EXERCISE-1

SECTION (A) : ELASTIC BEHAVIOUR LONGITUDINAL STRESS, YOUNG MODULUS

A 1. Why are springs made of steel and not of copper ?

A 2. Explain why steel is more elastic than rubber?

A 3. A cable is cut to half its original length. Why this change has no effect on the maximum load the cable can support?

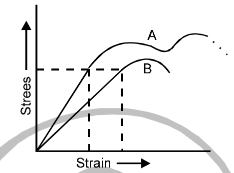
A 4. A steel wire is stretched by a weight of 400 N. If the radius of the wire is doubled, how will Young's modulus of the wire be affected?

A 5. A heavy wire is suspended from the roof but no weight is attached to its lower end. Is it under stress?

A 6. What causes the restoring stress when a wire is (i) stretched and (ii) compressed?

A 7. In the figure shown the strain versus stress graph for two values of young's modulus?

(i) which material is more ductile ? Explain.
(ii) Which material is more brittle? Explain.
(iii) Which material is stronger? Explain.



A 8. The stress required to double the length of a wire of Young's modulus Y is ______________.

A 9. A wire of length 1 meter and area of cross-section 4×10^{-8} m^2 increases in length by 0.2 cm when a force of 16 N is applied. The average distance between the atoms of the material of the wire is 2×10^{-10} m. If the wire be assumed as made up of m rows of atoms and each row contains n atoms, then calculate :
(i) value of Y for the material of the wire (ii) inter-atomic force-constant
(iii) value of n and m for the wire (iv) average increase in the distance between the atoms.

A 10. A mass of 5.0 kg is hung from a copper wire of 5 mm diameter and 2 m in length. Calculate the extension produced. What should be the minimum diameter of the wire so that its elastic limit is not exceeded? Elastic limit for copper $=1.5 \times 10^9$ dyne cm^{-2}, Y for copper $= 1.1 \times 10^{12}$ dyne cm^{-2}.

A 11. If a compressive force of 3.0×10^4 N is exerted on the end of 20 cm long bone of cross-sectional area 3.6 cm^2,
(a) will the bone break and (b) if not, by how much does it shorten?

Given, compressive strength of bone $= 7.7 \times 10^8$ Nm^{-2} and Young's modulus of bone $= 1.5 \times 10^{10}$ Nm^{-2}

A 12. A wire loaded by a weight of density 7.6 g cm^{-3} is found to measure 90 cm. On immersing the weight in water, the length decreased by 0.18 cm. Find the original length of wire.

A 13. Two exactly similar wires of steel and copper are stretched by equal force. If the difference in their elongation is 0.5 cm, find by how much each wire is elongated. Given Young's modulus for steel $= 2 \times 10^{12}$ dyne cm^{-2} and for copper 12×10^{11} dyne cm^{-2}.

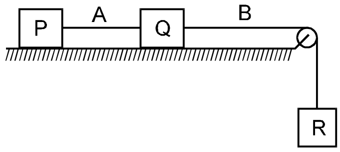
A 14. A mass of metal of volume 500 cm^3 hangs on the end of a wire whose upper end is rigidly fixed. When the metal is completely immersed in water, the length of the wire decreases by 1 mm. Find the length of the wire. Given diameter of wire = 0.4 mm, Young's modulus $= 7 \times 10^{11}$ dyne cm^{-2} and g = 980 cm s^{-2} .

A 15. A simple pendulum is made by attaching a 1 kg bob to a 5 m long copper wire of diameter 0.08 cm and it has a certain period of oscillation. Now a 10 kg bob is suspended instead of 1 kg bob. Calculate the change in the time period, if any. Y for copper is 12.4×10^{10} Nm^{-2} . **[REE - 88]**

A 16. A steel wire of length 2 m and diameter 0.8 mm is fastened between two points horizontally. When a weight

W is suspended from its middle-point, it is depressed by 1.0 cm. Calaculate the value of W, Y for steel = 2.0×10^{11} N m^{-2}.

A 17. Each of the three blocks P, Q and R shown in figure has a mass of 3 kg. Each of the wires A and B has cross-sectional area 0.005 cm^2 and Young's modulus 2×10^{11} N/m^2. Neglect friction. Find the longitudinal strain developed in each of the wires. Take g = 10 m/s^2.



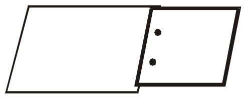
SECTION (B) : TANGENTIAL STRESS AND STRAIN, SHEAR MODULUS

B 1. Do liquid possess rigidity?

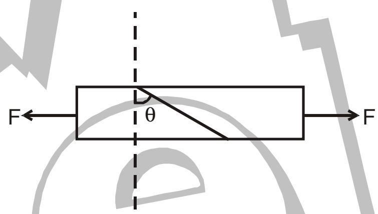
B 2. Modulus of rigidity of a fluid is _____________.

B 3. The upper face of a cube of edge 1 m moves through a distance of 1mm relative to the lower fixed surface under the action of a tangential force of 1.5×10^8 N. Calculate the tangential stress, strain and the modulus of rigidity.

B 4. Two long metallic strips are joined together by two rivet each of radius 2.0 mm (Figure). Each rivet can withstand a maximum shearing stress of 1.5×10^9 Pa. What is the maximum tensile force that the strip can exert, assuming each rivet shares the stretching load equally?



B 5. A bar of cross-section A is subjected to equal and opposite tensile forces F at its ends. Consider a plane through the bar making an angle θ with a plane at right angles to the bar



(a) What is the tensile stress at this plane in terms of F, A and θ ?
(b) What is the shearing stress at the plane, in terms of F, A and θ ?

(c) For what value of θ is the tensile stress a maximum ?
(d) For what value of θ is the shearing stress a maximum?

SECTION (C) : PRESSURE AND VOLUMETRIC STRAIN, BULK MODULUS OF ELASTICITY

C 1. Answer the following questions.
(i) What is the value of bulk modulus for perfectly rigid body
(ii) What is the value of bulk modulus for an incompressible liquid ?
(iii) What is the value of modulus of rigidity for a liquid ?
(iv) How does Young's modulus change with rise in temperature ?

C 2. If for a metal, Y = 6.6×10^{10} N/m^2 and Bulk modulus K = 11×10^{10} N/m^2, Poisson's ratio will be _____________.

C 3. Water is _____________ elastic than air.

C 4. Bulk modulus for an incompressible liquid is _____________.

