# Chapter 9 Elasticity

# **Interatomic Forces**

The forces between the atoms due to electrostatic interaction between the charges of the atoms are called interatomic forces. These forces are electrical in nature and these are active if the distance between the two atoms is of the order of atomic size *i.e.* 10<sup>-</sup> *metre*.

(1) Every atom is electrically neutral, the number of electrons (negative charge) orbiting around the nucleus is equal to the number of protons (positive charge) in the nucleus. So if two atoms are placed at a very large distance from each other then there will be a very small (negligible) interatomic force working between them.

(2) When two atoms are brought closer to each other to a distance of the order of  $10^{-}$  *m*, the distances between their positive nuclei and negative electron clouds get disturbed, and due to this, attractive interatomic force is produced between two atoms.

(3) This attractive force increases continuously with decrease in r and becomes maximum for one value of r called critical distance, represented by x (as shown in the forum). Bayond this the attractive force

figure). Beyond this the attractive force starts decreasing rapidly with further decrease in the value of *r*.

(4) When the distance between the two atoms becomes  $r_r$ , the interatomic force will be zero. This distance  $r_r$  is called normal or equilibrium distance.

(r = 0.74 Å for hydrogen).

(5) When the distance between the two atoms further decreased, the interatomic force becomes repulsive in nature and increases very rapidly with decrease in distance between two atoms.

(6) The potential energy U is related with the interatomic force F by the following relation.

$$F = \frac{-dU}{dr}$$



(i) When two atoms are at very large distance, the potential energy is negative and becomes more negative as r is decreased.

(ii) When the distance between the two atoms becomes r, the potential energy of the system of two atoms becomes minimum (*i.e.* attains maximum negative value). As the state of minimum potential energy is the state of equilibrium, hence the two atoms at separation r will be in a state of equilibrium.

 $(U_0 = -7.2 \times 10^{-19} Joule \text{ for hydrogen}).$ 

(iii) When the distance between the two atoms is further decreased (*i.e.* r < r) the negative value of potential energy of the system starts decreasing. It becomes zero and then attains positive value with further decrease in r (as shown in the figure).

# Intermolecular Forces

The forces between the molecules due to electrostatic interaction between the charges of the molecules are called intermolecular forces. These forces are also called Vander Waal forces and are quite weak as compared to inter-atomic forces. These forces are also electrical in nature and these are active if the separation between two molecules is of the order of molecular size *i.e.*  $\approx 10^{\circ}$  *m*.

(1) It is found that the force of attraction between molecules varies inversely as seventh power of the distance between them i.e.

$$F_{\rm att} \propto \frac{1}{r^7}$$
 or  $F_{\rm rep} = \frac{-a}{r^7}$ 

The negative sign indicates that the force is attractive in nature.

(2) When the distance between molecules becomes less than  $r_{j}$ , the forces becomes repulsive in nature and is found to vary inversely as ninth power of the distance between them *i.e.* 

$$F_{\rm rep} \propto \frac{1}{r^9}$$
 or  $F_{\rm rep} = \frac{b}{r^9}$ .

Therefore force between two molecules is given by  $-E + E = -\frac{-a}{a} + \frac{b}{b}$ .

 $F = F_{\text{att}} + F_{\text{rep}} = \frac{-a}{r^7} + \frac{b}{r^9}$ 

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The value of constants  $\boldsymbol{a}$  and  $\boldsymbol{b}$  depend upon the structure and nature of molecules.



(3) Intermolecular forces between two molecules has the same general nature as shown in the figure for interatomic forces.

(4) Potential Energy : Potential energy can be approximately expressed by the formula  $U = \frac{A}{r^n} - \frac{B}{r^m}$ 

where the term  $\frac{A}{r^n}$  represents repulsive contribution and term

 $\frac{B}{r^m}$  represents the attractive contribution. Constants *A*, *B* and numbers *m* 

and n are different for different molecules.

For majority of solids n = 12 and m = 6.

So potential energy can be expressed as  $U = \frac{A}{r^{12}} - \frac{B}{r^6}$ 

# Comparison Between Interatomic and Intermolecular Forces

- (1) Similarities
- (i) Both the forces are electrical in origin.
- (ii) Both the forces are active over short distances.

(iii) General shape of force-distance graph is similar for both the

forces.

(iv) Both the forces are attractive up to certain distance between atoms/molecules and become repulsive when the distance between them become less than that value.

### (2) Dissimilarities

(i) Interatomic force depends upon the distance between the two atoms, whereas the intermolecular force depends upon the distance between the two molecules as well as their relative orientation.

 $(\mathrm{ii})$  Interatomic forces are about 50 to 100 times stronger than intermolecular forces.

(iii) The value of r for two atoms is smaller than the corresponding value for the molecules. Therefore one molecule is not restricted to attract only one molecule, but can attract many molecule. It is not so incase of atoms, since the atoms of one molecule cannot bind the atoms of other molecules.

# **States of Matter**

The three states of matter differ from each other due to the following two factors.

(1) The different magnitudes of the interatomic and intermolecular forces.

(2) The extent of random thermal motion of atoms and molecules of a substance (which depends upon temperature).

Comparison Chart of Solid, Liquid and Gaseous States						
Property	Solid	Liquid	Gas			
Shape	Definite	Not definite	Not definite			
Volume	Definite	Definite	Not definite			
Density	Maximum	Less than solids but more than gases.	Minimum			
Compressibility	Incompressible	Less than gases but more than solids.	Compressible			
Crystallinity	Crystalline	Non-crystalline				
Interatomic or intermolecular distance	Constant	Not constant	Not constant			
Relation between kinetic energy <i>K</i> and potential energy ( <i>U</i> )	К < U	K- U	<i>К</i> >> <i>U</i>			
Intermolecular force	Strongest	Less than solids but more than gases.	Weakest			
Freedom of motion	Molecules vibrate about their mean position but cannot move freely.	Molecules have limited free motion.	Molecules are free to move.			
Effect of temperature	Matter remains in solid form below a certain temperature.	Liquids are found at temperatures more than that of solid.	These are found at temperatures greater than that of solids and liquids.			

**Note:** The fourth state of matter in which the medium is in the form of positive and negative ions, is known as plasma. Plasma occurs in the atmosphere of stars (including the sun) and in discharge tubes.

# Types of Solids

A solid is that state of matter in which its constituent atoms or molecules are held strongly at the position of minimum potential energy

and it has a definite shape and volume. The solids can be classified into two categories, crystalline and glassy or amorphous solids.

Comparison chart of Crystalline and Amorphous Solids			
Crystalline solids	Amorphous or glassy solids		
The constituent atoms, ions or molecules are arranged in a regular repeated three dimensional pattern, within the	The constituent atoms, ions or molecules are not arranged in a regular repeated three dimensional pattern, within the		

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solid.	solid.		
Definite external geometric shape.	No regularity in external shape.		
All the bonds in ions, or atoms or molecules are equally strong.	All the bonds are not equally strong.		
They are anisotropic.	They are isotropic.		
They have sharp melting point.	They don't have sharp melting point.		
They have a long-range order of atoms or ions or molecules in them.	They don't have a long-range order.		
They are considered true and stable solids.	They are not regarded as true and stable solids.		

### **Elastic Property of Matter**

(1) **Elasticity :** The property of matter by virtue of which a body tends to regain its original shape and size after the removal of deforming force is called elasticity.

(2) **Plasticity**: The property of matter by virtue of which it does not regain its original shape and size after the removal of deforming force is called plasticity.

(3) **Perfectly elastic body**: If on the removal of deforming forces the body regain its original configuration completely it is said to be perfectly elastic.

A quartz fibre and phosphor bronze (an alloy of copper containing 4% to 10% tin, 0.05% to 1% phosphorus) is the nearest approach to the perfectly elastic body.

(4) **Perfectly plastic body :** If the body does not have any tendency to recover its original configuration, on the removal of deforming force, it is said to be perfectly plastic.

 $\ensuremath{\mathsf{Paraffin}}$  wax, wet clay are the nearest approach to the perfectly plastic body.

Practically there is no material which is either perfectly elastic or perfectly plastic and the behaviour of actual bodies lies between the two extremes.

(5) **Reason of elasticity :** In a solids, atoms and molecules are arranged in such a way that each molecule is acted upon by the forces due to neighbouring molecules. These forces are known as intermolecular forces.

For simplicity, the two molecules in their equilibrium positions (at intermolecular distance r = r) are shown by connecting them with a spring.



In fact, the spring connecting the molecules represents the inter-

molecular force between them. On applying the deforming forces, the molecules either come closer or go far apart from each other and restoring forces are developed. When the deforming force is removed, these restoring forces bring the molecules of the solid to their respective equilibrium position (r = r) and hence the body regains its original form.

(6) **Elastic limit :** Elastic bodies show their property of elasticity upto a certain value of deforming force. If we go on increasing the deforming force then a stage is reached when on removing the force, the body will not return to its original state. The maximum deforming force upto which a body retains its property of elasticity is called elastic limit of the material of body.

Elastic limit is the property of a body whereas elasticity is the property of material of the body.

(7) **Elastic fatigue :** The temporary loss of elastic properties because of the action of repeated alternating deforming force is called elastic fatigue.

Due to elastic fatigue :

(i) Bridges are declared unsafe after a long time of their use.

 $(\mathrm{ii})$  Spring balances show wrong readings after they have been used for a long time.

(iii) We are able to break the wire by repeated bending.

(8) **Elastic after effect :** The time delay in which the substance regains its original condition after the removal of deforming force is called elastic after effect. It is the time for which restoring forces are present after the removal of the deforming force, it is negligible for perfectly elastic substance, like quartz, phosphor bronze and large for glass fibre.

#### Stress

When a force is applied on a body, there will be relative displacement of the particles and due to property of elasticity, an internal restoring force is developed which tends to restore the body to its original state.

The internal restoring force acting per unit area of cross section of the deformed body is called stress.

At equilibrium, restoring force is equal in magnitude to external force, stress can therefore also be defined as external force per unit area on a body that tends to cause it to deform.

If external force *F* is applied on the area *A* of a body then,

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

Unit :  $N/m^2$  (S.I.) ,  $dyne/cm^2$  (C.G.S.)

Dimension :  $[ML^{-1}T^{-2}]$ 

Stress developed in a body depends upon how the external forces are applied over it.

On this basis there are two types of stresses : Normal and Shear or tangential stress

(1) Normal stress : Here the force is applied normal to the surface.

It is again of two types : Longitudinal and Bulk or volume stress

(i) Longitudinal stress

(a) It occurs only in solids and comes in to picture when one of the three dimensions viz. length, breadth, height is much greater than other two.

(b) Deforming force is applied parallel to the length and causes increase in length.

 $\left(c\right)$  Area taken for calculation of stress is the area of cross section.

 $\left(d\right)$  Longitudinal stress produced due to increase in length of a body under a deforming force is called tensile stress.

 $(e) \ \ Longitudinal \ stress \ produced \ due \ to \ decrease \ in \ length \ of \ a \ body \ under \ a \ deforming \ force \ is \ called \ compressive \ stress.$ 

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(ii) Bulk or Volume stress

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(a) It occurs in solids, liquids or gases.

 $(b)\ \mbox{In case of fluids only bulk stress can be found.}$ 

(c) It produces change in volume and density, shape remaining same.

(d) Deforming force is applied normal to surface at all points.

(e) Area for calculation of stress is the complete surface area perpendicular to the applied forces.

 $(f)\ It \ is \ equal \ to \ change \ in \ pressure \ because \ change \ in \ pressure \ is$ responsible for change in volume.

(2) Shear or tangential stress : It comes into picture when successive layers of solid move on each other *i.e.* when there is a relative displacement between various layers of solid.

(i) Here deforming force is applied tangential to one of the faces.

(ii) Area for calculation is the area of the face on which force is applied.

(iii) It produces change in shape, volume remaining the same.



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Difference between Pressure and Stress		
Pressure	Stress	
Pressure is always normal to the area.	Stress can be normal or tangential.	
Always compressive in nature.	May be compressive or tensile in nature.	

### Strain

The ratio of change in configuration to the original configuration is called strain.

Being the ratio of two like quantities, it has no dimensions and units. Strain are of three types :

(1) Linear strain : If the deforming force produces a change in length alone, the strain produced in the body is called linear strain or tensile strain.

Linear strain = 
$$\frac{\text{Change in length}(\Delta l)}{\text{Originallength}(l)}$$

Linear strain in the direction of deforming force is called longitudinal strain and in a direction perpendicular to force is called lateral strain.

(2) Volumetric strain : If the deforming force produces a change in volume alone the strain produced in the body is called volumetric strain.



(3) Shearing strain : If the deforming force

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produces a change in the shape of the body without changing its volume, strain produced is called shearing strain.

It is defined as angle in radians through which a plane perpendicular to the fixed surface of the cubical body gets turned under the effect of tangential force.

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

Note: lacksquare When a beam is bent both compression strain as well as an extension strain is produced.



If by gradually increasing the load on a vertically suspended metal wire, a graph is plotted between stress (or load) and longitudinal strain (or elongation) we get the curve as shown in figure. From this curve it is clear that :



(1) When the strain is small  $(\overline{<2\%})$  (*i.e.*, in region *OP*) stress is proportional to strain. This is the region where the so called Hooke's law is obeyed. The point P is called limit of proportionality and slope of line OP gives the Young's modulus Y of the material of the wire. If  $\theta$  is the angle of *OP* from strain axis then  $Y = \tan \theta$ .

(2) If the strain is increased a little bit, i.e., in the region PE, the stress is not proportional to strain. However, the wire still regains its original length after the removal of stretching force. This behaviour is shown up to point E known as elastic limit or yield-point. The region OPE represents the elastic behaviour of the material of wire.

(3) If the wire is stretched beyond the elastic limit E, i.e., between EA, the strain increases much more rapidly and if the stretching force is removed the wire does not come back to its natural length. Some permanent increase in length takes place.

(4) If the stress is increased further, by a very small increase in it a very large increase in strain is produced (region AB) and after reaching point *B*, the strain increases even if the wire is unloaded and ruptures at *C*. In the region BC the wire literally flows. The maximum stress corresponding to B after which the wire begins to flow and breaks is called breaking or ultimate tensile strength. The region EABC represents the plastic behaviour of the material of wire.

(5) Stress-strain curve for different materials are as follows :

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# Hooke's law and Modulus of Elasticity

According to this law, within the elastic limit, stress is proportional to the strain.

Stress

0

Strain

Fig. 9.9

i.e. stress 
$$\propto$$
 strain or  $\frac{\text{stress}}{\text{strain}} = \text{constant} = E$ 

The constant E is called modulus of elasticity.

(1) It's value depends upon the nature of material of the body and the manner in which the body is deformed.

 $(2) \quad \mbox{It's value depends upon the temperature of the body.}$ 

(3) It's value is independent of the dimensions (length, volume etc.) of the body.

There are three modulii of elasticity namely Young's modulus (Y), Bulk modulus (K) and modulus of rigidity  $(\eta)$  corresponding to three types of the strain.

# Young's Modulus (Y)

It is defined as the ratio of normal stress to longitudinal strain within limit of proportionality.

$$Y = \frac{\text{Normal stress}}{\text{longitudial strain}} = \frac{F/A}{l/L} = \frac{FL}{Al}$$

If force is applied on a wire of radius  $\boldsymbol{r}$  by hanging a weight of mass  $\boldsymbol{M},$  then

$$Y = \frac{MgL}{\pi r^2 l}$$

(i) If the length of a wire is doubled,

Then longitudinal strain = 
$$\frac{\text{change in length}(\ell)}{\text{initiallength}(L)}$$

$$= \frac{\text{final length} - \text{initiallength}}{\text{Initiallength}} = \frac{2L - L}{L} = 1$$
  

$$\therefore \text{ Young's modulus} = \frac{\text{stress}}{\text{strain}} \implies Y = \text{stress}$$

[As strain = 1]

So young's modulus is numerically equal to the stress which will double the length of a wire.

(ii) Increment in the length of wire  $l = \frac{FL}{\pi r^2 Y}$ 

So if same stretching force is applied to different wires of same

 $\left[\operatorname{As} Y = \frac{FL}{Al}\right]$ 

terial, 
$$l \propto \frac{L}{r^2}$$
 [As F and Y are constant]

i.e., greater the ratio  $\frac{L}{r^2}$  , greater will be the elongation in the wire.

(iii) Elongation in a wire by its own weight : The weight of the wire Mg act at the centre of gravity of the wire so that length of wire which is stretched will be L/2.

$$\therefore \text{ Elongation } l = \frac{FL}{AY} = \frac{Mg(L/2)}{AY} = \frac{MgL}{2AY} = \frac{L^2dg}{2Y}$$

 $[As mass (M) = volume (AL) \times density (d)]$ 

(iv) Thermal stress : If a rod is fixed between two rigid supports, due to change in temperature its length will change and so it will exert a normal stress (compressive if temperature increases and tensile if temperature decreases) on the supports. This stress is called thermal stress.



So thermal stress =  $Y\alpha \ \Delta\theta$  [As Y = stress/strain]

And tensile or compressive force produced in the body = YA $\alpha \Delta \theta$ 

Note: In case of volume expansion Thermal stress  
= 
$$KY \wedge \theta$$



 $(\nu)$  Force between the two rods : Two rods of different metals, having the same area of cross section  ${\it A}_{i}$  are placed end to end between two

massive walls as shown in figure. The first rod has a length L, coefficient of linear expansion  $\alpha$  and young's modulus Y. The corresponding quantities for second rod are L,  $\alpha$  and Y. If the

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temperature of both the rods is now raised by T degrees.

Increase in length of the composite rod (due to heating) will be equal to  $% \left( \frac{\partial f_{\mu}}{\partial t} \right) = \left( \frac{\partial f_{\mu}}{\partial t} \right) \left( \frac{\partial f$ 

 $l_1 + l_2 = [L_1\alpha_1 + L_2\alpha_2]T \qquad [As \ l = L \ \alpha \ \Delta\theta]$ 

and due to compressive force F from the walls due to elasticity, decrease in length of the composite rod will be equal to

$$\left[\frac{L_1}{Y_1} + \frac{L_2}{Y_2}\right] \frac{F}{A} \qquad \left[Asl = \frac{FL}{AY}\right]$$

as the length of the composite rod remains unchanged the increase in length due to heating must be equal to decrease in length due to

prompression *i.e.* 
$$\frac{F}{A} \left[ \frac{L_1}{Y_1} + \frac{L_2}{Y_2} \right] = [L_1\alpha_1 + L_2\alpha_2]T$$
or
$$F = \frac{A[L_1\alpha_1 + L_2\alpha_2]T}{\left[ \frac{L_1}{Y_1} + \frac{L_2}{Y_2} \right]}$$

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(vi) Force constant of wire : Force required to produce unit elongation in a wire is called force constant of material of wire. It is denoted by k.

$$\therefore k = \frac{F}{l} \qquad \dots (i)$$

but from the definition of young's modulus

$$\frac{F}{l} = \frac{YA}{L} \qquad ...(ii)$$
from (i) and (ii)  $k = \frac{YA}{L}$ 

It is clear that the value of force constant depends upon the dimension (length and area of cross section) and material of a substance.

(vii) Actual length of the wire : If the actual length of the wire is L, then under the tension T, its length becomes L and under the tension T, its length becomes L.

$$L_1 = L + l_1 \implies L_1 = L + \frac{T_1}{k} \qquad \dots (i)$$

and 
$$L_2 = L + l_2 \implies L_2 = L + \frac{T_2}{k}$$
 ...(ii)

From (i) and (ii) we get  $L = \frac{L_1T_2 - L_2T_1}{T_2 - T_1}$ 

### Work Done in Stretching a Wire

In stretching a wire work is done against internal restoring forces. This work is stored in the wire as elastic potential energy or strain energy.

