TA^2}{V}$

34 **(a)**

Total upward force due to surface tension $= 2\sigma l$

Weight of lifted liquid $= (hld)\rho \mathrm{g}$

Equating, we get, $h = \frac{2\sigma}{\rho \mathrm{g} d}$

35 **(c)**

The density would increase by 0.1% if the volume decrease by 0.1%

$$K = \frac{\Delta P}{\Delta V/V}$$

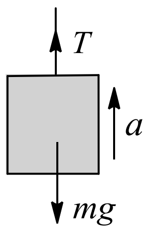
$$\Delta P = K\frac{\Delta V}{V} = 2 \times 10^9 \times \frac{0.1}{100} = 2 \times 10^6\ \text{N/m}^2$$

36 **(c)**

From the free-body diagram of the elevator,

$T - mg = ma$

$T = m(\mathrm{g} + a)$



Stress in cable is $\alpha = \frac{T}{A} = \frac{m(\mathrm{g}+a)}{a}$

From the given condition, $\alpha \le \frac{\alpha_{\max}}{2}$

$\frac{m(g+a)}{A} \leq \frac{\sigma_{\max}}{2}$

$g + a \leq \frac{2\times 10^9}{2} \times \frac{10^{-4}}{2\times 10^3} = 50$

$g + a \leq \frac{2\times 10^9}{2} \times \frac{10^{-4}}{2\times 10^3} = 50$

37 **(c)**

$$F = \frac{2A\sigma}{t} = \frac{2 \times 8 \times 75 \times 10}{0.12} \text{dyn} = 10^5 \text{ dyn}$$

38 **(d)**

$W = \frac{1}{2} F\, \Delta l$

$W = \frac{1}{2} \times \frac{Y\pi r^2 \Delta l}{l}\, \Delta l$ and $Y = \frac{Fl}{\pi r^2 \Delta l}$

or $W = \frac{Y\pi r^2 \Delta l^2}{2l}$ and $F = \frac{Y\pi r^2 \Delta l}{l}$

or $W \propto \frac{r^2}{l}, W' \propto \frac{(2r)^2 2}{l}$

$\frac{W'}{W} = 8$ or $W' = 8 \times 2 \text{ J} = 16 \text{ J}$

39 **(b)**

$V \propto r^4, V' \propto \left(r + \frac{1}{10} r\right)^4$

$\frac{V'}{V} = \frac{11 \times 11 \times 11 \times 11}{10 \times 10 \times 10 \times 10} = 1.4641$

or $\left(\frac{V'}{V} - 1\right) \times 100 = 46.4\%$

40 **(d)**

From the definition of Bulk modulus,

$B = -\frac{dp}{(dV/V)}$

Substituting the values we have,

$B = \frac{(1.165 - 1.01) \times 10^5}{\left(\frac{10}{100}\right)}$

$\text{Pa} = 1.55 \times 10^5 \text{ Pa}$

41 **(c)**

$m = alp, m$ and ρ are constants

$\therefore \frac{a_1}{a_2} = \frac{l_2}{l_1} = \frac{3}{2}$

Now, $Y = \frac{Fl}{a\Delta l}$ or $\Delta l \propto \frac{l}{a}$

or $\frac{\Delta l_1}{\Delta l_2} = \frac{l_1}{l_2} \times \frac{a_2}{a_1} = \frac{2}{3} \times \frac{2}{3}$ or $\frac{\Delta l_1}{\Delta l_2} = \frac{4}{9}$

42 **(c)**

$Y\, \mu$ weight applied

$\therefore \frac{Y_1}{Y_2} = \frac{W_1}{W_2} \Rightarrow \frac{W_1}{W_2} = \frac{3}{1}$

43 **(b)**

Consider a small element of the tube

$2T \sin\theta = \Delta p \times A$

Where $\Delta p = p_i - p_0$ and A is the area of element.

As θ is very small, $\sin\theta \approx \theta$ so, $2T \times \theta = \Delta p \times l \times (2r\theta)$

$\Rightarrow \Delta p = \frac{T}{lr} \sigma$ (stress developed in tube) $= \frac{\Delta T}{\Delta r \times l}$

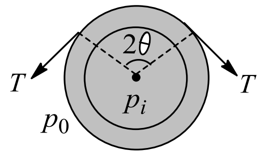
Where $\Delta r \times i$ is the cross-sectional area

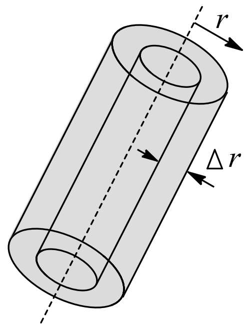
$\sigma = \frac{\Delta p \times lr}{\Delta r \times l} = \Delta p \times \frac{r}{\Delta r}$

For no rupturing, $\sigma \leq \sigma_{\max}$

So, $\Delta p \times \frac{r}{\Delta r} \leq \sigma_{\max}$

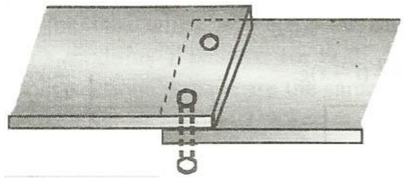
$\Delta p(\text{max, value}) = \sigma_{\max} \times \frac{\Delta r}{r}$





44 **(b)**

Let the maximum tensile force that each rivet can experience be F, then maximum shearing stress on each rivet is $\sigma = \frac{F}{A} = 1.5 \times 10^9$



$A = \pi r^2$, where $r = 2 \times 10^{-3}$ m

Required force is $2F$

45 **(c)**

$\frac{\rho'}{\rho} = \frac{\frac{M}{V-\Delta V}}{M/V} = \frac{V}{V-\Delta V}$

or $\frac{\rho'}{\rho} = V(V-\Delta V)^{-1}$ or $\frac{\rho'}{\rho} = 1 + \frac{\Delta V}{V}$

(using binomial theorem)

or $\frac{\Delta V}{V} = \frac{\rho'}{\rho} - 1$ or $\frac{\Delta V}{V} = \frac{\rho' - \rho}{\rho}$

Again, $k = k = \frac{\Delta P}{\frac{\Delta V}{V}} = \frac{\rho \Delta P}{\rho' - \rho}$ or $\rho' - \rho = \frac{\rho \Delta R}{K}$

But, $\Delta P = P$ (Given)

$\therefore \rho' - \rho = \frac{\rho P}{K}$

46 **(c)**

$m \times 10 = 2 \times 3 \times 10^{-2} \times \frac{10}{100}$

or $m = 6 \times 10^{-4}\text{kg} = 6 \times 10^{-4} \times 10^3\text{g} = 0.6 \text{ g}$

47 **(c)**

$Y = \frac{Fl}{a\Delta l}$; Y, l and a are constants

$\therefore F = \Delta l$

In the first case, $V\rho g = 16$

In the second case, $(V\rho g - V \times 1 \times g) = 14$

Dividing, $\frac{Vg(\rho - 1)}{Vg\rho} = \frac{14}{16} = \frac{7}{8}$

or $\frac{\rho - 1}{\rho} = \frac{7}{8}$ or $8\rho\ - 7\rho$ or $\rho = 8\ \text{g/cm}^3$

48 **(a)**

$\omega = \sqrt{\frac{K}{m}} = \sqrt{\frac{YA}{lm}}$

$= \sqrt{\frac{(n \times 10^9)\ (4.9 \times 10^{-7})}{1 \times 0.1}}$

Given,$\omega = 140$ rad s^{-1} in above equation, we get, $n = 4$

49 **(d)**

Energy released $= [n \times 4\pi a^2 -\ 4\pi b^2]\sigma$

Now, $n \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi b^3$ or $n = \frac{b^3}{a^3}$

Therefore, energy released is

$\left[\frac{b^3}{a^3} \times\ 4\pi a^2 -\ 4\pi b^2\right]\sigma = 4\pi b^2\ \left[\frac{b}{a} - 1\right]\sigma$

Now, $\frac{1}{2}\left(\frac{4}{3}\ \pi b^3\right)\rho v^2 = 4\pi b^2 \left[\frac{b}{a} - 1\right]\sigma$

or $v = \left[\frac{6\sigma}{\rho}\left(\frac{1}{a} - \frac{1}{b}\right)\right]^{1/2}$

50 **(b)**

$Y = \frac{F/A}{\Delta l/l} = \frac{Fl}{\Delta l A} = \frac{Fl}{\Delta l\ (\pi R^2)}$

Hence $Y \propto \frac{1}{R^2}$

$\frac{Y_B}{Y_S} = \frac{R_S^2}{R_B^2}$

$\frac{10 \times 10^{10}}{20 \times 10^{10}} = \frac{R_S^2}{R_B^2}$

$R_B^2 = 2R_S^2$

$R_B = \sqrt{2}\ R_S$

$\Rightarrow R_S = \frac{R_B}{\sqrt{2}}$

51 **(b)**

Suppose, $R =$ radius of water drop

and $r =$ radius of droplets

$\therefore\ \frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^3$

(Since volume remains constant)

