Exercise-1

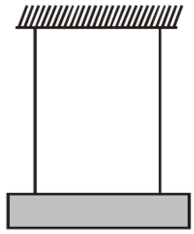
✍ **Marked Questions can be used as Revision Questions.**

OBJECTIVE QUESTIONS

Section (A) : Elastic behaviour longitudinal stress, young modulus

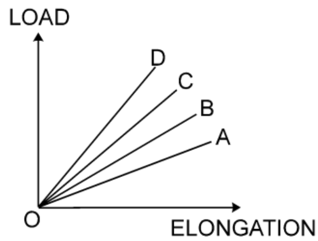
A-1.✍ The diameter of a brass rod is 4 mm and Young's modulus of brass is 9×10^{10} N/m^2. The force required to stretch by 0.1% of its length is :
(1) $360\,\pi$ N (2) 36 N (3) $144\,\pi \times 10^3$ N (4) $36\,\pi \times 10^5$ N

A-2.✍ 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



(1) $Y_1 + Y_2$ (2) $\frac{Y_1 + Y_2}{2}$
(3) $\frac{Y_1 Y_2}{Y_1 + Y_2}$ (4) $\sqrt{Y_1 Y_2}$

A-3. 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 :



(1) OC
(2) OD
(3) OA
(4) OB

Section (B) : Tangential stress and strain, shear modulus

B-1.✍ A square brass plate of side 1.0 m and thickness 0.005 m is subjected to a force F on its smaller opposite 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
(1) 4×10^3 N (2) 400 N (3) 4×10^4 N (4) 1000 N

Section (C) : Pressure and volumetric strain, bulk modulus of elasticity

C-1.✍ 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)
(1) 4×10^{-7} (2) 2×10^{-7} (3) 8×10^{-7} (4) 1×10^{-7}

Section (D) : Elastic Potential Energy

D-1. 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 :
(1) V/25 (2) 5 V (3) V/5 (4) 25 V

D-2.✍ 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 -
(1) 1/4 (2) 4 (3) 8 (4) 16

Section (E) : Viscosity

E-1. The terminal velocity of a sphere moving through a viscous medium is :
(1) directly proportional to the radius of the sphere
(2) inversely proportional to the radius of the sphere
(3) directly proportional to the square of the radius of sphere
(4) inversely proportional to the square of the radius of sphere

E-2. A sphere is dropped gently into a medium of infinite extent. As the sphere falls, the force acting downwards on it
(1) remains constant throughout
(2) increases for sometime and then becomes constant
(3) decreases for sometime and then becomes zero
(4) increases for sometime and then decreases.

E-3. A solid sphere falls with a terminal velocity of 10 m/s in air. If it is allowed to fall in vacuum,
(1) terminal velocity will be more than 10 m/s (2) terminal velocity will be less than 10 m/s
(3) terminal velocity will be 10 m/s (4) there will be no terminal velocity

Exercise-2

✍ **Marked Questions can be used as Revision Questions.**

* **Marked Questions may have more than one correct option.**

PART - I : OBJECTIVE QUESTIONS

1. 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 :
(1) F/2 (2) 2 F (3) 4 F (4) F/4

2. 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
(1) 1 : 1 (2) 1 : 4 (3) 1 : 16 (4) 1 : 32

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

4. 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 :
(1) 10^8 (2) 2×10^8 (3) 10^9 (4) 2×10^9

5. A ball of mass m and radius r is released in a viscous liquid. The value of its terminal velocity is proportional to :
(1) $\frac{1}{r}$ (2) $\frac{m}{r}$ (3) $\sqrt{\frac{m}{r}}$ (4) m only

6.✍ 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 :
(1) 1 : 1 (2) 2 : 1 (3) 4 : 1 (4) 16 : 1

7.✍ 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 ?
(1) 10 cm/s (2) 20 cm/s (3) 5 cm/s (4) – 5 cm/s

8. 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
(1) $\frac{L_a}{L_a - L_w}$ (2) $\frac{L_w}{L_a}$ (3) $\frac{L_a}{L_w}$ (4) $\frac{L_w}{L_a - L_w}$

9. An oil drop falls through air with a terminal velocity of 5×10^{-4} m/s.
(i) the radius of the drop will be :

(1) 2.5×10^{-6} m (2) 2×10^{-6} m (3) 3×10^{-6} m (4) 4×10^{-6} m

(ii) the terminal velocity of a drop of half of this radius will be : (Viscosity of air = $\frac{18 \times 10^{-5}}{5}$ N-s/m^2. density of oil = 900 Kg/m^3. Neglect density of air as compared to that of oil)

(1) 3.25×10^{-4} m/s (2) 2.10×10^{-4} m/s (3) 1.5×10^{-4} m/s (4) 1.25×10^{-4} m/s

PART - II : MISCELLANEOUS QUESTIONS

Section (A) : Assertion/ Reasoning

A-1. **Statement - 1 :** Steel is more elastic than rubber.
Statement - 2 : Under a given deforming force, steel deforms less than rubber.
(1) If both assertion and reason are true and reason is the correct explanation of assertion.
(2) If both assertion and reason are true but reason is not the correct explanation of assertion.
(3) If assertion is true but reason is false
(4) If assertion is false but reason is true.
(5) If both assertion and reason are false.