If a force F acts along the length L of the wire of cross-section A and stretches it by  $\boldsymbol{x}$  then

$$Y = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{x/L} = \frac{FL}{Ax} \implies F = \frac{YA}{L}x$$

So the work done for an additional small increase dx in length,

$$dW = Fdx = \frac{YA}{L}x.dx$$

Hence the total work done in increasing the length by  $l_i$ 

$$W = \int_0^l dW = \int_0^l F dx = \int_0^l \frac{11}{L} \cdot x \, dx = \frac{1}{2} \frac{11}{L} l^2$$

This work done is stored in the wire.

$$\therefore$$
 Energy stored in wire  $U = \frac{1}{2} \frac{YAl^2}{L} = \frac{1}{2} Fl \left[ As F = \frac{YAl}{L} \right]$ 

Dividing both sides by volume of the wire we get energy stored in unit volume of wire.

$$U_V = \frac{1}{2} \times \frac{F}{A} \times \frac{l}{L} = \frac{1}{2} \times \text{stress} \times \text{strain} = \frac{1}{2} \times Y \times (\text{strain})^2$$
$$= \frac{1}{2Y} (\text{stress})^2 \qquad [\text{As AL} = \text{volume of wire}]$$

Total energy stored in wire (U)	Energy stored in per unit volume of wire (U)
$\frac{1}{2}Fl$	$\frac{1}{2} \frac{Fl}{\text{volume}}$
$\frac{1}{2}$ × stress × strain × volume	$\frac{1}{2} \times \text{stress} \times \text{strain}$
$\frac{1}{2} \times Y \times (\text{strain})^2 \times \text{volume}$	$\frac{1}{2} \times Y \times (\text{strain})^2$
$\frac{1}{2Y} \times (\text{stress})^2 \times \text{volume}$	$\frac{1}{2Y} \times (\text{stress})^2$

NOte :  $\Box$  If the force on the wire is increased from  $F_{I}$  to  $F_{I}$  and the elongation in wire is I then energy stored in the wire  $U = \frac{1}{2} \frac{(F_{I} + F_{2})}{2} I$ 

 $\Box$  Thermal energy density = Thermal energy per unit volume =  $\frac{1}{2}$  ×

Thermal stress  $\times$  strain

$$=\frac{1}{2}\frac{F}{A}\frac{l}{L}=\frac{1}{2}(Y\alpha\Delta\theta)(\alpha\Delta\theta)=\frac{1}{2}Y\alpha^{2}(\Delta\theta)^{2}$$

### Breaking of Wire

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When the wire is loaded beyond the elastic limit, then strain increases much more rapidly. The maximum stress corresponding to B (see stress-strain curve) after which the wire begin to flow and breaks, is called breaking stress or tensile strength and the force by application of which the wire breaks is called the breaking force.

(i) Breaking force depends upon the area of cross-section of the wire i.e., Breaking force  $\propto A$ 

 $\therefore$  Breaking force = P × A

Here P is a constant of proportionality and known as breaking stress.



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(ii) Breaking stress is a constant for a given material and it does not depend upon the dimension (length or thickness) of wire.

 $(\rm iii)$  If a wire of length L is cut into two or more parts, then again it's each part can hold the same weight. Since breaking force is independent of the length of wire.

(iv) If a wire can bear maximum force F, then wire of same material but double thickness can bear maximum force 4F

 $\left(v\right)$  The working stress is always kept lower than that of a breaking stress.

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So that safety factor =  $\frac{\text{breaking stress}}{\text{workingstress}}$ , may have large value.

(vi) Breaking of wire under its own weight.

Breaking force = Breaking stress × Area of cross section

Weight of wire = 
$$Mg = ALdg = PA$$
 [*P*=Breaking stress]  
[As mass = volume × density = ALd]

$$\Rightarrow Ldg = P \quad \therefore \ L = \frac{P}{dg}$$

This is the length of wire if it breaks by its own weight.

#### **Bulk Modulus**

When a solid or fluid (liquid or gas) is subjected to a uniform pressure all over the surface, such that the shape remains the same, then there is a change in volume.

Then the ratio of normal stress to the volumetric strain within the elastic limits is called as Bulk modulus. This is denoted by K.



where p = increase in pressure; V = original volume;  $\Delta V =$  change in volume

The negative sign shows that with increase in pressure p, the volume decreases by  $\Delta V$  i.e. if p is positive,  $\Delta V$  is negative. The reciprocal of bulk modulus is called compressibility.

C = compressibility = 
$$\frac{1}{K} = \frac{\Delta V}{pV}$$

S.I. unit of compressibility is Nm and C.G.S. unit is dyne cm.

Gases have two bulk moduli, namely isothermal elasticity  $E_\theta$  and adiabatic elasticity  $E_\varphi$  .

(1) Isothermal elasticity  $(E_\theta)$  : Elasticity possess by a gas in isothermal condition is defined as isothermal elasticity.

For isothermal process, PV = constant (Boyle's law)

Differentiating both sides

$$PdV + VdP = 0 \implies PdV = -VdP$$

$$P = \frac{dP}{(-dV/V)} = \frac{\text{stress}}{\text{strain}} = E_{\theta} \quad \therefore \quad E_{\theta} = P$$

i.e., Isothermal elasticity is equal to pressure.

(2) Adiabatic elasticity  $(E_{\varphi})$  : Elasticity possess by a gas in adiabatic condition is defined as adiabatic elasticity.

For adiabatic process,  $PV^{\gamma}$  = constant (Poisson's law) Differentiating both sides,

$$P \gamma V^{\gamma-1} dV + V^{\gamma} dP = 0 \implies \gamma P dV + V dP = 0$$
$$\gamma P = \frac{dP}{\left(\frac{-dV}{V}\right)} = \frac{\text{stress}}{\text{strain}} = E_{\phi}$$
$$\therefore E_{\phi} = \gamma P$$

i.e., adiabatic elasticity is equal to  $\gamma$  times pressure.

[Where 
$$\gamma = \frac{C_p}{C_v}$$
]

Note: Ratio of adiabatic to isothermal elasticity  $\overline{E_{\phi}} \gamma P$ 

$$\frac{E_{\phi}}{E_{\theta}} = \frac{\gamma F}{P} = \gamma > 1 \quad \therefore \ E_{\phi} > E_{\theta}$$

*i.e.,* adiabatic elasticity is always more than isothermal elasticity.

### **Density of Compressed Liquid**

If a liquid of density  $\rho$ , volume V and bulk modulus K is compressed, then its density increases.

As density 
$$\rho = \frac{m}{V}$$
 so  $\frac{\Delta \rho}{\rho} = \frac{-\Delta V}{V}$  ...(i)

But by definition of bulk modulus

$$K = \frac{-V\Delta P}{\Delta V} \implies -\frac{\Delta V}{V} = \frac{\Delta P}{K}$$
 ...(ii)

From (i) and (ii) 
$$\frac{\Delta \rho}{\rho} = \frac{\rho' - \rho}{\rho} = \frac{\Delta P}{K}$$
 [As  $\Delta \rho = \rho' - \rho$ ]

or 
$$\rho' = \rho \left[ 1 + \frac{\Delta P}{K} \right] = \rho [1 + C\Delta P] \left[ As \frac{1}{K} = C \right]$$

# Fractional Change in the Radius of Sphere

A solid sphere of radius R made of a material of bulk modulus K is surrounded by a liquid in a cylindrical container.

A massless piston of area A floats on the surface of the liquid.

Volume of the spherical body 
$$V = \frac{4}{3} \pi R^3$$
  
 $\frac{\Delta V}{V} = 3 \frac{\Delta R}{R}$   
 $\therefore \frac{\Delta R}{R} = \frac{1}{3} \frac{\Delta V}{V}$  ...(i)

Bulk modulus 
$$K = -V \frac{\Delta P}{\Delta V}$$

B

$$\left|\frac{\Delta V}{V}\right| = \frac{\Delta P}{K} = \frac{mg}{AK} \qquad \dots \dots (ii)$$
$$\left[\operatorname{As} \Delta P = \frac{mg}{A}\right]$$

Substituting the value of  $\frac{\Delta V}{V}$  from equation (ii) in equation (i) we

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get 
$$\frac{\Delta R}{R} = \frac{1}{3} \frac{mg}{AK}$$

### Modulus of Rigidity

**CLICK HERE** 

Within limits of proportionality, the ratio of tangential stress to the shearing strain is called modulus of rigidity of the material of the body and

is denoted by  $\eta$ , i.e.  $\eta = \frac{\text{Shearing stress}}{\text{Shearing strain}}$ 

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In this case the shape of a body changes but its volume remains unchanged.

Consider a cube of material fixed at its lower face and acted upon by a tangential force F at its upper surface having area A. The shearing stress, then, will be

Shearing stress 
$$=\frac{F}{A}$$

This shearing force causes the consecutive horizontal layers of the cube to be slightly displaced or sheared relative to one another, each line such as PQ or RS in the cube is rotated through an angle  $\phi$  by this shear. The shearing strain is defined as the angle  $\phi$  in radians through which a line normal to a fixed surface has turned. For small values of angle,

Shearing strain = 
$$\phi = \frac{QQ'}{PQ} = \frac{x}{L}$$
  
So  $\eta = \frac{\text{shear stress}}{\text{shear strain}} = \frac{F/A}{\phi} = \frac{F}{A\phi}$ 

Only solids can exhibit a shearing as these have definite shape.

# **Poisson's Ratio**

When a long bar is stretched by a force along its length then its length increases and the radius decreases as shown in the figure.

Lateral strain : The ratio of change in radius or diameter to the original radius or diameter is called lateral strain.

Longitudinal strain : The ratio of change in length to the original length is called longitudinal strain.

The ratio of lateral strain to longitudinal strain is called Poisson's ratio ( $\sigma$ ).

i.e. 
$$\sigma = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$
  
 $\sigma = \frac{-dr/r}{dL/L}$ 

Negative sign indicates that the radius of the bar decreases when it is stretched.

Poisson's ratio is a dimensionless and a unitless quantity.

# Relation Between Volumetric Strain, Lateral Strain and Poisson's Ratio

If a long bar have a length L and radius r then volume  $V = \pi r^2 L$ 

Differentiating both the sides  $dV = \pi r^2 dL + \pi 2rLdr$ 

Dividing both the sides by volume of bar
$$\frac{dV}{V} = \frac{\pi r^2 dL}{\pi r^2 L} + \frac{\pi 2rL dr}{\pi r^2 L} = \frac{dL}{L} + 2\frac{dr}{r}$$

 $\Rightarrow$  Volumetric strain = longitudinal strain + 2(lateral strain)

$$\Rightarrow \frac{dV}{V} = \frac{dL}{L} + 2\sigma \frac{dL}{L} = (1 + 2\sigma) \frac{dL}{L}$$

$$\left[ \text{As } \sigma = \frac{dr/r}{dL/L} \Rightarrow \frac{dr}{r} = \sigma \frac{dL}{L} \right]$$
or  $\sigma = \frac{1}{2} \left[ \frac{dV}{AdL} - 1 \right]$ 

[where *A* = cross-section of bar]

(i) If a material having 
$$\sigma = -0.5$$
 then  $\frac{dV}{V} = [1 + 2\sigma]\frac{dL}{L} = 0$ 

 $\therefore$  Volume = constant or  $K = \infty$  *i.e.* the material is incompressible.

(ii) If a material having  $\sigma = 0$ , then lateral strain is zero *i.e.* when a substance is stretched its length increases without any decrease in diameter *e.g.* cork. In this case change in volume is maximum.

- (iii) Theoretical value of Poisson's ratio  $\,-1<\sigma<0.5$  .
- (iv) Practical value of Poisson's ratio  $0 < \sigma < 0.5$

### Relation between Y, k, $\eta$ and $\sigma$

Moduli of elasticity are three, *viz. Y*, *K* and  $\eta$  while elastic constants are four, *viz*, *Y*, *K*,  $\eta$  and  $\sigma$ . Poisson's ratio  $\sigma$  is not modulus of elasticity as it is the ratio of two strains and not of stress to strain. Elastic constants are found to depend on each other through the relations :

$$Y = 3K(1 - 2\sigma) \qquad \dots (i)$$

$$Y = 2\eta(1+\sigma) \qquad \dots (ii)$$

Eliminating  $\sigma$  or Y between these, we get

$$Y = \frac{9K\eta}{3K+\eta} \qquad \dots (iii)$$

$$\sigma = \frac{3K - 2\eta}{6K + 2\eta} \qquad \qquad \dots (iv)$$

# **Torsion of Cylinder**

maximum.

**CLICK HERE** 

If the upper end of a cylinder is clamped and a torque is applied at the lower end the cylinder gets twisted by angle  $\theta$ . Simultaneously shearing strain  $\phi$  is produced in the cylinder.

(i) The angle of twist  $\theta$  is directly proportional to the distance from the fixed end of the cylinder.

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(ii) The value of angle of shear  $\phi$  is directly proportional to the radius of the cylindrical shell.

At fixed end  $\theta = 0^{\circ}$  and at free end  $\theta$  =

At the axis of cylinder  $\phi$  = 0 and at the outermost shell  $\phi$  = maximum.

(iii) Relation between angle of twist ( $\theta$ ) and angle of shear ( $\phi$ )



Fixed face

Fig. 9.15

$$AB = r\theta = \phi I$$
  $\therefore \phi = \frac{r\theta}{I}$ 

 $(\mathrm{iv})$  Twisting couple per unit twist or torsional rigidity or torque required to produce unit twist.

$$C = \frac{\pi \eta r^4}{2l} \quad \therefore \quad C \propto r^4 \propto A^2$$

(v) Work done in twisting the cylinder through an angle heta is

$$W = \frac{1}{2}C\theta^2 = \frac{\pi\eta r^4\theta^2}{4l}$$

### Interatomic Force Constant

Behaviour of solids with respect to external forces is such that if their atoms are connected to springs. When an external force is applied on a solid, this distance between its atoms changes and interatomic force works to restore the original dimension.

The ratio of interatomic force to that of change in interatomic

distance is defined as the interatomic force constant.  $K = \frac{F}{\Lambda r}$ 

It is also given by  $K = Y \times r_0$  [Where Y = Young's modulus,  $r_0$  = Normal distance between the atoms of wire]

Unit of interatomic force constant is N/m and Dimension MT

 $Note: \square$  The number of atoms having interatomic distance r in length / of a wire, N = ||r|.

The number of atoms in area A of wire having interatomic

separation r is  $N = A / r_0^2$ .

# **Elastic Hysteresis**

When a deforming force is applied on a body then the strain does not change simultaneously with stress rather it lags behind the stress. The lagging of strain behind the stress is defined as elastic hysteresis. This is the reason why the values of strain for same stress are different while increasing the load and while decreasing the load.

**Hysteresis loop :** The area of the stress-strain curve is called the hysteresis loop and it is numerically equal to the work done in loading the material and then unloading it.



If we have two tyres of rubber having different hysteresis loop then rubber B should be used for making the car tyres. It is because of the reason that area under the curve *i.e.* work done in case of rubber B is lesser and hence the car tyre will not get excessively heated and rubber A should be used to absorb vibration of the machinery because of the large area of the curve, a large amount of vibrational energy can be dissipated.

#### Factors Affecting Elasticity

(1) Hammering and rolling : Crystal grains break up into smaller units by hammering and rolling. This results in increase in the elasticity of material.

(2) Annealing : The metals are annealed by heating and then cooling them slowly. Annealing results in decrease in the elasticity of material.

(3) Temperature : Intermolecular forces decreases with rise in temperature. Hence the elasticity decreases with rise in temperature but the elasticity of invar steel (alloy) does not change with change of temperature.

(4) Impurities : Due to impurities in a material, elasticity can increase or decrease. The type of effect depends upon the nature of impurities present in the material.

# Important Facts About Elasticity

 $({\bf l})$  The body which requires greater deforming force to produce a certain change in dimension is more elastic.

Example : Ivory and steel balls are more elastic than rubber.

(2) When equal deforming force is applied on different bodies then the body which shows less deformation is more elastic.

 $Example: (i) \ For \ same \ load, \ more \ elongation \ is \ produced \ in \ rubber wire \ than \ in \ steel \ wire \ hence \ steel \ is \ more \ elastic \ than \ rubber.$ 

 $(\mathrm{ii})$  Water is more elastic than air as volume change in water is less for same applied pressure.

 $({\rm iii})$  Four identical balls of different materials are dropped from the same height then after collision, balls rises upto different heights.

The order of their height can be given by  $h_{\rightarrow} > h_{\rightarrow} > h_{\rightarrow} > h_{\rightarrow}$  because  $Y_{\rightarrow} > Y_{\rightarrow} > Y_{\rightarrow} > Y_{\rightarrow} > Y_{\rightarrow}$ .

(3) The value of moduli of elasticity is independent of the magnitude of the stress and strain. It depends only on the nature of material of the body.

(4) For a given material there can be different moduli of elasticity depending on the type of stress applied and resulting strain.

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Strain	$\rightarrow$ Strain $\rightarrow$		
Name of substance	Fig. 9.1&oung's modulus (1) 10°N/m	Bulk modulus (K)	Modulus of rigidity ( $\eta$ ) 10°N/m
		10• <i>N/m</i>	
Aluminium	6.9	7.0	2.6
Brass	9.0	6.7	3.4
Copper	11.0	13.0	4.5
lron	19.0	14.0	4.6
Steel	20.0	16.0	8.4
Tungsten	36.0	20.0	15.0
Diamond	83.0	55.0	34.0

**CLICK HERE** 

Water	_	0.22	_
Glycerin	-	0.45	-
Air	_	1.01	_

(5) The moduli of elasticity has same dimensional formula and units as that of stress since strain is dimensionless. ... Dimensional formula is  $[ML^{-1}T^{-2}]$  while units *dyne/cm* or *Newton/m*.

(6) Greater the value of moduli of elasticity more elastic is the material. But as  $Y \propto (1/\hbar)$ ,  $K \propto (1/\Delta V)$  and  $\eta \propto (1/\phi)$  for a constant stress, so smaller change in shape or size for a given stress corresponds to greater elasticity.

(7) The moduli of elasticity  $\gamma$  and  $\eta$  exist only for solids as liquids and gases cannot be deformed along one dimension only and also cannot sustain shear strain. However K exist for all states of matter viz. solid, liquid or gas.

(8) Gases being most compressible are least elastic while solids are most *i.e.* the bulk modulus of gas is very low while that for liquids and solids is very high. K > K > K

(9) For a rigid body l,  $\Delta V$  or  $\phi = 0$  so Y, K or  $\eta$  will be  $\infty$ , *i.e.* elasticity of a rigid body is infinite.

Diamond and carborundum are nearest approach to rigid bodies.

(10) In a suspension bridge there is a stretch in the ropes by the load of the bridge. Due to which length of rope changes. Hence Young's modulus of elasticity is involved.

(1) In an automobile tyre as the air is compressed, volume of the air in tyre changes, hence the bulk modulus of elasticity is involved.

 $\left( 12\right)$  In transmitting power, an automobile shaft is sheared as it rotates, so shearing strain is set up, hence modulus of rigidity is involved.

(13) The shape of rubber heels changes under stress, so modulus of rigidity is involved.

# Practical Applications of Elasticity

(i) The metallic parts of machinery are never subjected to a stress beyond elastic limit, otherwise they will get permanently deformed.

(ii) The thickness of the metallic rope used in the crane in order to lift a given load is decided from the knowledge of elastic limit of the material of the rope and the factor of safety.

(iii) The bridges are declared unsafe after long use because during its long use, a bridge under goes quick alternating strains continuously. It results in the loss of elastic strength.

(iv) Maximum height of a mountain on earth can be estimated from the elastic behaviour of earth.

At the base of the mountain, the pressure is given by  $P = h\rho g$  and it must be less than elastic limit (K) of earth's supporting material.

$$K > P > h\rho g \therefore h < \frac{K}{\rho g}$$
 or  $h_{\max} = \frac{K}{\rho g}$ 

(v) In designing a beam for its use to support a load (in construction of roofs and bridges), it is advantageous to increase its depth rather than the breadth of the beam because the depression in rectangular beam.



To minimize the depression in the beam, it is designed as *I*-shaped girder.

(vi) For a beam with circular cross-section depression is given by  $WL^3$ 

$$r^{4}Y$$

(vii) A hollow shaft is stronger than a solid shaft made of same mass, length and material.

Torque required to produce a unit twist in a solid shaft

$$\tau_{\rm solid} = \frac{\pi \eta r^4}{2l} \qquad ...(i)$$

and torque required to produce a unit twist in a hollow shaft

$$\tau_{\text{hollow}} = \frac{\pi \eta (r_2^4 - r_1^4)}{2l} \qquad \dots (\mathbf{i})$$

From (i) and (ii),

$$\frac{\tau_{\text{hollow}}}{\tau_{\text{solid}}} = \frac{r_2^4 - r_1^4}{r^4} = \frac{(r_2^2 + r_1^2)(r_2^2 - r_1^2)}{r^4} \quad \dots \text{(iii)}$$

Since two shafts are made from equal volume  $\pi r^2 l = \pi (r_2^2 - r_1^2) l \implies r^2 = r_2^2 - r_1^2$ 

Substituting this value in (iii) equation get.  $\frac{\tau_{\text{hollow}}}{\tau_{\text{ould}}} = \frac{r_2^2 + r_1^2}{r^2} > 1 \quad \therefore \tau_{\text{un}} > \tau_{\text{un}}$ 

 $\tau_{\rm solid}$ 

i.e., the torque required to twist a hollow shaft is greater than the torque necessary to twist a solid shaft of the same mass, length and material through the same angle. Hence, a hollow shaft is stronger than a solid shaft.