$\therefore r = \frac{R}{2}$

Since excess pressure inside drop $= \frac{2T}{R}$

($T -$ surface tension, $R -$radius)

Therefore, pressure difference between inner and outer surface of big drop will be half of that for smaller droplet

52 **(a)**

$F = \frac{0.01 \times 100 \times 10}{0.1}$ dyn $= 100$ dyn

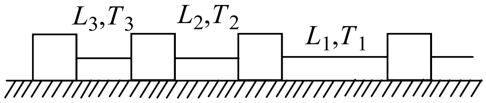
53 **(c)**

Shearing stress $= \frac{|\text{viscous force}|}{\text{area}}$

$= \frac{\eta A \frac{dv}{dx}}{A} = \eta \frac{dv}{dx}$

$= 10^{-3} \times \frac{5}{10}\text{N/m}^2 = 0.5 \times 10^{-3}\text{N/m}^2$

54 **(b)**



$T_1 > T_2 > T_3\ \Rightarrow$ lengths $L_1 > L_2 > L_3$

55 **(d)**

$\frac{20a \times\ 2.5 \times 10^3 \times 10 + 5 \times 10^5}{a} = 1.6 \times 10^6$

or $500a + 500 = 1600a$

or $1100a = 500$ or $a = \frac{5}{11}\text{m}^2 = 0.45\ \text{m}^2$

56 **(c)**

$\Delta l = \frac{Fl}{aY}$

$\Delta l = \frac{2 \times 10^5 \times 10^{-5} \times 1}{2\ \times 10^{-4} \times 10^4}$ or $\Delta l = 1$

So, new length is $2l$

57 **(a)**

In the condition of weightlessness, water rises to the whole of the available length

58 **(b)**

As the weight of wire acts at centre of gravity Therefore, only half the length of wire gets extended

Now $Y = \frac{F}{A} \cdot \frac{(L/2)}{\Delta l} = \frac{Mg(L/2)}{A\ \Delta l}$

$\Rightarrow\ \Delta l \frac{MgL}{2AY}\ \Rightarrow \Delta l \frac{AL\rho gL}{2AY}$

$\therefore \Delta l = \frac{\rho L^2 g}{2Y}$

59 **(c)**

$Y = \frac{Fl}{a\Delta l}$ or $\Delta l \propto \frac{1}{a}$

Again, $m = al\rho$ or m/a

$\therefore \Delta l \propto \frac{1}{m}$

$\frac{\Delta l_1}{\Delta l_2} = \frac{m_2}{m_1} = \frac{2}{3}$

60 **(b)**

If the rod is allowed to expand, then it will expand by $\Delta l = l\ \alpha\ \Delta T$ due to increase in temperature by ΔT. But as the length of the cylinder is kept constant by applying pressure, a stress is developed in the cylinder. The decrease in length of cylinder due to elasticity is $\Delta l = l\ \alpha\ \Delta T$ and a compressive stress will develop in it

Stress = Excess pressure applied at ends

$= Y \times \frac{\Delta l}{l}\ Y\alpha\Delta T$

$= 2 \times 10^{11} \times 11 \times 10^{-6} \times 100 = 2.2 \times 10^{3}\text{atm}$

61 **(c)**

Radius of the larger drop $= R$

Suppose radius of the droplets $= r$

Since volume will be remain constant,

$\frac{4}{3}\pi R^3 = 8 \times \frac{4}{3}\pi r^2$ (as no. of droplets = 8)

$\therefore r = \left(\frac{R^3}{8}\right)^{\frac{1}{3}} = \frac{R}{2}$

Therefore, work done= Increase in surface area × Surface tension $= \left[84\pi\ \left(\frac{R}{2}\right)^2 - 4\pi R^2\right] \times T$

$= (8\pi R^2 - 4\pi R^2) \times T = 4\pi R^2 T$

62 **(d)**

For equilibrium,

Total upward force by surface tension

= Weight of the water in tube

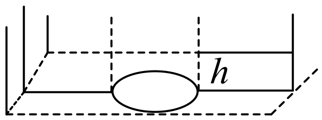
$\Rightarrow \pi \times\ D\ \times$ surface tension (circumference)

$= \pi\ (D/2)^2 \times\ h\ \times$ density × g (cross section)

Where D (diameter) = 0.1 mm = 0.01 cm

Density of water $=\ 1 \times 10^{-3}\text{g/cm}^3$

$\Rightarrow\ \pi \times\ (0.01) \times 75 \times 10^{-3}$



$= \pi \times \left(\frac{0.01}{2}\right)^2 \times h \times 1 \times 10^{-3} \times 1000$

$\therefore\ h = \frac{0.75 \times 0.01 \times 4}{0.01 \times 0.01} = 0.3\text{ m} = 30\text{ cm}$

63 **(a)**

Young's modulus is the property of material; it does not depend on shape and size of body

64 **(b)**

$Y = \frac{F/a}{\Delta l/l}$ or $Y = \frac{Fl}{a\Delta l}$

or $\Delta l = \frac{Fl}{aY} = \frac{Fl}{\pi r^2 Y}$

In the given problem, $\Delta l \propto \frac{l}{r^2}$

When both l and r are doubled, Δl is halved

65 **(c)**

$Y = \frac{Fl}{\pi r^2 \Delta l}$ or $\Delta l = \frac{Fl}{\pi r^2 Y}$

$\Delta l \propto \frac{1}{r^2}, \Delta l' \propto \frac{2l}{\left(\sqrt{2}r\right)^2}$ or $\Delta l' \propto \frac{1}{r^2}$

$\therefore \frac{\Delta l}{\Delta l'} = 1$

66 **(c)**

$Y = \frac{Fl}{a\Delta l}$

Y, l and a are constants

$\therefore \frac{Fl}{\Delta l}$ = constant or $\Delta l\ \propto F$

Now, $l_1 - l = T_1$ and $l_2 -\ l = T_2$

Dividing, $\frac{l_1 - l}{l_2 - l} = \frac{T_1}{T_2}$

or $l_1 T_2 - lT_2 = l_2 T_1 - lT_1$ or $T(T_1 - T_2) = l_2 T_1 - l_1 T_2$

or $l = \frac{l_2 T_1 - l_1 T_2}{T_1 - T_2}$ or $l = \frac{l_1 T_2 - l_2 T_1}{T_3 - T_1}$

67 **(c)**

Work done $= 10E - E\ =\ 9E$

68 **(c)**

Breaking stress $= \frac{\text{Maximum weight}}{\text{Area of cross section}}$

$10^6\ = \frac{al\rho g}{a} = l\rho g$

or $l\ = \frac{10^6}{\rho g} = \frac{10^6}{4\times 10^3 \times 10}\text{m} = 25\text{ m}$

69 **(d)**

We know $Y = \frac{\text{Stress}}{\text{Strain}} = \frac{Wl}{2Ax} \times \frac{2l^2}{x^2}$

$= \frac{Wl^3}{Ax^3}$ or $x = \left(\frac{W}{AY}\right)^{1/3} \times l$

70 **(b)**

$Y = \frac{F/A}{\Delta l/l}$

For the first wire, $Y = \frac{F \times L}{\pi r^2 \times l}$

For the second wire, $Y = \frac{2F \times 2L}{\pi(2r)^2 \times l'}$

Form the above two equations, $l' = l$

71 **(b)**

Pressure due to 15 cm long liquid column needs to be balanced

72 **(a)**

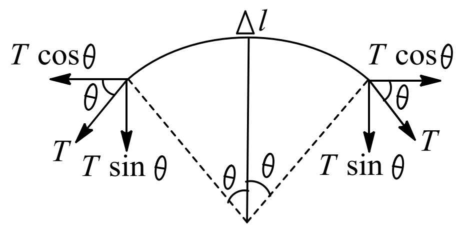
If y is the required distance, then

$a^2 y\rho g = mg + 4a\sigma$

or $y = \frac{mg \times 4a\sigma}{a^2\rho g} = \frac{20\times 980 + 4\times 3 \times 70}{3\times 3\times 1\times 980}\text{cm} = 2.3\text{ cm}$

73 **(c)**

When the soap film enclosed by the thread is pricked, the thread would take up a circular shape. Consider a small element of the thread. While horizontal components of tension get balanced, the vertical components get added up



or $2T \sin\theta = \sigma\,\Delta l$

or $2T\theta = \sigma(2\theta \times\ r)$

or $T = \sigma r = \sigma \times \frac{2\pi r}{2\pi}$

$= 0.030 \times \dfrac{6.28 \times 10^{-2}}{2\pi}$ N

$= 3 \times 10^{-4}$ N

74 **(a)**

$Y = \dfrac{\text{Stress}}{\text{Strain}} = \dfrac{x}{\frac{2l-l}{l}} = \dfrac{x}{l} = x$

Actually, the above expression is not exact for this much elongation

75 **(a)**

Breaking strength = Breaking stress $\times \frac{\pi D^2}{4}$

Breaking stress is unchanged

D is halved. So, breaking strength becomes one-fourth, i.e.,

$\dfrac{1}{4} \times 1.5 \times 10^5$ N or 0.375×10^5 N

76 **(b)**

Difference in apparent weights is due to difference in forces of surface tension. Due to 180°, the force surface tension in one case is opposite to the force of surface tension in the other case

