ELASTICITY

- **Rigid Body :**
  A body whose size and shape cannot be changed, however large the applied force may be is called rigid body.
  There is no perfectly rigid body in nature.
- **Deformation force :**
  The force which changes the size or shape or both of a body without moving it as a whole is called deformation force.
- **Restoring force :**
  The force which restores the size and shape of the body when deformation force is removed is called restoring force.
  Magnitude of restoring force is equal to the deformation force. But they are in opposite direction. They do not form action, reaction pair. This force is responsible for the elastic nature of the body.
- **Elasticity :**
  The property of a material by virtue of which it regains its original size and shape when defor mation force is removed is called elasticity.
  Ex : Steel, Rubber.
  No body is perfectly elastic, but quartz is the nearest example.
  Elasticity is molecular property of matter.
- **Plasticity :**
  The property of a material by virtue of which it does not regain the size and shape when the de formation force is removed is called Plasticity.
  Ex : Putty dough, Chewing gum, Lead sholder.
  No body is perfectly plastic but putty is nearest example.
- **Stress :**
  The restoring force per unit area is called stress.

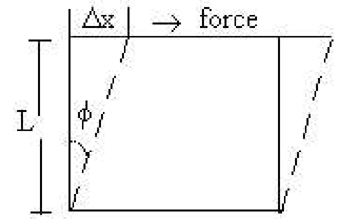
$$\text{Stress} = \frac{\text{restoring force}}{\text{area of cross section}} = \frac{F}{A}$$

Unit : N/m^2 or Pascal.

- **Strain :**
  The change produced per unit dimension is called strain.

$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

$$\text{Longitudinal strain} = \frac{\text{change in length}}{\text{original length}} = \frac{e}{\lambda}$$



$$\textit{Shearing strain} = \frac{\text{relative displacement of layers}}{\text{distance between the layers}}$$

$$= \frac{\Delta x}{L} = \phi$$

This strain is due to the change in shape of the body.
Volumetric strain (or) Bulk strain

$$= \frac{\text{change in volume}}{\text{original volume}} = \frac{-\Delta V}{V}$$

Shearing strain = 2 x e
(e is longitudinal strain).
Bulk strain (or) Volumetric strain = 3 x e
Longitudinal strain : Shearing strain : Bulk strain = 1 : 2 : 3.

- **Elastic limit :**
  The maximum value of the stress with in which the body regains its original size and shape is called elastic limit.
- **Hooke's law :**
  With in the elastic limit, stress is directly propor tional to strain.

$$\frac{\text{Stress}}{\text{Strain}} = E = \text{const.}$$

With in the elastic limit, stress-strain graph is a straight line passing through the origin.
Slope of the graph is E.
Spring balance works on the principle of Hooke's law.
Modulus of elasticity depends on the nature of the material, but it is independent of dimensions.

Young's modulus (Y) :

$$Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}} = \frac{F\lambda}{Ae}$$

If load attached to the wire is M, then F = Mg, and $A = \pi r^2$

$$Y = \frac{Mgl}{\pi r^2 e}$$

If the load attached to the wire and y are con stant

$$e \propto \frac{\lambda}{r^2}$$

If length is also constant

$$e \propto \frac{1}{r^2}$$

If volume of the wire is constant

$$e \propto \lambda^2 \ ; \ e \propto \frac{1}{A^2} \ ; \ e \propto \frac{1}{r^4}$$

- Elongation of a wire under its own weight

$$e = \frac{l^2 dg}{2Y}$$ (d is density).

If λ_1, λ_2 are the lengths of a wire under tensions T_1 & T_2 then the length of the unstretched wire.

$$\lambda = \frac{\lambda_1 T_2 - \lambda_2 T_1}{T_2 - T_1}$$

When a load is suspended from a wire its elon gation is e. If the load is immersed in a liquid of density 'ρ' then the new elongation.

$$e^1 = e(1 - \rho / d)$$

d is density of load

- Stress required to double the length of the wire is numerically equal to the Young's modulus.

If a load 'M' produced elongation e in a wire, the raise in temperature required to produce same elongation.

$$\lambda\alpha\,\Delta\theta = \frac{Mg\lambda}{AY}; \ \Delta\theta = \frac{Mg}{AY\alpha}$$

Two wires of same length and radius are joined end to end and loaded. If Young's moduli of the materials are Y_1 &Y_2, the Young's modulus of the combination is $\frac{2}{Y} = \frac{1}{Y_1} + \frac{1}{Y_2}; Y = \frac{2Y_1Y_2}{Y_1 + Y_2}$

For a perfectly elastic material e = 0. So Young's modulus is infinity.

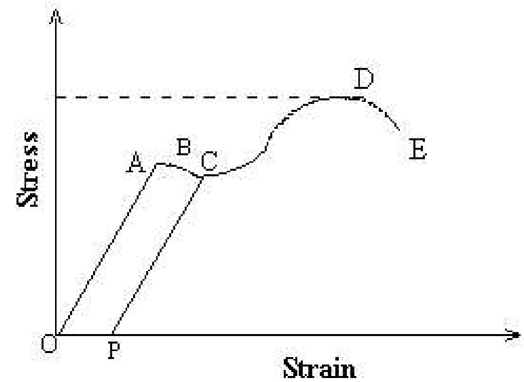
For a plastic material the Young's modulus is zero.

From Searle's experiment the Young's modulus of the material of wire.

$$Y = \frac{Mg\lambda}{\pi r^2 e}$$

The graph between load and elongation is a straight line passing through the origin.

Behaviour of a wire under increasing load.



Proportional limit (A) :

Upto the point A stress is directly proportional to the strain and the wire obeys Hooke's law.

Elastic limit (B) :

In the region AB, the wire does not obey Hooke's law but it regains, the original length when load is removed.

Yield point C:

The point where elasticity ends and plasticity begins is called yield point.

Here the wire behaves like fluid and it elongates with time.

Permanent set (OP) :

The permanent increase in length of the wire af ter removing the load is called permanent set.

Permanent set = OP x λ

- **Breaking Point :** The point in the graph where the wire breaks.
- **Breaking Stress :**

The stress required to break the wire is called breaking stress.

The maximum stress the material can with stand without breaking is called breaking stress.

Breaking stress

$$= \frac{\text{breaking force}}{\text{initial area of cross section}}$$

$$= \frac{Mg}{A} = \frac{A\lambda dg}{A} = \lambda dg$$

The maximum length of the wire that can hang without breaking under its own weight

$$\lambda = \frac{\text{breaking stress}}{dg}$$

Breaking stress depends on the nature of the material, but it is independent of dimensions.

Breaking stress per unit area is called tensile strength.
Breaking force = Breaking stress x area
Breaking force is independent of length of the wire, but it depends on the nature of material and area of cross section.

$F \propto A, F \propto r^2$

If we cut a wire that can support a maximum load W into two equal parts, then each part of the wire can support a maximum load W.

- **Elastic fatigue :**
The state of temporary loss of elastic property due to continuous strain is called elastic fatigue.
If some rest is given to the wire, it regains the elastic property.
Due to elastic fatigue
a) A wire can be broken with in the elastic limit.
b) A wire can be cut into two pieces without using instruments.
c) Railway tracks and bridges declared unsafe after long use.
d) Spring balance show wrong reading on long use.
e) If the material doesn't break after the elastic limit, it is used to prepare thin wires. It is called ductile metal.
Ex : Copper, Silver, Gold etc.
f) If the material braeaking after elastic limit, it is not used to prepare thin wires . It is called brittle metal. Ex : Glass.

- **Elastic after effect :**
The delay in regaining the original state on removal of the deforming force on a body is called elastic after effect.
For a perfectly elastic body, the elastic after effect is zero.
For a perfectly plastic body, the elastic after effect is infinity.
For a given load the elongation of steel wire is less than rubber. So steel is more elastic than rubber.
Springs are made of steel, because it is more elastic.
Elasticity of a material will decrease with increase of temperature.
For rubber elasticity will increase with temperature.
For invar steel elasticity is independent of temperature.
Annealing means slow cooling after heating. It decreases the elastic property.
Hammering and rolling increases with elastic property.
Elastic property of a material increase with addition of impurity.

- **Thermal force :**
When a metal bar is fixed between two supports and heated, it tries to expand and exerts force on the walls. This is called thermal force.

$F = AY\alpha\theta$

Thermal force is independent of length of the bar.
Thermal stress (linear compressive stress)

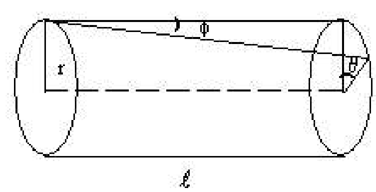
$$\frac{\text{force}}{\text{area}} = \frac{AY\alpha\theta}{A} = Y\alpha\theta.$$

- **Rigidity modulus :**
With in the elastic limit, the ratio of tangential stress to the shearing strain is called rigidity modulus.

$$\text{Rigidity modulus} = \frac{\text{tangential stress}}{\text{shearing strain}}$$

$$n = \frac{F}{A\theta}$$

a) If n is small for a wire, it can be twisted easily.
b) As the rigidity modulus of phsphor bronze is low, it is used as supspension wire in moving coil galvanometer.
c) A rod of length 'l' and radius r is fixed at one end.If the other free end is twisted through an angle θ. Then the angle of shear 'ϕ' is given by $\phi = \frac{r\theta}{\lambda}$.