#### Metals are polycrystalline materials.

Metals are elastic for small strains and for large strains, metals Ø become plastic.

X The substances having large molecular structure (formed by the union of two to several thousand simple molecules) are called polymers.

- Rubber is a polymer. ø
- Rubber is elastic for very large strains. ß
- It stretches easily at first but then becomes stiffer. ø
- Young's modulus is defined only for the solids. ø
- Bulk modulus was first defined by Maxwell. ø

ø Bulk modulus is defined for all types of materials, solids, liquids and gases.

Reciprocal of bulk modules is called compressibility.

🙇 Hooke's law is obeyed only for small values of strain.

 ${\ensuremath{ \ensuremath{ \e$ 

 $\boldsymbol{\mathscr{L}}$  The material which do not break well beyond the elastic limit are called ductile.

✗ The deformation beyond elastic limit is called plasticity.

 ${\boldsymbol{\mathscr L}}$  Rubber sustains elasticity even when stretched several times its length.

However it is not ductile. If breaks down as soon as the elastic limit is crossed.

**\checkmark** Within elastic limit, the force constant for a spring is given by VA

$$K = \frac{IA}{L}$$

Elastic after effect is a temporary absence of the elastic properties.

Isothermal elasticity = pressure (P)

Adiabatic elasticity = Ratio of specific heats × pressure = $\gamma P$ 

 $\mathcal{L}$  Elasticity is meaningless for the rigid bodies. It is the property of the non rigid bodies.

 ${oldsymbol {\mathscr E}}$  Elastic fatigue occurs, when a metal is subjected to repeated loading and unloading.

 $\bigstar$  Theoretical value of Poisson's ratio lies between -1 and +1/2 but practical value lies between zero and +1/2.

S Negative value of poisson's ratio means that if length increases then radius decreases.

Stress and pressure have the same units and dimensions, but the pressure is always normal to the surface but the stress may be parallel or perpendicular to the surface.

 $\mathscr{I}$  Normal stress is also called tensile stress when the length of the body tends to increase.

 $\checkmark$  Normal stress is also called compressive stress when length of the body tends to decrease.

🙇 Tangential stress is also called shearing stress.

**E** When the deforming force is inclined to the surface, both the tangential as well as normal stress are produced.

K When a body is sheared, two mutually perpendicular strains are produced. They are called longitudinal strain and compressional strain. Both are equal in magnitude.

 ${\mathscr E}$  When a beam is bent, both extensional as well as compressional strain is produced.

 $\mathscr{K}$  The energy stored by an elastic material is the area under the force-extension graph. The area under the stress-strain graph gives the

energy stored per unit volume.

**\mathscr{L}** Thermal stress in a rod =  $Y \alpha \Delta \theta$ . It is independent of the area of cross section or length of the wire.

 ${\boldsymbol{\mathscr{K}}}$  Breaking stress for a wire of unit cross-section is called tensile strength.

E Breaking stress does not depend on the length or area of cross section of the wire. However it depends on the material of the wire.

 ${\boldsymbol{\mathscr{K}}}$  Breaking force depends on the area of cross section. Breaking stress of a wire is called tensile strength.

 $\mathscr{K}$  If we double the radius of rope its breaking force becomes four times. But the breaking stress remains unchanged.

 $\mathcal{L}$  If a beam of rectangular cross-section is loaded its depression at the beam is inversely proportional to the cube of thickness.

inversely proportional to the fourth power of radius. *i.e.*  $\delta \propto \frac{1}{r^4}$ 

# Gruinary Thinking

# Objective Questions

### Young's Modulus and Breaking Stress

- The length of an iron wire is L and area of cross-section is A. The increase in length is I on applying the force F on its two ends. Which of the statement is correct [NCERT 1976]
  - (a) Increase in length is inversely proportional to its length L
  - (b) Increase in length is proportional to area of cross-section A
  - (c) Increase in length is inversely proportional to *A*
  - (d) Increase in length is proportional to Young's modulus
- **2.** The increase in length is *I* of a wire of length *L* by the longitudinal stress. Then the stress is proportional to

[MP PET 1986] (b) //L

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(c)  $l \times L$  (d)  $l^2 \times L$ 

(a) *L/1* 

**CLICK HERE** 

3. The dimensions of four wires of the same material are given below. In which wire the increase in length will be maximum when the same tension is applied

#### [ITT 1981; NCERT 1976; MP PET/PMT 1998; CPMT 1983, 90; MP PMT 1992, 94, 97; MP PET 1989, 90, 99]

- (a) Length 100 *cm*, Diameter 1 *mm*
- (b) Length 200 *cm*, Diameter 2 *mm*
- (c) Length 300 *cm*, Diameter 3 *mm*
- (d) Length 50 *cm*, Diameter 0.5 *mm*

4.	The ratio of the lengths of the 2 and the ratio of their dian same force, then the ratio of	wo wires <i>A</i> and <i>B</i> of same material is 1 : neter is 2 : 1. They are stretched by the increase in length will be[ <b>MP PMT 1986; M</b>	13. P Pet/PMT	In CGS system, the Young double the length of a v 1989 Jired is	's modulus of a steel wire is $2 \times 10^{12}$ . To wire of unit cross-section area, the force [MP PMT 1989]
	(a) 2:1	(b) 1:4		(a) $4 \times 10^6$ dynes	(b) $2 \times 10^{12}$ <i>dynes</i>
	(c) 1:8	(d) 8:1		(c) $2 \times 10^{12}$ newtons	(d) $2 \times 10^8$ dynas
	The Young's modulus of a w	ire of length L and radius r is $Y N/m$ . If	14.	The material which practic	cally does not show elastic after effect is[ <b>IIPME</b>
	the length and radius are re	educed to $L/2$ and $r/2$ , then its Young's		(a) Copper	(b) Rubber
	modulus will be			(c) Steel	(d) Quartz
		[MP PMT 1985; MP PET 1997; KCET 1999]	15.	If the temperature increase	es, the modulus of elasticity
	(a) <i>Y</i> /2	(b) <i>Y</i>		(a) Decreases	(b) Increases
	(c) $2Y$	(d) 4 <i>Y</i>		(c) Remains constant	(d) Becomes zero
	A beam of metal supported The depression at the centre	at the two ends is loaded at the centre. is proportional to	16.	A force <i>F</i> is needed to b force needed to break a co	reak a copper wire having radius <i>R</i> . The opper wire of radius 2 <i>R</i> will be
		[CPMT 1983, 84]		(-) <b>D</b> D	[MP PET 1990]
	(a) $Y^2$	(b) $\gamma$		(a) $F/2$ (c) $AF$	$\begin{array}{c} (\mathbf{b}) & \mathbf{z}\mathbf{r} \\ (\mathbf{d}) & \mathbf{E}\mathbf{A} \end{array}$
	(~) *		17.	The relationship between	Young's modulus Y. Bulk modulus K and
	(c) $1/Y$	(d) $1/Y^2$	.,.	modulus of rigidity $\eta$ is	
	When a certain weight is su	spended from a long uniform wire, its			[MP PET 1991; MP PMT 1997]
	length increases by one cm.	It the same weight is suspended from a diameter		(-) $V = \frac{9\eta K}{2}$	9YK
	half of the first one then the	increase in length will be		(a) I =	(b) $\overline{Y+3K}$
	(a) 0.5 <i>cm</i>	(b) 2 <i>cm</i>		9 <i>nK</i>	3nK
	(c) 4 <i>cm</i>	(d) 8 <i>cm</i>		(c) $Y = \frac{3}{3+K}$	(d) $Y = \frac{1}{9\eta + K}$
	Hook's law defines	[MP PMT/PFT 1088]	18.	The diameter of a brass ro	od is 4 <i>mm</i> and Young's modulus of brass
	(a) Stress	(b) Strain		is $9 \times 10^{10} N/m^2$ . The	force required to stretch by 0.1% of its
	(a) Modulus - f 1			length is	[MP PET 1991; BVP 2003]
	(c) modulus or elasticity	(d) Elastic milt		(a) 360 πN	(b) 36 N
	A wire is loaded by 6 kg at mm. If the radius of the wir are unchanged, then increase	its one end, the increase in length is 12 re is doubled and all other magnitudes in length will be[MP PMT 1987; AI SSCE 194	82]	(c) $144\pi \times 10^3 N$	(d) $36\pi \times 10^5 N$
	(a) 6 <i>mm</i>	(b) 3 <i>mm</i>	<sup>-</sup> 19.	If $x$ longitudinal strain is then energy stored in the	produced in a wire of Young's modulus <i>y</i> ,
	(c) $24 mm$	(d) 48 mm		[MP PMT 1987, 89, 92	: CPMT 1997: Pb. PMT 1999: KCET 2000: AllMS
	The area of gross section of	a wire of length 11 metry is 1 mm. It is		[	2001]
•	loaded with 1 kg. If	Young's modulus of copper is		(a) $yx^2$	(b) $2 yx^2$
	$1.1 \times 10^{11} N/m^2$ , then	the increase in length will be (1f		1 2	1 2
	$a = 10 m / s^2$	[MD DET 1090]		(c) $\frac{1}{2}y^2x$	(d) $\frac{1}{2}yx^2$
	g = 10 m/s )	[MP PET 1989]	20.	In a wire of length L, the	increase in its length is <i>l</i> . If the length is
	(a) 0.01 <i>mm</i>	(b) 0.075 <i>mm</i>		reduced to half, the increa	se in its length will be
	(c) 0.1 <i>mm</i>	(d) 0. 15 <i>mm</i>		(a) /	(b) 2 <i>1</i>
	On increasing the length by	0.5 $mm$ in a steel wire of length 2 $m$		(c) $\frac{l}{l}$	(d) None of the above
	and area of cross-section	$2mm^2$ , the force required is [Y for		2	(2)
	steel = $2.2 \times 10^{11} N/m^2$ ]]	[MP PET/PMT 1988]	21.	The Young's modulus of	a rubber string 8 <i>cm</i> long and density
	(a) $1.1 \times 10^5 N$	(b) $1.1 \times 10^4 N$		$1.5 kg / m^3$ is $5 \times 10^8 h$ room. The increase in leng	$N/m^2$ , is suspended on the ceiling in a sthe due to its own weight will be
	(c) $1.1 \times 10^3 N$	(d) $1.1 \times 10^2 N$		(a) $9.6 \times 10^{-5} m$	(b) $9.6 \times 10^{-11} m$
	If Young's modulus of iron is	s $2 \times 10^{11} N/m^2$ and the interatomic		(c) $9.6 \times 10^{-3} m$	(d) 9.6 <i>m</i>
	spacing between two molecu force constant is	ales is $3 \times 10^{-10}$ <i>metre</i> , the interatomic	22.	A and B are two wires. The stretched by the some load	he radius of <i>A</i> is twice that of <i>B</i> . They are d. Then the stress on <i>B</i> is
		[IIPMER 1078]			[MP PMT 1993]

- and Young's modulus of brass ired to stretch by 0.1% of its [MP PET 1991; BVP 2003]
  - 36 N

(c)	$144\pi \times 10^{3} N$	(d)	$36\pi \times 10^{3}$
(c)	$144\pi \times 10^{5} N$	(d)	$36\pi \times 10^{3}$

- $2 yx^2$
- $\frac{1}{2}yx^2$
- its length is *l*. If the length is gth will be 2/

(a) 
$$9.6 \times 10^{-5} m$$
 (b)  $9.6 \times 10^{-11} m$ 

- [MP PMT 1993]
- (a) Equal to that on A (b) Four times that on A
- (c) Two times that on A (d) Half that on A

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		32.
	(a) Half (b) Same	
	(c) Double (d) One fourth	
24.	To double the length of a iron wire having $0.5{\it cm}^2$ area of cross-	
	section, the required force will be $(Y = 10^{12} dyne / cm^2)$	
	(a) $1.0 \times 10^{-7} N$ (b) $1.0 \times 10^7 N$	33.
	(c) $0.5 \times 10^{-7} N$ (d) $0.5 \times 10^{12} dyne$	
25.	The spring balance does not read properly after its long use, because	
	(a) The elasticity of spring increases	
	(b) The elasticity decreases	
	(c) Its plastic power decreases	
	(d) Its plastic power increases	24
26.	Two wires of equal lengths are made of the same material. Wire <i>A</i> has a diameter that is twice as that of wire <i>B</i> . If identical weights are suspended from the ends of these wires, the increase in length is [EAMCET 1983: MP PMT 1990: MP PET 1995]	34.
	(a) Four times for wire A as for wire B	
	(b) Twice for wire <i>A</i> as for wire <i>B</i>	35.
	(c) Half for wire $A$ as for wire $B$	
	(d) One-fourth for wire $A$ as for wire $B$	
27.	Why the spring is made up of steel in comparison of copper	
	(a) Copper is more costly than steel	
	(b) Copper is more elastic than steel	
	(c) Steel is more elastic than copper	36.
<b></b>	(d) None of the above	•
20.	weight one after the other. Young's modulus of steel and copper are	
	$2 \times 10^{-10}$ N/M and $1.2 \times 10^{-10}$ N/M. The ratio of increase in	
	length [MP PET 1984]	37.
	length [MP PET 1984] (a) $\frac{2}{5}$ (b) $\frac{3}{5}$	37.
	length [MP PET 1984] (a) $\frac{2}{5}$ (b) $\frac{3}{5}$	37.
	length [MP PET 1984] (a) $\frac{2}{5}$ (b) $\frac{3}{5}$ (c) $\frac{5}{4}$ (d) $\frac{5}{2}$	37.
	length       [MP PET 1984]         (a) $\frac{2}{5}$ (b) $\frac{3}{5}$ (c) $\frac{5}{4}$ (d) $\frac{5}{2}$	37.
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If the length of a wire is reduced to half, then it can hold the ......

23.

(c)  $10^5 N$ 

- (d)  $10^9 N$ A rod of length I and area of cross-section A is heated from  $0^{\circ}C$  to 100°C. The rod is so placed that it is not allowed to increase in length, then the force developed is proportional to
  - (b)  $l^{-1}$ (a) 1
  - (d)  $A^{-1}$ (c) A [MP PMT 1987]
- An aluminum rod (Young's modulus  $= 7 \times 10^9 \ N \ / \ m^2$ ) has a breaking strain of 0.2%. The minimum cross-sectional area of the rod in order to support a load of  $10^4$  Newton's is

[MP PMT 1991]

- (a)  $1 \times 10^{-2} m^2$ (b)  $1.4 \times 10^{-3} m^2$
- (d)  $7.1 \times 10^{-4} m^2$ (c)  $3.5 \times 10^{-3} m^2$
- Two wires of copper having the length in the ratio 4 : 1 and their radii ratio as 1:4 are stretched by the same force. The ratio of longitudinal strain in the two will be
  - (a) 1:16 (b) 16:1 (d) 64 : 1 (c) 1:64
- A weight of 200 kg is suspended by vertical wire of length 600.5 cm. The area of cross-section of wire is  $1 mm^2$ . When the load is removed, the wire contracts by 0.5 cm. The Young's modulus of the material of wire will be

(a) 
$$2.35 \times 10^{12} N/m^2$$
 (b)  $1.35 \times 10^{10} N/m^2$ 

(c) 
$$13.5 \times 10^{11} N/m^2$$
 (d)  $23.5 \times 10^9 N/m^2$ 

If a load of 9 kg is suspended on a wire, the increase in length is 4.5 mm. The force constant of the wire is

(a)	$0.49 \times 10^4$	N/m	(b)	$1.96 \times 10^4 N/m$	
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(c) 
$$4.9 \times 10^4 N/m$$
 (d)  $0.196 \times 10^4 N/m$ 

The ratio of diameters of two wires of same material is n: 1. The length of wires are 4 m each. On applying the same load, the increase in length of thin wire will be

(a)  $n^2$  times (b) *n* times

(d) None of the above (c) 2*n* times

Longitudinal stress of  $1 kg / mm^2$  is applied on a wire. The

- percentage increase in length is  $(Y = 10^{11} N / m^2)$ [MP PET 1985] (a) 0.002 (b) 0.001
- (c) 0.003 (d) 0.01
- A steel wire is stretched with a definite load. If the Young's modulus of the wire is Y. For decreasing the value of Y
  - (a) Radius is to be decreased
  - (b) Radius is to be increased
  - (c) Length is to be increased
  - (d) None of the above

The interatomic distance for a metal is  $3 \times 10^{-10} m$ . If the interatomic force constant is  $3.6 \times 10^{-9} N / \text{\AA}$ , then the Young's modulus in  $N/m^2$  will be

(a) 
$$1.2 \times 10^{11}$$
 (b)  $4.2 \times 10^{11}$ 

(c)  $10.8 \times 10^{-19}$ (d)  $2.4 \times 10^{10}$ 

UNIVE SELF SC	RSAL ORER	460 Elasticity		
μ.	Two weig	identical wires of rubber ar ht, then the number of atoms	nd iro in t	on are stretched by the same he iron wire will be
	(a)	Equal to that of rubber		
	(b)	Less than that of the rubber		
	(c)	More than that of the rubber	•	
	(d)	None of the above		
2.	The	force constant of a wire does	not o	depend on
	(a)	Nature of the material	(b)	Radius of the wire
	(c)	Length of the wire	(d)	None of the above
13.	The	elasticity of <i>invar</i>		
	(a)	Increases with temperature r	ise	

- (b) Decreases with temperature rise
- (c) Does not depend on temperature
- $(d) \quad \text{None of the above} \\$
- **44.** After effects of elasticity are maximum for
  - (a) Glass (b) Quartz
  - (c) Rubber (d) Metal
- **45.** In suspended type moving coil galvanometer, quartz suspension is used because
  - (a) It is good conductor of electricity
  - (b) Elastic after effects are negligible
  - (c) Young's modulus is greater
  - $(d) \quad \text{There is no elastic limit} \\$
- **46.** A force of 200 N is applied at one end of a wire of length 2 m and having area of cross-section  $10^{-2} cm^2$ . The other end of the wire is rigidly fixed. If coefficient of linear expansion of the wire  $\alpha = 8 \times 10^{-6} / {}^{\circ}C$  and Young's modulus  $Y = 2.2 \times 10^{11} N / m^2$  and its temperature is increased by 5° C, then the increase in the tension of the wire will be

(a)	4.2 N	(b)	4.4 N
(c)	2.4 N	(d)	8.8 N

- 47. When compared with solids and liquids, the gases have
  - (a) Minimum volume elasticity
  - (b) Maximum volume elasticity
  - (c) Maximum Young's modulus
  - (d) Maximum modulus of rigidity
- **48.** The length of a wire is 1.0 *m* and the area of cross-section is  $1.0 \times 10^{-2} \text{ cm}^2$ . If the work done for increase in length by 0.2 *cm* is 0.4 *joule*, then Young's modulus of the material of the wire is

(a) 
$$2.0 \times 10^{10} N/m^2$$
 (b)  $4 \times 10^{10} N/m^2$ 

- (c)  $2.0 \times 10^{11} N/m^2$  (d)  $2 \times 10^{10} N/m^2$
- **49.** The quality of the material which opposes the change in shape, volume or length is called
  - (a) Intermolecular repulsion
  - (b) Intermolecular behaviour
  - (c) Viscosity
  - (d) Elasticity

50.	For silver, Young's modulus is	$7.25 \times 10^{10} \ N/m^2$ and Bulk			
	modulus is $11 \times 10^{10} N / m^2$ . Its	Poisson's ratio will be			
	(a) – 1	(b) 0.5			
	(c) 0.39	(d) 0.25			
51.	The longitudinal strain is only poss	ible in			
0	(a) Gases	b) Fluids			
	(c) Solids	(d) Liquids			
52.	If the density of the material increa	uses, the value of Young's modulus			
	(a) Increases	ises, the value of roung's modulus			
	(h) Decreases				
	(c) First increases then decreases				
	(d) First decreases then increases				
	(u) Thist decreases then increases	4 2			
53.	Young's modulus of rubber is	$10^4 N/m^2$ and area of cross-			
	section is $2 cm^2$ . If force of 2	$ imes 10^5$ dynes is applied along its			
	length, then its initial length / beco	omes			
	(a) 3 <i>L</i>	(b) 4 <i>L</i>			
	(c) 2 <i>L</i>	(d) None of the above			
54.	The elastic limit for a gas				
	(a) Exists				
	(b) Exists only at absolute zero				
	(c) Exists for a perfect gas				
55	(d) Does not exist If Young's modulus for a material	is zero, then the state of material			
55.	should be	is zero, then the state of material			
	(a) Solid	(b) Solid but powder			
	(c) Gas	(d) None of the above			
56.	Liquids have no Poisson's ratio, bec	ause			
	(a) It has no definite shape				
	(b) It has greater volume				
	(c) It has lesser density than solid	I			
~-	(d) None of the above				
57.	stretching the other end of the wi	re with a force <i>F</i> , the increase in			
	its length is $l$ if another wire of same material but of length 2L and				

(c) $\frac{l}{2}$	(d)	$\frac{l}{4}$
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will be

(a) /

**CLICK HERE** 

**58.** In steel, the Young's modulus and the strain at the breaking point are  $2 \times 10^{11} Nm^{-2}$  and 0.15 respectively. The stress at the breaking point for steel is therefore

radius 2r is stretched with a force of 2F, the increase in its length

# [MP PET 1990; MP PMT 1992; DPMT 2001]

- (a)  $1.33 \times 10^{11} Nm^{-2}$  (b)  $1.33 \times 10^{12} Nm^{-2}$ (c)  $7.5 \times 10^{-13} Nm^{-2}$  (d)  $3 \times 10^{10} Nm^{-2}$
- 59. Which of the following statements is correct [MP PET 1992]
  (a) Hooke's law is applicable only within elastic limit

(d) 0.6 cm

- (b) The adiabatic and isothermal elastic constants of a gas are equal
- (c) Young's modulus is dimensionless
- $(d) \quad \text{Stress multiplied by strain is equal to the stored energy} \\$
- **60.** The force required to stretch a steel wire of  $1 cm^2$  cross-section to

1.1 times its length would be  $(Y = 2 \times 10^{11} Nm^{-2})$ 

[MP PET 1992]

- (a)  $2 \times 10^6 N$  (b)  $2 \times 10^3 N$ (c)  $2 \times 10^{-6} N$  (d)  $2 \times 10^{-7} N$
- Which one of the following substances possesses the highest elasticity [MP PMT 1992;
   RPMT 1999; RPET 2000; MH CET (Med.) 2001]
  - (a) Rubber(b) Glass(c) Steel(d) Copper
- 62. Which one of the following quantities does not have the unit of force per unit area [MP PMT 1992]
  - (a) Stress(b) Strain
  - (c) Young's modulus of elasticity
  - (d) Pressure
- **63.** A copper wire and a steel wire of the same diameter and length are connected end to end and a force is applied, which stretches their combined length by 1 cm. The two wires will have
  - (a) Different stresses and strains
  - (b) The same stress and strain
  - (c) The same strain but different stresses
  - (d) The same stress but different strains
- **64.** A steel ring of radius r and cross-section area 'A' is fitted on to a wooden disc of radius R(R > r). If Young's modulus be E, then the force with which the steel ring is expanded is

#### [EAMCET 1986]

74.