$\therefore 2 \times \sigma_w \times \dfrac{10}{100} = 0.004 - 0.03$

or $\sigma_w \times \frac{0.014}{1} \times 5$ N/m $= 0.07$ N/m

77 **(a)**

Energy density $= \frac{1}{2} \times$ Stress $\times$ Strain

$= \dfrac{1}{2} \times \text{Stress} \times \dfrac{\text{Stress}}{Y} = \dfrac{(\text{Stress})^2}{2Y} \propto \dfrac{1}{D^4}$

Now, $\frac{u_A}{u_B} = \frac{D_B^4}{D_A^4} = [2]^4 = 16$

78 **(c)**

As already discussed in key concepts, if the cut is not very near to end of the bar, the internal developed force is distributed uniformly over the cross section

79 **(c)**

Work done=(increase in surface area) $\times$ surface tension

$= 2 \times \left[4\pi\left(\dfrac{2D}{2}\right)^2 - 4\pi\left(\dfrac{D}{2}\right)^2\right] \times T$

(Since for sap bubble, there are two free surfaces)

$= 2 \times (4\pi D^2 - \pi D^2)T = 6\pi D^2 T$

80 **(b)**

$F \propto h^2$

But $h^2 \propto \sigma^2$

$\therefore F \propto \sigma^2$

If σ is doubled, then F will become $4F$

81 **(c)**

$\dfrac{40}{100} \times 1000 \times 9.8 = \dfrac{2 \times 7 \times 10^{-2}}{R}$

or $R = \frac{14 \times 10^{-2} \times 100}{40 \times 1000 \times 9.8}$ m $= \frac{14 \times 1000}{40 \times 1000 \times 9.8}$ mm

$= \dfrac{1}{28}$ mm

Diameter $= 2R = \frac{1}{14}$ mm

82 **(d)**

$Y = \dfrac{F/a}{\Delta l/l} = \dfrac{Fl}{a\Delta l}$ or $\Delta l \propto \dfrac{1}{D^2}$

a. $\frac{100}{l^2} = 100$ b. $\frac{200}{4} = 50$

c. $\frac{300}{9} = 33.33$ d. $\frac{50}{(1/2)^2} = 200$

83 **(b)**

Work done $= \frac{1}{2} \times$ stretching force $\times$ extension

Therefore, net work done in increasing the length from 0.164 mm to 1.02 mm is

$W_2 - W_1 = \dfrac{1}{2} \times 5 \times 9.8 \times 1.02 \times 10^{-3} - \dfrac{1}{2} \times 3 \times 9.8 \times 0.61 \times 10^{-3} = 0.016$ J

84 **(b)**

$Y = \frac{Mg \times 4 \times l}{\pi D^2 \times \Delta l}$ or $\Delta l \propto \frac{1}{D^2}$

When D is doubled, Δl becomes one-fourth, i.e., $\frac{1}{4} \times 2.4$ cm, i.e. 0.6 cm

85 **(b)**

$h = \dfrac{2S\cos\theta}{r\rho g}$

Cross-sectional area increases four times, which means radius gets doubled

So, $h' = \frac{2S}{2(r\rho g)} = \frac{h}{2}$

86 **(a)**

$Y = \dfrac{Fl}{a^2\Delta l}$

$\Delta l \propto \dfrac{1}{a^2}$ or $\Delta l \propto \dfrac{1}{D^4}$

$\dfrac{\Delta l_A}{\Delta l_B} = \dfrac{D_B^4}{D_A^4} = \dfrac{1^4}{\left(\frac{1}{2}\right)^4} = 16$

$Y = \dfrac{F}{a} \times \dfrac{l}{\Delta l}$

Now, $V = al$ or $l = \frac{Y}{a}$ $\therefore Y = \frac{FV}{a^2\Delta l}$

87 **(b)**

$\Delta P = h\rho g = 200 \times 10^3 \times 10$ N/m^2

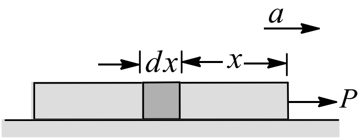
$= 2 \times 10^{-6}$ N/m^2

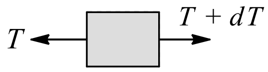
$K = \dfrac{\Delta P}{\frac{\Delta V}{V}} = \dfrac{2 \times 10^6}{\frac{0.1}{100}}$

$= \dfrac{2 \times 10^8}{0.1}$ N/m^2 $= 2 \times 10^9$ N/m^2

88 **(c)**

Let the force applied be p, then $P = ma$





$\Rightarrow\ p = 5 \times 2 = 10$ N

For the element shown in the figure,

$T = \dfrac{m}{l}(l - x) \times\ a$

$\Rightarrow\ T = \dfrac{5}{1}(1 - x) \times 2 = 10\ (1 - x)$

Elongation in dx is $\frac{\Delta(dx)}{dx} = \frac{T/A}{A}$

$\Delta(dx) = \dfrac{10(1 - x)}{(5 \times 10^{-2})^2} \times \dfrac{1}{5 \times 10^9}\ dx$

Total elongation, $\Delta l = \int_0^l \frac{10\ (l - x)}{25 \times 10^{-4}} \times \frac{1}{5 \times 10^9} dx =$ $0.4 \times\ 10^{-6}$ m

89 **(b)**

$\Delta l = \dfrac{Fl}{\pi r^2 Y}$ or $\dfrac{\Delta l}{l} \propto \dfrac{1}{r^2 Y}$

$\dfrac{\left(\frac{\Delta l}{l}\right)_s}{\left(\frac{\Delta l}{l}\right)_{\text{Cu}}} = \dfrac{r_{\text{Cu}}^2\ \text{Cu}}{r_S^2 Y_3} = \dfrac{4r_S^2\ \frac{Y_S}{2}}{r_S^2\ Y_S} = 2$

$\therefore\ \left(\dfrac{\Delta l}{l}\right)_s = 2\left(\dfrac{\Delta l}{l}\right)_{\text{Cu}}$

90 **(d)**

$Y = \dfrac{Fl}{a\Delta l}$

Y, l and F are constants

$\therefore \Delta l \propto \dfrac{1}{D^2}$

$\dfrac{\Delta l_2}{\Delta l_1} = \dfrac{D_1^2}{D_2^2} = \dfrac{1}{16}$

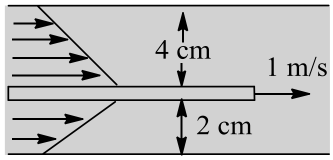
$\therefore \Delta l_2 = \dfrac{1}{16}$ mm

91 **(d)**

Surface tension force, $F = S \times$ length $F = S \times$ $[2\pi R + 2\pi r]$ as liquid surface is on the both sides

92 **(b)**

The profile of the velocity of fluid is as shown in the figure. The velocity of the layer of fluid, which is in contact with metal plates (fixed), is zero. As we move towards the centre from either plate, the velocity of the layer of fluid increase and it becomes maximum at the location of moving plate. This maximum value is same as that of the velocity of plate



93 **(d)**

$Y = \dfrac{Mg}{A} \times \dfrac{L/2}{\Delta L}$

(Length is taken as $L/2$ because weight acts at C.G.)

Now, $M = AL\rho$

(For the purpose of calculation of mass, the whole of geometrical length L is to be considered)

$\therefore Y = \dfrac{AL\rho gL}{2A\Delta L}$

or $\Delta L = \frac{\rho g L^2}{2Y} = \frac{1.5 \times 10^3 \times 10 \times 8 \times 8}{2 \times 5 \times 10^6}$ m

$= 9.6 \times 10^{-2}$ m $= 9.6 \times 10^{-2} \times 10^3$ mm

$= 96$ mm

94 **(b)**

$Y = \dfrac{FL}{Al} = \dfrac{4FL}{\pi l^2 l}; F = mg$

Where L = length of the wire

l = elongation of the wire

d = diameter of the wire

substituting the values, we get $Y = 2 \times 10^{11} N/m^2$

$\Rightarrow \dfrac{\Delta Y}{Y} = 2\dfrac{\Delta d}{d} + \dfrac{\Delta l}{l} = 2\left(\dfrac{0.01}{0.4}\right) + \dfrac{0.05}{0.8} = \dfrac{9}{80}$

$\Rightarrow \Delta Y = \dfrac{9}{80} \times Y = \dfrac{9}{80} \times 2 \times 10^{11}$

$= 0.2 \times 10^{11} N/m^2$

95 **(d)**

$25 \times 10^{-3} \times 2 \times 0.1 = m \times 10$

or $m = \frac{5 \times 10^{-3}}{10}$ kg $= 0.5$ g

96 **(b)**

Energy per unit volume $= \frac{1}{2} \times$ Stress $\times$ Strain

$\dfrac{1}{2} \times$ Stress $\times \dfrac{\text{Stress}}{Y}\Big| Y = \dfrac{\text{Stress}}{\text{Strain}} = \dfrac{S^2}{2Y}$