- One end of the rod is fixed the other free end is twisted through an angle θ by applying a torque τ. The work done on the rod is

$$W = \frac{1}{2}\tau\theta$$

When a spring is stretched, the strain involved is shear.
When a helical spring (thickness is large) is stretched, the strain involved is longitudinal and shearing strain.

- **Bulk modulus (K)**
With in the elastic limit the ratio between volume stress and bulk strain is called bulk modulus.

$$\text{Bulk modulus} = \frac{\text{volume stress}}{\text{bulk strain}}$$

$$K = \frac{\frac{F}{A}}{\frac{-\Delta V}{V}} = -\frac{V}{\Delta V}\frac{F}{A} = \frac{-PV}{\Delta V}$$

(- sign shows decrease in volume)
i) If a block of coefficient of cubical expansin γ is heated through a rise in temperature of θ, the pressure to be applied on it to prevent its expansion = $K\gamma\theta$ where K is its bulk modu lus.
ii) When a rubber ball of volume V, bulk modu lus K is taken to a depth 'h' in water decreases in its volume $\Delta V = \frac{hdgV}{K}$.
(d = density of material)
For an incompressible material, $\Delta V = 0$, so bulk modulus is infinity.
Solid possess y,n and k
Liquids and gases possess only K.
Isothermal bulk modulus of the gas = P(pressure)
Adiabatic bulk modulusof the gas = γp
(where $\gamma = \frac{C_p}{C_V}$)
The reciprocal of bulk modulus is called com pressibility

- **Poisson's ratio (σ)**
The ratio lateral contraction strain to the longi tudinal elongation strain is called Poisson's ratio.

$$\sigma = \frac{\text{lateral contraction strain}}{\text{longitudinal elongation strain}}$$

$$= \frac{\text{transverse strain}}{\text{longitudinal strain}} = \frac{\Delta r / r}{\Delta\lambda / \lambda} = \frac{\Delta r\lambda}{\Delta\lambda \text{ x } r}$$

i) As it is a ratio, it has no units and dimension.
ii) Theoretical limits of $\sigma = -1$ to 0.5
Practical limits of $\sigma = 0$ to 0.5
iii) For an incompressible substance $\sigma = 0.5$

Relation among elastic constants y,n,k.

i) $\frac{9}{y} = \frac{1}{K} + \frac{3}{n}$ **(or)** $y = \frac{9nk}{3K + n}$

ii) $y = 2n(1 + \sigma)$

iii) $y = 3k(1 - 2\sigma)$

iv) $\sigma = \frac{3K - 2n}{6K + 2n}$

- **Punching a hole**
Punching a hole of radius 'r' in a metal plate of thickness 't'. The force required is calaculated by the formula.
F = breaking stress x $2\pi rt$

- **Spring**
For a given spring $F \propto x$; $F = kx$; $k = \frac{F}{x}$
k is called spring constant (or) force constant (or) stiffness constant.
Spring constant interms of Young's modulus area of cross section and length $k = \frac{yA}{\lambda}$.

- P.E.energy of a streched spring

$$E = \frac{1}{2}Kx^2 \Rightarrow \frac{1}{2}Fx = \frac{F^2}{2K}$$

Two spring having force constants K_1 & K_2 ($K_1 > K_2$) are stretched by same amount then more work is done on the first spring $W \propto K$.
Two springs having force constants $K_1, K_2 (K_1 > K_2)$ are stretched by same force then more work is done on the second spring. $W \propto 1/K$.
If energy is same for both the springs the relation between force and spring constant $F \propto \sqrt{K}$.

- The work done in stretching a wire

$$W = \frac{1}{2}\text{Stress x Strain x Volume}$$

$$W = \frac{1}{2}Fe = \frac{1}{2}\frac{e^2 AY}{1}$$

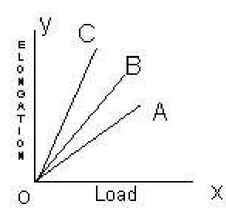
- Strain energy per unit volume (energy density)

$$E = \frac{1}{2}\text{x stress x strain} = \frac{1}{2}Y(Strain)^2$$

Also, $E = \frac{(Stress)^2}{2Y}\left[\therefore Y = \frac{Stress}{Strain}\right]$

CONCEPTUAL QUESTIONS

1. The breaking stress of a wire depends upon
   1) material of the wire 2) length of the wire
   3) radius of the wire 4) shape of the cross section
2. A wire can sustain the weight of 40kg before breaking. If the wire is cut into 4 equal parts, each part can sustain a weight of ...kg
   1) 40 2) 160 3)10 4) 20
3. Which of the following relation is not correct ?
   1) $\frac{y}{n}=2(1+\sigma)$ 2) $\frac{y}{3k}=1-2\sigma$
   3) $\frac{y}{n}=\frac{9kn}{3k+n}$ 4) $\frac{y}{n}+\frac{y}{3k}=3$
4. When an elastic material with young's modulus 'y' is subjected to a stretching stress 's', the elastic energy stored per unit volume is
   1) $\frac{s^2}{2y}$ 2) $\frac{ys^2}{2}$ 3) $\frac{s}{2y}$ 4) $\frac{ys}{2}$
5. When an elastic material of young's modulus 'y' is subjected to certain stress, the strain is 'x'. The elastic energy stored per unit volume is
   1) $\frac{1}{2}yx^2$ 2) $\frac{x^2}{2y}$ 3) $\frac{y^2}{2x}$ 4) xy^2
6. A wire extends by 'l' on the application of load 'mg'. Then, the work done is
   1) mgl 2) mgl/2 3) mg/1 4) mgl^2
7. Elongation of a wire under its own weight is independent of
   1) Length 2) Area of cross section
   3) Density 4) Young's modulus
8. The following substances which possess rigidity modulus
   1) Only Solids 2) Only liquids
   3) Liquids and Gases 4) Solids, Liquids and Gases
9. The young's modulus of a wire of length 'L' and radius 'r' is 'Y'. If length is reduced to L/2 and radius r/2, Youngs modulus will be
   1) Y/2 2) Y 3) 2Y 4) 4Y
10. A spiral spring is stretched by a force, the resultant strain produced in the spring is
    1) Volume strain 2) shearing strain
    3) longitudinal strain 4) all the above
11. A long string is stretched by 2cm and the P.E. is U. If the string is stretched by 10cm its P.E. will be
    1) U/25 2) U/5 3) 5U 4) 25 U
12. Steel is preferred for making springs over copper because
    1) Y of steel is more than that of copper
    2) Steel is cheaper
    3) Y of copper is more than steel
    4) Steel is less likely to be oxidised
13. Reason for the deformation of a regular body is
    1) bulk strain 2) shearing strain
    3) linear strain 4) lateral strain
14. A copper wire and a steel wire of the same diameter and length are connected end to end and a force is applied so that their combined length stretched by 1cm. The two wires have
    1) same stress, same strain
    2) same stress, different strains
    3) same strain different stress
    4) different stress, different strains
15. The poisson's ratio cannot have the value
    1) 0.7 2) 0.2 3) 0.1 4) 0.3
16. A metallic rod of length 'L' and cross-section 'A' has Young's modulus 'Y' and coefficient of linear expansion 'a'. If the rod is heated to a temperature 'T' the energy stored per unit volume is :
    1) $\frac{1}{2}Y\alpha^2T^2$ 2) $\frac{1}{2}YA\alpha^2T^2$
    3) $\frac{1}{2}YA\alpha T$ 4) $\frac{1}{2}YA^2\alpha^2T^2$
17. Three wires A, B, C made of different materials elongated by 1.5, 2.5, 3.5 mm, under a load of 5kg. If the diameters of the wires are the same, the most elastic material is that of
    1) A 2) B 3) C 4) All
18. Three wires A,B, C made of the same material and radius have different lenghts. The graphs in the figure show the elongation-load variation. The longest wire is



    1) A 2) B 3) C 4) All
19. In the above problem, all the wires have the same dimensions but are madeup of different, materials. The most elastic wire is
    1) A 2) B 3) C 4) All
20. A wire is under a load. If α is the longitudial strain and Y, the young modulus of the material of the wire, the elastic strain energy per unit volume of the wire is
    1) $\frac{1}{2}Y\alpha^2$ 2) $\frac{Y\alpha}{2}$ 3) $\frac{Y^2\alpha}{2}$ 4) $2Y\alpha$
21. The modulus of elasticity is dimensionally equivalent to
    1) Stress 2) Surface tension 3) Strain
    4) Coefficient of viscosity
22. Modulus of elasticity for a perfectly elastic body is
    1) Zero 2) Infinity 3) 1 4) 2