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(a) 
$$AE\frac{R}{r}$$
 (b)  $AE\left(\frac{R-r}{r}\right)$   
(c)  $\frac{E}{A}\left(\frac{R-r}{A}\right)$  (d)  $\frac{Er}{AR}$ 

**65.** 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 half the radius of cross-section. The elongation of the wire in *mm* will be

66. Two wires of the same material have lengths in the ratio 1 : 2 and

their radii are in the ratio  $1:\sqrt{2}$ . If they are stretched by applying equal forces, the increase in their lengths will be in the ratio

(a)	$2:\sqrt{2}$	(b) $\sqrt{2}:2$	
(c)	1:1	(d) 1:2	

- 67. When a weight of 10 kg is suspended from a copper wire of length 3 *metres* and diameter 0.4 *mm*, its length increases by 2.4 *cm*. If the diameter of the wire is doubled, then the extension in its length will be [MP PMT 1994]
  - (a) 9.6 *cm* (b) 4.8 *cm*

ст

**68.** A force of  $10^3$  *newton* stretches the length of a hanging wire by 1 *millimetre*. The force required to stretch a wire of same material and length but having four times the diameter by 1 *millimetre* is

(a) 
$$4 \times 10^{3} N$$
 (b)  $16 \times 10^{3} N$   
(c)  $\frac{1}{4} \times 10^{3} N$  (d)  $\frac{1}{16} \times 10^{3} N$ 

69. Two wires 'A' and 'B of the same material have radii in the ratio 2 :
 1 and lengths in the ratio 4 : 1. The ratio of the normal forces required to produce the same change in the lengths of these two wires is

**70.** Density of rubber is *d*. A thick rubber cord of length *L* and crosssection area *A* undergoes elongation under its own weight on suspending it. This elongation is proportional to

(a) 
$$dL$$
 (b)  $Ad/L$ 

- (c)  $Ad/L^2$  (d)  $dL^2$
- **71.** The ratio of two specific heats of gas  $C_p / C_v$  for argon is 1.6 and for hydrogen is 1.4. Adiabatic elasticity of argon at pressure *P* is *E*. Adiabatic elasticity of hydrogen will also be equal to *E* at the pressure

0

(a) 
$$P$$
 [MP PMT 1992] (b)  $\frac{3}{7}P$ 

(c) 
$$\frac{7}{8}P$$
 (d) 1.4 P

**72.** The relation between  $\gamma$ ,  $\eta$  and *K* for a elastic material is

(a) 
$$\frac{1}{\eta} = \frac{1}{3\gamma} + \frac{1}{9K}$$
 (b)  $\frac{1}{K} = \frac{1}{3\gamma} + \frac{1}{9\eta}$   
(c)  $\frac{1}{\gamma} = \frac{1}{3K} + \frac{1}{9\eta}$  (d)  $\frac{1}{\gamma} = \frac{1}{3\eta} + \frac{1}{9K}$ 

73. A fixed volume of iron is drawn into a wire of length *L*. The extension *x* produced in this wire by a constant force *F* is proportional to [MP PMT 1999]

(a) 
$$\frac{1}{L^2}$$
 (b)  $\frac{1}{L}$   
(c)  $L^2$  (d) L

A wire of cross-sectional area  $3 mm^2$  is first stretched between two fixed points at a temperature of 20°C. Determine the tension when the temperature falls to 10°C. Coefficient of linear expansion

$$\alpha = 10^{-5} \circ C^{-1}$$
 and  $Y = 2 \times 10^{11} N / m^2$   
(a) 20 N (b) 30 N

(c) 
$$60^{MP} = 1994$$
 (d) 120 N

**75.** To keep constant time, watches are fitted with balance wheel made of [EAMCET 1994]

- (a) Invar (b) Stainless steel
- (c) Tungsten (d) Platinum
- 76. A wire is stretched by 0.01 *m* by a certain force *F*. Another wire of same material whose diameter and length are double to the original wire is stretched by the same force. Then its elongation will be [EAMCET (Engg.)

	(a) 0.005 <i>m</i>	(b)	0.01 <i>m</i>					[AFMC 1999]
	(c) 0.02 <i>m</i>	(d)	0.002 <i>m</i>		(a) $19.6 \times 10^{-10}$	$^{10} N/m^2$	(b)	$19.6 \times 10^{15} N/m^2$
7.	The possible value of Poisson'	s ratio is			$() 10 < 10^{\circ}$	18	(1)	$10 < 10^{20} N / 2$
	(2) 1	(b)	[EAMCET (Med.) 1995]		(c) $19.6 \times 10^{-10}$	$N/m^2$	(d)	$19.6 \times 10^{-5} N/m^{-1}$
	(a) $(c) = 0.8$	(d)	0.9	86.	In solids, inter-at	tomic forces are		[DCE 1999]
2	The coefficient of linear even	(u)	brass and steel are α and		(a) Totally repu	alsive		
	a lf and talks a brass and a	f lamath	<i>l</i> and steel are $\alpha_1$ and <i>l</i>		(b) Totally attra	active		
	$\alpha_2$ . If we take a brass rod o		$l_1$ and steel rod or length $l_2$		(c) Combinatio	on of (a) and (b)		
	at 0°C, their difference in leng	gtn $(l_2 - $	$(t_1)$ will remain the same at a		(d) None of the	ese		
			12 12	87.	A force <i>F</i> is appl	lied on the wire	of rad	lius $r$ and length $L$ and change
	(a) $\alpha_1 l_2 = \alpha_2 l_1$	(b)	$\alpha_1 l_2^2 = \alpha_2 l_1^2$		of the same mat	wire is <i>l</i> . If the	same 2 <i>r</i> ar	d length 2 <i>L</i> , Then the change
	(c) $\alpha_1^2 l_1 = \alpha_2^2 l_2$	(d)	$\alpha_1 l_1 = \alpha_2 l_2$		in length of the	other wire is		
).	A rod is fixed between two p	points at	20° <i>C</i> . The coefficient of linear				<i>(</i> <b>1</b> )	[RPMT 1999]
	expansion of material of r	od is 1	$.1 \times 10^{-5}$ / °C and Young's		(a) /		(b)	2/
	modulus is $1.2 \times 10^{11} N/n$	ı. Find t	he stress developed in the rod		(c) //2		(d)	4/
	if temperature of rod become	s 10° <i>C</i>		88.	The modulus of	elasticity is dime	ension	ally equivalent to
			[RPET 1997]		( ) · · · · · · · · · · · · · · · · · ·			[MH CET (Med.) 1999]
	(a) $1.32 \times 10^7 N/m^2$	(b)	$1.10 \times 10^{15} N/m^2$		(a) Surface ten	sion	(b)	Stress
	(c) $1.32 \times 10^8 \ N/m^2$	(d)	$1.10 \times 10^{6} N/m^{2}$		(c) Strain	_	(d)	None of these
).	The extension of a wire by	the appli	cation of load is 3 <i>mm</i> . The	89.	Under elastic lim	nit the stress is		
	extension in a wire of the s	ame mat	erial and length but half the					[MH CET 1999; KCET 1999]
	radius by the same load is		[CMEET Bihar 1995]		(a) Inversely, p	roportional to st	rain	
	(a) 12 mm	(b)	0.75 mm		(b) Directly pro	oportional to stra	ain	
	(c) 15 <i>mm</i>	(d)	6 <i>mm</i>		(c) Square root	t of strain		
		$5 \times 10^{3}$	M/m <sup>2</sup> and Voung's modulus					
•	A rubber pipe of density 1	.5 ~ 10	ivim and roung's modulus		(d) Independen	it of strain		
•	A rubber pipe of density 1 $5 \times 10^6 N/m^2$ is suspende	ed from t	he roof. The length of the pipe	90.	(d) Independen A steel wire of li	nt or strain m long and 1 <i>m</i>	$m^2$ c	ross section area is hang from
	A rubber pipe of density 1 $5 \times 10^6 N/m^2$ is suspende is 8 <i>m</i> . What will be the chan	ed from t nge in leng	he roof. The length of the pipe gth due to its own weight	90.	(d) Independen A steel wire of h rigid en <b>(RPW) h99</b>	n long and 1 <i>m</i> Preight of 1 <i>kg</i> is	m <sup>2</sup> c	ross section area is hang from from it then change in length
ι.	A rubber pipe of density 1 $5 \times 10^{6} N / m^{2}$ is suspende is 8 <i>m</i> . What will be the chan (a) 9.6 <i>m</i>	ed from tl oge in leng (b)	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$	90.	(d) Independen A steel wire of h rigid en <b>RPWh99</b> will be (given <i>Y</i>	m long and $1 m$ Greight of 1kg is $f = 2 \times 10^{11} N / 10^{11}$	$m^2$ c hung $m^2$ )	cross section area is hang from from it then change in length
	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 <i>m</i> . What will be the chan (a) 9.6 <i>m</i> (c) 19.2 × 10 <sup>-2</sup> <i>m</i>	ed from the oge in leng (b)	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$	90.	(d) Independen A steel wire of h rigid er <b>孫昭和99</b> will be (given <i>Y</i>	m long and $1 m$ eight of $1 kg$ is $f = 2 \times 10^{11} N / 10^{11} N$	$m^2$ c hung $m^2$ )	ross section area is hang from from it then change in length [ <b>RPMT 2000</b> ]
	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$	ed from tl oge in leng (b) (d)	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$	90.	(d) Independen A steel wire of h rigid er【兆印初初99 will be (given Y (a) 0.5 mm	m long and $1 m$ Wreight of $1 kg$ is $f = 2 \times 10^{11} N /$	$m^2$ c hung $m^2$ ) (b)	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 <i>m</i> . What will be the chan (a) 9.6 <i>m</i> (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire	ed from t ed from t ge in leng (b) (d) um exten	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90.	(d) Independen A steel wire of h rigid er <b>(APW) 1499</b> will be (given <i>Y</i> (a) 0.5 <i>mm</i> (c) 0.05 <i>mm</i>	m long and $1 m$ Weight of $1 kg$ is $f = 2 \times 10^{11} N /$	$m^2$ c hung $m^2$ ) (b) (d)	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm
ı. 2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 \ cm, d = 0.05 \ mm$	ed from the ed fro	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90. 91.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid er (APW) 1499</li> <li>will be (given Y</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>A load W production</li> </ul>	m long and $1 m$ weight of $1 kg$ is $f = 2 \times 10^{11} N / 10^{11}$ uces an extension	$m^2$ c hung $m^2$ ) (b) (d) on of	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r.
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 \text{ cm}, d = 0.05 \text{ mm}$ (b) L = 200 cm, $d = 0.02 \text{ mm}$	ed from tl ed from tl (b) (d) um exten m	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90. 91.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid en APD have been and the steel wire of hrighten and the steel wire of her steel with the steel wire of the steel wire been and the steel wire</li></ul>	m long and $1 m$ weight of $1 kg$ is $= 2 \times 10^{11} N /$ uces an extension is made $4 W$ an	m <sup>2</sup> c hung m <sup>2</sup> ) (b) (d) on of d radi	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$	ed from tl gge in leng (b) (d) um exten m n n	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90. 91.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid er(現代)</li> <li>will be (given Y</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>A load W produced the load remaining same,</li> </ul>	m long and $1 m$ where $M = 2 \times 10^{11} N / 10^{11} M$ where $M = 2 \times 10^{11} N / 10^{11} M$ where $M = 10^{11} M$ m $M = 10^{11} M$ where $M = 10^{11} M$ where $M = 10^{11} M$ m $M = 10^{11} M$	m <sup>2</sup> c hung m <sup>2</sup> ) (b) (d) on of d radi ill bec	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$ (d) $L = 400 cm, d = 0.01 mm$	ed from the edge (b) (d) un extended of the edge of th	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90. 91.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid er (APW) (APW)</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>A load W produce</li> <li>Now if the load remaining same,</li> </ul>	m long and $1 m$ wheight of $1 kg$ is $f = 2 \times 10^{11} N / 10^{11} N$ uces an extension is made $4 W$ and the extension w	$m^2$ c hung $m^2$ ) (b) (d) on of d radi ill bec	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome [RPET 2000]
3.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$ (d) $L = 400 cm, d = 0.01 mm$ If a spring is extended to lenge	ed from tl gge in leng (b) (d) um exten m m m m	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90. 91.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid en APOTAGE</li> <li>will be (given Y</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>A load W produce</li> <li>Now if the load remaining same,</li> <li>(a) 4 mm</li> <li>(c) 1.0 mm</li> </ul>	m long and $1 m$ $\mathbf{G}$ leight of $1 kg$ is $\mathbf{f} = 2 \times 10^{11} N / 10^{11}$ uces an extension is made $4 W$ and the extension w [CPMT 1997]	$m^2$ c hung $m^2$ ) (b) (d) on of d radi ill bec (b)	rross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome [RPET 2000] 16 mm
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$ (d) $L = 400 cm, d = 0.01 mm$ If a spring is extended to lenge (a) $F = kl$	ed from tl gge in leng (b) (d) um exten m n r, th /, ther (b)	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90. 91.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid er (APC) (APC)</li> <li>will be (given Y)</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>A load W produces</li> <li>Now if the load remaining same,</li> <li>(a) 4 mm</li> <li>(c) 1 mm</li> </ul>	m long and 1 m weight of 1kg is $f = 2 \times 10^{11} N /$ uces an extension is made 4 W an the extension w [CPMT 1997]	$m^2$ c hung $m^2$ ) (b) (d) on of d radi ill bec (b) (d)	rross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome [RPET 2000] 16 mm 0.25 mm
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$ (d) $L = 400 cm, d = 0.01 mm$ If a spring is extended to leng (a) $F = kl$	ed from the sed fr	the roof. The length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997]	90. 91. 92.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid erl Philon (1990)</li> <li>will be (given Y)</li> <li>(a) 0.5 mm</li> <li>(b) 0.05 mm</li> <li>(c) 0.05 mm</li> <li>(c) 0.05 mm</li> <li>(d) 0.5 mm</li> <li>(d) 0.5 mm</li> <li>(e) 0.05 mm</li> <li>(f) 0.05 mm</li> <li>(f) 0.05 mm</li> <li>(g) 0.0</li></ul>	m long and $1 m$ <b>G</b> /eight of 1 <i>kg</i> is $f = 2 \times 10^{11} N /$ uces an extension is made 4 <i>W</i> and the extension w [CPMT 1997] mg 's modulus o	m <sup>2</sup> c hung m <sup>2</sup> ) (b) (d) on of d radi ill bec (b) (d) f elast	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome [RPET 2000] 16 mm 0.25 mm icity are
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 \text{ cm}, d = 0.05 \text{ rm}$ (b) $L = 200 \text{ cm}, d = 0.02 \text{ rm}$ (c) $L = 300 \text{ cm}, d = 0.03 \text{ rm}$ (d) $L = 400 \text{ cm}, d = 0.01 \text{ rm}$ If a spring is extended to leng (a) $F = kl$	ed from tl gge in leng (b) (d) um exten m n m n th /, ther (b)	The root of the length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997] according to Hook's law $F = \frac{k}{l}$ $F = \frac{k^2}{l}$	90. 91. 92.	<ul> <li>(d) Independen</li> <li>A steel wire of hrigid en APW hay will be (given Y</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>A load W produces a load W produces a load W produces a load with the load remaining same,</li> <li>(a) 4 mm</li> <li>(c) 1 mm</li> <li>The units of You</li> </ul>	m long and $1 m$ $\mathbf{G}$ leight of $1 kg$ is $\mathbf{f} = 2 \times 10^{11} N / 10^{11}$ uces an extension is made $4 W$ and the extension w [CPMT 1997] ang 's modulus o	m <sup>2</sup> c hung m <sup>2</sup> ) (b) (d) on of d radi ill bec (b) (d) f elast	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things one [RPET 2000] 16 mm 0.25 mm icity are [CPMT 2000; KCET 2000]
2.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 m. What will be the chan (a) 9.6 m (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$ (d) $L = 400 cm, d = 0.01 mm$ If a spring is extended to lenge (a) $F = kl$ (c) $F = k^{2}l$	ed from tl gge in leng (b) (d) um exten m n n th /, ther (b) (d)	The root of the length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997] according to Hook's law $F = \frac{k}{l}$ $F = \frac{k^2}{l}$	90. 91. 92.	<ul> <li>(d) Independent</li> <li>A steel wire of hrigid er (APC) (APC) (APC)</li> <li>(a) 0.5 mm</li> <li>(b) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>(c) 0.05 mm</li> <li>(c) 0.05 mm</li> <li>(d) 4 mm</li> <li>(c) 1 mm</li> <li>(c) 1 mm</li> <li>(c) 1 mm</li> <li>(c) 1 mm</li> </ul>	m long and $1 m$ weight of $1 kg$ is $= 2 \times 10^{11} N /$ uces an extension is made $4 W$ and the extension w [CPMT 1997] ang 's modulus of	m <sup>2</sup> c hung m <sup>2</sup> ) (b) (d) on of d radi ill bec (b) (d) f elast	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome [RPET 2000] 16 mm 0.25 mm icity are [CPMT 2000; KCET 2000] <i>N-m</i>
2. 3.	A rubber pipe of density 1 $5 \times 10^6 N/m^2$ is suspende is 8 <i>m</i> . What will be the chan (a) 9.6 <i>m</i> (c) 19.2 × 10 <sup>-2</sup> <i>m</i> In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$ (d) $L = 400 cm, d = 0.01 mm$ If a spring is extended to leng (a) $F = kl$ (c) $F = k^2 l$ Which of the following affects	ed from ti ge in leng (b) (d) um exten m n n th /, ther (b) (d) s the elast	The root of a substance (ATMC 1997) and root of a substance	90. 91. 92.	<ul> <li>(d) Independent</li> <li>A steel wire of hrigid erl POTAGE</li> <li>will be (given Y</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>(c) 0.05 mm</li> <li>A load W produce</li> <li>Now if the load remaining same,</li> <li>(a) 4 mm</li> <li>(c) 1 mm</li> <li>The units of You</li> <li>(a) Nm<sup>-1</sup></li> <li>(c) Nm<sup>-2</sup></li> </ul>	m long and $1 m$ weight of $1kg$ is $f = 2 \times 10^{11} N /$ uces an extension is made $4 W$ an the extension w [CPMT 1997] ung 's modulus o	<ul> <li>m<sup>2</sup> c</li> <li>hung</li> <li>m<sup>2</sup>)</li> <li>(b)</li> <li>(d)</li> <li>on of</li> <li>d radii</li> <li>ill bec</li> <li>(b)</li> <li>(d)</li> <li>f elast</li> <li>(b)</li> <li>(d)</li> </ul>	ross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome [RPET 2000] 16 mm 0.25 mm icity are [CPMT 2000; KCET 2000] N-m N-m
ı. 2. 3.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 <i>m</i> . What will be the chan (a) 9.6 <i>m</i> (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 cm, d = 0.05 mm$ (b) $L = 200 cm, d = 0.02 mm$ (c) $L = 300 cm, d = 0.03 mm$ (d) $L = 400 cm, d = 0.01 mm$ If a spring is extended to leng (a) $F = kl$ (c) $F = k^{2}l$ Which of the following affects (a) Hammering and annealing	ed from ti gge in leng (b) (d) um exten m m m r (b) (d) s the elast	The root of the length of the pipe gth due to its own weight $9.6 \times 10^{-3} m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997] according to Hook's law $F = \frac{k}{l}$ $F = \frac{k^2}{l}$ ticity of a substance [AIIMS 1999]	90. 91. 92.	<ul> <li>(d) Independent</li> <li>A steel wire of hrigid erf. POIN99</li> <li>will be (given Y</li> <li>(a) 0.5 mm</li> <li>(c) 0.05 mm</li> <li>A load W produce</li> <li>Now if the load remaining same,</li> <li>(a) 4 mm</li> <li>(c) 1 mm</li> <li>The units of You</li> <li>(a) Nm<sup>-1</sup></li> <li>(c) Nm<sup>-2</sup></li> <li>Two similar wire</li> </ul>	m long and $1 m$ weight of $1kg$ is $= 2 \times 10^{11} N /$ uces an extension is made $4 W$ and the extension w [CPMT 1997] mg 's modulus of es under the sa	m <sup>2</sup> c hung m <sup>2</sup> ) (b) (d) on of d radi ill bec (b) (d) f elast (b) (d) me lo	rross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1 mm in a thread of radius r. us is made 2r all other things ome [RPET 2000] 16 mm 0.25 mm icity are [CPMT 2000; KCET 2000] N-m N-m N-m <sup>2</sup> ad yield elongation of 0.1 mm
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2. }.	A rubber pipe of density 1 $5 \times 10^{6} N/m^{2}$ is suspende is 8 <i>m</i> . What will be the chan (a) 9.6 <i>m</i> (c) $19.2 \times 10^{-2} m$ In which case there is maxim is applied on each wire (a) $L = 500 \ cm, d = 0.05 \ mm$ (b) $L = 200 \ cm, d = 0.02 \ mm$ (c) $L = 300 \ cm, d = 0.03 \ mm$ (d) $L = 400 \ cm, d = 0.01 \ mm$ If a spring is extended to leng (a) $F = kl$ (c) $F = k^{2}l$ Which of the following affects (a) Hammering and annealin (b) Change in temperature (c) Impurity in substance (d) All of these	ed from tl ge in leng (b) (d) um exten m n r (b) (d) (d) s the elast	The root of the length of the pipe gth due to its own weight $9.6 \times 10^3 m$ $9.6 \times 10^{-2} m$ sion in the wire, if same force [AFMC 1997] according to Hook's law $F = \frac{k}{l}$ $F = \frac{k^2}{l}$ dicity of a substance [AIIMS 1999]	90. 91. 92.	(d) Independent A steel wire of h rigid erl <b>APWD1499</b> will be (given Y (a) 0.5 mm (c) 0.05 mm A load W produ Now if the load remaining same, (a) 4 mm (c) 1 mm The units of You (a) $Nm^{-1}$ (c) $Nm^{-2}$ Two similar wire and 0.05 mm re- wire is $4mm^2$ , (a) $6mm^2$	m long and $1 m$ <b>G</b> /eight of 1 <i>kg</i> is $i = 2 \times 10^{11} N /$ uces an extensic is made 4 <i>W</i> an the extension w [CPMT 1997] ang 's modulus of es under the sa espectively. If th then the area of	m <sup>2</sup> c hung m <sup>2</sup> ) (b) (d) on of d radi ill bec (b) (d) f elast (b) (d) me lo e area f cross (b)	rross section area is hang from from it then change in length [RPMT 2000] 0.25 mm 5 mm 1mm in a thread of radius r. us is made 2r all other things ome [RPET 2000] 16 mm 0.25 mm icity are [CPMT 2000; KCET 2000] N-m N-m <sup>2</sup> ad yield elongation of 0.1 mm of cross- section of the first s section of the second wire is[CP/ 8mm <sup>2</sup>