C 5. The bulk modulus of rubber is 9.8×10^8 N/m^2. When a rubber ball is taken at depth about 100 m in lake of water its volume is decreased by 0.1 %. State true or false.

C 6. A solid sphere of radius 10 cm is subjected to a uniform pressure equal to 5×10^8 Nm^{-2}. Calculate the change in volume. Bulk modulus of the material of the sphere is 3.14×10^{11} Nm^{-2}.

C 7. What will be the change in the radius of an air bubble of radius 1 cm, when it is well within a mercury trough at a depth of 1 m? Given that the compressibility of the mercury is 3.7×10^{-11} N^{-1} m^2 and density of mercury is 13.6 g cm^{-3}.

C 8. A spherical ball contracts in volume by 0.0098% when it is subjected to a pressure of 100 atmosphere. Calculate its bulk modulus.

SECTION (D) : ELASTIC POTENTIAL ENERGY

D 1. What will happen to the potential energy of the atoms of a solid when compressed ? On stretching a wire ?

D 2. A wire of length L and cross–sectional area A is made of a material of Young's modulus Y. If the wire is stretched by an amount x, the work done is _____________.

D 3. Energy stored per unit volume in a strained body is _____________.

D 4. A metal rod of Young's modulus 2×10^{10} N m^{-2}, undergoes an elastic strain of 0.06%. The energy stores per unit volume is 7200 J/m^3. State true or false.

D 5. Calculate the increase in energy of a brass bar of length 0.2 m and cross-sectional area 1 cm^2 when compressed with a load of 5 kg-weight along its length.
(Young's modulus of brass = 1.0×10^{11} N/m^2 and g = 9.8 m/s^2).

D 6. What work can be performed by a steel rod with a length ℓ and a cross-sectional area A when heated by t degrees ? α and E are are the coefficient of linear expansion and modulus of elasticity respectively.

D 7. When the load on a wire increased slowly from 2 kg wt. to 4 kg wt., the elongation increases from 0.6 mm to 1.00 mm. How much work is done during the extension of the wire?

SECTION (E) : VISCOSITY

E 1. Machine parts are jammed in winter. Explain why ?

E 2. Small air bubbles rise slower than the bigger ones through a liquid. Explain why ?

E 3. A flask contains glycerine and the other one contains water. Both are stirred rapidly and kept on the table. In which flask will the liquid come to rest earlier than the other one and why ?

E 4. Why do clouds float in the sky ?

E 5. Why is viscosity called internal friction ?

E 6. Why a hot liquid moves faster than a cold liquid ?

E 7. A spherical ball of radius 3.0×10^{-4} m and density 10^4 kg/m^3 falls freely under gravity through a distance h before entering a tank of water. If after entering the water the velocity of the ball does not change, find h. Viscosity of water is 9.8×10^{-6} N-s/m^2.

E 8. Eight rain drops of radius one mm each falling down with a terminal velocity of 5 cm s^{-1} coalesec to form a bigger drop. Calculate the terminal velocity of the bigger drop.

E 9. A ball bearing of radius of 1.5 mm made of iron of density 7.85 g cm^{-3} is allowed to fall through a long column of glycerine of density 1.25 g cm^{-3}. It is found to attain a terminal velocity of 2.25 cm s^{-1}. Determine the viscosity of glycerine in centipoise.

E 10. An air bubble of 1 cm radius is rising at a steady rate of 0.5 cm s^{-1} through a liquid of density 0.8 g cm^{-3}. Calculate the coefficient of viscosity of the liquid. Neglect the density of air.

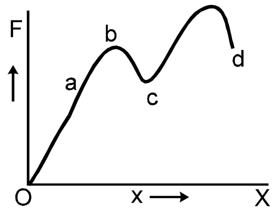
E 11. Calculate the terminal velocity with which an air bubble of diameter 0.8 mm will rise in a liquid of viscosity 10.5 poise and specific gravity 0.9.

EXERCISE-2

SECTION (A) : ELASTIC BEHAVIOUR LONGITUDINAL STRESS, YOUNG MODULUS

A 1. The Young's modulus of a wire of length L and radius r is = Y N/m^2. If the length and radius are reduced to L/2 and r/2, then its Young's modulus will be :
(A) Y/2 (B) Y (C) 2 Y (D) 4 Y

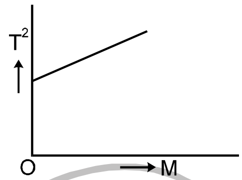
A 2. The graph is drawn between the applied force F and the strain (x) for a thin uniform wire. The wire behaves as a liquid in the part :



(A) ab (B) bc
(C) cd (D) oa

A 3. An Indian rubber cord L metre long and area of cross-section 'a' metre^2 is suspended vertically. Density of rubber is D kg/metre^3 and Young's modulus of rubber is E newton/ metre^2. If the wire extends by ℓ metre under its own weight, then extension ℓ is :
(A) L^2 Dg/E (B) L^2 Dg/2E (C) L^2Dg/4E (D) L

A 4. The graph shown was obtained from experimental measurements of the period of oscillations T for different masses M placed in the scale pan on the lower end of the spring balance. The most likely reason for the line not passing through the origin is that the :



(A) Spring did not obey Hooke's Law (B) Amplitude of the oscillations was too large
(C) Clock used needed regulating (D) Mass of the pan was neglected

A 5. A force F is needed to break a copper wire having radius R. The force needed to break a copper wire of radius 2 R will be :
(A) F/2 (B) 2 F (C) 4 F (D) F/4

A 6. The diameter of a brass rod is 4 mm and Young's modulus of brass is 9×10^{10} N/m^2. The force required to stretch by 0.1% of its length is :
(A) 360 π N (B) 36 N (C) 144 $\pi \times 10^3$ N (D) 36 $\pi \times 10^5$ N

A 7. To break a wire, a force of 10^6 N/m^2 is required. If the density of the material is 3×10^3 kg/m^3, then the length of the wire which will break by its own weight will be :
(A) 34 m (B) 30 m (C) 300 m (D) 3 m

A 8. A rod (Young's modulus = 7×10^9 N/m^2) has a breaking strain of 0.2%. The minimum cross sectional area of the rod in order to support a load of 10^4 newtons is :
(A) 1×10^{-2} m^2 (B) 1.4×10^{-3} m^2 (C) 3.5×10^{-3} m^2 (D) 7.1×10^{-4} m^2