23. A wire of length 'L' and radius 'r' is fixed at one end. A force 'F' applied to the other end produces an extension 'l'. The extension produced in another wire of the same material of length '2L', radius '2 r' by a force F is

1) l 2) $\frac{l}{2}$ 3) $8l$ 4) $2l$

24. An iron bar of length l, cross section A and Young's modulus Y is heated from 0 to 100^{0}C. If this bar is held so that it is not permitted to bend to expand, the force F that is develped, is proportional to

1) l 2) $\sqrt{l}$ 3) l^0 4) l^{-1}

25. As temperature increases the Young's modulus of the material of a wire

1) increases 2) decreases
3) remains the same 4) becomes infinite

26. When a rubber cord is stretched, the change in volume is negligible compared to the change in its linear dimension. Then poisson's ratio for rubber is

1) infinite 2) zero 3) 0.5 4) -1

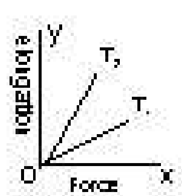
27. Hooke's law states that

1) Stress is inversely proportional to strain
2) Stress is directly proportional to strain
3) Stress is independent of strain
4) Stress is proportional to elastic modulus

28. If stress is numerically equal to young's modulus, the elongation will be

1) 1/4 the original length
2) 1/2 the original length
3) equal to the original length
4) Twice the original length

29. Force vs Elongation graph of a wire is shown in the figure. Then, at two different temperatures T_1 & T_2



1) $T_1 = T_2$ 2) $T_1 < T_2$ 3) $T_1 > T_2$
4) cannot be predicted.

30. A material has poisson's ratio of 0.5. If a uniform rod suffers a longitudinal strain of 2 x 10^{-3} the percentage increase in its volume is

1) 2% 2) 0.5% 3) 4% 4) 0%

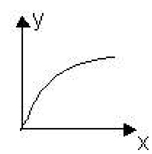
31. The elastic after effect shows that the

1) strain in a material is lagging behind stress
2) strain produced is quick
3) elasticity of the material vanishes
4) stress is developed very slowly.

32. A wire elongates by 1 mm when a load W is hung 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

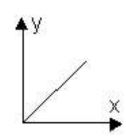
1) 0.5mm 2) 1 mm 3) 2 mm 4) 4mm

33. The graph shows the behaviour of a steel wire in the region for which the wire obeys Hooke's law. The graph is a part of a parabola. The variables x and y might represent.



1) x = stress ; y = strain 2) x = strain ; y = stress
3) x = strain ; y = elastic energy
4) x = elastic energy ; y = strain

34. A student plotted a graph from his readings on the determination of Young's modulus of a metal wire but forgotten to label. The quantities on x and y cannot represent.



1) weight hung and extension
2) stress applied and extension
3) stress applied and strain produced
4) stress applied and energy stored

KEY

01) 1	02) 1	03) 3	04) 1	05) 1	06) 2
07) 2	08) 1	09) 2	10) 3	11) 4	12) 1
13) 2	14) 2	15) 1	16) 1	17) 1	18) 3
19) 1	20) 1	21) 1	22) 2	23) 2	24) 3
25) 2	26) 3	27) 2	28) 3	29) 2	30)4
31) 1	32) 2	33) 4	34) 4		

LEVEL -1

1. A 20 Kg load is suspended by a wire of cross section 0.4 mm^2. The stress produced in N/m^2 is

1) 4.9 x 10^{-6} 2) 4.9 x 10^8
3) 49 x 10^8 4) 2.45 x 10^{-6}

2. A force of 30N acts on a rod of area of cross section 5 x 10^{-6} m^2. The stress produced in dyne/cm^2 is

1) 6 x 10^6 2) 6 x 0^7 3) 6 x 10^5 4) 0.16 x 10^{-6}

3. The length of a wire is 4m. Its length is increased by 2mm when a force acts on it. The strain is

1) 0.5 x 10^{-3} 2) 5 x 10^{-3} 3) 2 x 10^{-3} 4) 0.05

4. The length of a wire under stress changes by 0.01%. The strain produced is

1) 1 x 10^{-4} 2) 0.01 3) 1 4) 104

5) Two steel wires have equal volumes. Their diameters are in the ratio 2 : 1. When same force is applied on them, the elongation produced will be in the ratio of

1) 1:8 2) 8:1 3) 1:16 4) 16:1

6. Two wires of the same material and length have diameters in the ratio 2 : 3. When they are stretched by same force, the ratio of energies stored in them is

1) 2 : 3 2) 3 : 2 3) 4 : 9 4) 9 : 4

7. The diameters of two steel wires are in the ratio 2 : 3. Their lengths are equal. When same force is applied on them, the ratio of the elongation produced is

1) 4 : 9 2) 9 : 4 3) 3 : 2 4) 2 : 3

8. A metallic wire of force constant 'k' is cut into two parts of lengths in the ratio 1:2. The force constant of larger one is

1) k/3 2) 3k/2 3) 2k/3 4) k/2

9. The force that must be applied to a steel wire 6m long and diameter 1.6mm to produce an extension of 1mm [$y=2.0 \times 10^{11}$ $N.m^{-2}$] is approximately.

1) 100N 2) 50N 3) 67N 4) 33.5N

10. Two wires A and B of same material have lengths in the ratio 1:2 and diameter in the ratio 2:1. If they are stretched by same force, the ratio of the increase in their lengths will be

1) 2:1 2) 1:4 3) 8:1 4) 1: 8

11. A wire of length 'l' and radius 'r' is clamped rigidly at one end. When the other end of the wire is pulled by a force 'F', its length increases by 'x'. Another wire of same material of length '2l' and radius '2r' is pulled by a force '2F', the increase in its length will be

1) x 2) 2x 3) x/2 4) 4x

12. The area of cross section of a wire is $10^{-6}m^2$. When its length is increased by 0.1%, a tension of 1000N is produced. The young's modulus of the wire will be

1) $10^{12}N/m^2$ 2) $10^{11}N/m^2$
3) $10^{10}N/m^2$ 4) $10^9N/m^2$

13. A steel wire of length 1m has cross sectional area $1cm^2$. If young's modulus of steel is $10^{11} N/m^2$, then force required to increase the length of wire by 1mm will be

1) 10^{11}N 2) 10^7N 3) 10^4N 4) 10^2N

14. If the poisson's ratio of a solid is 2/5, then the ratio of its young's modulus to the rigidity modulus is

1) 5/4 2) 7/15 3) 14/9 4) 14/5

15. Force required to increase the length of a wire of area of cross-section 'A' by one percent, (Y is young's modulus) is

1) AY 2) AY/10 3) AY/100 4) AY/1000

16. Four wires made of same materials are stretched by the same load. Their dimensions are given below. The one which elongates more is ?

1) Wire of length 1 m and diameter 1 mm
2) Length 2m, diameter 2 mm
3) Length 3m, diameter 3 mm
4) Length 0.5m, diameter 0.5mm

17. An elongation of 0.1% in a wire of cross section 10^{-6} m^2 causes a tension of 100N. Y for the wire is

1) $10^{12}N/m^2$ 2) $10^{11}N/m^2$
3) $10^{10}N/m^2$ 4) 100 N/m^2

18. When the load on a wire is slowly increased from 3 to 5kg wt, the elongation increases from 0.61 to 1.02 mm. The work done during the extension of wire is ($g=10ms^{-2}$)

1) 0.16J 2) 0.016J 3) 1.6J 4) 16J

19. A rod has poisson's ratio 0.2. If a rod suffers a longitudinal strain of 2×10^{-3}, then the percentage change in volume is

1) +0.12 2) -0.12 3) 0.28 4) -0.28

20. The breaking force for a wire of radius 'r' is 'F'. The breaking force for the wire of same material but double the length and double the radius is

1) F 2) 2F 3) 4F 4) 8F

21. Young's modulus of material of a wire is 200G.Pa. The stress required to produce a strain of 4×10^{-3} in pa is

1) 8×10^{12} 2) 0.2×10^{-11}
3) 5×10^7 4) 8×10^8

22. A wire of 10m long and $1mm^2$ area of cross section is stretched by a force of 20N. If the elongation is 2mm, the young's modulus of the material of the wire (in pa) is

1) 1×10^9 2) 2×10^{-9}
3) 1×10^{11} 4) 1×10^{12}

23. The force required to double the length of a steel wire of area of cross section $5 \times 10^{-5}m^2$ ($y=20 \times 10^{10}$pa.) (in N) is

1) 10^7 2) 10^6 3) 10^{-7} 4) 10^5

24. The lengths of two wires of the same material and diameter are 100cm and 125cm. If same force is applied on them, the elongation in the first wire is 4mm, then the elongation in the second wire (in mm) is

1) 4 2) 5 3) 0.8 4) 1.25

25. Ratio of lengths of two brass wires is 3 : 4; their areas of cross section are in the ratio 2:3. When same force is applied on them, the elongations produced will be in the ratio:

