Exercise-1

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

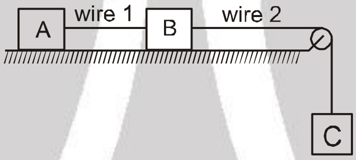
PART - I : SUBJECTIVE QUESTIONS

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

A-1.✍ 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, how much will it shorten?
Given, compressive strength of bone = $7.7 \times 10^8 \text{ Nm}^{-2}$ and Young's modulus of bone = $1.5 \times 10^{10} \text{Nm}^{-2}$

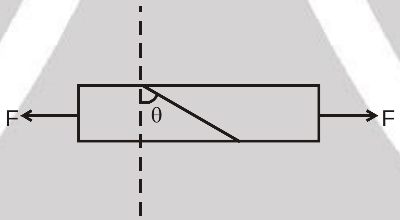
A-2. Two exactly similar wires of steel and copper are stretched by equal force. If the difference in their elongation is 0.5 cm, find by how much each wire has elongated. (Given Young's modulus for steel = 2×10^{12} dyne cm^{-2} and for copper 12×10^{11} dyne cm^{-2})

A-3.✍ Three blocks A, B and C each of mass 4 kg are attached as shown in figure. Both the wires has equal cross sectional area 5×10^{-7} m^2. The surface is smooth. Find the longitudinal strain in each wire if Young modulus of both the wires is 2×10^{11} N/m^2 (Take g = 10 m/s^2)



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

B-1.✍ 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.✍ A spherical ball contracts in volume by 0.001% when it is subjected to a pressure of 100 atmosphere. Calculate its bulk modulus.

Section (D) : Elastic potential energy

D-1. 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-2.✍ 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? [g = 9.8 m/s^2]

Section (E) : Viscosity

E-1.✍ 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. [g = 9.8 m/s^2]

PART - II : ONLY ONE OPTION CORRECT TYPE

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

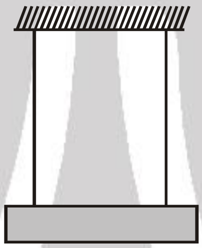
A-1. The diameter of a brass rod is 4 mm and Young's modulus of brass is 9×10^{10} N/m^2. The force required to stretch it by 0.1% of its length is :

(A) $360\,\pi$ N (B) 36 N (C) $144\,\pi \times 10^3$ N (D) $36\,\pi \times 10^5$ N

A-2. 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

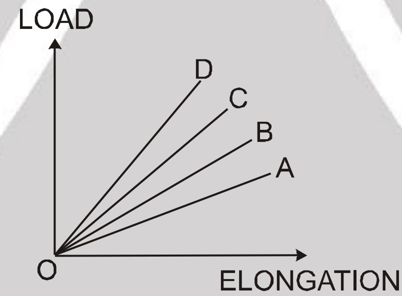
(A) $\frac{L_a}{L_a - L_w}$ (B) $\frac{L_w}{L_a}$ (C) $\frac{L_a}{L_w}$ (D) $\frac{L_w}{L_a - L_w}$

A-3. Two wires of equal length and cross-section area suspended as shown in figure. Their 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-4. 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

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

(A) 4×10^3 N (B) 400 N (C) 4×10^4 N (D) 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)

(A) 4×10^{-7} (B) 2×10^{-7} (C) 8×10^{-7} (D) 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 :

(A) V/25 (B) 5 V (C) V/5 (D) 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 –
(A) 1/4 (B) 4 (C) 8 (D) 16

Section (E) : Viscosity

E-1. 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^{-6} m (C) 3×10^{-6} m (D) 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, g = 10 m/s^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-2. 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-3. 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-4. 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

PART - III : MATCH THE COLUMN

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

Exercise-2

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

PART - I : ONLY ONE OPTION CORRECT TYPE

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 :

(A) F/2 (B) 2 F (C) 4 F (D) 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 momentum after they have attained terminal velocity is