A 9. In steel, the Young's modulus and the strain at the breaking point are 2×10^{11} Nm^{-2} and 0.15 respectively. The stress at the breaking point for steel is therefore
(A) 1.33×10^{11} Nm^{-2} (B) 1.33×10^{12} Nm^{-2} (C) 7.5×10^{-13} Nm^{-2} (D) 3×10^{10} Nm^{-2}

A 10. Which of the following statements is correct :
(A) Hooke's law is applicable only within elastic limit
(B) The adiabatic and isothermal elastic constants (Bulk Modulus) of a gas are equal at same pressure
(C) Young's modulus is dimensionless
(D) Stress multiplied by strain is equal to the stored energy

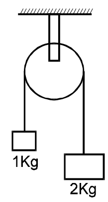
A 11. The force required to stretch a steel wire of 1 cm^2 cross-section to 1.1 times its length would be ($Y = 2 \times 10^{11}$ Nm^{-2})
(A) 2×10^6 N (B) 2×10^3 N (C) 2×10^{-6} N (D) 2×10^{-7} N

A 12. Which one of the following substances possesses the highest elasticity :
(A) Rubber (B) Glass (C) Steel (D) Copper

A 13. Which one of the following quantities does not have the unit of force per unit area :
(A) Stress (B) Strain
(C) Young's modulus of elasticity (D) Pressure

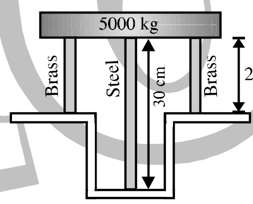
A 14. A copper wire and a steel wire of the same diameter and length are connected end to end and a force is applied, which stretches their combined length by 1 cm. The two wires will have :
(A) Different stresses and strains
(B) The same stress and strain
(C) The same strain but different stresses
(D) The same stress but different strains

A 15. A steel rod with a cross section A = 1 cm^2 is tightly fitted between two stationary absolutely rigid walls. Force F will the rod act with on the walls if it is heated by Δt = 5ºC will be : (The coefficient of linear thermal expansion of steel $\alpha = 1.1 \times 10^{-5}$ deg^{-1} and its modulus of elasticity E = 2 × 10^5 N/mm^2)
(A) 1200 N (B) 1100 N (C) 550 N (D) 2200 N



A 16. Two blocks of masses 1 Kg and 2 Kg are connected by a metal wire going over a smooth pulley as shown in figure. The breaking stress of the metal is 2 × 10^9 N/m^2. What should be the minimum radius of the wire used if it is not to break ? Take g = 10 m/s^2.
(A) 4.6 × 10^{-4} m (B) 4.6 × 10^{-5} m (C) 3.6 × 10^{-5} m (D) 3.6 × 10^{-4} m

A 17. A thin uniform metallic rod of length 0.5 m rotates with an angular velocity 400 rad/s in a horizontal plane about a vertical axis passing through one of its ends. The elongation of the rod will be : (The density of the material of the rod is 10^4 kg/m^3 and the Young's modulus is 2 × 10^{11} N/m^2)
(A) 3.33 × 10^{-4} m (B) 3.33 × 10^{-5} m (C) 3.33 × 10^{-6} m
(D) 3.33 × 10^{-7} m



A 18. A steel rod of cross-sectional area 16 cm^2 and two brass rods each of cross sectional area 10cm^2 together support a load of 5000 kg as shown in figure. The stress in steel rod will be : (Take Y for steel = 2.0 × 10^6 kg/cm^2 and for brass = 1.0 × 10^6 kg/cm^2)
(A) 161.2 $\frac{kg}{cm^2}$ (B) 151.4 $\frac{kg}{cm^2}$ (C) 131.4 $\frac{kg}{cm^2}$ (D) None of these

A 19. A copper wire and a steel wire of the same diameter and length 1m and 2m respectively are connected end to end and a force is applied which stretches their combined length by 1cm. How much each wire is elongated respectively. Y of copper = 1.2×10^{10} Nm^{-2} and Y of steel = 2.0 × 10^{10} Nm^{-2}.
(A) 0.45 cm, 0.55 cm (B) 0.55 cm, 0.45 cm (C) 0.045 cm, 0.55 cm (D) 0.45 cm, 0.055 cm

A 20. Four wires of the same material are stretched by the same load. The dimension of the wires are as given below. The one which has the maximum elongation is of
(A) diameter 1 mm and length 1 m (B) diameter 2 mm and length 2 m
(C) diameter 0.5 mm and length 0.5 m (D) diameter 3 mm and length 3 m

A 21. Four wires of different material but the same area of cross-section are loaded by the same force. Their lengths and elongations are as follows. The one whose material's Young's modulus is the largest is
(A) L = 2m, l = 1 mm (B) L = 1 m, l = 0.25 mm
(C) L = 1.5 m, l = 0.5 mm (D) L = 2.5 m, l = 1.5 mm

A 22. A steel wire of length 2.0 m and cross-sectional area 1 × 10^{-6} m^2 is held between two rigid supports with a tension 200N. If the wire is pulled 5 mm in the direction perpendicular to the wire, the change in the tension of the wire is (Y = 2 × 10^{11} N/m^2)
(A) 5.2 N (B) 0.25 N (C) 5.0 N (D) 2.5 N

A 23. A brass rod of length 2 m and cross-sectional area 2.0 cm^2 is attached end to end to a steel rod of length L and cross-sectional area 1.0 cm^2. The compound rod is subjected to equal and opposite pulls of magnitude 5 × 10^4 N at its ends. If the elongations of the two rods are equal, the length of the steel rod (L) is

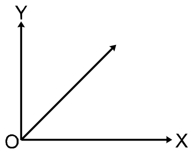
($Y_{Brass} = 1.0 \times 10^{11}$ N/m^2 and $Y_{Steel} = 2.0 \times 10^{11}$ N/m^2)
(A) 1.5 m (B) 1.8 m (C) 1 m (D) 2 m

A 24. A vertical wire 5 m long and 0.0080 cm^2 cross-section has $Y = 2 \times 10^{11}$ N/m^2. An object weighing 2kg is fastened to its end and stretches the wire elastically. If the object is now pulled down a little and released, it undergoes vertical SHM. Its period of vibration is
(A) 0.2 s (B) 0.05 s (C) 0.1 s (D) 1.0 s

A 25. A uniform steel bar of cross-sectional area A and length L is suspended so that it hangs vertically. The stress at the middle point of the bar is (ρ is the density of steel)

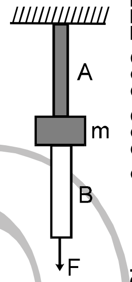
(A) $\frac{L}{2A}\rho g$ (B) $\frac{L\rho g}{2}$ (C) $\frac{LA}{\rho g}$ (D) $L\rho g$

A 26*. An elastic rod will change its length when it :
(A) slides on a rough surface (B) rotates about an axis at one end
(C) falls vertically under its weight (D) is pulled along its length by a force acting at one end



A 27*. A student performs an experiment for the determination of Young's modulus of the material of a wire. He obtains the following graph (figure) from his readings. The quantities on X and Y-axes 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



A 28*. The wires A and B shown in the figure, are made of the same material and have radii r_A and r_B. A block of mass m kg is tied between them : When a force F is mg/3, one of the wires breaks.