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**Elasticity** 463

94.	A 5 <i>m</i> long aluminium wire ( $Y = 7 \times 10^{10} N/m^2$ ) of diameter 3 <i>mm</i>
	supports a 40 kg mass. In order to have the same elongation in a
	copper wire $(Y = 12 \times 10^{10} N / m^2)$ of the same length under the
	same weight, the diameter should now be, in mm.

(4)		(0)	
(c)	2.5	(d)	5.0

**95.** How much force is required to produce an increase of 0.2% in the length of a brass wire of diameter 0.6 *mm* 

#### [MP PMT 2000]

(Young's modulus for brass =  $0.9 \times 10^{11} N / m^2$ )

- (a) Nearly 17 N (b) Nearly 34 N
- (c) Nearly 51 N (d) Nearly 68 N
- **96.** On applying a stress of  $20 \times 10^8$  N/m<sup>2</sup> the length of a perfectly elastic wire is doubled. Its Young's modulus will be

[MP PET 2000]

- (a)  $40 \times 10^8 N / m^2$  (b)  $20 \times 10^8 N / m^2$ (c)  $10 \times 10^8 N / m^2$  (d)  $5 \times 10^8 N / m^2$
- **97.** When a uniform wire of radius *r* is stretched by a 2kg weight, the increase in its length is 2.00 *mm*. If the radius of the wire is r/2 and other conditions remain the same, the increase in its length is **[EAMCET (Engg.) 2000**] 1.

(a)	2.00 mm	(b)	4.00 <i>mm</i>
(c)	6.00 <i>mm</i>	(d)	8.00 mm

**98.** The length of an elastic string is *a metre* when the longitudinal tension is 4 *N* and *b metre* when the longitudinal tension is 5 *N*. The length of the string in *metre* when the longitudinal tension is 9 *N* is [EAMCET 2001]

(a)	a-b	(b)	5b-4a
(c)	$2b - \frac{1}{4}a$	(d)	4 <i>a</i> -3 <i>b</i>

99. Stress to strain ratio is equivalent to [RPET 2001]

- (a) Modulus of elasticity
- (b) Poission's Ratio
- (c) Reyhold number
- (d) Fund number
- **100.** Which is correct relation
  - (a)  $Y < \sigma$  (b)  $Y > \sigma$
  - (c)  $Y = \sigma$  (d)  $\sigma = +1$
- 101. If the interatomic spacing in a steel wire is 3.0Å and  $Y_{steel} = 20 \times 10^{10} N / m^2$  then force constant is

[RPET 2001]

[RPET 2001]

(a) 
$$6 \times 10^{-2} N / Å$$
 (b)  $6 \times 10^{-9} N / Å$ 

(c) 
$$4 \times 10^{-5} N/\AA$$
 (d)  $6 \times 10^{-5} N/\AA$ 

102. A copper wire of length 4.0*m* and area of cross-section  $1.2 \text{ cm}^2$  is stretched with a force of  $4.8 \times 10^3$  N. If Young's modulus for copper is  $1.2 \times 10^{11} N / m^2$ , the increase in the length of the wire will be [MP PET 2001]

- (a) 1.33 mm (b) 1.33 cm (c) 2.66 mm (d) 2.66 cm
- **103.** A metal bar of length L and area of cross-section A is clamped between two rigid supports. For the material of the rod, its Young's modulus is Y and coefficient of linear expansion is  $\alpha$ . If the temperature of the rod is increased by  $\Delta t^{o}C$ , the force exerted by the rod on the supports is

(a)  $Y A L \Delta t$  (b)  $Y A \alpha \Delta t$ 

(c) 
$$\frac{YL \alpha \Delta t}{A}$$
 (d)  $Y \alpha A L \Delta t$ 

- 104.
   According to Hook's law of elasticity, if stress is increased, the ratio of stress to strain
   [KCET 2000 AllMS 2001]
  - (a) Increases (b) Decreases
  - (c) Becomes zero (d) Remains constant
- 105. A pan with set of weights is attached with a light spring. When disturbed, the mass-spring system oscillates with a time period of 0.6 s. When some additional weights are added then time period is 0.7 s. The extension caused by the additional weights is approximately given by

[UPSEAT 2002]

[MP PMT 2001]

**106.** A uniform plank of Young's modulus *Y* is moved over a smooth horizontal surface by a constant horizontal force *F*. The area of cross section of the plank is *A*. The compressive strain on the plank in the direction of the force is

[Kerala PET 2002]

[AIIMS 2002]

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(a) 
$$F / AY$$
 (b)  $2F / AY$   
(c)  $\frac{1}{2}(F / AY)$  (d)  $3F / AY$ 

**107.** The mean distance between the atoms of iron is  $3 \times 10^{-10} m$  and interatomic force constant for iron is 7 N / m The Young's modulus of elasticity for iron is [JIPMER 2002]

(a) $2.33 \times 10^5 N / m^2$	(b)	$23.3 \times 10^{10}$	$N/m^2$
--------------------------------	-----	-----------------------	---------

(c)  $233 \times 10^{10} N/m^2$  (d)  $2.33 \times 10^{10} N/m^2$ 

**108.** Two wires *A* and *B* are of same materials. Their lengths are in the ratio 1 : 2 and diameters are in the ratio 2 : 1 when stretched by force  $F_A$  and  $F_B$  respectively they get equal increase in their lengths. Then the ratio  $F_A / F_B$  should be

[Orissa JEE 2002] (a) 1:2 (b) 1:1 (c) 2:1 (d) 8:1

**109.** The breaking stress of a wire depends upon

- (a) Length of the wire
- (b) Radius of the wire

**CLICK HERE** 

- (c) Material of the wire
- $(d) \quad \text{Shape of the cross section} \\$

110.	The area of cross section of	f a steel wire $(Y = 2.0 \times 10^{11} N/m^2)$ is		substance which will break un vertically, is	nder its own weight [DPMT 2004]	when suspended
	$0.1\ cm^2$ . The force require	ed to double its length will be		(a) 66.6 m 2002]	(b) 60.0 <i>m</i>	
	(a) $2 \times 10^{12} N$	(b) $2 \times 10^{11} N$		(c) 33.3 <i>m</i>	(d) 30.0 <i>m</i>	
	(c) $2 \times 10^{10} N$	(d) $2 \times 10^6 N$	120.	A rubber cord 10 <i>m</i> long is su stretch under its own weight $5 \times 10 N/m$ g = 10 m/g)	Ispended vertically. H (Density of rubber is	ow much does it 1500 <i>kg/m, Y</i> =
1.	A rubber cord catapult has	cross-sectional area $25mm^2$ and initial		$5 \times 10^{-10/11}$ , g = 10 m/s	(b) 7.5×10; m	
	length of rubber cord is 10	0 cm. It is stretched to $5 cm$ . and then		(a) $13 \times 10^{-111}$	(d) $7.5 \times 10^{-1} m$	
	released to project a	missile of mass $5 gm$ . Taking	121	The value of Poisson's ratio lies	(u) 25×10 m	
	$Y_{nubber} = 5 \times 10^8  N / m^2$	velocity of projected missile is	121.		AllMS 1985: MP PET	1986: DPMT 2002]
		[CPMT 2002]		1	3 1	
	(a) $20  ms^{-1}$	(b) $100  ms^{-1}$		(a) $-1$ to $\frac{1}{2}$	(b) $-\frac{3}{4}$ to $-\frac{3}{2}$	2
	(c) $250  ms^{-1}$	(d) $200  ms^{-1}$		(c) $-\frac{1}{2}$ to 1	(d) 1 to 2	
2.	According to Hook's law for	rce is proportional to	122.	The Poisson's ratio cannot have	e the value	[EAMCET 1989]
		[RPET 2003]		(a) 0.7	(b) 0.2	
	(a) $\frac{1}{2}$	(b) $\frac{1}{1}$		(c) 0.1	(d) 0.5	
	$\begin{pmatrix} a \end{pmatrix} \xrightarrow{-} x$	(b) $\frac{x^2}{x^2}$	123.	There is no change in the vo length on stretching. The Pois	olume of a wire due son's ratio of the mat	to change in its cerial of the wire
	(c) <i>x</i>	(d) $x^-$		is	[MH CET 200	4]
3.	In the Young's experiment	, It length of wire and radius both are		(a) $+ 0.50$	(b) $-0.50$	
	doubled then the value of 1	( <b>KPEf 2003</b> )		(c) 0.25	(d) - 0.25	1 6
	(a) 2 times	(b) 4 times	124.	A material has Poisson's ratio	0.50. If a uniform ro	od of it suffers a
	(c) Remains same	(d) Half		longitudinal strain of $2 \times 10$	) <sup>°</sup> , then the perce	IEAMCET 1087
4.	Minimum and maximum value	es of Poisson's ratio for a metal lies between		[Orissa JEE 2003]	(b) 04	
	(a) $-\infty$ to $+\infty$	(b) 0 to 1		(c) $0.3$	(d) Zero	
	(c) $-\infty$ to 1	(d) 0 to 0.5	125.	Four identical rods are stretch	ed by same force. Ma	ximum extension
5.	A wire of diameter 1 <i>mm</i> be wire, of same material as th breaks under a tension of	reaks under a tension of 1000 <i>N</i> . Another at of the first one, but of diameter 2 <i>mm</i>		(a) $L = 10 cm, D = 1 mm$	(b) $L = 100  cm$	D = 2mm
		[Orissa ]EE 2003]		(c) $L = 200  cm, D = 3mm$	(d) $L = 300  cn$	n, D = 4 mm
	(a) 500 <i>N</i>	(b) 1000 N	_	Dulla M		
	(c) 10000 N	(d) 4000 N		Buik M	odulus	
6.	Young's modulus of perfect	v rigid body material is	1.	The isothermal elasticity of a g	as is equal to	
	0	[KCET 2003]		The locale mare decising of a g	CPMT 19	81: MP PMT 2004]
	(a) Zero	(b) Infinity		(a) Density	(b) Volume	
	(c) $1 \times 10^{10} N / m^2$	(d) $10 \times 10^{10} N/m^2$		(c) Pressure	(d) Specific heat	
7.	A wire of length 2 <i>m</i> is ma	de from $10  \text{cm}^3$ of copper. A force <i>F</i> is	2.	The adiabatic elasticity of a gas	s is equal to	[CPMT 1982]
	applied so that its length in	creases by 2 <i>mm.</i> Another wire of length		(a) $\gamma \times \text{density}$	(b) $\gamma \times \text{volume}$	
	8 <i>m</i> is made from the sat applied to it, its length will	me volume of copper. If the force $F$ is increase by	<i>ا</i> ا م	(c) $\gamma \times \text{pressure}$ <b>MP PET 2003</b> ] The specific best at constant =	(d) $\gamma \times \text{specific}$	heat
	(a) 0.8 <i>cm</i>	(b) 1.6 <i>cm</i>	3.	ideal gas are $C$ and $C$	and its adiabatic	and isothermal
	(c) 2.4 <i>cm</i>	(d) 3.2 <i>cm</i>		abstigition are $F \rightarrow F$	mastively The	f F + F = F
18.	A wire of cross section 4 <i>w</i> weight. How far (length) w	<i>mm</i> is stretched by 0.1 <i>mm</i> by a certain vill be wire of same material and length nder the action of same force		(a) $C_{\mu} / C_{\rho}$ [Kerala PMT 2004]	(b) $C_p / C_v$	Si $E_{\phi}$ to $E_{ heta}$ is[N
	(a) 0.05 <i>mm</i>	(b) 0.10 <i>mm</i>		(c) $C_n C_n$	(d) $1 / C_n C_n$	
	(c) 0.15 <i>mm</i>	(d) 0.20 mm	4	The only electic modulus that	applies to fluids is	
	(e) 0.25 <i>mm</i>		4.	The only elastic modulus that a	applies to nulus is	

A substance breaks down by a stress of 10 N/m. If the density of the 119. material of the wire is  $3\times10^{\circ}$  kg/m, then the length of the wire of the [BCECE 2003]

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(a) Young's modulus (b) Shear modulus

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KCET 1999; Pb. PMT 2003]

[MP PET 2000]

	(c) Modulus of rigidity	(d) Bulk modulus			
5.	The ratio of the adiabatic to isothermal elasticities of a triatomic ga				
	is	[MP PET 1991]			
	(a) 3/4	(b) 4/3			
	(c) 1	(d) 5/3			
c	16.1 1 6.1	C			

- 6. If the volume of the given mass of a gas is increased four times, the temperature is raised from 27°C to 127°C. The elasticity will become
  (a) 4 times
  (b) 1/4 times
  - (c) 3 times (d) 1/3 times
- 7. The compressibility of water is  $4 \times 10^{-5}$  per unit atmospheric pressure. The decrease in volume of 100 cubic centimeter of water under a pressure of 100 *atmosphere* will be

(a) 0.4 <i>cc</i>	(b)	$4 \times 10^{-5} cc$
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- (c) 0.025 *cc* (d) 0.004 *cc*
- 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  $1 \times 10^3 \text{ kg} / m^3$

and  $g = 10 m / s^2$ , then the volume elasticity in  $N / m^2$  will be

- (a)  $10^8$  (b)  $2 \times 10^8$
- (c)  $10^9$  (d)  $2 \times 10^9$
- 9. The compressibility of a material is
  - (a) Product of volume and its pressure
  - (b) The change in pressure per unit change in volume strain
  - (c) The fractional change in volume per unit change in pressure(d) None of the above
- 10. When a pressure of 100 atmosphere is applied on a spherical ball, then its volume reduces to 0.01%. The bulk modulus of the material of the rubber in  $dyne / cm^2$  is

			[MP PET 1985; DPMT 2002]
(a)	$10 \times 10^{12}$	(b)	$100 \times 10^{12}$
(c)	$1 \times 10^{12}$	(d)	$20 \times 10^{12}$

- **11.** In the three states of matter, the elastic coefficient can be
  - (a) Young's modulus
  - (b) Coefficient of volume elasticity
  - (c) Modulus of rigidity
  - (d) Poisson's ratio

12.

- Bulk modulus was first defined by [CPMT 1987]
- (a) Young (b) Bulk
- (c) Maxwell (d) None of the above
- A uniform cube is subjected to volume compression. If each side is decreased by 1%, then bulk strain is

		[EAMCET (Engg.) 1995; DPMT 200	0]
(a)	0.01	(b) 0.06	

- (c) 0.02 (d) 0.03
- A ball falling in a lake of depth 200 m shows 0.1% decrease in its volume at the bottom. What is the bulk modulus of the material of the ball [AFMC 1997]
  - (a)  $19.6 \times 10^8 N/m^2$  (b)  $19.6 \times 10^{-10} N/m^2$ (c)  $19.6 \times 10^{10} N/m^2$  (d)  $19.6 \times 10^{-8} N/m^2$
- 15. The isothermal bulk modulus of a gas at atmospheric pressure is

- (a) 1 mm of Hg (b) 13.6 mm of Hg
- (c)  $1.013 \times 10^5 N/m^2$  (d)  $2.026 \times 10^5 N/m^2$
- **16.** Coefficient of isothermal elasticity  $E_{\theta}$  and coefficient of adiabatic elasticity  $E_{\phi}$  are related by  $(\gamma = C_p / C_v)$ 
  - (a)  $E_{\theta} = \gamma E_{\phi}$  (b)  $E_{\phi} = \gamma E_{\theta}$
  - (c)  $E_{\theta} = \gamma / E_{\phi}$  (d)  $E_{\theta} = \gamma^2 E_{\phi}$

17.

18.

19.