1) 9 : 8 2) 8 : 9 3) $2\sqrt{2}$:3 4) 1 : 1

26. The length of two wires are in the ratio 3 : 4. Ratio of the diameters is 1:2; young's modulus of the wires are in the ratio 3:2; If they are subjected to same tensile force, the ratio of the elongation produced is

1) 1 :1 2) 1 :2 3) 2 : 3 4) 2 : 1

27. The compressibility of water is 4 x 10^{-5} per unit atmosphere pressure. The decrease in volume of $100cm^{-3}$ water under a pressure of 100atm will be

1) 0.4 cm^3 2) 4 x $10^{-5}cm^3$
3) 0.025 cm^3 4) 0.04cm^3

28. A uniform wire of length 4m and area of cross section $2mm^2$ is subjected to longitudinal force produced an elongation of 1mm. If Y=0.2 x 10^{11} NM^{-2}, elastic potential energy stored in the body is

1) 0.5J 2) 0.05J 3) 0.005J 4) 5.0J

29. A solid sphere hung at the lower end of a wire is suspended from a fixed point so as to give an elongation of 0.4mm. When the first solid sphere is replaced by another one made of same material but twice the radius, the new elongation is

1) 0.8mm 2)1.6mm 3) 3.2mm 4)1.2mm

30. The ratio of lengths of two wires made of same material is 2 :3. The ratio of their respective longitudinal stress to produce same elongation is

1) 4 : 9 2) 9 : 4 3) 2 : 3 4) 3: 2

31. The elongation produced in a copper wire of length 2m and diameter 3mm, when a force of 30N is applied is [y=1x10^{11}N.M^{-2}]

1) 8.5mm 2) 0.85mm 3) 0.085mm 4) 85mm

32. The breaking stress of a material is 10^6 N.m^{-2} and its density is 3 x 10^3 kg.m^{-3}. The least length of the wire which when suspended vertically breaks under its own weight (in m) is $g=10m/s^2$

1) 34m 2) 3.4m 3) 0.34m 4) 0.034m

33. A metallic rod undergoes a strain of 0.05%. The energy stored per unit volume is
(Y=2 x 10^{11} Nm^{-2})

1) 0.5 x 10^4 Jm^{-3} 2) 0.5 x 10^5 J m^{-3}
3) 2.5 x 10^5 J m^{-3} 4) 2.5 x 10^4 Jm^{-3}

34. The strain is 0.01%. Young's modulus for the material of the wire is 20 x 10^{10} N/m^2. The stress on the wire is

1) 5 x 10^4 N/m^2 2) 20 x 10^4 N/m^2
3) 20 x 10^6 N/m^2 4) 20 x 10^8 N/m^2

35. A steel wire of length 4m is stretched by a force of 100N. The work done to increase the length of the wire by 2mm is

1) 0.4J 2) 0.2J 3) 0.1J 4) 1J

36. The length of a wire of cross sectional area 1 x 10^{-6} m^2 is 10m. The young's modulus of the material of the wire is 25 G.pa. When the wire is subjected to a tensile force of 100N, the elongation produced in mm is

1) 0.04 2) 0.4 3) 4 4) 40

37. The 'Y' of a material of a rod is 200G pa. Its coefficient of linear expansion is 15 x $10^{-6}/^0C$. It is fixed at two ends and is cooled by 100^0C. The thermal stress produced in the rod
(in $N.m^{-2}$) is

1) 3 x 10^{-7} 2) 3 x 10^8 3) 3 x 10^6 4) 0.33 x 10^7

38. The fractional change in the volume of oil is 1 percent when a presure of 2 x 10^7 N/m^2 is applied. The bulk modulus and its compressibility is

1) 3 x 10^8 N/m^2, 0.33 x 10^{-9} m^2/N
2) 5 x 10^9 N/m^2, 2×10^{-10} m^2/N
3) 3 x 10^9 N/m^2, 5×10^{-10} m^2/N
4) 3 x 10^{+9} N/m^2, 5×10^{-9} m^2/N

KEY

01) 2	02) 2	03) 1	04) 1	05) 3	06) 4
07) 2	08) 2	09) 3	10) 4	11) 1	12) 1
13) 3	14) 4	15) 3	16) 4	17) 2	18) 2
19) 1	20) 3	21) 4	22) 3	23) 1	24) 2
25) 1	26) 4	27) 1	28) 3	29) 3	30) 4
31) 3	32) 1	33) 4	34) 3	35) 3	36) 4
37) 2	38) 3				

HINTS

5. $e=\frac{FL}{AY}=\frac{FV}{A^2Y}, \; e\,\alpha\frac{1}{r^4}$

6. $E=\frac{1}{2}Fe=\frac{1}{2}\frac{F^2L}{AY}; \; E\alpha\frac{1}{r^2}$

8. $K_m=\frac{(m+n)k}{m}$

14. $Y=2n(1+\sigma)$

18. $Y=\frac{1}{2}(F_1e_1-F_2e_2)$

27. Compressibility $=\frac{\Delta V}{VP}$

32. Breaking stress = l dg

37. Stress = $Y\alpha t$

LEVEL - 2

39. A load of 4.0 kg is suspended from a ceiling through a steel wire of length 20m and radius 2.0mm. It is found that the length of the wire increases by 0.031 mm. as equilibrium is achieved. If g=3.1 x π ms^{-2}, the value of young's modulus in N.m^{-2} is

1) 2.0 x 10^{12} 2) 4.0 x 10^{11}
3) 2.0 x 10^{11} 4) 0.02 x 10^9

40. The stress produced in a wire of young's modulus 1.2 x 10^{11} N.m^{-2} is 7 x 10^6 pa. The strain it undergoes is

1) 5.8 x 10^{-5} 2) 3.5 x 10^{-3} 3) 3.5 4) 0.35

41. Two wires of equal cross section, but one made up of steel and the other copper are joined end to end. When the combination is kept under tension, the elongations in the two wires are found to be equal. If Y_{steel} = 2.0 x 10^{11} N.m^{-2} and Y_{copper} = 1.1 x 10^{11} Nm^{-2}, the ratio of the lengths of the two wires is

1) 20 : 11 2) 11:20 3) 5 : 4 4) 4 : 5

42. A rope of 1 cm in diameter breaks if tension in it exceeds 500N. The maximum tension that may be given to a smaller rope of diameter 2cm (in N) is

1) 500 2) 250 3) 1000 4) 2000

43. A stress 10^7 pa produces a strain of 4 x 10^{-3}. The energy stored per unit volume of the body (in J.m^{-3}) is

1) 2 x 10^3 2) 2 x 10^4 3) 2.5 x 10^{10} 4) 0.8 x 10^4

44. The force constant of a spring is 4 x 10^4 N.m^{-1}. The energy stored in the spring when it is stretched by 1cm in joules is

1) 1 2) 2 3) 0.2 4) 4

45. Young's modulus of a metal is 15 x 10^{11} pa. If its poisson's ratio is 0.4. The bulk modulus of the metal in pa is

1) 25 x 10^{11} 2) 2.5 x 10^{11}
3) 250 x 10^{11} 4) 0.25 x 10^{11}

46. Young's modulus of a metal is 15 x 10^9 pa. Its rigidity modulus is 6 x 10^9 pa. Its poisson's ratio is

1) 0.25 2) 0.5 3) 0.2 4) 0.15

47. If Young's modulus of iron be 2 x 10^{11} N/m^{-2} and interatomic distance be 3 x 10^{-10}m, the interatomic force constant will be

1) 60 N/m 2) 120 N/m 3) 30 N/m 4) 180 N/m

48. Breaking stress for steel is 8 x 10^6 N/m^2. The density of steel is 8 x 10^3 Kg/m^3 and g =10m/s^2. The maximum length of steel wire which can be hung without breaking under its load is

1) 200m 2) 100m 3) 50m 4) 25m

49. A wire can be broken by 400kg.wt. The load required to break the wire of double the thickness of the same material will be

1) 800 kg.wt 2) 1600 kg.wt.
3) 3200 kg. wt 4) 6400 kg. wt.