(A) A will break before B if $r_A < 2r_B$
(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 lengths of A and B must be known to decide which wire will break

A 29*. When a wire is stretched to double its length
(A) strain is unity
(B) stress is equal to Young's modulus of elasticity
(C) its radius is halved
(D) Young's modulus is equal to twice the elastic potential energy per unit volume

A 30. An elevator cable is to have a maximum stress of 7×10^7 N/m^2 to allow for appropriate safety factors. Its maximum upward acceleration is 1.5 m/s^2. If the cable has to support the total weight of 2000 kg of a loaded elevator, the area of cross-section of the cable should be
(A) 3.28 cm^2 (B) 2.38 cm^2 (C) 0.328 cm^2 (D) 8.23 cm^2

A 31. Let Y_g and Y_r represent Young's modulus for glass and rubber respectively. It is said that glass is more elastic than rubber. Therefore, it follows
(A) $Y_g = Y_r$ (B) $Y_g < Y_r$ (C) $Y_g > Y_r$ (D) $Y_g / Y_r = 0$

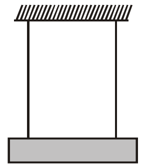
A 32. A steel wire is suspended vertically from a rigid support. When loaded with a weight in air, it expands by L_a and when the weight is immersed completely in water, the extension is reduced to L_w. Then relative density of the material of the weight is

(A) $\frac{L_a}{L_a - L_w}$ (B) $\frac{L_w}{L_a}$ (C) $\frac{L_a}{L_w}$ (D) $\frac{L_w}{L_a - L_w}$

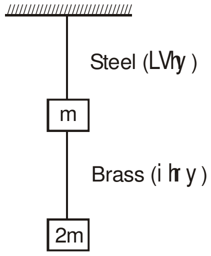
A 33. A wire of cross-sectional area A is stretched horizontal between two clamps located at a distance 2ℓ metres from each other. A weight W kg is suspended from the mid point of the wire. The strain produced in the wire, (if the vertical distance through which the mid point of the wire moves down $x < \ell$) will be
(A) x^2/ℓ^2 (B) $2x^2/\ell^2$ (C) $x^2/2\ell^2$ (D) $x/2\ell$

A 34. In above question, the stress in the string is

(A) $\frac{4x\,W}{\ell A}$ (B) $\frac{2x\,W}{\ell A}$ (C) $\frac{W\ell}{4x\,A}$ (D) $\frac{W\ell}{2x\,A}$



A 35. Two wires of equal length and cross-section area suspended as shown in figure. Thier Young's modulus are Y_1 and Y_2 respectively. The equivalent Young's modulus will be



(A) $Y_1 + Y_2$ (B) $\frac{Y_1 + Y_2}{2}$ (C) $\frac{Y_1 Y_2}{Y_1 + Y_2}$ (D) $\sqrt{Y_1\ Y_2}$

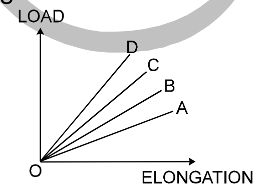
A 36. If the ratio of lengths, radii and Young's modulii of steel and brass wires in the figure are a, b, c respectively. Then the corresponding ratio of increase in their lengths would be :

(A) $\frac{2ac}{b^2}$ (B) $\frac{3a}{2b^2c}$ (C) $\frac{3c}{2ab^2}$ (D) $\frac{2a^2c}{b}$

A 37. An iron bar of length ℓ and having cross-section A is heated from 0°C to 100°C. If this bar is so held that it is not permitted to expand or bend, the gigantic force that is developed is :
(A) directly proportional to the length of the bar
(B) Inversely proportional to the length of the bar
(C) Independent of the length of the bar
(D) Inversely proportional to the cross-section of bar

A 38. Two rods of different materials having co-efficients of thermal expansion α_1 and α_2 and Young's modulli 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 the rods. If $\alpha_1 : \alpha_2 = 2 : 6$ 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

A 39. The rubber cord catapult has a cross-sectional area 1 mm^2 and total unstretched length 10.0 cm. It is stretched to 12.0 cm and then released to project a missile of mass 5.0 g. Taking Young's modulus for rubber as 5.0×10^8 Nm^{-2}, the tension in the cord is -
(A) 1000 N (B) 100 N (C) 10 N (D) 1 N



A 40. In above question 56, the velocity of projection of the missile is -
(A) 0.2 ms^{-1} (B) 2 ms^{-1} (C) 20 ms^{-1} (D) 200 ms^{-1}

A 41. The load versus elongation graph for four wires of the same materials is shown in the figure. The thinnest wire is represented by the line :

(A) OC (B) OD (C) OA (D) OB

A 42. A copper ring with a radius of r = 100 cm and a cross sectional area of A = 4 mm^2 is to be fitted on to a steel rod with a radius R = 100.125 cm. With what force F will the ring the be expanded if the modulus of elasticity of copper E = 1.2×10^5 N/mm^2 ? (Disregard the deformation of the rod)

(A) $\frac{600}{2\pi}\pi$ (B) $\frac{500}{2\pi}\pi$ (C) 500 N (D) 600 N

SECTION (B) : TANGENTIAL STRESS AND STRAIN, SHEAR MODULUS

B 1. A cube of aluminium of sides 0.1 m is subjected to a shearing force of 100 N. The top face of the cube is displaced through 0.02 cm with respect to the bottom face. The shearing strain would be :
(A) 0.02 (B) 0.1 (C) 0.005 (D) 0.002