The bulk modulus of an ideal gas at constant temperature [MP PMT 1990]

- [MP PMT 2004] (a) Is equal to its volume V (b) Is equal to p/2
- (c) Is equal to its pressure p (d) Can not be determined

The Bulk modulus for an incompressible liquid is

- [BHU 2004]
- (a)
   Zero [MP PMT 1991]
   (b)
   Unity

   (c)
   Infinity
   (d)
   Between 0 to 1
- The pressure applied from all directions on a cube is *P*. How much its temperature should be raised to maintain the original volume ? The volume elasticity of the cube is  $\beta$  and the coefficient of volume expansion is  $\alpha$

(a) 
$$\frac{P}{\alpha\beta}$$
 (b)  $\frac{P\alpha}{\beta}$   
(c)  $\frac{P\beta}{\alpha}$  (d)  $\frac{\alpha\beta}{P}$ 

**20.** The pressure of a medium is changed from  $1.01 \times 10^{\circ}$  *Pa* to  $1.165 \times 10^{\circ}$  *Pa* and change in volume is 10% keeping temperature constant. The Bulk modulus of the medium is

(a)  $204.8 \times 10^{\circ} Pa$  (b)  $102.4 \times 10^{\circ} Pa$ 

- (c)  $51.2 \times 10^{\circ} Pa$  (d)  $1.55 \times 10^{\circ} Pa$
- **21.** For a constant hydraulic stress on an object, the fractional change in the object's volume  $\left(\frac{\Delta V}{V}\right)$  and its bulk modulus (*B*) are related as

(a) 
$$\frac{\Delta V}{V} \propto B$$
  
(b)  $\frac{\Delta V}{V} \propto \frac{1}{B}$   
(c)  $\frac{\Delta V}{V} \propto B^2$   
(d)  $\frac{\Delta V}{V} \propto B^{-2}$ 

### **Rigidity Modulus**

1. Modulus of rigidity of diamond is

- (a) Too less
- (b) Greater than all matters
- (c) Less than all matters
- (d) Zero

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2. The ratio of lengths of two rods A and B of same material is 1:2 and the ratio of their radii is 2:1, then the ratio of modulus of rigidity of A and B will be

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(a) 4 :[AIIMS 2000; (b) 16 : 1

ELF SCORER	400 Elasticity							
(c)	8 : 1	(d)	1:1		(a)	0.02	(b)	0.1
Whic	h statement is true for a me	etal	[DPMT 2001]		(c)	0.005	(d)	0.002
(a)	$Y < \eta$	(b)	$Y = \eta$	12.	The	reason for the ch	ange in shape of	a regular body is
(c)	$Y > \eta$	(d)	$Y < 1/\eta$					[EAMCET 1980
Whic	h of the following relations	is tru	e [CPMT 1084]		(a)	Volume stress	(b)	Shearing strain
whice	in or the following relations	13 11 1			(c)	Longitudinal stra	ain (d)	Metallic strain
(a)	$3Y = K(1-\sigma)$	(b)	$K = \frac{9\eta Y}{Y + \eta}$	13.	The app type	lower surface of lied at an angle of 2	a cube is fixed. f 30° from its su	On its upper surface, force i rface. The change will be of th
(c)	$\sigma = (6K + \eta)Y$	(d)	$\sigma = \frac{0.5Y - \eta}{1000}$		(a)	Shape	(b)	Size
		. ,	η		(c)	None	(d)	Shape and size
Two the r suppo	wires <i>A</i> and <i>B</i> of same ler respective radii $r_1$ and $r_2$ . ort, and at the other end eq	ngth a Their Jual t	and of the same material have r one end is fixed with a rigid wisting couple is applied. Then	14.	The clan angl	upper end of a nped and its othe le of shear is	wire of radius r end is twisted	4 mm and length 100 cm i through an angle of 30°. Then [NCERT 1990; MP PMT 1996
the r	atio of the angle of twist at e end of B will be	the e	and of A and the angle of twist		(a)	12*	(d)	0.12
			[AIIMS 1980]	15	(C) Mar		(u) ement	0.012
	2		2	1.3.	(a)	Sliding of molec	cular laver is mu	ch easier than compression o
(a)	$\frac{r_1^2}{r^2}$	(b)	$\frac{r_2^2}{r_2^2}$		(-)	expansion	····	<b>-</b>
	<i>I</i> <sub>2</sub>		<i>'</i> <sub>1</sub>		(b)	Reciprocal of bu	lk modulus of el	asticity is called compressibility
(c)	$r_{2}^{4}$	(d)	$r_{1}^{4}$		(c)	It is difficult to	twist a long rod	as compared to small rod
(C)	$r_1^4$	(u)	$r_2^4$		(d)	Hollow shaft is and same mass	much stronger t	han a solid rod of same lengt
When strair	n a spiral spring is stretchen n produced is called	ed by	suspending a load on it, the	16.	A 2 twis	<i>m</i> long rod of rac of 0.8 radians. 7	dius 1 <i>cm</i> which i The shear strain o	is fixed from one end is given a developed will be
(a)	Shearing	(b)	Longitudinal		(a)	0.002	(b)	0.004
(c)	Volume	(d)	Transverse		(c)	0.008	(d)	0.016
The ` and will b	Young's modulus of the ma there is no transverse strai be	terial n in	of a wire is $6 \times 10^{12} N / m^2$ it, then its modulus of rigidity	17.	A ro radi rigio twis	od of length / and us r/2 of same m d base and the fre st angle at the joir	d radius <i>r</i> is join naterial. The free ee end of larger nt will be [ <b>RF</b>	ned to a rod of length $l/2$ and end of small rod is fixed to rod is given a twist of $\theta^{\circ}$ , th <b>PET 1997</b> ]
(a)	$3 \times 10^{12} N/m^2$	(b)	$2 \times 10^{12} N/m^2$		(a)	$\theta$ / 4	(b)	heta / 2
(a)	$10^{12} N/m^2$	(d)	None of the above		(c)	$5\theta/6$	(d)	80/9
(C)		( <b>u</b> )		18.	Shea	aring stress causes	s change in	
lf the rigidi	e Young's modulus of the ity then its volume elasticity	mate will	rial is 3 times its modulus of he					[RPET 2002; BCECE 2001, 04
(a)	Zero	(b)	Infinity		(a)	Length	(b)	Breadth
(1)	$2 \times 10^{10} M/c^2$	(0)	$2 10^{10} N / 2$		(c)	Shape	(d)	Volume
(c)	$2 \times 10^{10} N/m^2$	(d)	$3 \times 10^{10} N/m^2$	-	_			
Modi	ulus of rigidity of a liquid		[RPET 2000]			work Don	e in Stretc	ning a wire
(a) (b)	Non zero constant Infinite			1.	lf th its p	ne potential energy potential energy w	y of a spring is 1 hen it is stretche	∕on stretching it by 2 <i>cm</i> , the ed by 10 <i>cm</i> will be
(c)	Zero				(a)	V/25	(b)	5 <i>V</i>
(d)	Can not be predicted				(c)	V/5	(d)	25 V
For a rigidi	a given material, the Your ity modulus. Its Poisson's rat	ng's 1 tio is	nodulus is 2.4 times that of	2.	The stra	work done in st in energy in a stro	retching an elas	tic wire per unit volume is o
			[EAMCET 1990; RPET 2001]				[NCERT 198	I; EAMCET (Med.) 1995; MNR 198

				[L, Wiebi	•
(a)	2.4	(b)	1.2		
(c)	0.4	(d)	0.2		

**11.** A cube of aluminium of sides 0.1 m is subjected to a shearing force of 100 N. The top face of the cube is displaced through 0.02 cm with respect to the bottom face. The shearing strain would be

Calculate the work done, if a wire is loaded by '*Mg*' weight and the increase in length is '*I*

(a) Stress × Strain

»

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(c)  $2 \times strain \times stress$ 

(b)  $\frac{1}{2} \times$  Stress  $\times$  Strain

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(d) Stress/Strain



	[CP	MT 1999; DCE 1999, 2001; Pb. PET 2000, 01]
	(a) Mgl	(b) Zero
	(c) <i>Mgl</i> /2	(d) 2 <i>Mgl</i>
4.	Two wires of same diameter of and 2 <i>l</i> . If the force F is appli in the two wires will be	of the same material having the length <i>l</i> ied on each, the ratio of the work done [MP PET 1989]
	(a) 1:2	(b) 1:4
	(c) 2:1	(d) 1:1
5.	A 5 <i>metre</i> long wire is fixed t at the lower end and is 1 elongated by 1 <i>mm</i> . The ener is	to the ceiling. A weight of 10 <i>kg</i> is hung <i>metre</i> above the floor. The wire was 'gy stored in the wire due to stretching [MP PET 1989]
	(a) Zero	(b) 0.05 <i>joule</i>
	(c) 100 <i>joule</i>	(d) 500 <i>joule</i>
6.	If the force constant of a wir length of the wire by / is	re is <i>K</i> , the work done in increasing the [MP PMT 1989]
	(a) <i>Kl</i> /2	(b) <i>Kl</i>
	(c) $Kl^2 / 2$	(d) $Kl^2$
7.	If the tension on a wire is rer	noved at once, then
	(a) It will break	
	(b) Its temperature will redu	uce
	(c) There will be no change	in its temperature

- (d) Its temperature increases
- **8.** When strain is produced in a body within elastic limit, its internal energy

(a)	Remains constant	(b)	Decreases
-----	------------------	-----	-----------

- (c) Increases (d) None of the above
- **9.** When shearing force is applied on a body, then the elastic potential energy is stored in it. On removing the force, this energy
  - (a) Converts into kinetic energy
  - (b) Converts into heat energy
  - (c) Remains as potential energy
  - (d) None of the above
- 10. A brass rod of cross-sectional area  $1 \text{ cm}^2$  and length 0.2 *m* is compressed lengthwise by a weight of 5 kg. If Young's modulus of elasticity of brass is  $1 \times 10^{11} N/m^2$  and  $g = 10 m/\text{sec}^2$ , then increase in the energy of the rod will be

(a) 
$$10^{-5} J$$
 (b)  $2.5 \times 10^{-5} J$ 

(c) 
$$5 \times 10^{-5} J$$
 (d)  $2.5 \times 10^{-4} J$ 

- 11. If one end of a wire is fixed with a rigid support and the other end is stretched by a force of 10 *N*, then the increase in length is 0.5 *mm*. The ratio of the energy of the wire and the work done in displacing it through 1.5 *mm* by the weight is
  - (a)  $\frac{1}{3}$  (b)  $\frac{1}{4}$ (c)  $\frac{1}{2}$  (d) 1

12. A wire is suspended by one end. At the other end a weight equivalent to  $20 \ N$  force is applied. If the increase in length is 1.0 mm, the increase in energy of the wire will be

- (c) 0.04 J (d) 1.00 J
- 13. In the above question, the ratio of the increase in energy of the wire to the decrease in gravitational potential energy when load moves downwards by 1 *mm*, will be

1

(a) 1 (b) 
$$\frac{1}{4}$$
  
(c)  $\frac{1}{3}$  (d)  $\frac{1}{2}$ 

The Young's modulus of a wire is Y. If the energy per unit volume is E, then the strain will be

14.

(a) 
$$\sqrt{\frac{2E}{Y}}$$
 (b)  $\sqrt{2EY}$   
(c)  $EY$  (d)  $\frac{E}{Y}$ 

- **15.** The ratio of Young's modulus of the material of two wires is 2 : 3. If the same stress is applied on both, then the ratio of elastic energy per unit volume will be
  - (a) 3:2 (b) 2:3 (c) 3:4 (d) 4:3
- **16.** The length of a rod is 20 cm and area of cross-section  $2 cm^2$ . The

Young's modulus of the material of wire is  $1.4 \times 10^{11} N/m^2$ . If the rod is compressed by 5 *kg-wt* along its length, then increase in the energy of the rod in joules will be

- (a)  $8.57 \times 10^{-6}$  (b)  $22.5 \times 10^{-4}$
- (c)  $9.8 \times 10^{-5}$  (d)  $45.0 \times 10^{-5}$
- **17.** If a spring extends by x on loading, then the energy stored by the spring is (if T is tension in the spring and k is spring constant)

(a) 
$$\frac{T^2}{2x}$$
 (b)  $\frac{T^2}{2k}$ 

(c) 
$$\frac{2x}{T^2}$$
 (d)  $\frac{2T^2}{k}$ 

18. On stretching a wire, the elastic energy stored per unit volume is

(a) 
$$Fl/2AL$$
 (b)  $FA/2L$   
(c)  $FL/2A$  (d)  $FL/2$ 

19. When a force is applied on a wire of uniform cross-sectional area  $3 \times 10^{-6} m^2$  and length 4m, the increase in length is 1 mm. Energy [MP PMT [991] stored in it will be  $(Y = 2 \times 10^{11} N/m^2)$ 

[MP PET 1995; Pb. PET 2002]

- (a) 6250 *J* (b) 0.177 *J*
- (c) 0.075 *J* (d) 0.150 *J*
- **20.** *K* is the force constant of a spring. The work done in increasing its extension from  $l_1$  to  $l_2$  will be

### [MP PET 1995; MP PMT 1996]

(a)  $K(l_2 - l_1)$  (b)  $\frac{K}{2}(l_2 + l_1)$ 

(c) 
$$K(l_2^2 - l_1^2)$$
 (d)  $\frac{K}{2}(l_2^2 - l_1^2)$ 

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**21.** When a 4 kg mass is hung vertically on a light spring that obeys Hooke's law, the spring stretches by 2 *cms*. The work required to be done by an external agent in stretching this spring by 5 *cms* will be  $(g = 9.8 metres / sexc^2)$ 

[MP PMT 1995]

(a) 4.900 *joule* (b) 2.450 *joule* 

- (c) 0.495 *joule* (d) 0.245 *joule*
- **22.** A wire of length *L* and cross-sectional area *A* is made of a material of Young's modulus *Y*. It is stretched by an amount *x*. The work done is

[MP PET 1996; BVP 2003; UPSEAT 2001]

(a) 
$$\frac{YxA}{2L}$$
 (b)  $\frac{Yx^2A}{L}$ 

(c) 
$$\frac{Y_x^2 A}{2L}$$
 (d)  $\frac{2Y_x^2 A}{L}$ 

**23.** The elastic energy stored in a wire of Young's modulus *Y* is

[MP PMT 1999]

2.

3.

4.

5.

[AIIMS 2000]

(a) 
$$Y \times \frac{\text{Strain}^2}{\text{Volume}}$$

(b) Stress × Strain × Volume

(c) 
$$\frac{\text{Stress}^2 \times \text{Volume}}{2Y}$$

- (d)  $\frac{1}{2}Y \times \text{Stress} \times \text{Strain} \times \text{Volume}$
- 24. A wire of length 50 cm and cross sectional area of 1 sq. mm is extended by 1 mm. The required work will be  $(Y = 2 \times 10^{10} Nm^{-2})$  [RPET 1999]

(a) 
$$6 \times 10^{-2} J$$
 (b)  $4 \times 10^{-2} J$ 

- (c)  $2 \times 10^{-2} J$  (d)  $1 \times 10^{-2} J$
- **25.** The work per unit volume to stretch the length by 1% of a wire with cross sectional area of  $1 mm^2$  will be.  $[Y = 9 \times 10^{11} N/m^2]$

(a) $9 \times 10^{11} J$ (b)	$4.5 \times 10^7 J$
------------------------------	---------------------

- (c)  $9 \times 10^7 J$  (d)  $4.5 \times 10^{11} J$
- **26.** When load of 5kg is hung on a wire then extension of 3m takes place, then work done will be **[RPMT 2000]** 
  - (a) 75 *joule* (b) 60 *joule*
  - (c) 50 *joule* (d) 100 *joule*
- **27.** A stretched rubber has
  - (a) Increased kinetic energy
  - (b) Increased potential energy
  - (c) Decreased kinetic energy
  - (d) Decreased potential energy
- 28. Which of the following is true for elastic potential energy density
  - (a) Energy density =  $\frac{1}{2} \times \text{strain} \times \text{stress}$
  - (b) Energy density =  $(strain)^2 \times volume$
  - (c) Energy density =  $(strain) \times volume$
  - (d) Energy density =  $(stress) \times volume$

- **29.** A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower end. The weight stretches the wire by 1 mm Then the elastic energy stored in the wire is
  - (a) 0.1 *J* (b) 0.2 *J*
  - (c) 10 *J* (d) 20
- **30.** Wires *A* and *B* are made from the same material. A has twice the diameter and three times the length of *B*. If the elastic limits are not reached, when each is stretched by the same tension, the ratio of energy stored in *A* to that in *B* is

[Kerala PMT 2004]

 (a) 2:3
 (b) 3:4

 (c) 3:2
 (d) 6:1



- An Indian rubber cord *L* metre long and area of cross-section  $Ametre^2$  is suspended vertically. Density of rubber is *D*  $kg / metre^3$  and Young's modulus of rubber is *E*  $newton / metre^2$ . If the wire extends by *I metre* under its own weight, then extension *I* is
  - (a)  $L^2 Dg / E$  (b)  $L^2 Dg / 2E$
  - (c)  $L^2 Dg / 4E$  (d) L
- To break a wire, a force of  $10^6 N/m^2$  is required. If the density of the material is  $3 \times 10^3 kg/m^3$ , then the length of the wire which will break by its own weight will be

### [Roorkee 1979; DPMT 2004]

(a)	34 <i>m</i>	(b)	30 <i>m</i>	
(c)	300 <i>m</i>	(d)	3 <i>m</i>	

Two rods of different materials having coefficients of linear [RPET 1999] expansion  $\alpha_1, \alpha_2$  and Young's moduli  $Y_1$  and  $Y_2$  respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of rods. If  $\alpha_1 : \alpha_2 = 2 : 3$ , the thermal stresses developed in the

two rods are equally provided  $Y_1: Y_2$  is equal to

(a)	2:3	(b)	1:1
(c)	3:2	(d)	4:9

The extension in a string obeying Hooke's law is x. The speed of sound in the stretched string is v. If the extension in the string is increased to 1.5x, the speed of sound will be

[IIT 1996]

- (a) 1.22 *v*
- (c) 1.50 v (d) 0.75 v
- One entropy W is attached rigidly to a point in the roof and a weight  $W_1$  is suspended from its lower end. If S is the area of cross-section of the wire, the stress in the wire at a height 3L/4 from its lower end is

(b) 0.61 v

(a) 
$$\frac{W_1}{S}$$
 (b)  $\frac{W_1 + (W/4)}{S}$   
(c)  $\frac{W_1 + (3W/4)}{S}$  (d)  $\frac{W_1 + W}{S}$ 

None of the above

6. There are two wires of same material and same length while the diameter of second wire is 2 times the diameter of first wire, then ratio of extension produced in the wires by applying same load will be

	[DCE 2000; Roorkee 2000; DCE 2003]
(a) 1:1	(b) 2:1
(c) 1:2	(d) 4:1

- A particle of mass m is under the influence of a force F which varies 7. with the displacement x according to the relation  $F = -kx + F_0$  in which k and  $F_0$  are constants. The particle when disturbed will oscillate [UPSEAT 2001]
  - about x = 0, with  $\omega \neq \sqrt{k} / m$ (a)
  - about x = 0, with  $\omega = \sqrt{k/m}$ (b)
  - (c) about  $x = F_0 / k$  with $\omega = \sqrt{k / m}$
  - (d) about  $x = F_0/k$  with  $\omega \neq \sqrt{k/m}$
- An elastic material of Young's modulus Y is subjected to a stress S. 8. The elastic energy stored per unit volume of the material is

MP PMT 1990, 96; IIT 1992; AIIMS 1997]



# Graphical Questions

The graph shown was obtained from experimental measurements of 1. the period of oscillations T for different masses M placed in the scale pan on the lower end of the spring balance. The most likely reason for the line not passing through the origin is that the [NCERT 1978]



- (a) Spring did not obey Hooke's Law
- (b) Amplitude of the oscillations was too large
- Clock used needed regulating (c)
- (d) Mass of the pan was neglected
- 2. A graph is shown between stress and strain for a metal. The part in which Hooke's law holds good is



(c) Yield point

5.

6.

7.

8.

- 4. In the above graph, point *D* indicates
  - (a) Limiting point

(b) Yield point (d) None of the above

- (c) Breaking point
- The strain-stress curves of three wires of different materials are shown in the figure. P, Q and R are the elastic limits of the wires. The figure shows that

(d)



- Elasticity of wire *P* is maximum (a)
- (b) Elasticity of wire Q is maximum
- Tensile strength of R is maximum (c)
- None of the above is true





- It will be easier to compress this rubber than expand it 1.
- Rubber does not return to its original length after it is 11. stretched
- The rubber band will get heated if it is stretched and released 111.