(A) 1 : 1 (B) 1 : 4 (C) 1 : 16 (D) 1 : 32

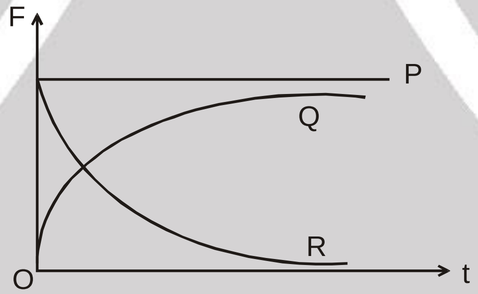
3.✍ A 50 kg motor rests on four cylindrical rubber blocks. Each block has a height of 4 cm and a cross-sectional area of 16 cm^2. The shear modulus of rubber is 2×10^6 N/m^2. A sideways force of 500 N is applied to the motor. The distance that the motor moves sideways is

(A) 0.156 cm (B) 1.56 cm (C) 0.312 cm (D) 0.204 cm

4.✍ 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

5. 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

6. The compressibility of water is 46.4×10^{-6}/atm. This means that

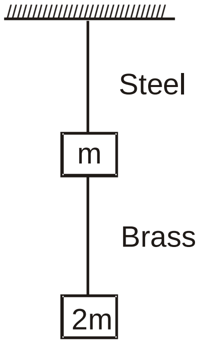
(A) the bulk modulus of water is 46.4×10^6 atm

(B) volume of water decreases by 46.4 one-millionths of the original volume for each atmosphere increase in pressure

(C) when water 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.

7. If the ratio of lengths, radii and Young's modulii of steel and brass wires in the figure are a, b and 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) $\frac{2a^2c}{b}$

8. 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

9. 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

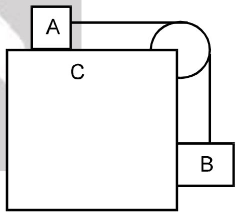
10. A small steel ball falls through a syrup at constant speed of 10 cm/s. If the steel ball is pulled upwards with a force equal to twice its effective weight, how fast will it move upwards ?
(A) 10 cm/s (B) 20 cm/s (C) 5 cm/s (D) – 5 cm/s

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. A rod 1 m long is 10 cm^2 in area for a portion of its length and 5 cm^2 in area for the remaining. The strain energy of this stepped bar is 40 % of that a bar 10 cm^2 in area and 1 m long under the same maximum stress. What is the length of the portion 10 cm^2 in area.

2. The cross-section of a bar is given by $\left[1+\frac{x^2}{100}\right]$ cm^2, where 'x' is the distance from one end. If the extension under a load of '20 kN' on a length of 10 cm is $\lambda \times 10^{-3}$ cm then find λ. Y = 2×10^5 N/mm^2.

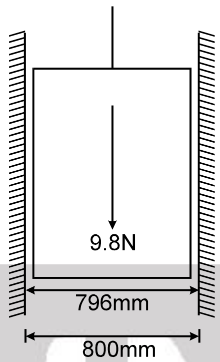
3. Two block A and B are connected to each other by a string, passing over a frictionless pulley as shown in figure. Block A slides over the horizontal top surface of a stationary block C and block B slide along the vertical side of C both with uniform speed. The coefficient of friction between the surface of blocks is 0.2. String stiffness is 2000 N/m. If mass of block B is 2 kg. Calculate ratio (in kg/J) of the mass of block A and the energy stored in the string.



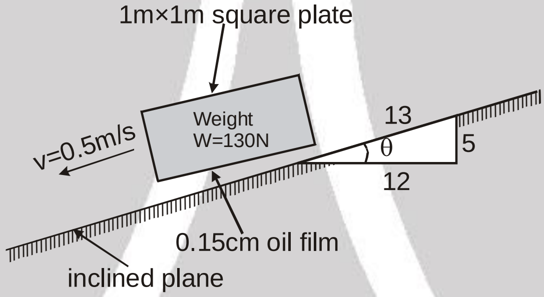
4. A thin ring of radius R is made of a material of density ρ and Young's modulus Y. If the ring is rotated about its centre in its own plane with angular velocity ω, if the small increase in its radius is $\frac{2\rho\omega^2R^3}{\lambda Y}$ then find λ.