50. A cube of gelatin 7cm on an edge is resting in a dish. Pushing horizontally on the top face with a force of 0.21N causes the top to undergo a displacement of 3mm. Then, the rigidity modulus of gelatin is

1) 100N/m^2 2) 10N/m^2 3) 1000N/m^2 4) 10^4N/m^2

51. A sphere contracts in volume by 0.01% when taken to the bottom of lake 1km deep. If the density of water is 1gm/cc, the bulk modulus of water is

1) 9.8 x 10^5N/m^2 2) 9.8 x 10^8N/m^2
3)9.8 x 10^{10}N/m^2 4) 9.8 x 10^6N/m^2

52. Two exactly similar wires of steel (y=20 x 10^{11} dyne/cm^2) and copper (y = 12 x 10^{11} dyne/cm^2) are stretched by equal forces. If the total elongation is 1cm, elongation of copper wire is

1) 3/5 cm 2) 5/3 cm 3) 3/8 cm 4) 5/8 cm

53. A rubber cord of length 40cm and area of cross section 4 x 10^{-6} m^2 is extended by 10cm. If the energy gained is 20 joule, young's modulus of rubber is

1) 10^8 Nm^{-2} 2) 2 x 10^8 Nm^{-2}
3) 4 x 10^8 Nm^{-2} 4) 1.5 x 10^6 Nm^{-2}

54. At 0^0C, a square steel bar of 1 cm side is rigidly clamped at both ends so that its length cannot increase. Young's modulus for steel is 20 x 10^{10} Nm^{-2} and coefficient of linear expansion of steel is 11 x 10^{-6} per ^{0}C. When the temperature is raised to 10^0C, the force exerted on the clamps is

1) 2200N 2) 1100 N 3) 100N 4) 50N

55. A steel wire is 1 m long and 1mm^2 in area of cross-section. If it takes 200N to stretch this wire by 1mm, the force that will be required to stretch the wire of the same material and cross-sectional area from a legnth of 10m to 1002 cm

1) 100N 2) 200 N 3) 400 N 4) 2000N

56. When load is applied to a wire, the extension is 3mm. The extension in the wire of same material and length but half the radius extended by the same load is :

1) 0.75mm 2) 6mm 3) 1.5mm 4) 12.0mm

57. Two wires A and B of the same dimensions are under loads of 4 and5.5 kg respectively. The ratio of Young's moduli of the materials of the wires for the same elongation is

1) 64 : 121 2) $\sqrt{11}:\sqrt{8}$ 3) 11:8 4) 8 : 11

58. A force of 10^5 N is applied on the uper surface of a cube of side 10 cm, keeping the lower surface fixed. The upper surface shifts by 0.05 cm parallel to itself. The rigidity modulus of the material of the cube is

1) 5 x 10^8N/m^2 2) $\frac{1}{5}\times 10^8\ N/m^2$
3) 2 x 10^9 N/m^2 4) 10^{10} N/m^2

59. A sphere contracts in volume by 0.01%. When subjected to a pressure of 100 atmosphere. The bulk modulus of the material of the ball is (1 atm = 10^5 pa)

1) 10^{10} N/m^2 2) 10^9 N/m^2
3) 5 x 10^{10}N/m^2 4) 10^{11}N/m^2

60. A lift is tied with thick iron wire and its mass is 1000kg. If the maximum acceleration of the lift is 1.2 ms^{-2} and the maximum stress of the wire is 1.4 x 10^8 Nm^{-2} what should be the minimum diameter of the wire ?

1) 10^{-2} m 2) 10^{-4} m b 3) 10^{-6} m 4) 0.5 x10^{-2} m

61. On taking a solid rubber ball from the surface to the bottom of a lake 200m deep, the reduction in volume is found to be 0.5%. If the density of water is 10^3 kgm^{-3} and $g=10\ ms^{-2}$, find the bulk modulus of rubber.

1) 2×10^8 Pa 2) 4×10^8 Pa

3) 6×10^8 Pa 4) 8×10^8 Pa

62. Mild steel ruptures, when a shear stress of 5×10^8 Pa is applied. Find the force needed to punch a 1 cm diameter hole in a steel sheet 7mm thick.

1) 2.2×10^5 N 2) 3.3×10^5 N

3) 4.4×10^5 N 4) 1.1×10^5 N

63. On loading a steel wire of radius 0.5mm and length 2m by a mass of 250 kg, it extended by 20mm and suddenly broken from the point of support. Find the rise in temperature of the wire if the density of steel is 9000 kgm^{-3} and specific heat is 420 $Jkg^{-1}K^{-1}$.

1) $3.1^\circ C$ 2) $4.7^\circ C$ 3) $4.1^\circ C$ 4) $5.1^\circ C$

64. A body of mass 10 kg is attached to a wire 0.3m long. Its breaking stress is 4.8×10^7 Pa. The area of cross-section of the wire is $10^{-6} m^2$. What is the maximum angular velocity with which it can be rotated in the horizontal circle ?

1) 1 rad/s 2) 4 rad/s 3) 3 rad/s 4) 2 rad/s

KEY

39) 1	40) 1	41) 1	42) 4	43) 2	44) 2
45) 1	46) 1	47) 1	48) 2	49) 2	50) 3
51) 3	52) 4	53) 3	54) 1	55) 3	56) 4
57) 4	58) 3	59) 4	60) 1	61) 2	62) 4
63) 3	64) 2				

HINTS

47. Interatomic force constant = Yr

52. Stress is equal $e_s y_s = e_c y_c$

$$e = e_s + e_c; \qquad e_c = \frac{eY_s}{Y_s + Y_c}$$

53. $E = \frac{1}{2}\frac{e^2 AY}{l}$

54. $F = YA\alpha t$

55. $\frac{F_1 l_1}{e_1} = \frac{F_2 l_2}{e_2}$

LEVEL - 3

65. A wire of length 1 m fixed at one end has a sphere attached to it at the other end. The sphere is projected horizontally with a velocity of $\sqrt{9g}$. When it describes a vertical circle, the ratio of elongations of the wire when the sphere is at the top and bottom of the circle is

1) 2 : 5 2) 5 : 2 3) 3 : 5 4) 5 : 3

66. One end of a wire 2m long and $0.2 cm^2$ in cross section is fixed to a ceiling and a load of 4.8kg is attached to its free end. The elongation in the wire in mm is (if y = $2.0 \times 10^{11}\ N.m^{-2}$, g =$10 ms^{-2}$)

1) 2.4×10^{-5} 2) 2.4 3) 0.024 4) 0.0024

67. A force of 15N increases the length of a wire by 1mm. The additional force required to increase the length by 2.5mm in N is

1) 22.5 2) 37.5 3) 52.5 4) 75

68. Two wires each of length 1m and area of cross section 1sq.mm are joined end to end and suspended at the lower end of composite wire. If their young's moduli are 2×10^{10} pa and 5×10^{10} pa, the total elongation in mm is

1) 2 2) 2.5 3) 3 4) 3.5

69. A piece of copper wire has twice the radius of steel wire. One end of the copper wire is joined to one end of steel wire so that both of them can be subjected to the same longitudinal force. Y for steel is twice that of copper. When the length of copper wire is increased by 1%, the steel wire will be stretched by

1) 2% of its original length 2) 1% of its original length

3) 4% of its original length 4) 0.5% of its original length

70. A uniform metal rod of $2mm^2$ cross section is heated from 0^0C to 20^0C. The coefficient of linear expansion of the rod is $12 \times 10^{-6}/^0C$. Its young's modulus of elasticity is $10^{11}\ N/m^2$. The energy stored per unit volume of the rod is

1) 2800 J/m^3 2) 1500 J/m^3 3) 5760 J/m^3 4) 1440 J/m^3

71. A 8m long string of rubber, having density $1.5 \times 10^3\ kg/m^3$ and young's modulus $5 \times 10^6 N/m^2$ is suspended from the ceiling of a room. The increase in its length due to its own weight will be ($g = 10m/s^2$)

1) 9.6×10^{-2}m 2) 19.2×10^{-5}m

3) 9.6×10^{-3}m 4) 9.6 m

72. A steel wire of length 20cm and cross sectional area 1.0 mm^2 is clamped at both the ends. The coefficient of linear expansion for steel $\alpha = 1.1 \times 10^{-5}/^0C$ and $Y=2 \times 10^{11}\ N/m^2$. If the temperature of wire is reduced from 40^0C to 20^0C, the tension developed in the wire will be

1) 2.2×10^6N 2) 8 N 3) 16N 4) 44N

73. A brass rod has a length of 0.2m, area of cross section $1.0cm^2$ and young's modulus $10^{11}\ Nm^{-2}$. If it is compressed by 5kg.wt. along its length, then the change in its energy will be

1) an increase of 2.4×10^{-5} J

2) a decrease of 2.4×10^{-5}J

3) an increase of 2.4×10^7 J

4) a decrease of 2.4×10^7 J

74. A 20 kg load is sxuspended from the lower end of a wire 10cm long and $1mm^2$ in cross sectional area. The upper half of the wire is made of iron and the lower half with aluminium. The total elongation in the wire is

($Y_{iron} = 20 \times 10^{10}\ N/m^2$, $Y_{Al} = 7 \times 10^{10}\ N/m^2$)

1) 18.9×10^{-3}m 2) 17.8×10^{-3}m

3) 1.78×10^{-3} m 4) 1.89×10^{-3} m

75. A body of mass 10kg is attached to a wire 0.3m long. It breaking stress is 4.8 x 10^7 N/m^2. The area of cross section of the wire is $10^{-6}m^2$. The maximum angular velocity with which it can be rotated in a horizontal circle without breaking is

1) 2 rad/s 2) 4 rad/s 3)6 rad/d 4) 8 rad/s

76. The rubber cord of a catapult has a cross-sectional area 1mm^2 and total unstretched length 10cm. It is stretched to 12cm and then released to project a missile of mass 5gm. Taking 'Y' for rubber 5 x 10^8 N/m^2, the velocity of projection is