B 2. A square lead slab of side 50 cm and thickness 5.0 cm is subjected to a shearing force (on its narrow face) of magnitude 9.0×10^4 N. The lower edge is riveted to the floor. The upper edge displacement if the shear modulus of lead is 5.6×10^9 Pa will be (Pa means Pascal = Nm^{-2}).
(A) 3.2×10^{-3} m (B) 3.2×10^{-6} m (C) 3.2×10^{-5} m (D) 3.2×10^{-4} m

B 3. A 50 kg motor rests on four cylindrical rubber blocks. Each block has a height of 4 cm and a cross-sectional area of 16 cm^2. The shear modulus of rubber is 2×10^6 N/m^2. A sideways force of 500 N is applied to the motor. The distance that the motor moves sideways is
(A) 0.156 cm (B) 1.56 cm (C) 0.312 cm (D) 0.204 cm

B 4. After the motor referred to in the above problem is disturbed, it is released to vibrate back and fourth. Its frequency of vibration is
(A) 26 Hz (B) 21 Hz (C) 13 Hz (D) 18 Hz

B 5. A square brass plate of side 1.0 m and thickness 0.005 m is subjected to a force F on each of its edges, causing a displacement of 0.02 cm. If the shear modulus of brass is 0.4×10^{11} N/m^2, the value of the force F is
(A) 4×10^3 N (B) 400 N (C) 4×10^4 N (D) 1000 N

B 6. A cube is subjected to a uniform volume compression. If the side of the cube decreases by 2%, the bulk strain is -
(A) 0.02 (B) 0.03 (C) 0.04 (D) 0.06

SECTION (C) : PRESSURE AND VOLUMETRIC STRAIN, BULK MODULUS OF ELASTICITY

C 1. The isothermal elasticity of a gas is equal to :
(A) Density (B) Volume (C) Pressure (D) Specific heat

C 2. The adiabatic elasticity of a gas is equal to
(A) $\gamma \times$ density (B) $\gamma \times$ volume (C) $\gamma \times$ pressure (D) $\gamma \times$ specific heat

C 3. The only elastic modulus that applies to fluids is :
(A) Young's modulus (B) Shear modulus (C) Modulus of rigidity (D) Bulk Modulus

C 4. The compressibility of water is 4×10^{-5} per unit atmospheric pressure. The decrease in volume of 100 cubic centimeter of water under a pressure of 100 atmosphere will be :
(A)* 0.4 cc (B) 4×10^{-5} cc (C) 0.025 cc (D) 0.004 cc

C 5. If a rubber ball is taken at the depth of 200 m in a pool its volume decreases by 0.1%. If the density of the water is 1×10^3 kg/m^3 and g = 10 m/s^2, then the volume elasticity in N/m^2 will be :
(A) 10^8 (B) 2×10^8 (C) 10^9 (D) 2×10^9

C 6. The pressure required to stop the increase in volume of a copper block when it is heated from 50ºC to 70ºC will be : (Coefficient of linear expansion of copper = 8.0×10^{-6} C^{-1} and bulk modulus of elasticity = 3.6×10^{11} Nm^{-2}.)
(A) 2.73×10^8 Nm^{-2} (B) 3.73×10^8 Nm^{-2} (C) 4.73×10^8 Nm^{-2} (D) 1.73×10^8 Nm^{-2}

C 7. The compressibility of water is 46.4×10^{-6}/atm. This means that
(A) the bulk modulus of water is 46.4×10^6 atm
(B) volume of water decreases by 46.4 one-millionths of the original volume for each atmosphere increase in pressure
(C) when wter is subjected to an additional pressure of one atmosphere, its volume decreases by 46.4%
(D) When water is subjected to an additional pressure of one atmosphere, its volume is reduced to 10^{-6} of its original volume.

C 8. A metal block is experiencing an atmospheric pressure of 1×10^5 N/m^2, when the same block is placed in a vacuum chamber, the fractional change in its volume is (the bulk modulus of metal is 1.25×10^{11} N/m^2)
(A) 4×10^{-7} (B) 2×10^{-7} (C) 8×10^{-7} (D) 1×10^{-7}

C 9. The bulk modulus of water is 2.1×10^9 N/m^2. The pressure required to increase the density of water by 0.1 % is
(A) 2.1×10^3 N/m^2 (B) 2.1×10^6 N/m^2 (C) 2.1×10^5 N/m (D) 2.1×10^7 N/m^2

C 10. The increase in pressure required to decrease the 200 litres volume of a liquid by 0.004% in kP_a is (bulk modulus of the liquid = 2100 M P_a)
(A) 8.4 (B) 84 (C) 92.4 (D) 168

C 11. A solid sphere of radius r made of a material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area 'a' floats on the surface of the liquid. When a mass m is placed on the

piston to compress the liquid, the fractional change in the radius of the sphere (dr/r)
(A) Ka/mg (B) Ka/3mg (C) mg/3Ka (D) mg/Ka

C 12. The volume elasticity is possessed by :
(A) Solids only (B) Liquids only (C) Gases only (D) All the three states of matter

C 13. One litre of a gas is maintained at pressure 72 cm of mercury. It is compressed isothermally so that its volume becomes 900 cm^3. The values of stress and strain will be respectively :
(A) 0.106 N m^{-2} and 0.1 (B) 1.06 N m^{-2} and 0.1
(C) 106.62 N m^{-2} and 0.1 (D) 10662.4 N m^{-2} and 0.1

C 14. The mean density of sea water is ρ, and bulk modulus is K. The change in density of sea water in going from the surface of water to a depth h is :

(A) $\frac{\rho gh}{K}$ (B) $K\rho gh$ (C) $\frac{\rho^2 gh}{K}$ (D) $\frac{K\rho^2}{gh}$

SECTION (D) : ELASTIC POTENTIAL ENERGY

D 1. If x longitudinal strain is produced in a wire of Young's modulus y, then energy stored in the material of the wire per unit volume is :
(A) yx^2 (B) 2 yx^2 (C) ½ y^2x (D) ½ yx^2

D 2. A load of 31.4 kg is suspended from a wire of radius 10^{-3} m and density 9×10^3 kg/m^3. Calculate the change in temperature of wire if 75% of the work done is converted into heat will be : (The Young's modulus and heat capacity of the material of the wire are 9.8×10^{10} N/m^2 and 490 J/Kg K, respectively)

(A) $\frac{1}{12}$ ºC (B) $\frac{1}{120}$ ºC (C) $\frac{1}{90}$ ºC (D) $\frac{1}{9}$ ºC

D 3. If the potential energy of a spring is V on stretching it by 2 cm, then its potential energy when it is stretched by 10 cm will be :
(A) V/25 (B) 5 V (C) V/5 (D) 25 V