5. A uniform copper bar of density ρ, length L, cross-sectional area S and Young's modulus Y is moving on a frictionless horizontal surface with constant acceleration a_0. If total elongation in the wire is $\frac{\rho a_0 L^2}{\lambda Y}$ then find λ.

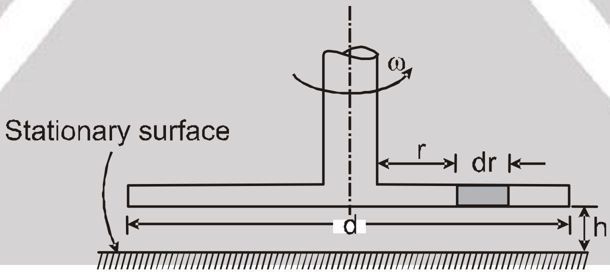
6. A piston of 796 mm diameter and 200 mm long works in a cylinder of 800 mm diameter as shown in figure. If the annular space is filled with a lubricating oil of viscosity 5 centipoises, calculate the constant speed (nearest to integer) (in m/s) of descent of piston in vertical position. The weight of piston and the axial load are 9.8 N.



7. If the approximate viscosity of the oil for the following case is $\lambda \times 10^{-2}$ Ns/m^2 then find λ :

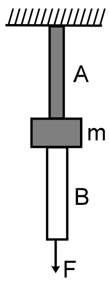


8. A circular disc of a diameter 'd' is slowly rotated in a liquid of large viscosity 'η' at a small distance 'h' from a fixed surface as shown in figure. If an expression for torque 'τ' necessary to maintain an angular velocity 'ω' is $\frac{\pi\eta\omega d^4}{\lambda h}$ then find λ.



PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

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.



(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

2. A small ball bearing is released at the top of a long vertical column of glycerine of height 2h. The bal bearing falls through a height h in a time t_1 and then the remaining height with the terminal velocity in time t_2. Let W_1 and W_2 be the work done against viscous drag over these height. Therefore,

(A) $t_1 < t_2$ (B) $t_1 > t_2$ (C) $W_1 = W_2$ (D) $W_1 < W_2$

3. 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

PART - IV : COMPREHENSION

Comprehension-1

When a tensile or compressive load 'P' is applied to rod or cable, its length changes. The change in length x which, for an elastic material is proportional to the force (Hook's law).

$P \propto x$ or $P = kx$

The above equation is similar to the equation of spring. For a rod of length L, area A and young modulus Y, the extension x can be expressed as -

$x = \frac{PL}{AY}$ or $P = \frac{AY}{L}x$, hence $K = \frac{AY}{L}$

Thus rods or cables attached to lift can be treated as springs. The energy stored in rod is called strain energy & equal to $\frac{1}{2}$ Px. The loads placed or dropped on the floor of lift cause stresses in the cables and can be evaluated by spring analogy. If the cable of lift is previously stressed and load is placed or dropped, then maximum extension in cable can be calculated by energy conservation.