1) 10m/s 2) 15 m/s 3) 20 m/s 4) 25 m/s

77. A mass 'm' kg is whirled in a vertical plane by tieing it at the end of a flexible wire of length 'l' and area of cross-section 'A' such that it just completes the vertical circle. When the mass is at its lowest position, the strain produced in the wire is (Young's modulus of the wire is 'Y')

1) AY/ 6 mg 2) 6mg/AY 4) 5mg/AY 4) AY/5mg

78. Two rods of different materials having coefficient of linear expansions α_1 and α_2 and Young's modulii y_1 and y_2 are rigidly fixed between two pillars. If they are raised to the same temperature and they do not bend, the ratio of their elasticities for the same stress to be developed in the two, will be

1) 2 : 3 2) 1 : 1 3) 3 : 2 4) 4 : 9

79. When a sphere of radius 2 cm is suspended at the end of a wire, elongation is 'e'. When the same wire is loaded with a sphere of radius 3 cm and made of the same material, the elongation would be :

1) $\frac{8}{27}e$ 2) $\frac{27}{8}e$ 3) $\frac{4}{9}e$ 4) $\frac{9}{4}e$

80. A wire suspended from one end carries a sphere at its other end. The elongation in the wire reduces from 2 mm to 1.6mm on completely immersing the sphere in water. The density of the material of the sphere is

1) 3200 kg/m^3 2) 800 kg/m^3
3) 1250 kg/m^3 4) 5000 kg/m^3

81. The length of an elastic spring is 'a' when tension is 4 N and 'b' when the tension is 5N. The length of the spring when tensionis 9N is

1) 4a - 5b 2) 5b - 4a 3) 5b + 4a 4) 5(b-a)

82. A uniform pressure 'P' is exerted on all sides of a solid cube at temperature 0^0C. In order to bring the volume of the cube to the original volume, the temperature of the cube must be increased by t^0c. If α is the linear coefficient and K the bulk modulus of the material of the cube, then t is equal to

1) $\frac{3P}{K\alpha}$ 2) $\frac{P}{2\alpha K}$ 3) $\frac{P}{3\alpha K}$ 4) $\frac{P}{\alpha K}$

83. The volume of oil contained in a certain hydraulic press is 0.2m^3. The compressibility of oil is 20 x 10^{-6} per atmosphere. The decrease in volume of the oil when subjected to 200 atmospheres is (1 atmosphere = 1.02 x 10^5 N/m^2)

1) 4 x 10^{-4}m^3 2) 8 x 10^{-4}m^3
3) 16 x 10^{-4}m^3 4) 2 x 10^{-4}m^3

84. One end of uniform wire of length L and weight W is attached to rigid point in the roof and a weight w_1 is suspended from its lower end. If S is the area of cross-section of the wire the stress in the wire at a height (3L/4) from its lower end is

1) $\frac{w_1}{S}$ 2) $\frac{\left(w_1+\frac{w}{4}\right)}{S}$ 3) $\frac{\left(w_1+\frac{3w}{4}\right)}{S}$ 4) $\frac{(w_1+w)}{S}$

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

1. $\frac{l_a}{l_w}$ 2) $\frac{l_a}{l_a-l_w}$ 3) $\frac{l_w}{l_a-l_w}$ 4) $\frac{l_w}{l_a}$

86. A solid sphere of radius R made of 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 liquid. When a mass 'm' is placed on the piston to compress the liquid, the fractional change in the radius of the sphere $\frac{\delta R}{R}$ is

1) $\frac{mg}{AK}$ 2) $\frac{mg}{3AK}$ 3) $\frac{mg}{A}$ 4) $\frac{3mg}{AK}$

KEY

65) 1	66) 3	67) 1	68) 4	69) 1	70) 1
71) 1	72) 4	73) 1	74) 3	75) 2	76) 3
77) 2	78) 3	79) 2	80) 4	81)2	82) 3
83) 2	84) 3	85) 2	86) 2		

HINTS

65. $V_{top}=\sqrt{xrg};V_{bottom}=\sqrt{(x+4)rg}$

$V_{top}=\sqrt{5g}$

$T_{bottom}=\frac{mv_b^2}{r}+mg=10mg$

$T_{top}=\frac{mv_t^2}{r}-mg=4mg$

$$\frac{e_t}{e_b}=\frac{4mg}{10mg}$$

68. $e=e_1+e_2$ but $e=e_2=\frac{Fl}{AY}$

69. $F=AY\left(\frac{e}{1}\right)=$ constant

$$A_sY_s\left(\frac{e}{1}\right)_s=A_cY_c\left(\frac{e}{1}\right)_c$$

75. mrw^2 = B $\times$ stress x A

76. $\frac{1}{2}mv^2=\frac{1}{2}Fe;F=\frac{YAe}{l}$

77. $F=6mg$ strain $=\frac{F}{AY}$

78. $Y_1\alpha_1=Y_2\alpha_2$

80. $\frac{e_w}{e_a}=\frac{d_s-d_w}{d_s}$

$$\frac{1.6}{2}=\frac{d_s-d_w}{d_s}\Rightarrow d_s=5000kg/m^3$$

81. Let 'l' be the original length, then

$$y=\frac{4\lambda}{A(a-\lambda)}=\frac{5\lambda}{A(b-\lambda)}=\frac{9\lambda}{A(x-\lambda)}$$

$$\Rightarrow x=5b-4a$$

82. $k=\frac{P}{\frac{\Delta V}{V}};\frac{\Delta V}{V}=\gamma t=3\alpha t$

83. $\frac{\Delta V}{V}$ = PC (C is compressibility)

84. Force acting at $\frac{3}{4}$ length from bottom

$$F=\frac{3}{4}\ w+w_1$$

85. $\frac{l_a}{l_w}=\frac{mg}{mg\left(1-\frac{1}{d_{rel}}\right)}\left[\because e\alpha F\right]$

86. $\frac{\Delta V}{V}=\frac{F}{AK}=\frac{mg}{AK}$

$$\frac{\Delta R}{R}=\frac{1}{3}\frac{\Delta V}{V}$$

OBJECTIVES FROM PREVIOUS EAMCET ENTRANCE PAPERS

1. Two wires of same material and same diameter have lengths in the ratio 2:5. They are streched by same force. The ratio of workdone in streching them is (E-2005M)
   1) 5 : 2 2) 2 : 5 3) 1:3 4) 3 : 1
2. The radii and youngs modulus of two uniform wires A & B are in the ratio 2:1 and 1:2 respectively. Both the wires are subjected to the same longitudinal force. If increase in the length of wire A is 1% . Then the increase in length wire B is (2005 E)
   1) 1 2) 1.5 3) 2 4) 3
3. The increase in length of a wire on stretching is 0.025%. If its Poisson's ratio is 0.4, then the percentage decrease in the diameter is : (M-2004)
   1) 0.01 2) 0.02 3) 0.03 4) 0.04
4. A metallic ring of radius 'r' cross sectional area 'A' is fitted in to a wooden circular disk of radius 'R' (R>r). If the Young's modulus of the material of the ring is 'Y', the force with which the metal ring expands is : (M-2004)
   1) $\frac{AYR}{r}$ 2) $\frac{AY(R-r)}{r}$
   3) $\frac{Y(R-r)}{Ar}$ 4) $\frac{YR}{Ar}$
5. Consider the statements A and B, identify the correct answer given below :
   (A) : If the volume of a body remains unchanged when subjected to tensile strain, the value of poisson's ratio is $^1/_2$.
   (B) : Phosper bronze has low Young's modulus and high rigidity modulus. (M-2003)
   1) A and B are correct
   2) A and B are wrong
   3) A is correct and B is wrong
   4) A is wrong and B is right
6. Bulk modulus of water is 2 x 10^9 N/m^2. The pressure required to increase the density of water by 0.1% in N/m^2 is : (M-2003)
   1) 2 x 10^9 2) 2 x 10^8 3) 2 x10^6 4) 2 x 10^4
7. The elongation of a spring of length 'L' and of negligible mass due to a force is 'x'. The spring is cut into two pieces of lengths in ratio 1 : n. The ratio of the respective spring constants is (M-2002)
   1) n :1 2) 1 : n 3) n^2 : 1 4) 1 : n^2
8. Two springs of force constants 1000 N/m and 2000 N/m are stretched by same force. The ratio of their respective potential energies is : (M-2002)
   1) 2 :1 2) 1 : 2 3) 4 : 1 4) 1 : 4

9. The increase in pressure required to decrease the 200 litres volume of a liquid by 0.004% in kPa is : (bulk modulus of the liquid = 2100 MPa) (M-2002)
1) 8.4 2) 84 3) 92.4 4) 168

10. The Poisson's ratio of a material is 0.4. If a force is applied to a wire of this material, there is a decrease of cross-sectional area by 2%. The percentage increase in its length is : (M-2002)
1) 3% 2) 2.5% 3) 1% 4) 0.5%