97 **(a)**

Total upward force due to surface tension $=$ $\sigma\ (2r_1 +\ 2\pi_2)$. This supports the weight of the liquid column of height h. Weight of liquid column $= h\ [\pi r_2^2 -\ \pi r_1^2]\rho g$

Equating, we get $h\pi\ (r_2 + r_1)(r_2 - r_1)\rho g =$ $2\pi\sigma\ (r_1 +\ r_2)$

or $h(r_2 -\ r_1)\rho g = 2\sigma$ or $h = \frac{2\sigma}{(r_2 - r_1)\ \rho g}$

98 **(c)**

Final surface energy $= 1000 \times\ 4\pi r^2\sigma$

Initial surface energy, $E = 4\pi R^2\sigma$

Again, $\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^2$ or $R = 10r$

Now, final energy

$1000 \times 4\pi r^2\sigma = 10 \times 4\pi R^2\sigma = 10E$

99 **(a)**

$Y = \dfrac{F/A}{\Delta l/l}$

So $\frac{Y_s}{Y_c} = \frac{F\times l_s}{A_s \times \Delta l} \div \frac{F}{A_c} \times \frac{l_c}{\Delta l}$

$\dfrac{A_c l_s}{A_s l_c} = \dfrac{4\times10^{-6}\times4.7}{3\times10^{-6}\times3.5} = 1.8$

100 **(c)**

Height, $h = \frac{2T\cos\theta}{r\rho g}$

$\therefore$ For water, $h_w = \frac{2\times T_w \times \cos 0°}{r\times 1\times g}$

And, for mercury,

$h_w = -\dfrac{2\times T_m \times \cos 135°}{r\times 13.6\times g}$

$\therefore \dfrac{h_w}{h_m} = \dfrac{2\times\ T_m\times1}{r\times1\times g}\times\dfrac{r\times13.6\times g\times\sqrt{2}}{2\times T_m\times1}$

$[\because \cos 135° = -1/\sqrt{2}]$

$\Rightarrow \dfrac{10}{3.42} = \dfrac{T_w}{T_m}\times 13.6\times\sqrt{2}$

$\therefore \dfrac{T_w}{T_m} = \dfrac{10}{3.42\times13.6\times1.414} = \dfrac{1}{6.5}$

$\therefore\ T_w : T_m = 1 : 6.5$

101 **(c)**

Force = Weight suspended + Weight of $3L/4$ of wire

$= W_1 + \dfrac{3W}{4}$

Stress $= \frac{\text{Force}}{\text{Area}}$

102 **(a)**

$W\ = \dfrac{1}{2}\tau\phi = \dfrac{1}{2}\times8\times\dfrac{\pi}{4} = \pi$ J

103 **(b)**

Tension in any of the wire is same at all points as cross-sectional area are the same and tension also. So stress $(= F/A)$ in both the wires would be the same but from Strain = Stress/Strain as Y is different for both. So strain is different in both

104 **(b)**

The maximum load which a wire can sustain is a property of the material of wire and it depends on the cross-sectional area. σ_{breaking} is a characteristic property of material of wire and is independent of length or breadth (dimensions) of the wire

105 **(b)**

$V\rho g + F = V\ (4\rho)g$

or $F = 3V\rho g = 3mg$ or $\frac{F}{mg} = 3$

106 **(b)**

$v_0 = \dfrac{2}{9}\dfrac{r^2\ (\rho-\rho')g}{\eta}$ or $\eta = \dfrac{2r^2\ (\rho-\rho')g}{9v_0}$

$= \dfrac{2\times0.2\times0.2\times9\times980}{9\times8}$ poise $= 9.8$ poise

107 **(c)**

The air pressure is greater inside the smaller bubble $(4T/r)$. Hence, air flows from the smaller to the larger bubble

108 **(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), $v \propto \sqrt{x}$

$\therefore v' = \sqrt{1.5}\ v = 1.22\ v$

109 **(d)**

10 m column of water exerts nearly 1 atmosphere pressure. So, 100 m column of water exerts nearly 10 atmosphere pressure, i.e. 10×10^{-5} Pa or 10^6 Pa

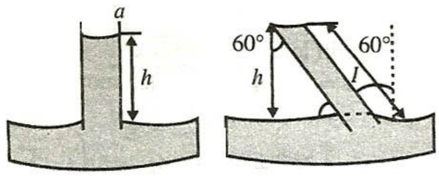
Now, $K = \frac{(\Delta P)V}{\Delta V} = \frac{10^6\times100}{0.1}$ Pa $= 10^9$ Pa

110 **(b)**

When two bubbles come into contact, they try to minimize the surface area for which air flows from bubble having higher pressure (smaller radius) to bubble having lower pressure

111 **(a)**

Since water rises to height of 2 cm in a capillary



If tube is at 60°, in this case height must be equal to

$h = 2$ cm $\Rightarrow \cos 60° = \frac{h}{l}$

$\therefore\ l = \dfrac{h}{\cos 60°} = \dfrac{2}{1/2} = 4$ cm

112 **(b)**

$T = \dfrac{2m_1m_2}{m_1+m_2}\ g = \dfrac{2\times1\times\ 2}{1+2}\times10\ \text{N} = \dfrac{40}{3}\text{N}$

If r is the minimum radius, then

Breaking stress $= \frac{\frac{40}{3}}{\pi r^2}$ or $\frac{40}{3\pi}\times10^6 = \frac{40}{3\pi r^2}$

or $r^2 = \frac{1}{10^6}$ or $r = \frac{1}{10^3}$ m

or $r\ = \frac{1}{10^3}\times10^3$ m = 1 mm

113 **(a)**

$Y = \frac{\text{stress}}{\Delta L/L}$ or $\frac{\Delta L}{L} = \frac{\text{stress}}{Y} = \frac{5 \times 10^7}{2 \times 10^{11}}$

$= 2.5 \times 10^{-4}$

Now, $V = \pi r^2 L$

$\frac{\Delta V}{V} = \frac{\pi \Delta (r^2 L)}{\pi r^2 L}$

or $\frac{\Delta V}{V} = \frac{r^2\,\Delta L + L \times 2r\Delta r}{r^2\,L}$ or $\frac{\Delta V}{V} = \frac{\Delta L}{L} + 2\frac{\Delta r}{r}$

or $2\frac{\Delta r}{r} = \frac{\Delta V}{V} - \frac{\Delta L}{L}$ or $2\frac{\Delta r}{r} = \frac{0.02}{100} - 2.5 \times 10^{-4}$

or $\frac{\Delta r}{r} = 1 \times 10^{-4} - \frac{2.5}{2} \times 100^{-4} = -0.25 \times 10^{-4}$

114 **(b)**

For the same radius, terminal velocity is proportional to the density difference

115 **(b)**

$m = \frac{4}{3}\pi r^3 \rho m$

Keeping m constant, if r is halved, ρ will increased by a factor of 8

Now, $v_0 \propto r^2 \rho$

$v_0' \propto \frac{r^2}{4}\ (8\rho)$ or $v_0' \propto 2r^2\rho$

Dividing, $\frac{v_0'}{v_0} = 2$ or $v_0' = 2v_0$

or $v_0' = 2v$

116 **(d)**

As in vacuum, there is no viscosity, no resistive force and hence no terminal velocity can be acquired

117 **(c,d)**

The angle of contact at the free liquid surface inside the capillary tube will change such that the vertical component of the surface tension forces just balances the weight of the liquid column

118 **(a,d)**

Statement (a) is correct because the Young's modulus of steel is greater than that of rubber

Statement (b) is incorrect. If a spring is stretched, both the total length of the wire in the coil and the volume of the wire do not change. Only the shape of the coils of the wire undergoes a change. Hence, it is the shear modulus that determines the stretching of the coil

Statement (c) is also incorrect. The bending moment of the prongs of a tuning fork is determined by the Young's modulus of the material. Hence, the restoring force on the prongs depends on Young's modulus which determines the frequency of the fork. Statement (d) is correct. When the material is not subjected to any stress, its atoms are in their normal (equilibrium) positions. When a tensile stress is applied, the separation R between the atoms becomes greater than the equilibrium separation R_0. For $R > R_0$, the interatomic forces are attractive

119 **(a,b)**

a. Within elastic limit,

Stress = strain

b. Beyond elastic limit, a small increase in stress produces large deformation, i.e., large strain. So, $\frac{\text{Stress}}{\text{Strain}}$ decreases

c. Both the wires will have the same stress

Again $Y = \frac{\text{Stress}}{\text{Strain}}$ or Strain $= \frac{\text{Stress}}{Y}$

Since Y is different, strain will be different. So, option (c) is not correct

120 **(a,d)**

We know that $Y = \frac{FL}{Al}$

$\therefore\ l = \frac{FL}{AY}$

Since, the two wires are made of the same material, Young's modulus Y is same for both.