1. If rod of length 4 m, area $4cm^2$ and young modulus 2×10^{10} N/m^2 is attached with mass 200 kg, then angular frequency of SHM (rad/sec.) of mass is equal to -

(A) 1000 (B) 10 (C) 100 (D) 10π

2. In above problem if mass of 10 kg falls on the massless collar attached to rod from the height of 99cm then maximum extension in the rod is equal (g = 10 m/sec^2) -

(A) 9.9 cm (B) 10 cm (C) 0.99 cm (D) 1 cm

3. In the above problem, the maximum stress developed in the rod is equal to - (N/m^2)

(A) 5×10^7 (B) 5×10^8 (C) 4×10^7 (D) 4×10^8

4. If two rods of same length (4m) and cross section areas 2 cm^2 and 4 cm^2 with same young modulus 2×10^{10} N/m^2 are attached one after the other with mass 600 kg then angular frequency is -

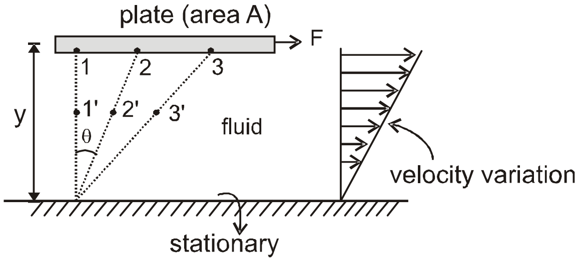
(A) $\frac{1000}{3}$ (B) $\frac{10}{3}$ (C) $\frac{100}{3}$ (D) $\frac{10\pi}{3}$

5. Four identical rods of geometry as described in problem (2) are attached with lift. If weight of the lift cage is 1000 N, and elastic limit of each rod is taken as 9×10^6N/m^2 then the number of persons it can carry safely is equal to. (g = 10m/sec^2, assume average mass of a person as 50 kg and lift moves with constant speed)

(A) 7 (B) 26 (C) 24 (D) 25

Comprehension-2

Viscosity is the property of fluid by virtue of which fluid offers resistance to deformation under the influence of a tangential force.

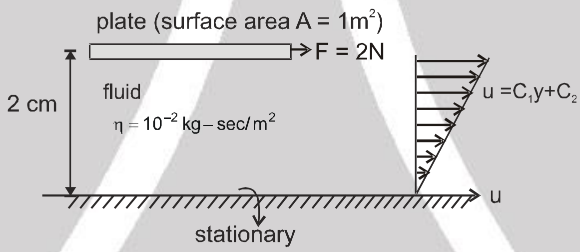


In the given figure as the plate moves the fluid particle at the surface moves from position 1 to 2 and so on, but particles at the bottom boundary remains stationary. If the gap between plate and bottom boundary is small, fluid particles in between plate and bottom moves with velocities as shown by linear velocity distribution curve otherwise the velocity distribution may be parabolic. As per Newton's law of viscosity the tangential force is related to time rate of deformation -

$\frac{F}{A} \propto \frac{d\theta}{dt}$ but $y\frac{d\theta}{dt} = u$, $\frac{d\theta}{dt} = \frac{u}{y}$ then $F = \eta A \frac{u}{y}$, η = coefficient of viscosity

for non-linear velocity distribution $F = \eta A \frac{du}{dy}$ where $\frac{u}{y}$ or $\frac{du}{dy}$ is known as velocity gradient.

6. In the given figure if force of 2N is required to maintain constant velocity of plate, the value of constant C_1 & C_2 are -

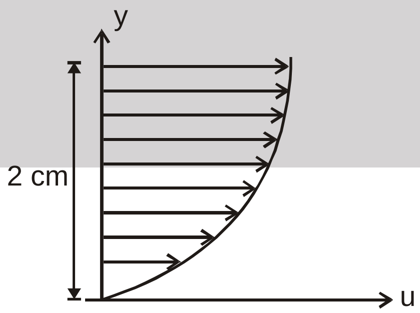


(A) 100, 100 (B) 0, 100 (C) 200, 0 (D) 0, 200

7. In previous question the value of constant speed of plate (m/sec.) is equal to -

(A) 0 (B) 4 (C) 2 (D) 1

8. If velocity distribution is given as (parabolic) $u = c_1y^2 + c_2y + c_3$



for the same force of 2N and the speed of the plate 2 m/sec, the constants C_1, C_2 & C_3 are-