Which of these can be deduced from the graph

- (a) Ill only (b) 11 and 111
- (c) 1 and 111 (d) 1 only
- The stress versus strain graphs for wires of two materials A and Bare as shown in the figure. If  $\,Y_{A}\,$  and  $\,Y_{B}\,$  are the Young 's modulii of the materials, then



- material is shown in the figure. The thickest wire is represented by the line
- (a) OD

(b) *OC* 



[KCET 2001]

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Stress

- (d)

- (c) *OB*
- (d) *OA*
- **9.** The adjacent graph shows the extension  $(\Delta l)$  of a wire of length 1m suspended from the top of a roof at one end with a load W connected to the other end. If the cross sectional area of the wire is
  - $10^{-6}m^2$ , calculate the young's modulus of the material of the wire[IIT-JEE (Screen Screen Scre



10. The graph is drawn between the applied force F and the strain (x) for a thin uniform wire. The wire behaves as a liquid in the part[CPMT 1988]

- (d) *oa*
- **11.** The graph shows the behaviour of a length of wire in the region for which the substance obeys Hook's law. *P* and *Q* represent[AMU 2001]

С

- (a) P = applied force, Q = extension
- (b) P = extension, Q = applied force
- (c) P = extension, Q = stored elastic energy
- (d) P = stored elastic energy, Q = extension
- 12. The potential energy *U* between two molecules as a function of the distance *X* between them has been shown in the figure. The two molecules are [CPMT 1986, 88, 91]



- (a) Attracted when *x* lies between *A* and *B* and are repelled when *X* lies between *B* and *C*
- (b) Attracted when x lies between B and C and are repelled when X lies between A and B
- (c) Attracted when they reach *B*
- (d) Repelled when they reach *B*

13.

The value of force constant between the applied elastic force F and displacement will be



- **14.** The diagram shows stress v/s strain curve for the materials *A* and *B*. From the curves we infer that [AIIMS 1987]
  - (a) A is brittle but B is ductile
  - (b) A is ductile and B is brittle
  - (c) Both *A* and *B* are ductile ening) 2003]





(a) (b)  $8.0 \times 10^{11}$ (c)  $10 \times 10^{11}$ (d)  $2.0 \times 10^{11}$ (a)  $2.0 \times 10^{11}$ (c)  $10 \times 10^{11}$ 

The diagram shows the change x in<sup>2</sup> the<sup>4</sup> length<sup>8</sup> of <sup>1</sup>/<sub>8</sub> thin uniform wire caused by the application of stress F at two different temperatures T and T. The variations shown suggest that

- (a)  $T_1 > T_2$
- (b)  $T_1 < T_2$
- (c)  $T_1 = T_2$
- (d) None of these



Strain

A student plots a graph from his reading on the determination of Young's modulus of a metal wire but forgets to label. The quantities on *X* and *Y* axes may be respectively.



- (b) Stress applied and length increased X
- $(c) \quad \text{Stress applied and strain developed} \\$
- (d) Length increased and weight hung
- The points of maximum and minimum attraction in the curve between potential energy (U) and distance (r) of a diatomic molecules are respectively
  - (a) Sand R
  - (b) T and S
  - (c) R and S
  - (d) S and T



The stress-strain curves for brass, steel and rubber **a**re shown in the figure. The lines *A, B* and *C* are for



- (a) Rubber, brass and steel respectively
- (b) Brass, steel and rubber respectively
- (c) Steel, brass and rubber respectively
- (d) Steel, rubber and brass respectively

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	R	Assertion & Reason
		For AIIMS Aspirants
Kead	the assertion	and reason carefully to mark the correct option out of
(a)	If Doth ass	ertion and reason are true and the reason is the correct
<i>(</i> <b>b</b> )	If both and	or the assertion.
(D)	evolanation	of the assertion
(c)	If assertion	is true but reason is false.
(d)	If the asser	tion and reason both are false.
(e)	lf assertion	is false but reason is true.
1.	Assertion	: The stretching of a coil is determined by its shear modulus.
	Reason	<ul> <li>Shear modulus change only shape of a body keeping its dimensions unchanged.</li> </ul>
2.	Assertion	: Spring balances show correct readings even after they had been used for a long time interval.
	Reason	: On using for long time, spring balances losses its elastic strength.
3.	Assertion	: Steel is more elastic than rubber.
	Reason	: Under given deforming force, steel is deformed less than rubber.
4.	Assertion	: Glassy solids have sharp melting point.
	Reason	: The bonds between the atoms of glassy solids get broken at the same temperature.
5.	Assertion	: A hollow shaft is found to be stronger than a solid shaft made of same material.
	Reason	<ul> <li>The torque required to produce a given twist in hollow cylinder is greater than that required to twist a solid cylinder of same size and material.</li> </ul>
6.	Assertion	: Bulk modulus of elasticity (K) represents incompressibility of the material.
	Reason	: Bulk modulus of elasticity is proportional to change in pressure.
7.	Assertion	: Strain is a unitless quantity.
	Reason	: Strain is equivalent to force.
8.	Assertion	: The bridges declared unsafe after a long use.
	Reason	: Elastic strength of bridges losses with time.
9.	Assertion	<ul> <li>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.</li> </ul>
	Reason	: lvory and wet-clay have same elasticity.
10.	Assertion	: Young's modulus for a perfectly plastic body is zero.
	Reason	: For a perfectly plastic body, restoring force is zero.
11.	Assertion	<ul> <li>Identical springs of steel and copper are equally stretched. More work will be done on the steel spring.</li> </ul>
	Reason	: Steel is more elastic than copper.
12.	Assertion	: Sterss is the internal force per unit area of a body.

Reason : Rubber is less elastic than steel.

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Young's Modulus and Breaking Stress

1	c	2	b	3	d	4	c	5	b
6	C	7	C	8	C	9	b	10	C
11	d	12	а	13	b	14	d	15	а
16	C	17	а	18	а	19	d	20	C
21	b	22	b	23	b	24	d	25	b
26	d	27	C	28	b	29	b	30	b
31	b	32	C	33	d	34	b	35	а
36	b	37	а	38	b	39	d	40	а
41	C	42	d	43	C	44	а	45	b
46	d	47	а	48	C	49	d	50	C
51	C	52	а	53	C	54	а	55	b
56	а	57	а	58	d	59	а	60	а
61	C	62	b	63	d	64	b	65	а
66	C	67	d	68	b	69	а	70	d
71	b	72	d	73	C	74	C	75	а
76	a	77	d	78	d	79	а	80	а
81	d	82	d	83	а	84	d	85	а
86	C	87	C	88	b	89	b	90	C
91	C	92	C	93	b	94	C	95	C
96	b	97	d	98	b	99	а	100	b
101	b	102	а	103	b	104	d	105	b
106	а	107	d	108	d	109	C	110	d
111	с	112	C	113	С	114	d	115	d
116	b	117	d	118	а	119	C	120	а
121	а	122	а	123	b	124	b	125	b

**Bulk Modulus** 

1	C	2	C	3	b	4	d	5	b
6	d	7	а	8	d	9	C	10	C
11	b	12	C	13	d	14	а	15	C
16	b	17	C	18	C	19	a	20	d
21	b								

# **Rigidity Modulus**

1	b	2	d	3	C	4	d	5	C
6	а	7	а	8	b	9	С	10	d
11	d	12	b	13	d	14	b	15	С
16	b	17	d	18	C				

# Work Done in Stretching a Wire

1	d	2	b	3	c	4	а	5	b
6	С	7	d	8	C	9	b	10	b
11	С	12	а	13	d	14	а	15	а
16	а	17	b	18	а	19	C	20	d
21	b	22	C	23	C	24	С	25	b
26	а	27	b	28	а	29	а	30	b

# **Critical Thinking Questions**

1	b	2	а	3	C	4	а	5	C
6	d	7	C	8	b				

# Graphical Questions

1	d	2	a	3	C	4	C	5	d
6	а	7	d	8	а	9	a	10	b
11	С	12	b	13	b	14	b	15	d
16	а	17	С	18	d	19	C		

# Assertion and Reason

1	а	2	е	3	а	4	d	5	а
6	а	7	С	8	а	9	d	10	а
11	а	12	b						



# Young's Modulus and Breaking Stress

**1.** (c) 
$$l = \frac{FL}{YA} \Longrightarrow l \propto \frac{1}{A}$$

**2.** (b) Stress  $\propto$  Strain  $\Rightarrow$  Stress  $\propto \frac{l}{L}$ 

3. (d) 
$$Y = \frac{F}{A} \frac{L}{A} \Rightarrow l \propto \frac{L}{A} \propto \frac{L}{\pi d^2}$$
  
 $\therefore l \propto \frac{L}{d^2}$  [As

[As F and Y are constant]

The ratio of  $\frac{L}{d^2}$  is maximum for case (d)

(c) 
$$l = \frac{FL}{AY} \Rightarrow l \propto \frac{L}{d^2} \Rightarrow \frac{l_1}{l_2} = \frac{L_1}{L_2} \times \left(\frac{d_2}{d_1}\right)^2 = \frac{1}{2} \times \left(\frac{1}{2}\right)^2 = \frac{1}{8}$$

(b) Young's modulus of wire does not varies with dimension of wire. It is the property of given material.

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Depression in beam 6. (c)

$$\delta = \frac{WL^3}{4Ybd^3} \qquad \qquad \delta = \frac{b}{\delta}$$

- (c)  $l = \frac{FL}{AY} \Longrightarrow l \propto \frac{1}{r^2}$  (*F*, *L* and *Y* are constant) 7.  $\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = (2)^2 = 4 \implies l_2 = 4l_1 = 4cm$ (c)
- 8.

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(d)

(b)  $l \propto \frac{1}{r^2}$ . If radius of the wire is doubled then increment in 9. 1 12

length will become 
$$\frac{1}{4}$$
 times *i.e.*  $\frac{1}{4} = 3mm$   
(c)  $l = \frac{mgL}{AY} = \frac{1 \times 10 \times 1.1}{1.1 \times 10^{11} \times 10^{-6}} m = 0.1 mm$ 

**n.** (d) 
$$F = \frac{YAl}{L} = \frac{2.2 \times 10^{11} \times 2 \times 10^{-6} \times 5 \times 10^{-4}}{2} = 1.1 \times 10^2 N$$

(a) Interatomic force constant  $K = Y \times r_0$ 12.

$$= 2 \times 10^{11} \times 3 \times 10^{-10} = 60 \ N/m$$

(b) To double the length of wire, Stress = Young's modulus

$$\frac{F}{A} = 2 \times 10^{12} \frac{dyne}{cm^2}$$

W

If A = 1 then  $F = 2 \times 10^{\circ}$  dyne

- (a) Because due to increase in temperature intermolecular forces 15. decreases.
- Breaking Force  $\propto$  Area of cross section of wire  $(\pi r)$ 16. (c) If radius of wire is double then breaking force will become four times.
- $Y = 3K(1 2\sigma)$  and  $Y = 2\eta(1 + \sigma)$ 17. (a) Eliminating  $\sigma$  we get  $Y = \frac{9\eta K}{\eta + 3K}$

18. (a) 
$$F = \frac{YAl}{L} = \frac{9 \times 10^{10} \times \pi \times 4 \times 10^{-6} \times 0.1}{100} = 360 \ \pi \ N$$

**19.** (d) Energy stored per unit volume = 
$$\frac{1}{2} \times \text{Stress} \times \text{Strain}$$

$$= \frac{1}{2} \times \text{Young's modulus} \times (\text{Strain})^2 = \frac{1}{2} \times Y \times x^2$$

(c)  $l \propto L~$  i.e. if length is reduced to half then increase in length 20. will be  $\frac{l}{2}$ .

21. (b) 
$$l = \frac{L^2 dg}{2Y} = \frac{(8 \times 10^{-2})^2 \times 1.5 \times 9.8}{2 \times 5 \times 10^8} = 9.6 \times 10^{-11} m$$
  
22. (b) Stress =  $\frac{\text{force}}{\text{Area}}$   $\therefore$  Stress  $\propto \frac{1}{\pi r^2}$   
 $\frac{S_B}{S_A} = \left(\frac{r_A}{r_B}\right)^2 = (2)^2 \Rightarrow S_B = 4S_A$ 

(b) Breaking force  $\propto$  Area of cross section of wire 23.

i.e. load hold by the wire does not depend upon the length of the wire.

(d) If length of wire doubled then strain = 1  

$$Y = \text{stress} \implies F = Y \times A = 10^{12} \times 0.5 = 0.5 \times 10^{12} \, dyne$$

(b) Due to elastic fatigue its elastic property decreases.

26. (d) 
$$l = \frac{FL}{AY} \Rightarrow l \propto \frac{1}{r^2}$$
 (*F,L* and *Y* are same)  
 $\frac{l_A}{l_B} = \left(\frac{r_B}{r_A}\right)^2 = \left(\frac{r_B}{2r_B}\right)^2 = \frac{1}{4} \Rightarrow l_A = 4l_B$  or  $l_B = \frac{l_A}{4}$ 

32.

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**28.** (b) 
$$l = \frac{FL}{AY} \Rightarrow \frac{l_S}{l_{cu}} = \frac{Y_{cu}}{Y_S}$$
 (F,L and Y are constant)  
 $\therefore \frac{l_s}{l_{cu}} = \frac{1.2 \times 10^{11}}{2 \times 10^{11}} = \frac{3}{5}$ 

(b) If length of the wire is doubled then strain = 129.

$$\therefore$$
 Y = Stress =  $\frac{\text{Force}}{\text{Area}} = \frac{2 \times 10^5}{2} = 10^5 \frac{dyne}{cm^2}$ 

**30.** (b) 
$$l = \frac{FL}{AY} \Longrightarrow l \propto \frac{L}{r^2}$$
 (F and Y are same)  
 $\therefore \frac{l_2}{l_1} = \frac{L_2}{L_1} \left(\frac{r_1}{r_2}\right)^2 = 2 \times \left(\frac{1}{2}\right)^2 = \frac{1}{2} \Longrightarrow l_2 = \frac{l_1}{2} = \frac{l}{2} = 0.5mm.$ 

**31.** (b) 
$$F = \text{force developed} = YA \alpha(\Delta \theta)$$

$$= 10^{11} \times 10^{-4} \times 10^{-5} \times 100 = 10^{4} \text{ A}$$
  
(c)  $F = YA \alpha \Delta \theta \therefore F \propto A$ 

33. (d) 
$$Y = \frac{F/A}{\text{strain}} \Rightarrow A = \frac{F}{Y \times \text{strain}} = \frac{10^4}{7 \times 10^9 \times 0.002}$$
  
=  $\frac{1}{14} \times 10^{-2} = 7.1 \times 10^{-4} m^2$ 

34. (b) strain 
$$\propto$$
 stress  $\propto \frac{F}{A}$ 

Ratio of strain 
$$=$$
  $\frac{A_2}{A_1} = \left(\frac{r_2}{r_1}\right)^2 = \left(\frac{4}{1}\right)^2 = \frac{16}{1}$ 

**35.** (a) 
$$F = 2000N, L = 6m, l = 0.5 \ cm, A = 10^{-6} m^2$$
  
 $FL = 2000 \times 6$ 

$$F = \frac{1}{Al} = \frac{10^{-6} \times 0.5 \times 10^{-2}}{10^{-6} \times 0.5 \times 10^{-2}} = 2.53 \times 10^{-10} \text{ N/m}$$

**36.** (b) 
$$F = Kx \Rightarrow K = \frac{F}{x} = \frac{5 \times 5.6}{4.5 \times 10^{-3}} = 1.96 \times 10^4 \, N \, / m$$

**37.** (a) 
$$l \propto \frac{FL}{r^2 Y} \Rightarrow l \propto \frac{1}{r^2}$$
 (*F*, *L* and *Y* are constant)  
 $\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = (n)^2 \Rightarrow l_2 = n^2 l_1$ 

**38.** (b) Longitudinal strain 
$$\frac{l}{L} = \frac{\text{stress}}{Y} = \frac{10^6}{10^{11}} = 10^{-5}$$

Percentage increase in length 
$$=10^{-5} \times 100 = 0.001\%$$

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8mm



$$= 0.15 \times 2 \times 11 = 3 \times 10^{10} Nm^{-2}$$

60. (a) 
$$F = A \times Y \times \text{strain} = 1 \times 10^{-4} \times 2 \times 10^{11} \times 0.1 = 2 \times 10^{6} \text{ A}$$
  
61. (c)

**63.** (d) Stress = 
$$\frac{\text{Force}}{\text{area}}$$
.

In the present case, force applied and area of cross-section of wires are same, therefore stress has to be the same.

rain = 
$$\frac{\text{Stress}}{V}$$

St

Since the Young's modulus of steel wire is greater than the copper wire, therefore, strain in case of steel wire is less than that in case of copper wire.

Initial length (circumference) of the ring =  $2\pi r$ (b) 64. Final length (circumference) of the ring =  $2\pi R$ Change in length =  $2\pi R - 2\pi r$ .

strain = 
$$\frac{\text{change in length}}{\text{original length}} = \frac{2\pi(R-r)}{2\pi r} = \frac{R-r}{r}$$

Now Young's modulus  $E = \frac{F/A}{l/L} = \frac{F/A}{(R-r)/r}$ 

$$\therefore F = AE\left(\frac{R-r}{r}\right)$$

65. (a) 
$$l = \frac{FL}{\pi r^2 r} \Longrightarrow l \propto \frac{F}{r^2}$$
 (Y and L are constant)  
 $\frac{l_2}{l_1} = \frac{F_2}{F_1} \times \left(\frac{r_1}{r_2}\right)^2 = 2 \times (2)^2 = 8 \therefore l_2 = 8l_1 = 8 \times 1 = 1$ 

66. (c) 
$$l = \frac{FL}{\pi r^2 Y} \Longrightarrow l \propto \frac{L}{r^2}$$
 (F and Y are constant)  
 $\frac{l_1}{l_2} = \frac{L_1}{L_2} \left(\frac{r_2}{r_1}\right)^2 = \frac{1}{2} \left(\sqrt{2}\right)^2 \therefore \frac{l_1}{l_2} = 1:1$ 

**67.** (d) 
$$l \propto \frac{1}{2}$$
 (*F,L* and *Y* are constant)

$$\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = \left(\frac{1}{2}\right)^2 \implies l_2 = \frac{l_1}{4} = \frac{2.4}{4} \implies l_2 = 0.6 \text{ cm}$$

**68.** (b) 
$$F = Y \times A \times \frac{l}{L} \Longrightarrow F \propto r^2$$
 (Y,l and L are constant)  
If diameter is made four times then force required will be 10 times. *i.e.* 16 × 10° N

69. (a) 
$$F = Y \times A \times \frac{l}{L} \Rightarrow F \propto \frac{r^2}{L}$$
 (Y and *l* are constant)  
 $\therefore \frac{F_1}{F_2} = \left(\frac{r_1}{r_2}\right)^2 \left(\frac{L_2}{L_1}\right) = \left(\frac{2}{1}\right)^2 \left(\frac{1}{4}\right) = 1 \Rightarrow \frac{F_1}{F_2} = 1:1$ 

**70.** (d) Increment in length 
$$l = \frac{L^2 dg}{2Y} \therefore l \propto L^2 d$$

**71.** (b) Adiabatic elasticity 
$$E = \gamma P$$
  
For argon  $E_{Ar} = 1.6 P$  ....(i)  
For hydrogen  $E_{H2} = 1.4 P'$  ....(ii)  
As elasticity of hydrogen and argon are equal  
 $\therefore 1.6P = 1.4P' \Rightarrow P' = \frac{8}{7}P$ 

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73.

(c) 
$$l = \frac{FL}{AY} = \frac{FL^2}{(AL)Y} = \frac{FL^2}{VY}$$
.  
If volume is fixed then  $l \propto L^2$ 

74. (c) 
$$F = YA \alpha \Delta t = 2 \times 10^{11} \times 3 \times 10^{-6} \times 10^{-5} \times (20 - 10) = 60 N$$

 $FL^2$ 

VY

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**76.** (a) 
$$l = \frac{FL}{\pi r^2 Y}$$
 :  $l \propto \frac{L}{r^2}$  (*Y* and *F* are constant)

If density of the material increases then more force (stress) is

$$\frac{r_2}{r_1} = \left(\frac{Y_1}{Y_2}\right)^{1/2} = \left(\frac{7 \times 10^{10}}{12 \times 10^{10}}\right)^{1/2}$$
$$\implies r_2 = 1.5 \times \left(\frac{7}{12}\right)^{1/2} = 1.145 \ mm \therefore \ \text{dia} = 2.29 \ mm$$

**95.** (c) 
$$F = \frac{YAl}{L} = 0.9 \times 10^{11} \times \pi \times (0.3 \times 10^{-3})^2 \times \frac{0.2}{100} = 51 N$$

(b) Young's modules = 
$$\frac{\text{stress}}{\text{strain}}$$
  
As the length of wire get doubled therefore strain = 1  
 $\therefore$  Y = strain = 20 × 10<sup>o</sup> N/m

**97.** (d) 
$$l = \frac{FL}{\pi r^2 Y} \therefore l \propto \frac{1}{r^2}$$
 (*F,L* and *Y* are constant)  
 $\frac{l_2}{l_1} = \left(\frac{r_1}{r_2}\right)^2 = (2)^2 \implies l_2 = 4l_1 = 4 \times 2 = 8 mm.$ 

96.