Since, load F and the cross-sectional area A are the same,

$\therefore\ l \propto L$

i.e., extension is proportional to the length of the wire. Hence, option (a) is correct. The strain in a wire is given by

$\frac{l}{L} = \frac{4F}{AY}$

Since F, A and Y are the same, the strains in wires A and B will be equal. Thus, the correct options are (a) and (d)

121 **(a,b)**

$h = \frac{T}{Rdg}$

Given that h, T, d and g are fixed, hence R must be same. As weight of the liquid is balanced by force due to surface tension ($T \cos\theta$ and R are fixed for a given liquid, given material of capillary at a constant temperature) hence, weights of liquids in both the capillaries must be equal

So, options (a) and (b) are correct

122 **(a)**

$Y = \frac{T/A}{\Delta l/l}$

$\therefore\ \Delta l = \frac{T \times l}{A \times Y} = \frac{T}{Y} \times \frac{l}{A}$

Here, $\frac{T}{Y}$ is constant

Therefore, $\Delta l \propto l/A$. As a result, l/A is largest in the first case

123 **(a,b)**

Loss in gravitational potential energy of M is Mgl as M falls down by l

Elastic potential energy stored in wire is

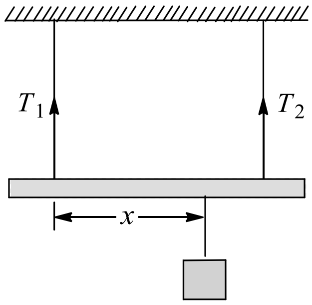
$U = \frac{1}{2} \times \text{Stress} \times \text{Strain} \times \text{Volume}$

$= \frac{1}{2}\frac{1}{2} \times \frac{Mg}{A} \times \frac{l}{L} \times AL = \frac{Mgl}{2}$

Now, work done by gravity force is not equal to elastic potential energy stored in wire. This is due to the fact that some work has been done against air friction etc., which increases the internal energy of wire

124 **(a,b,c)**

$\frac{T_1}{0.1} = \frac{T_2}{0.2}$ or $\frac{T_1}{T_2} = \frac{1}{2} = 0.5$



Further, $T_1 x = T_2(2 - x)$

or $\frac{T_1}{T_2} = \frac{2-x}{x}$

Hence, $\frac{2-x}{x} = 0.5 = \frac{1}{2}$ or $4 - 2x = x$

or, $x = \frac{4}{3}\text{m} = \frac{400}{3}\text{cm}$

125 **(b,c,d)**

Work done $W = \frac{1}{2} Y \times (\text{strain})^2 \times \text{volume}$

$= \frac{1}{2} Y \left(\frac{l}{L}\right)^2 \times Al = \frac{YAl^2}{2L}$

This work done appears as elastic potential energy stored in the wire . Here heat is produced during the elongation of wire as the work is done against the restoring forces.

126 **(a,b,c,d)**

Here, the graph is a straight line, so it is so for a wire within elastic limit for all the four options.

127 **(a,c)**

Velocity of water as it comes out through the hole is

$v = \sqrt{2\text{gh}} = \sqrt{2 \times 10 \times 5} = 10$ m

From equation of continuity, $Av =$ constant as water falls down, after coming through hole its speed increases and hence A decreases. From Bernoulli's theorem

$P_0 + \frac{\rho v^2}{2} + 0 = p_0 + \frac{p v_1^2}{2} - \rho gh$

(Just outside the hole and 5 m below the bottom of tank)

$\Rightarrow \frac{\rho v_1^2}{2} = \frac{\rho v^2}{2} + \rho gh \Rightarrow v_1 = 14.14$ m/s

From $Av =$ constant

$\Rightarrow 2 \times 10 = A_1 \times 14.14 \Rightarrow A_1 = 1.414$ cm^2

128 **(a,c,d)**

Loss in gravitational PE of mass $M = Mgl$

Elastic potential energy stored in wire = work done

= average force × extension

$= \left(\frac{0+Mg}{2}\right) l = \frac{1}{2} Mgl$

This work done appears as heat so, heat produced $= \frac{1}{2} Mgl$

129 **(a,c)**

Let S = surface tension

= surface energy per unit area

r = radius of each small drop

R = radius of a single drop

$n \times \frac{4}{3}\pi r^3 = \frac{4}{3}\pi R^3$ or $R = rn^{1/3}$

Initial surface energy,

$E_i = n \times 4\pi r^2 \times S = nE$

Final surface energy,

$E_f = 4\pi R^2 S = 4\pi r^2 n^{2/3} S = n^{2/3} E$

Therefore, energy released $= E_i - Ef = E(n - n^{2/3})$

130 **(a,c)**

Area of cross section,

$A = \frac{\pi d^2}{4}$

Where d is the diameter of the wire. Therefore,

$l = \frac{4FL}{\pi d^2 Y}$

Since F, L and Y are the same for wires A and B

$\therefore l \propto \frac{l}{d^2}$

i.e., the extension is inversely proportional to the square of the diameter. Hence, choice (a) is correct. The strain is

$\frac{l}{L} = \frac{4F}{\pi d^2 Y}$

Thus, strain $\propto \frac{1}{d^2}$

Hence, the correct choices are (a) and (c)

131 **(a,b,d)**

For most of material ; $\eta = \frac{1}{3} Y$

Deforming force along length of a rod, decreases diameter of rod and increases length of rod.

Stress is not a vector quantity as it has no fixed direction.

As $Y \propto \frac{1}{\Delta l}$, a material which stretches less for a given load is more elastic.

132 **(b,c)**

Since, wires A and B are made of the same material they have the same Young's modulus. Now, breaking load = breaking stress × cross-sectional area
The wire having a greater area of cross section can withstand a greater load. Hence, the correct options are (b) and (c)

133 **(a,c)**

Here, tension in B, $T_B = F = mg/3$

Tension in $A, T_A = T_B + mg = \frac{mg}{3} + mg = \frac{4mg}{3}$

$\therefore T_A = 4\,T_B$

A wire will break when the stress is breaking stress

Stress, $(S) = \frac{\text{tension}}{\text{area of cross−section}} = \frac{T}{\pi r^2}$

For $r_A = 2r_B$, $S_A = 4S_B$, So, A will break before B

For $r_A = 2r_B, S_B = \frac{T_B}{\pi r_B^2}$

And $S_A = \frac{T_B}{\pi r_A^2} = \frac{4T_B}{\pi(2r_B)^2} = \frac{T_B}{\pi r_B^2} = S_B$

As the stresses are equal, higher wire may break.

134 **(a,b,c)**

a. Bulk modulus is reciprocal of compressibility
b. Breaking force D^2

135 **(a,c)**

Viscous force is somewhat like a frictional force but not exactly the same because it differs from it due to the two main following statements:
i. Viscous force is velocity dependent while frictional force is not
ii. Viscous force is temperature dependent while frictional force is not
So, options (a) and (c) are correct

136 **(a,c,d)**

In this question, the applied force is not constant. Let us consider at any instant the wire elongates by x. Then work done by F to elongate is more by dx is

$$dW = Fdx = \frac{YAx}{L}\,dx\ [x \ll L]$$

$$W = \int_0^l \frac{YAxdx}{L} = \frac{YAl^2}{2L}$$

As internal restoring force and applied force are almost same (equal and opposite), numerical value of work done by these two forces would be equal

137 **(a,b,d)**

Here, for all three wires, length l, elongation Δl and cross-sectional area A are the same. From

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{T/A}{\Delta l/l}$$

$\Rightarrow T \propto Y$

Let T_1, T_2 and T_3 be tension in three wires I, II and III, respectively
For vertical equilibrium,
$T_1 \times T_2 + T_3 = 150$ g
For rotation equilibrium,
$T_1 \times x - T_3 x = 0$
$\Rightarrow T_1 = T_3$ so $Y_1 = Y_3$
$\Rightarrow \frac{T_2}{T_1} = \frac{T_2}{Y_1} = 2$
$\Rightarrow T_2 = 2T_1$
So, $2T_1 + T_2 = 150$ g
$\Rightarrow T_2 = 75$ g

138 **(a,c)**

The compressive force in the rod will be same at left end therefore, compressive stress will be maximum at this end. Hence, option (b) alone is correct

139 **(a,d)**

The slope of the linear portion of the curve gives the Young's modulus of the material. The slope of the linear portion OP for material A is greater than that of the linear portion OR for material B. Hence, statement (a) is correct. The plastic region for material A (from P to Q) is greater than that (from R to S) for material B, which indicates that material A is more ductile. Hence, statement (b) is correct. The breaking stress for material for material B (i.e. stress corresponding to point S) is less than that for material A (i.e. stress corresponding to point Q), which implies that material B can break more easily than material A. Thus, material B is more brittle. Hence, choice (c) is also incorrect. Material A is stronger than material B because it can withstand a greater stress before it breaks. The breaking stress is the stress corresponding to point Q for material A and to point S for material B. Hence, the correct choices are (a) and (d)

140 **(a,b,c,d)**

i. Excess pressure inside a spherical liquid drop $= 2T/R$, because there is only one free surface here

ii. In case of spherical meniscus of radius of curvature R, also excess pressure $= 2T/R$ because again there is only one free surface

iii. Excess pressure inside a cylindrical drop of radius $R = T/R$. Hence, for a cylindrical bubble in air, excess pressure is $2T/R$, because there exist two free surfaces in this case

iv. For a spherical bubble in water, excess pressure $= T/R$, as there is only one free surface