(A) 200, 200, 0 (B) 5000, 200, 0 (C) 5000, 0, 0 (D) 500, 200, 0

9. The velocity gradient just below the plate. in above problem is equal to - (per second)

(A) Zero (B) 100 (C) 500 (D) 200

10. The velocity gradient just near the bottom boundary is equal to -

(A) Zero (B) 100 (C) 500 (iv) 200

Exercise-3

✍ **Marked Questions can be used as for Revision Questions.**
*** Marked Questions may have more than one correct option.**

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

1.✍ A small sphere falls from rest in a viscous liquid. Due to friction, heat is produced. Find the relation between the rate of production of heat and the radius of the sphere at terminal velocity. **[JEE 2004, 2/60]**

2.✍ A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1m 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 : **[JEE 2010, 3/252]**

3. 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 ms^{-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]**

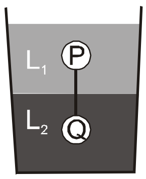
(A) 1.6×10^{-19} C (B) 3.2×10^{-19} C (C) 4.8×10^{-19} C (D) 8.0×10^{-19} C

4.✍ 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,–1]**

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

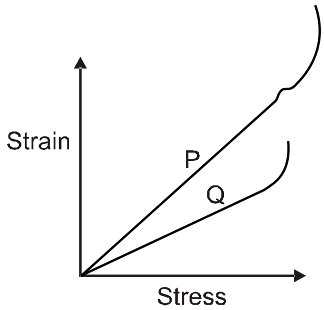
5. Durring Searle's experiment, zero of the Vernier scale lies between 3.20×10^{-2} m and 3.25×10^{-2} m of the main scale. The 20th division of the Vernier scale exactly coincides with one of the main scale divisions. When an additional load of 2 kg is applied to the wire, the zero of the Vernier scale still lies between 3.20×10^{-2} m and 3.25×10^{-2} m of the main scale but now the 45th division of Vernier scale coincides with one of the main scale divisions. The length of the thin metallic wire is 2m and its cross-sectional area is 8×10^{-7} m^2. The least count of the Vernier scale is 1.0×10^{-5} m. The maximum percentage error in the Young's modulus of the wire is **[JEE (Advanced) 2014, P-1, 3/60]**

6*. Two spheres P and Q of equal radii have densities ρ_1 and ρ_2, respectively. The spheres are connected by a massless string and placed in liquids L_1 and L_2 of densities σ_1 and σ_2 viscosities η_1 and η_2, respectively. They float in equilibrium with the sphere P in L_1 and sphere Q in L_2 and the string being taut (see figure). If sphere P alone in L_2 has terminal velocity $\vec{V}_P$ and Q alone in L_1 has terminal velocity $\vec{V}_Q$, then **[JEE (Advanced) 2015 ; P-2,4/88, –2]**



(A) $\frac{|\vec{V}_P|}{|\vec{V}_Q|} = \frac{\eta_1}{\eta_2}$ (B) $\frac{|\vec{V}_P|}{|\vec{V}_Q|} = \frac{\eta_2}{\eta_1}$ (C) $\vec{V}_P.\vec{V}_Q > 0$ (D) $\vec{V}_P.\vec{V}_Q < 0$

7*. In plotting stress versus strain curves for the materials P and Q, a student by mistake puts strain on the y-axis and stress on the x-axis as shown in the figure. Then the correct statement(s) is(are)



[JEE (Advanced) 2015 ; P-2,4/88, –2]

(A) P has more tensile strength than Q
(B) P is more ductile than Q
(C) P is more brittle than Q
(D) The Young's modulus of P is more than that of Q.