D 4*. A metal wire of length L is suspended vertically from a rigid support. When a bob 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 $Mg\ell$
(B) The elastic potential energy stored in the wire is $Mg\ell$
(C) The elastic potential energy stored in the wire is $\frac{1}{2}Mg\ell$
(D) Heat produced is $\frac{1}{2}Mg\ell$

D 5. The workdone in increasing the length of a one metre long wire of cross-sectional area 1 mm^2 through 1 mm will be (Y = 2 x 10^{11} Nm^{-2}) :
(A) 0.1 J (B) 5 J (C) 10 J (D) 250 J

D 6. If work done in stretching a wire by 1mm is 2J, the work necessary for stretching another wire of same material, but with double the radius and half the length by 1mm in joule is -
(A) 1/4 (B) 4 (C) 8 (D) 16

D 7. Two wires of the same material and length but diameter in the ratio 1 : 2 are stretched by the same force. The ratio of potential energy per unit volume for the two wires when stretched will be :
(A) 1 : 1 (B) 2 : 1 (C) 4 : 1 (D) 16 : 1

D 8. A steel rod of length L are of cross-section A, Young's modulus Y and linear coefficient of expansion α is heated through tºC. The work that can be performed by the rod when heated as :

(A) $\frac{1}{2}(YA\alpha t) \times (l\alpha t)$ (B) $(YA\alpha t) \times (l\alpha t)$ (C) $2(YAat) \times (l\alpha t)$ (D) $\frac{1}{2}(YA\alpha t) \times \left(\frac{1}{2}\ell\ \alpha\ t\right)$

D 9*. A metal wire of length L area of cross-section A and Young's modulus Y is stretched by a variable force F such that F is always slightly greater than the elastic force of resistance in the wire. When the elongation of the wire is l :

(A) the work done by F is $\frac{YA^2}{L}$

(B) the work done by F is $\frac{YA\ell^2}{2L}$

(C) the elastic potential energy stored in the wire is $\frac{YA\ell^2}{2L}$

(D) heat is produced during the elongation

SECTION (E) : VISCOSITY

E 1. A metal plate 10 cm square rests on a 2 mm thick caster oil layer. Calculate the horizontal force needed to move the plate with speed 3 cm^{-1} s^{-1} will be (Coefficient of viscosity of caster oil is 15 poise.)
(A) 2.25×10^{-2} (B) 2.25×10^{-1} (C) 2.25×10^{-3} (D) 2.25×10^{-4}

E 2. A ball bearing of radius of 1.5 mm made of iron of density 7.85 g cm^{-3} is allowed to fall through a long column of glycerine of density 1.25 g cm^{-3}. It is found to attain a terminal velocity of 2.25 cm s^{-1}. The viscosity of glycerine in centipoise will be:
(A) 14370.33 (B) 143.733 (C) 1437.33 (D) 17.33

E 3. An oil drop falls through air with a terminal velocity of 5×10^{-4} m/s.
(i) the radius of the drop will be :
(A) 2.5×10^{-6} m (B) 2.10×10^{-6} m (C) 3.14×10^{-6} m (D) 4.18×10^{-6} m

(ii) the terminal velocity of a drop of half of this radius will be : (Viscosity of air = 1.8×10^{-5} N-s/m^2. density of oil = 900 Kg/m^3. Neglect density of air as compared to that of oil)
(A) 3.25×10^{-4} m/s (B) 2.10×10^{-4} m/s (C) 1.5×10^{-4} m/s (D) 1.25×10^{-4} m/s

E 4. Viscosity of gases is :
(A) about hundred times less than those of liquids
(B) about twenty times less than those of liquids
(C) about five hundred times less than those of liquids
(D) about ten hundred times less than those of liquids

E 5. Viscosity of liquids :
(A) increases with increase in temperature (B) is independent of temperature
(C) decreases with decrease in temperature (D) decreases with increase in temperature

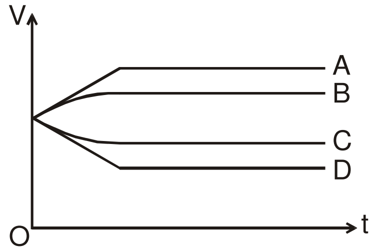
E 6. The terminal velocity of a sphere moving through a viscous medium is :
(A) directly proportional to the radius of the sphere
(B) inversely proportional to the radius of the sphere
(C) directly proportional to the square of the radius of sphere
(D) inversely proportional to the square of the radius of sphere

E 7. The terminal velocity of a sphere moving through a medium is :
(A) directly proportional to viscosity
(B) inversely proportional to viscosity
(C) directly proportional to the square of viscosity
(D) inversely proportional to the square of viscosity

E 8. A sphere is dropped gently into a medium of infinite extent. As the sphere falls, the force acting downwards on it
(A) remains constant throughout
(B) increases for sometime and then becomes constant
(C) decreases for sometime and then becomes zero
(D) increases for sometime and then decreases.

E 9. Two hail stones with radii in the ratio of 1 : 2 fall from a great height through the atmosphere. Then the ratio of their momenta after they have attained terminal velocity is
(A) 1 : 1 (B) 1 : 4 (C) 1 : 16 (D) 1 : 32

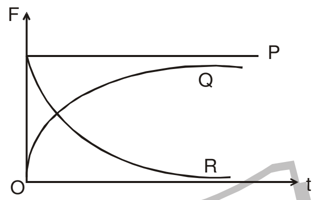
E 10. A small spherical solid ball is dropped from a great height in a viscous liquid. Its journey in the liquid is best described in the diagram given below (V = velocity and t = time) by the



(A) curve A (B) curve B (C) curve C (D) curve D.