Hence, all the four options are correct

141 **(b,d)**

$Y = \frac{F}{A} \times \frac{l}{\Delta l}; ie, Y \propto \frac{1}{\Delta l}$

For a given load, $\Delta l > \Delta l_s, so, Y_s > Y_r$

Stretching of a coil is related with the modulus of elasticity of its material

142 **(a,b,c)**

Even a small stress causes large strain. In the case of a perfectly rigid body, strain is zero

143 **(b,c)**

Thermal force $= YA\alpha d\theta = \text{Y}\pi r^2 \alpha d\theta$

$r_1 = r, r_2 = r\sqrt{2}, r_3 = r\sqrt{3}, r_4 = 2r$

$F_1 : F_2 : F_3 : F_4 = 1 : 2 : 3 : 4$

Thermal stress $= Y\alpha d\theta$

As Y and α are same for all the rods, hence stress developed in each rod will be the same. As strain $= \alpha d\theta$, so strain will also be the same

$E =$ Energy stored

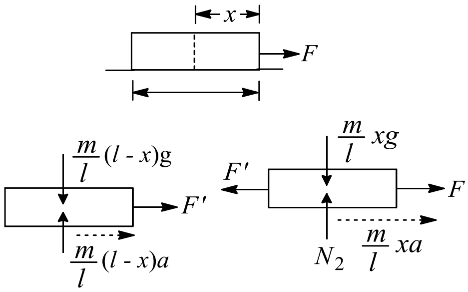
$= \frac{1}{2} Y(\text{strain})^2 \times A \times L$

$\therefore\ E_1 : E_2 : E_3 : E_4 = 1 : 2 : 4$

So, options (b) and (c) are correct

144 **(b,c)**

Since, force is applied at one end only, the plank starts to accelerate along the direction of this force and a stress is developed in its material. Hence, option (c) is incorrect



To calculate stress in the material of the plank, at a distance x from the end at which force is applied, the free-body diagrams are considered as shown in the figure

$\therefore F' = \frac{m}{l}(l - x)a$ (i)

$F - F' = \frac{m}{l} xa$

From these two equations, $F' = \frac{F(l - x)}{l}$

$\therefore$ Stress $= \frac{F'}{A} = \frac{F(l - x)}{Al}$

Where A is cross-sectional area of the plank. It shows that stress varies linearly with x. It is maximum at $x = 0$ and zero at $x = l$

Hence, option (a) is correct

145 **(a,b,c)**

The two free liquid surfaces must provide a net upward force due to surface tension to balances the weight of liquid column

146 **(c)**

$Y = \frac{\text{Stress}}{\text{Strain}}$ and $\Delta l = l\alpha\Delta T$

$\therefore$ Strain $= \frac{\Delta l}{l} = \alpha\Delta T \Rightarrow$ Stress $= Y\alpha\Delta T$

For first rod, stress $= \gamma_1\alpha_1\Delta T$. For the second rod, stress $= \gamma_2\alpha_2\Delta T$. Since stresses are equal, Therefore,

$\gamma_1\alpha_1\Delta T \Rightarrow \frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{3}{2}$

147 **(a,b,c)**

$(\text{Stress})_S = \frac{F}{2A}, (\text{stress})_{\text{Cu}} = \frac{F}{A}$

Given that $\frac{Y_S}{Y_{\text{Cu}}} = \frac{2}{1}$

$\frac{(\text{strain})}{(\text{strain})_{\text{Cu}}} = \frac{(\text{stress})_S / Y_S}{(\text{stress})_{\text{Cu}} / Y_{\text{Cu}}}$

$= \frac{(\text{Stress})_S}{(\text{stress})_{\text{Cu}}} \times \frac{Y_{\text{Cu}}}{Y_S} = \frac{(F/2A)}{(F/A)} \times \frac{1}{2} = \frac{1}{4}$

or $\frac{L_S/\Delta L_S}{L_{\text{Cu}}/\Delta L_{\text{Cu}}} = \frac{1}{4}$ or $\frac{L_S/\Delta L_{\text{Cu}}}{L_{\text{Cu}}/\Delta L_S} = \frac{1}{4}$

or $\frac{25}{50} \times \frac{\Delta L_{\text{Cu}}}{\Delta L_S} = \frac{1}{4}$ or $\frac{\Delta L_{\text{Cu}}}{\Delta L_S} = \frac{1}{2}$

So, options (a), (b) and (c) are correct

148 **(a,b,c)**

Tension in $B = T_B = \frac{mg}{3}$

Tension in $A = T_A = T_B + mg = \frac{4mg}{3}$

$\therefore T_A = 4T_B$

Stress $\frac{T}{\pi r^2} = S$

Wire breaks when S is equal to breaking stress

For $r_A = r_B, S_A = 4S_B$

Therefore, A breaks before B

For $r_A = 2r_B$

$$S_B = \frac{T_B}{\pi r_A^2} - \frac{T_B}{\pi r_A^2} = \frac{4T_B}{\pi(2r_B)^2} = \frac{T_B}{\pi r_B^2} = S_B$$

As the stresses are equal, either of the wires may break

149 **(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

$\therefore \quad Y = 0$

150 **(b)**

Here, both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

As $k = \frac{F}{A}\frac{F}{\Delta l}$ and $Y = \frac{F}{A}\frac{l}{\Delta l}$ or $\frac{F}{\Delta l} = \frac{YA}{l} = k$

151 **(a)**

Bulk modulus of elasticity measures how good the body is to regain its original volume on being compressed. Therefore, it represents incompressibility of the material

$K = \frac{-PV}{\Delta V}$ where P is increase in pressure, ΔV is change in volume

152 **(a)**

Elasticity is a measure of tendency of the body to regain its original configuration. As steel is deformed less than rubber therefore steel is more elastic than rubber

154 **(d)**

In a glassy solid ($i.e.$ amorphous solid) the various bonds between the atoms or ions or molecules of a solid are not equally strong. Different bonds are broken at different temperatures. Hence there is no sharp melting point for a glassy solid

155 **(a)**

Because, the stretching of coil simply changes its shape without any change in the length of the wire used in coil. Due to which shear modulus of elasticity is involved

156 **(c)**

In a small drop, the force due to the surface tension is very large as compared with its weight and hence it is spherical in shape. A big drop becomes oval in shape due to its large weight. The surface tension of liquid decreases with increase of temperature

157 **(d)**

Ivory is more elastic than wet-day. Hence the ball of ivory will rise to a greater height. In fact the ball of wet-day will not rise at all, it will be somewhat flattened permanently

159 **(a)**

A bridge during its use undergoes alternating strains for a large number of times each day, depending upon the movement of vehicles on it when a bridge is used for long time, if losses its elastic strength. Due to which the amount strain in the bridge for a given stress will become large and ultimately, the bridge may collapse. This may not happen's if the bridges are declared unsafe after long use.

160 **(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

161 **(b)**

The viscous force on a body depends on its velocity. The greater the velocity, the greater its viscous force. When a body falls from a sufficient height it acquires enough velocity to produce a viscous force that balances its height. The resultant force on the body being zero, the body moves with uniform velocity called terminal velocity

162 **(a)**

According to the ascent formula

$$h = \frac{2T\cos\theta}{r\rho g} \Rightarrow h \propto \frac{1}{r}$$

From the relation, radius is less, and the height to which the liquid rises will be greater

163 **(a)**

Here, both Assertion and Reason are true and Reason is the true explanation of Assertion.

164 **(a)**

The free surface of a liquid drop tries to acquire minimum surface area due to surface tension. Since for a given volume, the surface area of sphere is minimum, the liquid drops acquire sphere is minimum, the liquid drops acquire spherical shape

165 **(c)**
From the formula,

Express pressure $= \frac{2T}{r}$

Here, T is surface tension; r is the radius of liquid drop. Hence, excess pressure is inversely proportional to radius and hence the surface, area. Therefore, the excess pressure inside a smaller drop is larger as compared to the larger drop due to which smaller drop of liquid resists deforming forces better than a larger drop

166 **(e)**
When a spring balance has been used for a long time, the spring in the balance gets fatigued and there is loss of strength of the spring. In such a case, the extension in the spring is more for a given load and hence the balance gives wrong readings

167 **(a)**
The shape of the liquid is actually controlled by two forces viz. surface tension and gravitational force. When size of drop is small, surface tension and force > gravitational force, which means net force is due to surface tension. In this case, PE is minimum when the surface area is minimum. So, the drop is spherical.

When the size of the drop is larger, gravitational force > surface tension. It means net force is due to gravitational force. In this case, gravitational PE is minimum when centre of gravity of the drop at the minimum. So, The drop is no more spherical

168 **(c)**
Since the particles of dust are like spheres of very small radii and when it acquires the terminal velocity they begin through air. As from the definition, the terminal velocity of dust particles is directly proportional to the square of its radii. Thus, the terminal velocity of dust particle is very small and so they settle down in a closed room after some time

169 **(a)**
Stress $= \frac{\text{force}}{\text{area}} =$ pressure. Hence, both Assertion and Reason are true and Reason is the correct explanation of Assertion.