8. 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 ; P-1, 3/62]**

9*. Consider a thin square plate floating on a viscous liquid in a large tank. The height h of the liquid in the tank is much less than the width of the tank. The floating plate is pulled horizontally with a constant velocity u_0. Which of the following statements is (are) true? **[JEE (Advanced) 2018, P-2, 4/60, –2]**
(A) The resistive force of liquid on the plate is inversely proportional to h
(B) The resistive force of liquid on the plate is independent of the area of the plate
(C) The tangential (shear) stress on the floor of the tank increases with u_0
(D) The tangential (shear) stress on the plate varies linearly with the viscosity η of the liquid

10. A solid horizontal surface is covered with a thin layer of oil. A rectangular block of mass m = 0.4kg is at rest on this surface. An impulse of 1.0 N s is applied to the block at time t = 0 so that it starts moving along the x-axis with a velocity $v(t) = v_0e^{-t/\tau}$, where v_0 is a constant and τ = 4s. The displacement of the block, in metres, at $t = \tau$ is __________. Take $e^{-1} = 0.37$. **[JEE (Advanced) 2018, P-2, 3/60]**

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

1. 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

2. 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) $\frac{S}{2Y}$

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

4. 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, 3/165, –1]**

(1) ℓ (2) 2ℓ (3) zero (4) $\ell/2$

5. 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 v, i.e., $F_{viscous} = -kv^2$ ($k > 0$). 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) $\sqrt{\frac{Vg(\rho_1-\rho_2)}{k}}$

6. 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

7. If a ball of steel (density $p = 7.8$ 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 ($p = 1.2$ g cm^{-3}, $\eta = 13.2$ Pa.s.) would be, nearly : **[AIEEE 2011, 11 May; 4/120, –1]**

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

8. 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 : (For steel Young's modulus is 2×10^{11} N m^{-2} and coefficient of thermal expansion is 1.1×10^{-5} K^{-1}) **[JEE (Main) 2014 ; 4/120, –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

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

10. 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) $\frac{Ka}{3mg}$

Answers

EXERCISE-1

PART – I

Section (A)

A-1. No, $\frac{10}{9}$ x 10^{-3} m = 1.11 mm.

A-2. 0.75 cm, 1.25 cm

A-3. $\frac{4}{3}\times10^{-4}$, $\frac{8}{3}\times10^{-4}$

Section (B) :

B-1. (a) $\frac{F\cos^2\theta}{A}$ (b) $\frac{F\sin2\theta}{2A}$

(c) $\theta = 0^o$ (d) $\theta = 45^o$

Section (C) :

C-1. 10^7 atmosphere

Section (D) :

D-1. 2.4×10^{-5} J. **D-2.** 13.72×10^{-3} J

Section (E) :

E-1. $\frac{81}{49} \times 10^3$ m

PART - II

Section (A) :

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

A-4. (C)

Section (B) :

B-1. (C)

Section (C) :

C-1. (C)

Section (D) :

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

Section (E) :

E-1. (i) (C) ; (ii) (D) **E-2.** (C)

E-3. (C) **E-4.** (D)

PART - III

1. (A) $\rightarrow$ p ; (B) $\rightarrow$ q ; (C) $\rightarrow$ r ; (D) $\rightarrow$ q

EXERCISE-2

PART - I

1. (C) **2.** (D) **3.** (A)
4. (D) **5.** (C) **6.** (B)
7. (C) **8.** (D) **9.** (D)
10. (A)

PART - II

1. 40 **2.** 8 **3.** 100
4. 2 **5.** 2 **6.** 8
7. 15 **8.** 32

PART - III

1. (ABC) **2.** (BD) **3.** (BC)

PART – IV

1. (C) **2.** (D) **3.** (A)
4. (C) **5.** (B) **6.** (C)
7. (B) **8.** (C) **9.** (D)
10. (A)

EXERCISE-3

PART - I

1. $\frac{dQ}{dt} \propto r^5$ **2.** 4
3. (D) **4.** (C) **5.** 8
6. (AD) **7.** (AB) **8.** 3
9. (ACD) **10.** 6.30

PART - II

1. (2) **2.** (2) **3.** (3)
4. (1) **5.** (4) **6.** (3)
7. (1) **8.** (1) **9.** (1)
10. (1)