11. A metal cube of side length 8.0 cm has its uper surface displaced with respect to the bottom by 0.10 mm when a tangential force of 4×10^9 N is applied at the top with bottom surface fixed. The rigidity modulus of the material of the cube is (M-2001)
1) 4×10^9 N/m^2 2) 5×10^9 N/m^2
3) 8×10^9 N/m^2 4) 1×10^8 N/m^2

12. The length of an elastic string is 'a' metres when the longitudinal tension is 4N and 'b' meters when the longitudinal tension is 5N. The length of the string in metres when the longitudinal tension is 9 N is (M-2001)
1) a-b 2) 5b-4a 3) 2b-(1/4)a 4) 4a-3b

13. When a tension F is applied, the elongation produced in uniform wire of length 'L', radius 'r' is 'e'. When tension 2 F is applied, the elongation produced in another uniform wire of length '2L' and radius '2r' made of same material is (M-2000)
1) 0.5e 2) 1.0e 3) 1.5e 4) 2.0e

14. When a uniform wire of radius r is stretched by a 2 kg weight, the increase in its length is 2.00 mm. If the radius of the wire is r/2 and other conditions remain in the same, increase in its length is (E-2000)
1) 2.00mm 2) 4.00 mm 3) 6.00 mm 4) 8.00mm

15. Y, k, n represent respectively the young's modulus, bulk modulus and rigidity modulus of a body. If rigidity modulus is twice the bulk modulus, then (M-1999)
1) Y = 5k/18 2) Y = 5n/9
3) Y = 9k/5 4) Y = 18k/5

16. The elongation of a steel wire stretched by a force is 'e'. If a wire of the same material of double the length and half the diameter is subjected to double the force, its elongatin will be (E-1999)
1) 16e 2) 4e 3) (1/4)e 4)(1/16)e

17. A spring balance is suspended from a ceiling and another spring balance is attached to the end of the first. A 5 kg mass is hung to the lower balance. Then (M-1998)
1) Both balances will read 5kg weight each
2) the upper reads 5kg weight and lower zero
3) both of them read 2.5 kg weight each
4) the reading may be different but add up to 5kg weight.

18. An iron wire of length 4m and diameter 2 mm is loaded with a weight of 8kg. If the young's modulus 'Y' for iron is 2×10^{11} N/m^2, then the increase in the length of the wire is (M-1998)
1) 0.2 mm 2) 0.5mm
3) 2mm 4) 1 mm

19. The Poisson's ratio σ should satisfy the relation (M-1998)
1) $-1<\sigma<0.5$ 2) $-0.5<\sigma<1.0$
3) $0.5<\sigma<1.0$ 4) $-1.0<\sigma<-0.5$

20. A copper solid cube of 60mm side is subjected to a pressure of 2.5×10^7 Pa. If the bulk modulus of copper is 1.25×10^{11} pascals, the change in the volume of cube is (M-1997)
1) -43.2 mm^3 2) -43.2m^3
3) -43.2 cm^3 4) -432 m m^3

21. A wire whose cross sectional area is 2 mm^2 is stretched by 0.1 mm by a certasin load. If a similar wire of triple the area of cross section is stretched by the same load, the elongation of the second wire would be (E-1996)
1) 0.33m 2) 0.033mm
3) 0.3mm 4) 0.0033 mm

22. According to Hook's law of elasticity, the ratio of stress to strain (M-1996)
1) does not remain constant 2) remains constant
3) increases 4) decreases

23. Possible value of Poisson's ratio is (M-1995)
1) 1 2) 0.9 3) 0.8 4) 0.4

24. Strain energy in a stretched string is (M-1995)
1) 1/2 x stress x strain 2) stress x strain
3) (stress x strain)^2 4) stress / strain

25. When a certain force is applied on a string it extends by 0.01cm. When the same force is applied on another string of same material, twice the length and double the diameter, then the extension in second string is (M-1995)
1) 0.005 cm 2) 0.02 cm 3) 0.08 cm 4) 0.04 cm

26. The length of a cube increases by 0.1%, what is the bulk strain ? (E-1995)
1) 0.003 2) 0.006 3) 0.002 4) 0.001

27. Two wires made of same material have their lengths L and 2 L and the radii 2R and R. If they are stretched by the same force, their extensions are e_1 and e_2, then $e_1 : e_2$ (M-1994)
1) 1:8 2) 8:1 3) 1:4 4) 2:1

28. Which of the following relations is not correct Y = young's modulus, K = bulk modulus, n= rigidity modulus, σ = poisons ratio (M-1994)
1) 1/Y = 9n K/(3K +n) 2) $Y/n = 2(1+\sigma)$
3) $Y/3K = 2(1-2\sigma)$ 4) (Y/n) +(Y/3K)=3

29. A steel wire of length 5m is pulled to have an extension of 1mm. Its Y is 1.9×10^4 N/m^2. The energy per unit volume stored in it is(E-1994)
1) 3.8×10^{-4} J/m^3 2) 7.6×10^{-4} J/m^3
3) 1.9×10^{-4} J/m^3 4) 0.95×10^{-4} J/m^3

30. A spring of force constant K is cut into two equal parts. Then the force constant of each piece is (E-1994)
1) 2K 2) K/2 3) 4K 4) K

31. An aluminium wire and steel wire of the same length and cross section are joined end to end. The composite wire is hung from a rigid support and a load is suspended from the free end. The young's modulus of steel is 20/7 times the aluminium. The ratio of increase of length of steel aluminium is (M-1993)
1) 20/7 2) 400/49 3) 7/20 4) 49/400

32. The extension of a wire by the application of a load is 0.3 cm. The extension in the wire of the same material but of double the length and half the radius of cross section in cm is (E-1993)
1) 3 2) 0.3 3) 1.2 4) 2.4

33. For a material $Y = 6.6 \times 10^{10}\ N/m^2$ and bulk modulus $K = 11 \times 10^{10}\ N/m^2$, then its Poissons's ratio is
1) 0.8 2) 0.35 3) 0.7 4) 0.4

34. A steel wire is 1 m long and 1 mm^2 in area of cross-section. If it taken 200 N to stretch this wire by 1 mm, how much force will be required to stretch the wire of the same material and diameter from its normal length of 10 m to a length of 1002 cm (M-1992)
1) 100N 2) 200N 3) 400N 4) 2000N

35. A uniform spring of force constant K is cut into two pieces whose lengths are in the ratio 1:2. The force constant of the larger piece of the spring is (M-1992)
1) 2K/3 2) 3K/2 3) K/2 K/3

36. When a spring is stretched bya force the resultant strain is (M-1992)
1) longitudinal 2) transverse
3) shear 4) both longitudinal and transverse

37. If the work done in stretching a wire by 1 mm is 2 J, the work necessary for stretching another wire of same material but withdouble radius of cross section and half the length by 1mm is in joules (M-1991)
1) 16 2) 8 3) 4 4) 1/4

38. For a given material the Young's modulus is 2.4 times that of its rigidity modulus. Its Poisson's raio is (M-1990)
1) 2.4 2) 1.2 3) 0.4 4) 0.2

39. The stress required to double the length of a wire of Youngs modulus E is (M-1990)
1) 2E 2) E 3) E/2 4) 3E

40. The Poisson ratio cannot have the value (M-1989)
1) 0.7 2) 0.2 3) 0.1 4) -0.5

41. The Y of a material having a cross section area of 1 cm^2 is 2×10^{12} dynes/cm^2. If the length is to be doubled the force required is (M-1989)
1) 1×10^{12}dynes 2) 2×10^{12}dynes
3) 0.5×10^{12}dynes 4) 4×10^{12}dynes

42. A copper and steel wire of 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 (M-1988)
1) The same stress and strain
2) The same stress but different strains
3) the same strain but different stresses
4) different stress and strains.