A-2. **Statement - 1 :** Bulk modulus of incompressible fluid is zero.
Statement - 2 : Bulk modulus of elasticity (B) = $-\frac{\Delta p}{\Delta V / V}$ where symbols have their standard meaning.
(1) If both assertion and reason are true and reason is the correct explanation of assertion.
(2) If both assertion and reason are true but reason is not the correct explanation of assertion.
(3) If assertion is true but reason is false
(4) If assertion is false but reason is true.
(5) If both assertion and reason are false.

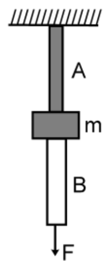
Section (B) : Match the column

B-1. 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 :

Column - I	Column - II
(1) The loss in gravitational potential energy of mass M is equal to	(p) $Mg\ell$
(2) The elastic potential energy stored in the wire is equal to	(q) $\frac{1}{2} Mg\ell$
(3) The elastic constant of the wire is equal to	(r) Mg/ℓ
(4) Heat produced during extension is equal to	(s) $\frac{1}{4} Mg\ell$

Section (C) : One or More Than One Options Correct

C-1. 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 : If the force F is mg/3, one of the wires breaks.
(1) A will break before B if $r_A < 2r_B$
(2) A will break before B if $r_A = r_B$
(3) Either A or B will break if $r_A = 2r_B$
(4) The lengths of A and B must be known to decide which wire will break



C-2.✍ 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 :

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

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

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

(4) heat is produced during the elongation

Exercise-3

✍ **Marked Questions can be used as Revision Questions.**

PART - I : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

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

[AIEEE 2003; 3/225, –1]

(1) 0.2 J (2) 10 J (3) 20 J (4) 0.1 J

2. Spherical balls of radius R are falling in a viscous fluid of viscosity η with a velocity ν. The retarding viscous force acting on the spherical ball is : **[AIEEE 2004; 3/225, –1]**

(1) directly proportional to R but inversely proportional to ν

(2) directly proportional to both radius R and velocity ν

(3) inversely proportional to both radius R and velocity ν

(4) inversely proportional to R but directly proportional to ν

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

[AIEEE 2005; 3/225, –1]

(1) 8 cm (2) 10 cm (3) 4 cm (4) 20 cm

4. If 'S' is stress and 'Y' is Young's modulus of material of a wire, the energy stored in the wire per unit volume is : **[AIEEE 2005; 3/225, –1]**

(1) $2S^2Y$ (2) $\frac{S^2}{2Y}$ (3) $\frac{2Y}{S^2}$ (4) $\frac{S}{2Y}$

5. If the terminal speed of a sphere of gold (density = 19.5 kg/m^3) is 0.2 m/s in a viscous liquid then find the terminal speed of sphere of silver (density = 10.5 kg/m^3) of the same size in the same liquid (density = 1.5 kg/m^3). **[AIEEE 2006; 3/165, –1]**

(1) 0.2 m/s (2) 0.4 m/s (3) 0.133 m/s (4) 0.1 m/s

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

[AIEEE 2006, 4½/180]

(1) $\ell/2$ (2) ℓ (3) 2ℓ (4) zero

7.✍ A spherical solid ball of volume V is made of a material of density ρ_1. It is falling through a liquid of density ρ_2 ($\rho_2 < \rho_1$). Assume that the liquid applies a viscous force on the ball that is proportional to the square of its speed ν, i.e., $F_{viscous} = -k\nu^2$ ($k > 0$). The terminal speed of the ball is **[AIEEE-2008, 3/105]**

(1) $\frac{Vg\rho_1}{k}$ (2) $\sqrt{\frac{Vg\rho_1}{k}}$ (3) $\frac{Vg(\rho_1 - \rho_2)}{k}$ (4) $\sqrt{\frac{Vg(\rho_1 - \rho_2)}{k}}$

8. Two wires are made of the same material and have the same volume. However wire 1 has cross-sectional area A and wire 2 has cross-sectional area 3A. If the length of wire 1 increases by Δx on applying force F, how much force is needed to stretch wire 2 by the same amount ? **[AIEEE-2009, 4/144]**

(1) 4F (2) 6F (3) 9F (4) F

9. If a ball of steel (density ρ = 7.8 g cm^{-3}) attains a terminal velocity of 10 cm s^{-1} when falling in a water (Coefficient of Viscosity $\eta_{water} = 8.5 \times 10^{-4}$ Pa.s) then its terminal velocity in glycerine (ρ = 1.2 g cm^{-3}, η= 13.2 Pa.s.) would be, nearly : **[AIEEE 2011, 11 MAY; 4/120, –1]**