170 **(c)**
When a needle is placed carefully on the surface of water, it floats on the surface of water due to the surface tension of water, which does not allow the needle to sink. In case of a steel ball, the surface tension of the water is not sufficient to keep it floating, so it sinks down

171 **(d)**
Excess pressure inside a soap bubble is given by $p_i - p_0 = 4S/r$ as $p_i - p_0 \propto 1/r$, so as r increase. p_1 decreases (p_0 constant); therefore Statement I is wrong.

Statement II is correct as more air has to be forced in to cause the bubble to grow but contrary to the process of blowing up a rubber balloon, the excess pressure required to force air into the bubble decrease with the bubble size

172 **(a)**
The surface tension of liquid can be measured as the force per unit length (force gradient) on an imaginary line drawn on the liquid surface, which acts perpendicularly to the line on its either side at every point and tangentially to the liquid surface

Therefore, surface tension and force gradient have the same dimensions

173 **(a)**
Surface tension can be understood as a property of a surface due to which it tries to acquire the minimum possible area. If cohesive force is more, the liquid is having the capability to shrink its surface more, i.e., surface area of the liquid is less and hence more is the surface tension

174 **(a)**
Work done in stretching a spring of spring constant
k is $W = \frac{1}{2}kx^2$ or $W \propto k$ where x is constant.
Since, k for steel is more than for copper, hence more work will be done on steel than copper.

175 **(a)**
When a raindrop falls in air (viscous medium), after falling through the same height, the viscous drag balances the weight of the drop. Through the

rest of its height, velocity is constant or it attains a terminal velocity

176 **(a)**
On spraying, surface area increases and hence surface energy; this increase in surface energy is on the expense of decrease in internal energy and hence temperature decreases

177 **(d)**
A hollow shaft is found to be stronger than solid shaft of the given size and material. Hence, Assertion-1 is false. Torque required to produce a given twist in hollow cylinder is greater than that required to twist a solid cylinder. Hence, Reason is true.

178 **(d)**
Directly from the theory. (Here, we assumed that in longitudinal and tensile stress that cubicle and parallelopiped are of the same shape, i.e. both are parallel lepipeds)

179 **(a)**
The forces acting on the plate are weight of the plate vertically downwards
$W = m\text{g} = 20$ gf
i. Buoyant force due to liquid
$F_b = V\rho_l \text{g}$
$= \left(\frac{lbt}{2}\right)\rho_l \text{g} = \left(\frac{10 \times 4 \times 0.4}{2}\right) \times 1$ gf
$= 8$ gf
ii. Force due to surface tension, vertically downward
$F = T \times$ perimeter of plate in contact with water
$= \frac{70}{980} \times 2\ (10 + 0.4)\text{gf} = 1.5$ gf
iii. Apparent weight of the plate $= (W + F) - F$
$= (20 + 1.5) - 8 = 13.5$ gf

180 **(d)**
Based on theory

181 **(b)**
For A and B, the rod is in equilibrium and hence internal restoring force developed per unit area across any cross-section is same and stress developed in the rod is uniform, while in C and D, the case is reverse

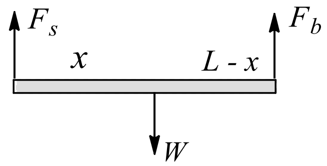
182 **(a)**
For A and C: In this case, the final surface area is greater than the initial surface area, and hence surface energy increases the expanse of internal energy; hence it causes cooling
For B, reverse of the above reasoning

183 **(a)**
Based on theory

184 **(b)**
Here $n = 0.02$ kg; $v = 20\ \text{ms}^{-1}$;
$l = 42$ cm $= 0.42$m
$\Delta l = 20\text{cm} = 0.20\text{cm}$; $r = 3\text{mm} = 3 \times 10^{-3}$m
Due to extension, energy is stored in the cord. This is converted into kinetic energy when the stone files off.
$\therefore$ Work done $= \frac{1}{2}mv^2 = \frac{1}{2}F\Delta l$
Or $F = \frac{mv^2}{\Delta l} = \frac{0.02 \times (20)^2}{0.20} = 40$ N
Stress $= \frac{F}{\pi r^2} = \frac{40}{(22/7)(3 \times 10^{-3})^2}$
$= 1.4 \times 10^6\ \text{Nm}^{-2}$

185 **(a)**
Elongation, $\Delta l = \frac{F}{\pi r^2} \times \frac{l}{Y}$
$= (3.18 \times 10^8) \times \frac{1}{2 \times 10^{11}} = 1.59 \times 10^{-3}$m
$= 1.59$ mm

186 **(a)**
Let F_x and F_b be the forces in the wires A and B respectively. The free-body diagram of the rod is shown in the figure
Applying the condition of rotational equilibrium about the point of application of load, we get,
$F_s X = F_b\ (L - x)$



$\frac{F_s}{F_b} = \frac{L - x}{x}$ (i)
If the stresses are equal in two wires, we have
$\frac{F_s}{F_b} = \frac{A_s}{A_b}$
Here $A_s = 1 \times 10^{-5}\ \text{m}^2$ and $A_b = 2 \times 10^{-5}\ \text{m}^2$
$\frac{F_s}{F_b} = \frac{1}{2}$ (ii)
From Eqs. (i) and (ii), we get
$\frac{L - x}{x} = \frac{1}{2}$ or $x = \frac{2L}{3}$
Since $L = 2$ m, $x = (4/3) = 1.33$ m

187 **(d)**
If ρ_w is the density of water, then the density of the lead sphere and the density of the liquid are given by
$\rho_0 = 11.20\ \rho_w$ and $\rho = 1.26\ \rho_w$
Thus, the equation $T = 2\pi\sqrt{\frac{1}{2\text{g}}}$ may be written as
$\eta = \frac{2}{9}\frac{r^2}{v}\ (11.20 - 1.26)\rho_w \text{g}$

Here, $r = 0.5 \times 10^{-3}$m; $v = 0.7 \times 10^{-2}$ m/s; g = 9.8 m/s^2; $\rho_w = 10^3$ kg/m^3

$$\eta = \frac{2}{9}\frac{(0.5 \times 10^{-3})^2}{0.7 \times 10^{-2}}(11.20 - 1.26)(10^3)(9.8)$$

$= 0.77$ N s/m^2

188 **(c)**

Here $s = 7.0 \times 10^{-2}$ N/m; $r = 0.2 \times 10^{-3}$ m; $r = 10^3$ kg/m^3

We know that the height of liquid rise in the tube is $h = 2\sigma\cos\theta/\rho R g$ where R is the radius of the meniscus, and θ is the angle of contact

Since $\theta = 0$ (given), radius of the meniscus is equal to the radius of the capillary tube, i.e., $R = r$

$$\therefore\ h = \frac{2(7.0 \times 10^{-2})}{(10)^3\,(0.2 \times 10^{-3})(10)} = 0.07 \text{ m}$$

or $h = 7.0$ cm

When the length of the capillary tube above the free surface of the liquid is less than the height of liquid that rise in the tube, radius R of the free surface is not equal to the radius of the tube. It is greater than r as the surface tends to be flatter

According to the equation, $p_1 - p_2 = (4\sigma/R)$, the pressure difference across the surface is given by

$$\Delta p = \frac{2\sigma\cos\theta}{R}$$

If p_1 and p_2 are the pressure just above and below the meniscus, respectively, then $p_1 - p_2 = \rho g h_0$

$\therefore\ \rho g h_0 = \frac{2\sigma}{r}$ (i)

In part (a) we have seen that when $h_0 = h$; $\theta = 0, R = r$

and $\rho g h = \frac{2\sigma}{r}$ (ii)

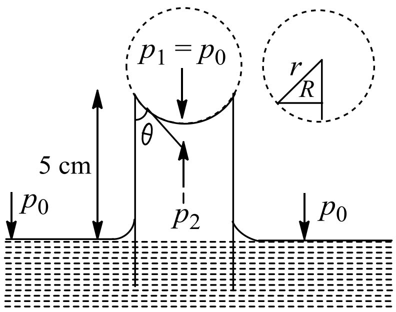
Therefore, dividing Eq. (i) by Eq. (ii), we have

$\frac{r}{R} = \frac{h_0}{h}$

From the figure, it is clear that $\cos\theta = \frac{r}{R}$

Therefore, the angle of contact is

$$\theta = \cos^{-1}\frac{h_0}{h} = \cos^{-1}\left(\frac{5}{7}\right) \approx 44°$$