E 11. Typical salt (hard mud) particle of radius 20 μm is on the top of lake water, its density is 2000 kg/m^3 and the viscosity of lake water is 1.0 m Pa-s, density is 1000 kg/m^3. If the lake is still (has no internal fluid motion), the terminal speed with which the particle hits the bottom of the lake is ....mm/s.
(A) 0.67 (B) 0.77 (C) 0.87 (D) 0.97

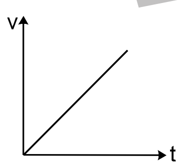
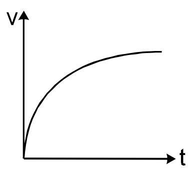
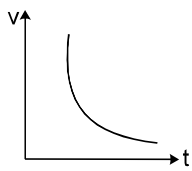
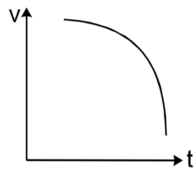
E 12. A spherical ball is dropped in a long column of viscous liquid. Which of the following graphs represent the variation of



(i) gravitational force with time
(ii) viscous force with time
(iii) net force acting on the ball with time
(A) Q, R, P (B) R, Q, P (C) P, Q, R (D) R, P, Q

E 13. A small sphere of mass m is dropped from a height. After it has fallen 100 m, it has attained its terminal velocity and continues to fall at that speed. The workdone by air friction against the sphere during the first 100 m of fall is
(A) greater than the workdone by air friction in the second 100 m
(B) less than the workdone by air friction inthe second 100 m
(C) equal to 100 mg
(D) greater than 100 mg.

E 14. A spherical ball is dropped in a long column of a viscous liquid. The speed (v) of the ball as a function of time (t) may be represented by :

(A)  (B)  (C)  (D) 

E 15. A solid sphere falls with a terminal velocity of 10 m/s in air. If it is allowed to fall in vacuum,
(A) terminal velocity will be more than 10 m/s (B) terminal velocity will be less than 10 m/s
(C) terminal velocity will be 10 m/s (D) there will be no terminal velocity

E 16. The force of viscosity is
(A) gravitational (B) weak (C) electromagnetic (D) nuclear

E 17. A spherical ball of iron of radius 2 mm is falling through a column of glycerine. If densities of glycerine and iron are respectively : 1.3×10^3 kg/m^3 and 8×10^3 kg/m^3 η for glycerine = 0.83 kgm/sec,, then the terminal velocity is :
(A) 0.7 m/s (B) 0.07 m/s (C) 0.007 m/s (D) 0.0007 m/s

E 18. A space ship entering the earth's atmosphere is likely to catch fire. This is due to
(A) the surface tension of air (B) the viscosity of air
(C) the temperature of the upper atmosphere
(D) the greater proportion of oxygen in the atmosphere at high altitudes

E 19. A ball of mass m and radius r is released in a viscous liquid. The value of its terminal velocity is proportional to :

(A) $\frac{1}{r}$ (B) $\frac{m}{r}$ (C) $\sqrt{\frac{m}{r}}$ (D) m only

E 20. A small steel ball falls through a syrup at constant speed of 10 cm/s. If the steel ball is pulled upwards with a force equal to twice its effective weight, how fast will it move upwards ?
(A) 10 cm/s (B) 20 cm/s (C) 5 cm/s (D) – 5 cm/s

E 21. A rain drop of radius 1.5 mm, experiences a drag force $F = (2 \times 10^{-5} v)$ N, while falling through air from a height 2 km, with a velocity v. The terminal velocity of the rain drop will be nearly (use $g = 10$ m/s^2) :
(A) 200 m/s (B)60 m/s (C) 7 m/s (D) 3 m/s

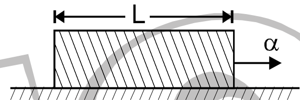
EXERCISE-3

1. A point M is suspended at the end of a massless wire of length L and cross-section A. If Y is the Young's modulus for the wire, find out the frequency of oscillation for the simple harmonic motion along the vertical line. **[CEE - 90, JEE-78]**

2. A copper wire is clamped its two ends between two rigid supports. When the temperature is 30ºC then there is no tension in the wire. What will be the speed of the transverse wave in the wire at 10ºC ? Young's modulus of copper $Y = 1.3 \times 10^{11}$ N/m^2, coefficient of linear expansion $\alpha = 1.7 \times 10^{-5}$ per ºC and density $= 9 \times 10^3$ kg/m^3. **[JEE- 79]**

3. The following wires are made of the same material. Which of these will have the largest extension when the same tension is applied ? **[JEE - 81]**
(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

4. Fill in the blanks :



(i) Rubber is .... elastic than steel.

(ii) A wire of length L and cross-sectional area A is made of a material of Young's modulus Y. If the wire is stretched by an amount x, the work done is .... **[JEE - 87]**

(iii) A uniform rod of length L and density ρ is being pulled along a smooth floor with a horizontal acceleration α. The magnitude of the stress at the transverse cross-section through the mid-point of the rod is ....

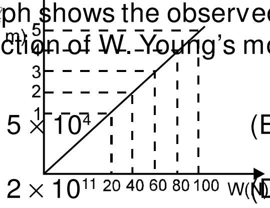
5. Two rods of different materials having coefficient of linear thermal expansion α_1, α_2 and Young's moduli Y_1, Y_2 respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of the rods. If $\alpha_1 : \alpha_2 = 2 : 3$, the thermal stresses developed in the two rods are equal provided $Y_1 : Y_2$ is equal to -
(A) 2 : 3 (B) 1 : 1 (C) 3 : 2 (D) 4 : 9 **[JEE - 89]**

6. A load of 31.4 kg is suspended from a wire of radius 10^{-3} m and density 9×10^3 kg/m^3. Calculate the change in temperature of the wire if 75% of the work done is converted into heat. The Young's modulus and the specific heat of the material of the wire are 9.8×10^{10} N/m^2 and 490 J (kg-K) respectively. **[JEE- 93]**

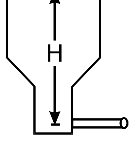
7. One end of a long metallic wire of length L, area of cross-section, A and Young's modulus Y is tied to the ceiling. The other end is tied to a massless spring of spring-constant k. A mass m hangs freely from the free end of the spring. When m is slightly pulled down and released, it oscillates up and down. Find the time period T. **[JEE- 93]**

8. A thin rod of negligible mass and area of cross-section 4×10^{-6} m^2, suspended vertically from one end has a length of 0.5 m at 10°C. The rod is cooled at 0°C, but prevented from contracting by attaching a mass at the lower end. Find **[JEE - 97]**
(i) This mass and (ii) The energy stored in the rod.
Given for this rod, $Y = 10^{11}$ Nm^{-2}, coefficient of liner a expansion $= 10^{-5}$ K^{-1} and $g = 10$ms^{-2}.