(1) 6.25×10^{-4} cm s^{-1} (2) 6.45×10^{-4} cm s^{-1} (3) 1.5×10^{-5} cm s^{-1} (4) 1.6×10^{-5} cm s^{-1}

10. The pressure that has to be applied to the ends of a steel wire of length 10 cm to keep its length constant when its temperature is raised by 100°C is : **[JEE(Main)-2014; 4/120, –1]**

(For steel Young's modulus is 2×10^{11} N m^{-2} and coefficient of thermal expansion is 1.1×10^{-5} K^{-1})

(1) 2.2×10^{8} Pa (2) 2.2×10^{9} Pa (3) 2.2×10^{7} Pa (4) 2.2×10^{6} Pa

11. A pendulum made of a uniform wire of cross sectional area A has time period T. When an additional mass M is added to its bob, the time period changes to T_M. If the Young's modulus of the material of the wire is Y then $\frac{1}{Y}$ is equal to : (g = gravitational acceleration) **[JEE(Main)-2015; 4/120, –1]**

(1) $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{A}{Mg}$ (2) $\left[\left(\frac{T_M}{T}\right)^2 - 1\right]\frac{Mg}{A}$ (3) $\left[1 - \left(\frac{T_M}{T}\right)^2\right]\frac{A}{Mg}$ (4) $\left[1 - \left(\frac{T}{T_M}\right)^2\right]\frac{A}{Mg}$

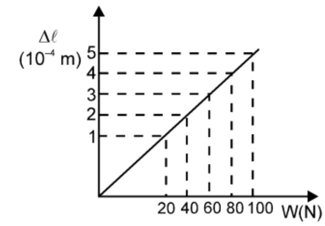
12. A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area a floats on the surface of the liquid, covering entire crosssection of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\frac{dr}{r}\right)$ is : **[JEE(Main)-2018; 4/120, –1]**

(1) $\frac{mg}{3Ka}$ (2) $\frac{mg}{Ka}$ (3) $\frac{Ka}{mg}$ (4) $\frac{Ka}{3mg}$

PART - II : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

1. 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 in SI units is **[JEE (Scr.), 2003, 3/84, –1]**



(A) 5×10^{4} (B) 2×10^{5} (C) 2×10^{11} (D) 5×10^{11}

2. A tiny spherical oil drop carrying a net charge q is balanced in still air with a vertical uniform electric field of strength $\frac{81\pi}{7} \times 10^5$ Vm^{-1}. When the field is switched off, the drop is observed to fall with terminal velocity 2×10^{-3} m s^{-1}. Given g = 9.8 m s^{-2}, viscosity of the air = 1.8×10^{-5} Ns m^{-2} and the density of oil = 900 kg m^{-3}, the magnitude of q is : **[JEE-2010, 5/237, –2]**

(A) 1.6×10^{-19} C (B) 3.2×10^{-19} C (C) 4.8×10^{-19} C (D) 8.0×10^{-19} C

3. One end of a horizontal thick copper wire of length 2L and radius 2R is welded to an end of another horizontal thin copper wire of length L and radius R. When the arrangement is stretched by a applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is :
[JEE(Advanced)-2013 ; 3/60]

(A) 0.25 (B) 0.50 (C) 2.00 (D) 4.00

4. Consider two solid spheres P and Q each of density 8 gm cm^{-3} and diameters 1 cm and 0.5 cm, respectively. Sphere P is dropped into a liquid of density 0.8 gm cm^{-3} and viscosity η = 3 poiseulles. Sphere Q is dropped into a liquid of density 1.6 gm cm^{-3} and viscosity η = 2 poiseulles. The ratio of the terminal velocities of P and Q is : **[JEE(Advanced) 2016; 4/60]**

Answers

EXERCISE # 1

Section (A) :

A-1. (1) **A-2.** (2) **A-3.** (3)

Section (B) :

B-1. (3)

Section (C) :

C-1. (3)

Section (D) :

D-1. (4) **D-2.** (4)

Section (E) :

E-1. (3) **E-2.** (3) **E-3.** (4)

EXERCISE # 2

PART- I

1. (3) **2.** (4) **3.** (2)

4. (4) **5.** (2) **6.** (4)

7. (1) **8.** (1)

9. **(i)** (3) **(ii)** (4)

PART- II

Section (A) :

A-1. (1) **A-2.** (4)

Section (B) :

B-1. (1 → p); (2 → q); (3 → r); (4 → q)

Section (C) :

C-1. (1,2,3) **C-2.** (2,3)

EXERCISE # 3

PART- I

1. (4) **2.** (2) **3.** (4)

4. (2) **5.** (4) **6.** (3)

7. (4) **8.** (3) **9.** (1)

10. (1) **11.** (1) **12.** (1)

PART- II

1. (C) **2.** (D) **3.** (C)

4. 3