189 **(c)**

a. Using Poiseuille's equation, we get

$$Q = \frac{(p_1 - p_2)\pi D^4}{128\,\eta L}$$

Here, $p_1 - p_2 = 38.4 \times 10^3$ N/m^2

$D = 2.5$ cm $= 2.5 \times 10^{-2}$ m

$L = 30$ m; $h = 0.12$ N/m^2

$$\therefore\ Q = \frac{(38.4 \times 10^3)(3.14)(2.5 \times 10^{-2})^4}{128\,(0.12)(30)}$$

$$= 1.0 \times 10^{-4}\ \text{m}^3/\text{s}$$

b. We know that $\tau = -\frac{dp}{dx}\frac{r}{2}$

At the wall of the pipe, i.e., $r = R$

$$\tau_{\max} = -\frac{dp}{dx}\frac{R}{2} = \left(\frac{p_1 - p_2}{L}\right)\frac{D}{4}$$

$$= \left(\frac{38.4 \times 10^{-3}}{30}\right)\frac{2.5 \times 10^{-2}}{4} = 8 \times 10^{-6}\ \text{N/m}^2$$

c. We know that $P = \frac{128\,\eta Q^2 L}{\pi D^4} = (p_1 - p_2)Q$

$\therefore P = (38.4 \times 10^3)(1 \times 10^{-4})$ or $P = 3.84W$

190 **(b)**

Since $\alpha_t > \alpha_b$, the tube tries to expand more than the bolt when assembly is heated. But the tube is tightened by the bolt therefore its expansion cannot be more than that of the bolt. Hence, a compressive stress is developed in the tube and a tensile stress in bolt

Let the initial length of the assembly be l and let its elongation be Δl. Elongation of the tube if it would be free to expand $= l\alpha_t\Delta\theta$. But its actual elongation is Δl, therefore elongation prevented in it is equal to $(l\alpha_t\Delta\theta - \Delta l)$

Therefore, compressive strain in tube

$$E_t = \frac{(l\alpha_t\Delta\theta - \Delta l)}{l} = 5 \times 10^{-5}$$

191 **(d)**

Young's modulus is a material constant. So, length and radius do not affect its value. So, ratio has to be 1:1

192 **(a)**

Excess pressure is always on the concave side of the surface. For angle of contact of $2\pi/3$, the liquid should have a convex surface. So, the excess pressure should be in the upward direction

193 **(b)**

Bernoulli's theorem is used in this arrangement. Plant gun uses this principle. Spherical shape of bullets and spray are also working under this pressure concept

194 **(c)**

$$P_A = P_0 - \frac{2S}{r}$$

The pressure inside a concave meniscus is less than the pressure outside (atmospheric). Assuming the meniscus to be spherical (as for thin capillaries), excess pressure is $2S/r$ where r

is the radius of the hemispherical surface

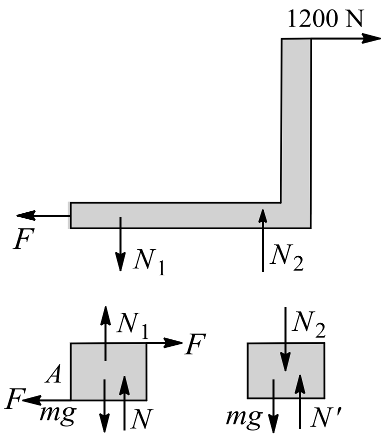
195 **(b)**

Here, first of all, draw the free-body diagram of the steel rods and the L-shaped structure as shown in the figure

The direction of N_1 and N_2 can be found by using the equilibrium condition

For L-shaped structure,

For vertical equilibrium, $N_1 = N_2$,



For horizontal equilibrium, $F = 1200$ N

For rotational equilibrium, torque about E (or any other point) $= 0$

$\Rightarrow\ N_2 \times 4 - 1200 \times 3 = 0$

$\Rightarrow\ N_2 = 900$ N

Shearing stress in $A = \frac{F}{A} = \frac{1200}{5} \text{N/m}^2 =$ $240\ \text{N/cm}^2$

Shearing stress in $B = 0$

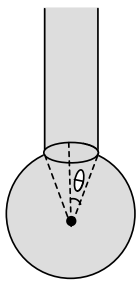
Longitudinal stress in $A = \frac{N_1}{A} = 180\ \text{N/cm}^2$

Longitudinal stress in $B = \frac{N_2}{A} = 180\ \text{N/cm}^2$

(Compressive in nature)

196 **(c)**

Surface tension force $= 2\pi rT\,\frac{r}{R} = \frac{2\pi r^2 T}{R}$



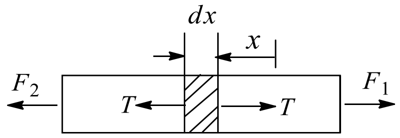
197 **(4)**

$$\omega = \sqrt{\frac{YA}{mL}}$$

198 **(1)**

Consider an element of thickness dx. Change in the length of the element is $dl = \frac{T}{S}\frac{dx}{Y}$ and

$T = F_1 - (F_1 - F_2)\frac{x}{l}$



$$\int_0^{\Delta l} dl = \int_0^{l} \frac{F_1 - \frac{(F_1 - F_2)x}{l}}{SY}\, dx$$

$$\Delta l = \frac{F_1 + F_2}{2SY}\Big| = \frac{200 \times 1}{2 \times 0.5 \times 2 \times 10^{11}}$$

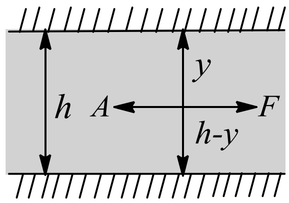
$= 1 \times 10^{-9}$ m

$x = 1$

199 **(5)**

Case I : $y_1 = y_2 = h/2$

$$\frac{\partial u}{\partial y} = \frac{v}{h/2} = \frac{2v}{h}$$



Viscous free $= \frac{\eta_0 2V}{h} A$

The plate has two sides

Total force $F = \frac{4\eta_c va}{h}$

Case II :

$$F = \frac{\eta vA}{y} + \frac{\eta vA}{y - h} = \frac{\eta vAh}{y(h-y)}$$

$$\frac{\eta vAh}{y(h-y)} = \frac{4v^2 Av}{h}$$

$$\frac{3}{16}\ h^2 = y(h-y)$$

Solving, we get $y = \frac{h}{4}, \frac{3h}{4}$

Hence, for minimum distance from top

$y = \frac{20}{4} = 5$ cm

200 **(3)**

$$\frac{F}{A} = y\frac{\Delta L}{L}$$

$$\frac{mg}{A} = y \times (\alpha\Delta\theta)$$

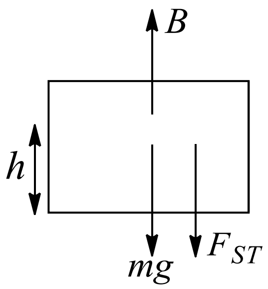
$$m = \frac{Ay\alpha(\Delta\theta)}{g} = \frac{\pi r^2 y\alpha(\Delta\theta)}{g}$$

$$= \frac{\pi(10^{-3})^2 \times 10^{11} \times 10^{-5} \times 10}{10} = \pi \approx 3$$

201 **(2)**

$Mg + F_{ST} = B$

$mg + 4aT = a^2 h\rho_w\, \text{g}$

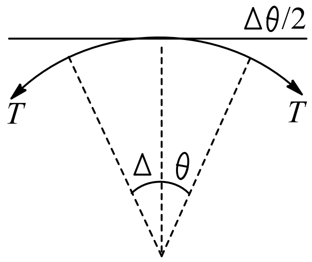


$$10 + 4 \times \frac{10}{4} = 10h$$

$h = 2$ m

202 **(2)**

$$2T \ \sin\frac{\Delta\theta}{2} = dm\omega^2 r$$



$$2T\left(\frac{\Delta\theta}{2}\right) = \rho \times A \times r^2\omega^2$$

$$\sigma = \frac{T}{A} = \rho r^2\omega^2$$

$$\therefore \omega = \frac{1}{r}\sqrt{\frac{\sigma}{\rho}} = 2 \text{ rad/s}$$

203 **(5)**

$Mg = PA$; A is sectional area

$Alqg = 10^5 A$

$$l = \frac{10^5}{2 \times 10^3 \times 10} = 5 \text{ m}$$

204 **(8)**

$$\frac{4}{3}\pi R^3 = n \times \frac{4}{3}\pi r^3$$

or $R^3 = nr^3$ or $R = n^{1/3} r$

or $R = 2\pi^{1/3}$ mm

$v_0 \propto r^2, v_0' \propto R^2$

Now, $\frac{v_0'}{v_0} = \frac{R^2}{r^2} = \frac{4n^{2/3}}{4}f$

or $\frac{32}{8} = n^{2/3}$ or $n^{2/3} = 4$

or $n = 4^{3/2} = \sqrt{64}$

or $n = 8$

205 **(5)**

We have

$\rho V = mRT$

$$\left(p_0 + \rho_w gh - \frac{4T}{d}\right)\frac{\pi}{6} d^3 = \left(p_0 + \frac{4T}{d}d\right)\frac{\pi}{6} n^3 d^3$$

(the bubble has only one surface)

$$\therefore h = \frac{d\,(n^3 - 1)p_0 + 4T\,(n^2 - 1)}{\rho_w gd}$$

or $h = \frac{4\times 10^{-6}\,(1\times 1^3 - 1)\times 10^5 + 4 \times 0.07\,(1\times 1^2 - 1)}{1000\times 9.8 \times 4 \times 10^{-6}} =$ 5 m