43. A wire extends by 1 mm when a force is applied. Double the force is applied to another wire of same material and length but of half the radius of cross-section. The elongation of wire in mm will be (M-1986)
1) 8 2) 4 3) 2 4) 1

44. A wire is subjected to a longitudinal strain of 0.05. If its material has a Poisson's ratio 0.25, the lateral strain experienced by it is (E-1986)
1) 0.00625 2) 0.125 3) 0.0125 4) 0.0625

45. A tensile force of 2×10^5 dynes doubles the length of an elastic cord whose area of cross-section is 2 sq. cm. Young's modulus of the material of the cord is (M-1985)
1) 1×10^5 dynes /cm^2 2) 2×10^5 dynes /cm^2
3) 0.5×10^5 dynes /cm^2 4) 4×10^5 dynes /cm^2

KEY

1. 2	2. 2	3. 1	4. 2	5. 3
6. 3	7. 2	8. 1	9.2	10. 2
11. 2	12. 2	13.2	14. 4	15. 4
16. 1	17. 1	18. 2	19. 1	20. 1
21. 2	22. 2	23. 4	24. 1	25. 1
26. 1	27. 1	28. 1	29. 1	30. 1
31. 3	32. 4	33. 4	34. 3	35. 2
36. 3	37. 1	38. 4	39. 2	40. 1
41. 2	42. 2	43. 1	44. 3	
45. 1				

QUESTIONS FROM OTHER COMPETITIVE EXAMS

1. Dimensional formula of youngs modulus is **B.TECH-1983**
1) $M^1 L^{-1} T^{-2}$ 2) $M^1 L^1 T^1$
3) $M^{-1} L^2 T^{-1}$ 4) $M^{-1} L^3 T^{-2}$

2. An iron bar of length L, cross-section A and Young's modulus Y is pulled by a force F from ends so as to produce an elongation λ. Which of the following statements is correct ? (NCERT-76)
1) $\lambda \alpha \frac{1}{L}$ 2) $1 \alpha A$ 3) $\lambda \alpha \frac{1}{A}$ 4) $\lambda \alpha Y$

3. A wire of length L and radius r fixed at one end and a force F applied to the other end produces and extension λ. The extension produced in another wire of the same material of length 2L and radius 2r by a force 2 F is (NCERT -1980)
1) λ 2) 2λ 3) $\frac{\lambda}{2}$ 4) 4λ

4. Two rods of different materials having coefficients of linear expansion $\alpha_1 : \alpha_2$ and Young's moduli Y_1 : Y_2 are fixed between two rigid massibve 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 stress developed in the rods are equal, provided $Y_1 : Y_2$ is equla to IIT-1989
1) 2 : 3 2) 1 : 1 3) 3 : 2 4) 4 : 9

5. A fixed volume of iron is drawn into a wire of length λ. The extension produced in this wire by a constant force F is proportional to (MP-PMT=1999)
1) $\frac{1}{\lambda^3}$ 2) λ^2 3) $\frac{1}{\lambda}$ 4) $\frac{1}{\lambda^2}$

6. A force of 10^6 N/m^2 is required for breaking a material. If the density of the material is 3 x 10^3 kg/m^3, then what should be the length of the wire made of the same material so that it breaks by its own weight ? (g=10m/s^2) (ROORKEE-1979)
1) 34m 2) 3.4m 3) 34cm 4) 3.4cm

7. A ball falling in a lake to a depth 200m shows a decrease of 0.1% in its volume at the bottom. What is bulk modulus ? AFMC - 1997
1) 19.6 x 10^8 N/m^2 2) 19.6 x 10^{-10} N/m^2
3) 19.6 x 10^{10} N/m^2 4) 19.6 x 10-^{8} N/m^2

8. Consider an iron rod of length 1m and cross section 1 cm^2. We wish to calculate the force by which the two ends must be pulled to produce an elongation of 1mm. it is equal to
(Y=10^{11} N/m^2) (NCERT-76)
1) 10^4N 2) 10^{11}N 3) 10^3N 4) 10^{12}N

9. On stretching a wire, the elastic energy stored per unit volume is (MPPMT-88)
1) Fdλ/2Aλ 2) FA/2λ 3) Fλ/2A 4) Fλ/2

10. A wire of 1m length and 4mm radius is clampted at upper end. The lower end is twisted by an angle of 30^0. What is the angle of shear ? (NCERT-90)
1) 0.12^0 2) 1.2^0 3) 12^0 4) 0.012^0

11. A steel wire of mass 3.16 Kg is stretched to a tensile strain of 1 x 10^{-3}. What is the elastic deformation energy if density ρ=7.9 g/cc and y=2x10^{11} N/m^2 ? (ROORKE98)
1) 4 KJ 2) 0.4 KJ 3) 0.04KJ 4) 4J

12. What percent of length of a wire will increase by applying a stress of 1 kg. wt/mm^2 on it. [Y=1x10^{11}Nm^{-2} and 1 kg wt = 9.8N] (MNR-99)
1) 0.0078% 2) 0.0088% 3) 0.0098% 4) 0.0067%

13. A wire of density 9 x 10^3 kg/m^3 is stretched between 2 clamps 1m apart and is subjected to an extensionof 4.9 x 10^{-4}m. The lowest frequency of transverse vibration in the wire is (Y = 9 x 10^{10} N/m^2) (UPSET 2000)
1) 20 Hz 2) 30 Hz 3) 35 Hz 4) 40 Hz

KEY

1)1	2) 3	3) 1	4)3	5) 2
6) 1	7) 1	8) 1	9) 1	10) 1
11) 2	12) 3	13) 3		

NEW MODEL QUESTIONS

1. Consider the following two statements A and B and identify the correct answer .
A. A metal wire held vertically is longer than when it placed on a horizontal table.
B) Due to its own weight, some elongation is produced when it is held vertically.
1) Both A & B are true 2) A is false but B is true
3) A is true but B is false 4) Both A & B are false

2. Consider the following two statements A and B and identify the correct answer.
A) The bulk modulus for an incompressible liquid is infinite.
B) Young's modulus increases with raise of temperature.
1) Both A & B are true 2) A is true but B is false
3) Both A & B are false 4) A is false but B is true

3. Consider the following two statements A and B and identify the correct answer.
A) The reciprocal of rigidity modulus is called compressibility.
B) Elastic restoring forces are strictly conservative only when Hooke's law is obeyed.
1) Both A & B are true 2) A is false but B is true
3) A is true but B is false 4) Both A & B are false

4. Consider the following two statements A and B and identify the correct answer.
A) The product of bulk modulus of elasticity and compressibility is one.
B) Tangential stress applied on the body only produes change in shape but not in size.
1) Both A & B are true 2) A is true but B is false
3) A is false but B is true 4) Both A & B are false

5. Consider the following two statements A and B and identify the correct answer.
A) When the length of a wire is doubled, the Young's modulus of the wire is also doubled
B) For elastic bodies Poisson's ratio is + Ve and for inelastic bodies Poissons ratio is -Ve
1) Both A & B are true 2) A is true but B is false
3) A is true but B is true 4) Both A & B are false

6. Consider the following two statements A and B and identify the correct answer.
A) We cannot define Young's modulus and rigidity modulus for liquids and gases.
B) The theoritical limits of Poissons ratio are
-1 to 0.5
1) Both A & B are false 2) A is true but B is false
3) Both A & b are false 4) A is true but B is false

ASSERTION AND REASON TYPE QUESTIONS

Directions :

A : Assertion

R : Reason

A) If both Assertion and Reason are true and the Reason is correct explanation of the Assetion.

B) If both Assertion and Reason are true, but Reason is not correct explanation of the Assetion.

C) If Assertion is true, but the Reason is false.

D) If Assetion is false, but the reason is true.

7. A : Steel is more elastic than rubber.
R : Under a given deforming force, steel is deformed less than rubber.
1) A 2) B 3) C 4) D

8. A : Lead is more elastic than rubber.
R : If the same load is attached to lead and rubber wires of the same cross-sectional area, the strain of lead is very much less than that of rubber.
1) A 2) B 3) C 4) D

9. A : Two identical solid balls, one of ivory and the other of wet-clay are dropped from the same height on the floor. Both the balls will rise to same height after bouncing.
R : Ivory is more elastic than wet-clay.
1) A 2) B 3) C 4) D

10. A : With increase of temperature, elastic property of a substance decreases.
R : Elasticity is due to intermolecular forces which decreases with the increase of intermolecular distance.
1) A 2) B 3) C 4) D

11. A : Addition of carbon to iron increases the elastic property.
R : Carbon and iron belong the same group of elements.
1) A 2) B 3) C 4) D

12. A : Stress is the internal force per unit area of the body.
R : Rubber is more elastic than steel
1) A 2) B 3) C 4) D

13. A : Stress is restoring force per unit area.
R : Interatomic forces in solids are responsible for the property of elasticity
1) A 2) B 3) C 4) D

14. A : Young's modulus for a perfectly plastic body is zero.
R : For a perfectly plastic body, restoring force is zero.
1) A 2) B 3) C 4) D

15. A : Bulk modulus of elasticity (K) represents incompressibility of the material.
R : $K = \frac{\Delta P}{\Delta V / V}$, where symbols have their standard meaning.
1) A 2) B 3) C 4) D

16. A : Rigidity modulus of a liquid is infinity.
R : For a ductile material yield point and breaking point are separated by larger distance than for brittle materials on the stress-starin curve.
1) A 2) B 3) C 4) D

17. A : Silver is a ductile material,
R : For a ductile material yield point and breaking point are separated by larger distance than for brittle materials on the stress-strain curve.
1) A 2) B 3) C 4) D

18. A : The elastic potential energy of a spring increases when it is elongated and decreases when it is compressed.
R : Work done on spring is stored in it as elastic potential energy.
1) A 2) B 3) C 4) D

KEY

1.1	2. 2	3. 4	4. 1
5.4	6. 3	7. 1	8. 1
9.4	10. 1	11. 3	12.2
13. 1	14.1	15. 2	16. 4
17. 1	18.4		

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