9. A 1m long metal wire of cross sectional area 10^{-6} m^2 is fixed at one end from a rigid support and a weight W is hanging at its other end. The graph shows the observed extension of length $\Delta\ell$ of the wire as a function of W. Young's modulus of material of the wire is SI units is



(A) 5×10^4 (B) 2×10^5
(C) 2×10^{11} (D) 5×10^{11} **[JEE Scr. 2003, 3]**



10. A cylindrical container of the shape shown in the figure has a diameter of 0.9 m at the top and 0.3 m at the bottom. A horizontal capillary tube of length L , inner radius a and outer radius 0.002 m is fixed at the bottom of the container. The container is filled with a liquid of density $\rho = 1.6 \times 10^3$ kg m^{-3} to a height H above the tube and a pressure P is applied on the top. The rate of flow of liquid from the tube is . With the same P and H and the tube removed, the liquid comes out with a speed of v = 10 m s^{-1}. Determine the viscosity μ (in Nsm^{-2}) of the liquid. Given $\pi a^2 = 2 \times 10^{-6}$ m^2 and $(a^2/L) = 10^{-6}$ m. **[Not in Syallabus now]** **[JEE 2003, 4/60]**

11. Small spherical particles falling under gravity in a viscous medium heat the medium due to friction. Find how the rate of heating depends on the radius of the particles after they reach their terminal speed. **[JEE 2004, 2/60]**

ANSWER

EXERCISE - 1

SECTION : A

A 1. Due to high modulus of elasticity.

A 2. For the same strain, stress in steel is more than rubber.

A 3. It is the property of material.

A 4. No change.

A 5. Yes, due to its self weight.

A 6. In both cases intermolecular forces.

A 7. (i) A (ii) B (iii) A

A 8. Y

A 9. (i) 2×10^{11} N/m^2 (ii) 40 N/m (iii) 5×10^9 , 1×10^{12} (iv) 4×10^{-13} m.

A 10. d' = 0.65 mm, $\Delta\ell$ = 0.045 mm

A 11. 1.11×10^{-3} m = 1.11 mm.

A 12. 88.632cm

A 13. 0.758 cm, 1.258 cm

A 14. 179.6 cm

A 15. 1.0007

A 16. 0.01 kg wt.

A 17. strain in wire A = 10^{-4}. strain in wire B = 2×10^{-4}.

SECTION : B

B 1. No

B 2. Zero.

B 3. 1.5×10^8 Nm^{-2} , 1.5×10^{11} Nm^{-2}

B 4. 3.77×10^4 N

B 5. (a) $\frac{F\cos^2\theta}{A}$ (b) $\frac{F\sin 2\theta}{2A}$ (c) $\theta = 0^o$ (d) $\theta = 45^o$

SECTION (C) :

C 1. (i) infinite (ii) infinite (iii) very small (iv) decreases with the increase of temperature.

C 2. 0.4 **C 3.** more

C 4. infinite **C 5.** True

C 6. 6.67×10^{-6} m^3 **C 7.** 1.7×10^{-4} m

C 8. 1.02×10^6 atmosphere

SECTION (D) :

D 1. In both cases it is increased.

D 2. $\frac{1}{2}\frac{YAx^2}{L}$

D 3. $\frac{1}{2} \times$ stress $\times$ strain

D 4. False **D 5.** 2.4×10^{-5} J.

D 6. $\frac{1}{2}AE\ell\alpha^2t^2$ **D 7.** 13.72×10^{-3} J.

SECTION (E) :

E 1. At low temperature, viscosity of lubricant increases.

E 2. Terminal velocity $\propto$ (radius)^2

E 3. glycerine, due to higher viscosity.

E 4. Due to higher Buoyant force .

E 5. It is the property of liquid which opposes the relative motion of different part of liquid.

E 6. Due to lesser viscosity.

E 7. 1.65×10^3 m

E 8. 20 cm/s

E 9. 1437.33

E 10. 348.44 poise

E 11. 0.21 cm s^{-1}

EXERCISE - 2

SECTION (A) :

A 1.	B	**A 2.**	B	**A 3.**	B
A 4.	D	**A 5.**	C	**A 6.**	A
A 7.	A	**A 8.**	D	**A 9.**	D
A 10.	A	**A 11.**	A	**A 12.**	C
A 13.	B	**A 14.**	D	**A 15.**	B
A 16.	B	**A 17.**	A	**A 18.**	A
A 19.	A	**A 20.**	C	**A 21.**	B
A 22.	D	**A 23.**	D	**A 24.**	B
A 25.	B	**A 26*.**	A, D	**A 27*.**	A,B,C,D
A 28*.	A	**A 29*.**	A,B,D	**A 30.**	A
A 31.	C	**A 32.**	A	**A 33.**	C
A 34.	D	**A 35.**	B	**A 36.**	B
A 37.	C	**A 38.**	C	**A 39.**	B
A 40.	C	**A 41.**	C	**A 42.**	B

SECTION (B) :

B 1.	D	**B 2.**	C	**B 3.**	A
B 4.	C	**B 5.**	C	**B 6.**	D

SECTION (C) :

C 1.	C	**C 2.**	C	**C 3.**	D
C 4.	A	**C 5.**	D	**C 6.**	D
C 7.	B	**C 8.**	C	**C 9.**	B
C 10.	B	**C 11.**	C	**C 12.**	D
C 13.	D	**C 14.**	C		

SECTION (D) :

D 1.	D	**D 2.**	B	**D 3.**	D
D 4*.	C,D	**D 5.**	A	**D 6.**	D
D 7.	D	**D 8.**	A	**D 9*.**	B,C,D

SECTION (E) :

E 1.	A	**E 2.**	C	**E 3.**	(i) C (ii) D
E 4.	A	**E 5.**	D	**E 6.**	C
E 7.	B	**E 8.**	C	**E 9.**	D
E 10.	B	**E 11.**	C	**E 12.**	C
E 13.	A	**E 14.**	B	**E 15.**	D
E 16.	C	**E 17.**	B	**E 18.**	B
E 19.	B	**E 20.**	A	**E 21.**	C

EXERCISE - 3

1. $\frac{1}{2\pi}\sqrt{\frac{YA}{ML}}$ **2.** 70 m/s

3. A

4. (i) less , (ii) $\frac{Yx^2A}{2L}$ (iii) $\frac{L\rho\alpha}{2}$

5. C

6. $\frac{1}{120}$ ºC.

7. $2\pi\sqrt{\frac{m\,(kL+YA)}{YAk}}$

8. (i) 40kg (ii) 0.1 J

9. C

10. $\frac{\pi a^4(P+\rho gH)}{8\eta L}$, 2.5×10^{-2} Nsm^{-2}

11. The rate of heating is proportional to the fifth power of the radius

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