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98. (b) Let L is the original length of the wire and K is force constant of wire.Final length = initial length + elongation

For first condition 
$$a = L + \frac{4}{K}$$
 ...(ii)  
For second condition  $b = L + \frac{5}{K}$  ...(ii)  
By solving (i) and (ii) equation we get  
 $L = 5a - 4b$  and  $K = \frac{1}{b-a}$   
Now when the longitudinal tension is 9N, length of the string =  
 $L + \frac{9}{K} = 5a - 4b + 9(b-a) = 5b - 4a$ .  
(a)  
(b)

101. (b) 
$$K = Yr_0 = 20 \times 10^{10} \times 3 \times 10^{-10} = 60 \ N/m$$
  
=  $6 \times 10^{-9} \ N/Å$ 

102. (a) 
$$l = \frac{FL}{AY} = \frac{4.8 \times 10^3 \times 4}{1.2 \times 10^{-4} \times 1.2 \times 10^{11}} = 1.33 \text{ mm}$$
  
103. (b)

104. (d) 
$$Y = \frac{\text{Stress}}{\text{Strain}} = \text{Constant}$$
  
It depends only on nature of material.  
105. (b)  $2\pi \sqrt{\frac{m}{k}} = 0.6$  ...(i) and  $2\pi \sqrt{\frac{m+m'}{k}} = 0.7$  ...(ii)  
Dividing (ii) by (i) we get  $\left(\frac{7}{k}\right)^2 = \frac{m+m'}{k} = \frac{49}{k}$ 

$$\frac{m+m'}{m} - 1 = \frac{49}{36} - 1 \Rightarrow \frac{m'}{m} = \frac{13}{36} \Rightarrow m' = \frac{13m}{36}$$
Also  $\frac{k}{m} = \frac{4\pi^2}{(0.6)^2}$ 
Desired extension  $= \frac{m'g}{k} = \frac{13}{36} \times \frac{mg}{k}$ 

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$$=\frac{13}{36} \times 10 \times \frac{0.36}{4\pi^2} \approx 3.5 \ cm$$

**106.** (a) 
$$Y = \frac{F/A}{\text{Strain}} \Rightarrow \text{strain} = \frac{F}{AY}$$

107. (d) 
$$Y = \frac{k}{r_0} = \frac{7}{3 \times 10^{-10}} = 2.33 \times 10^{10} N/m^2$$

108. (d) 
$$F = Y \times A \times \frac{l}{L} \Longrightarrow F \propto \frac{r^2}{L}$$
 (Y and *l* are constant)  
 $\frac{F_A}{F_B} = \left(\frac{r_A}{r_B}\right)^2 \times \left(\frac{L_B}{L_A}\right) = \left(\frac{2}{1}\right)^2 \times \left(\frac{2}{1}\right) = \frac{8}{1}$ 

109. (c)

m.

(d) When the length of wire is doubled then l = L and strain = 1 110. F ÷.

$$Y = \text{strain} = \frac{A}{A}$$

:. Force = 
$$Y \times A = 2 \times 10^{11} \times 0.1 \times 10^{-4} = 2 \times 10^{6} N$$

(c) Potential energy stored in the rubber cord catapult will be converted into kinetic energy of mass. Г 2

$$\frac{1}{2}mv^{2} = \frac{1}{2}\frac{YAl^{2}}{L} \Rightarrow v = \sqrt{\frac{YAl^{2}}{mL}}$$
$$= \sqrt{\frac{5 \times 10^{8} \times 25 \times 10^{-6} \times (5 \times 10^{-2})^{2}}{5 \times 10^{-3} \times 10 \times 10^{-2}}} = 250 \text{ m/s}$$

(c) 112.

- 113. (c)
- (d) 114.

115. (d) Breaking force  $\propto r$ 

If diameter becomes double then breaking force will become four times *i.e.*  $1000 \times 4 = 4000 N$ 

(b) 116.

118.

**117.** (d) 
$$l = \frac{FL}{AY} = \frac{FL^2}{(AL)Y} = \frac{FL^2}{VY}$$

 $\therefore l \propto L^2$  If volume of the wire remains constant

$$\frac{l_2}{l_1} = \left(\frac{L_2}{L_1}\right)^2 = \left(\frac{8}{2}\right)^2 = 16$$
  
::  $l_2 = 16 \times l_1 = 16 \times 2 = 32mm = 3.2cm$ 

(a) 
$$l = \frac{FL}{AY} \therefore l \propto \frac{1}{A}$$
 (*F,L* and *Y* are constant]  
 $\frac{l_2}{l_1} = \frac{A_1}{A_2} = \frac{4}{8} = \frac{1}{2} \implies l_2 = \frac{l_1}{2} = \frac{0.1}{2} = 0.05mm$ 

**119.** (c) 
$$L = \frac{p}{dg} = \frac{10^6}{3 \times 10^3 \times 10} = \frac{100}{3} = 33.3m$$

120. (a) 
$$l = \frac{L^2 dg}{2Y} = \frac{(10)^2 \times 1500 \times 10}{2 \times 5 \times 10^8} = 15 \times 10^{-4} m$$

121. (a) 
$$Y = 3K(1-2\sigma), Y = 2\eta(1+\sigma)$$
  
For  $Y = 0$ , we get  $1-2\sigma = 0$ , also  $1+\sigma = 0$   
 $\Rightarrow \sigma$  lies between  $\frac{1}{2}$  and  $-1$ .

(a) Value of Poisson's ratio lie in range of -1 to  $\frac{1}{2}$ 122.

**123.** (b) We know that 
$$\frac{dV}{V} = (1+2\sigma)\frac{dL}{L}$$

If 
$$\sigma = -\frac{1}{2}$$
 then  $\frac{dV}{V} = 0$ 

*i.e.* there is no change in volume. 117 11

124. (b) 
$$\frac{dV}{V} = (1+2\sigma)\frac{dL}{L}$$
  
 $\frac{dV}{V} = 2 \times 2 \times 10^{-3} = 4 \times 10^{-3} \left[ \because \sigma = 0.5 = \frac{1}{2} \right]$ 

 $\therefore$  Percentage change in volume =  $4 \times 10^{-1} = 0.4\%$ 

125. (b) 
$$l = \frac{FL}{\pi r^2 Y} \therefore l \propto \frac{L}{r^2}$$

Ratio of 
$$\frac{L}{r^2}$$
 is maximum for wire in option (b).

# **Bulk Modulus**

- (c) Isothermal elasticity  $K_i = P$ 1.
- 2. (c) Adiabatic elasticity  $K_a = \gamma P$

(b) Ratio of adiabatic and isothermal elasticities  

$$\frac{E\phi}{E\theta} = \frac{\gamma P}{P} = \gamma = \frac{C_p}{C_v}$$

3.

**5.** (b) For triatomic gas 
$$\gamma = \frac{4}{3}$$

6. (d) From the ideal gas equation 
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{E_2}{E_1} = \frac{P_2}{P_1} = \frac{V_1}{V_2} \times \frac{T_2}{T_1} = \left(\frac{1}{4}\right) \times \left(\frac{400}{300}\right) = \frac{1}{3} \Longrightarrow E_2 = \frac{E_1}{3}$$

*i.e.* elasticity will become  $\frac{1}{3}$  times.

7. (a) 
$$C = \frac{1}{K} = \frac{\Delta V/V}{\Delta P} \Rightarrow \Delta V = C \times \Delta P \times V$$
  
=  $4 \times 10^{-5} \times 100 \times 100 = 0.4 cc$ 

8. (d) 
$$K = \frac{\Delta P}{\Delta V/V} = \frac{h\rho g}{\Delta V/V} = \frac{200 \times 10^3 \times 10}{0.1/100} = 2 \times 10^9$$

9. (c) 
$$\frac{1}{K} = \text{compressibility} = \left(\frac{-\Delta V/V}{\Delta P}\right)$$

10. (c) 
$$K = \frac{100}{0.01/100} = 10^6 atm = 10^{11} N/m^2 = 10^{12} dyne/cm^2$$
  
11. (b)

(c)

13. (d) If side of the cube is *L* then 
$$V = L^3 \Rightarrow \frac{dV}{V} = 3\frac{dL}{L}$$
  
 $\therefore$  % change in volume = 3 × (% change in length)  
= 3 × 1% = 3%  $\therefore$  Bulk strain  $\frac{\Delta V}{V} = 0.03$   
14. (a)  $B = \frac{\Delta p}{\Delta V/V} = \frac{h\rho g}{0.1/100} = \frac{200 \times 10^3 \times 9.8}{1/1000}$ 

$$=19.6 \times 10^8 N/m^2$$

(c) Isothermal elasticity 
$$K_i = P = 1atm = 1.013 \times 10^5 N/m^2$$

15.

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19. (a) If coefficient of volume expansion is 
$$\alpha$$
 and rise in  
temperature is  $\Delta\theta$  then  $\Delta V = V\alpha\Delta\theta \Rightarrow \frac{\Delta V}{V} = \alpha\Delta\theta$   
Volume elasticity  $\beta = \frac{P}{\Delta V/V} = \frac{P}{\alpha\Delta\theta} \Rightarrow \Delta\theta = \frac{P}{\alpha\beta}$   
20. (d)  $K = \frac{\Delta p}{\Delta V/V} = \frac{(1.165 - 1.01) \times 10^5}{10/100} = \frac{0.155 \times 10^5}{1/10}$   
 $= 1.55 \times 10^5 pa$   
21. (b)  $B = \frac{\Delta p}{\Delta V/V} \Rightarrow \frac{1}{B} \propto \frac{\Delta V}{V}$  [ $\Delta p$  = constant]

# **Rigidity Modulus**

1. (b)  
2. (d) Modulus of rigidity is the property of material.  
3. (c) 
$$Y = 2\eta(1 + \sigma)$$
  
4. (d)  $Y = 2\eta(1 + \sigma) \Rightarrow \sigma = \frac{0.5Y - \eta}{1 + \sigma}$ 

(c) Twisting couple  $C = \frac{\pi \eta r^4 \theta}{2l}$ 5. If material and length of the wires A and B are equal and equal twisting couple are applied then

η

$$\theta \propto \frac{1}{r^4} \therefore \frac{\theta_1}{\theta_2} = \left(\frac{r_2}{r_1}\right)^4$$

6. (a) A small part of the spring bear tangential stress, causing straining strain.

(a)  $Y = 2\eta(1+\sigma)$ 7. For no transverse strain ( $\sigma$  = 0)  $Y = 2\eta \Longrightarrow \eta = \frac{Y}{2} = 3 \times 10^{12} N / m^2$ 

8. (b) 
$$Y = 2\eta(1+\sigma) \Rightarrow 3\eta = 2\eta(1+\sigma) \Rightarrow \sigma = \frac{3}{2} - 1 = \frac{1}{2}$$

Now substituting the value of  $\boldsymbol{\sigma}$  in the following expression.

$$Y = 3K(1-2\sigma) \implies K = \frac{Y}{3(1-2\sigma)} = \infty$$

(c) 9. 10.

(d)  $Y = 2\eta(1+\sigma)$  $2.4\eta = 2\eta(1+\sigma) \Longrightarrow 1.2 = 1+\sigma \Longrightarrow \sigma = 0.2$ 

**11.** (d) Shearing strain 
$$\phi = \frac{x}{L} = \frac{0.02cm}{10cm}$$
  $\therefore \phi = 0.002$ 

12. (b)

(d) There will be both shear stress and normal stress. 13.

14. (b) Angle of shear 
$$\phi = \frac{r\theta}{L} = \frac{4 \times 10^{-1}}{100} \times 30^{\circ} = 0.12^{\circ}$$

(c) For twisting, Angle of shear  $\phi \propto \frac{1}{L}$ 15. *i.e.* if *L* is more then  $\phi$  will be small.

**16.** (b) 
$$r\theta = L\phi \Longrightarrow 10^{-2} \times 0.8 = 2 \times \phi \Longrightarrow \phi = 0.004$$

**17.** (d) 
$$\tau = C.\theta = \frac{\pi \eta r^4 \theta}{2L} = \text{Constant}$$

$$\Rightarrow \frac{\pi \eta r^4 (\theta - \theta_0)}{2l} = \frac{\pi \eta (r/2)^4 (\theta_0 - \theta')}{2(l/2)}$$
$$\Rightarrow \frac{(\theta - \theta_0)}{2} = \frac{\theta_0}{16} \Rightarrow \theta_0 = \frac{8}{9} \theta$$

18.

1.

(c)

# Work Done in Stretching a Wire

(d) 
$$U = \frac{1}{2} \left(\frac{YA}{L}\right) l^2 \therefore U \propto l^2$$
  
 $\frac{U_2}{U_1} = \left(\frac{l_2}{l_1}\right)^2 = \left(\frac{10}{2}\right)^2 = 25 \Rightarrow U_2 = 25U_1$   
*i.e.* potential energy of the spring will be 25 V  
(b)

2.

**3.** (c) Work done = 
$$\frac{1}{2}Fl = \frac{Mgl}{2}$$

4. (a) 
$$W = \frac{1}{2} Fl \therefore W \propto l$$
 (F is constant)  
 $\therefore \frac{W_1}{W_2} = \frac{l_1}{l_2} = \frac{l}{2l} = \frac{1}{2}$   
5. (b)  $W = \frac{1}{2} \times F \times l = \frac{1}{2} mgl$   
 $= \frac{1}{2} \times 10 \times 10 \times 1 \times 10^{-1} = 0.05 J$ 

(c) 
$$K = \frac{F}{l}$$
 and  $W = \frac{1}{2}Fl = \frac{1}{2}Kl \times l = \frac{1}{2}Kl^2$ 

- 7. (d) Due to tension, intermolecular distance between atoms is increased and therefore potential energy of the wire is increased and with the removal of force interatomic distance is reduced and so is the potential energy. This change in potential energy appears as heat in the wire and thereby increases the temperature.
  - Due to increase in intermolecular distance. (c)

9. (b)

6.

8.

1

**CLICK HERE** 

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10. (b) 
$$U = \frac{1}{2} \times \frac{(\text{stress})^2}{Y} \times \text{volume} = \frac{1}{2} \times \frac{F^2 \times A \times L}{A^2 \times Y}$$
  
 $= \frac{1}{2} \times \frac{F^2 L}{AY} = \frac{1}{2} \times \frac{(50)^2 \times 0.2}{1 \times 10^{-4} \times 1 \times 10^{11}} = 2.5 \times 10^{-5} J$ 

11. (c) Work done in stretching a wire  

$$W = \frac{1}{2} Fl = \frac{1}{2} \times 10 \times 0.5 \times 10^{-3} = 2.5 \times 10^{-3} J$$
Work done to displace it through 1.5 mm  

$$W = F \times l = 5 \times 10^{-3} J$$
The ratio of above two work = 1 : 2  
12. (a) Increase in energy  $= \frac{1}{2} \times 20 \times 1 \times 10^{-3} = 0.01 J$ 

**3.** (d) Ratio of work done = 
$$\frac{1/2Fl}{Fl} = \frac{1}{2}$$

14. (a) Energy per unit volume 
$$=\frac{1}{2} \times Y \times (\text{strain})^2$$
  
∴ strain  $= \sqrt{\frac{2E}{Y}}$ 

**5.** (a) Energy per unit volume = 
$$\frac{(\text{stress})^2}{2Y}$$

$$\frac{E_1}{E_2} = \frac{Y_2}{Y_1} \text{ (Stress is constant)} \therefore \frac{E_1}{E_2} = \frac{3}{2} \qquad 4.$$
  
**16.** (a) Energy  $= \frac{1}{2}FI = \frac{1}{2} \times F \times \left(\frac{FL}{AY}\right) = \frac{1}{2} \times \frac{F^2L}{AY}$ 
 $= \frac{1}{2} \times \frac{(50)^2 \times 20 \times 10^{-2}}{4 \times 1.4 \times 10^{11}} = 8.57 \times 10^{-6} J$ 
  
**17.** (b)  $U = \frac{F^2}{2K} = \frac{T^2}{2K}$ 
  
**18.** (a) Energy stored per unit volume  $= \frac{1}{2} \left(\frac{F}{A}\right) \left(\frac{1}{L}\right) = \frac{FI}{2AL}$ 
  
**19.** (c)  $U = \frac{1}{2} \times \frac{YAI^2}{L} = \frac{1}{2} \times \frac{2 \times 10^{11} \times 3 \times 10^{-6} \times (1 \times 10^{-3})^2}{4}$ 
 $= 0.075 J$ 
  
**20.** (d) At extension  $l_1$ , the stored energy  $= \frac{1}{2}KI_1^2$ 
  
At extension  $l_2$ , the stored energy  $= \frac{1}{2}KI_2^2$ 
  
**7.** Work done in increasing its extension from  $l_1$  to  $l_2$ 
 $= \frac{1}{2}K(l_2^2 - l_1^2)$ 
  
**21.** (b)  $K = \frac{F}{x} = \frac{40}{2 \times 10^{-2}} = 0.2 N/m$ 
  
Work done  $= \frac{1}{2}Kx^2 = \frac{1}{2} \times (0.2) \times (0.05)^2 = 2.5 J$ 
  
**22.** (c)
  
**23.** (c)
  
**24.** (c)  $W = \frac{YAI^2}{2L} = \frac{2 \times 10^{10} \times 10^{-6} \times (10^{-3})^2}{2 \times 50 \times 10^{-2}} = 2 \times 10^{-2} J$ 
  
**24.** (c)  $W = \frac{YAI^2}{2L} = \frac{2 \times 10^{10} \times 10^{-6} \times (10^{-3})^2}{2 \times 50 \times 10^{-2}} = 2 \times 10^{-2} J$ 
  
**25.** (b)  $U = \frac{1}{2} \times F \times (\text{Strain})^2 = \frac{1}{2} \times 9 \times 10^{11} \times (\frac{1}{100})^2$ 
  
**26.** (a)  $W = \frac{1}{2} FI = \frac{1}{2} \times Mg \times I = \frac{1}{2} \times 5 \times 10 \times 3 = 75 J$ 
  
**27.** (b)   
**30.** (b)  $U = \frac{1}{2} FI = \frac{F^2}{2AY}$ .  $U \propto \frac{L}{r^2}$  (F and Y are constant)
 $\therefore \frac{U_A}{U_B} = (\frac{L_A}{L_B}) \times (\frac{r_A}{r_B})^2 = (3) \times (\frac{1}{2})^2 = \frac{3}{4}$ 
  
**6.**
  
**7.** (b)
  
**7.** (c) (c) Thermal stress and rise in temperature are equal then  $Y \propto \frac{1}{\alpha} \Rightarrow \frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{3}{2}$ 

. (a) Speed of sound in a stretched string  $v = \sqrt{\frac{T}{\mu}}$  ...(i) Where T is the tension in the string and  $\mu$  is mass per unit

length. According to Hooke's law,  $F \propto x \therefore T \propto x$  ...(ii) From (i) and (ii)  $v \propto \sqrt{x} \therefore v' = \sqrt{1.5} v = 1.22 v$ 

(c) Total force at height 
$$3L/4$$
 from its lower end  
= Weight suspended + Weight of 3/4 of the chain  
=  $W_1 + (3W/4)$ 

Hence stress  $= \frac{W_1 + (3W/4)}{S}$ 

- **5.** (d)  $l = \frac{FL}{AY} \therefore l \propto \frac{1}{r^2}$  (*F*, *L* and *Y* are constant)  $\frac{l_1}{l_2} = \left(\frac{r_2}{r_1}\right)^2 = (2)^2 = 4$
- . (c) Restoring force is zero at mean position

$$F = -Kx + F_0 \Rightarrow 0 = -Kx + F_0 \Rightarrow x = \frac{F_0}{K}$$

*i.e.* the particle will oscillate about  $x = \frac{F_0}{K}$ 

**8.** (b)

# **Graphical Questions**

**1.** (d) 
$$T = 2\pi \sqrt{\frac{M}{K}} \Rightarrow T^2 \propto M$$

If we draw a graph between  $T^2$  and M then it will be straight line.

and for M = 0, T = 0

*i.e.* the graph should pass through the origin.

but from the it is not reflected it means the mass of pan was neglected.

- (a) In the region *OA*, stress  $\propto$  strain *i.e.* Hooke's law hold good.
- . (c) . (c)
  - (d) As stress is shown on x-axis and strain on y-axis

So we can say that 
$$Y = \cot \theta = \frac{1}{\tan \theta} = \frac{1}{\text{slope}}$$

So elasticity of wire *P* is minimum and of wire *R* is maximum

(a) Area of hysterisis loop gives the energy loss in the process of stretching and unstretching of rubber band and this loss will appear in the form of heating.

(d) 
$$\frac{Y_A}{Y_B} = \frac{\tan \theta_A}{\tan \theta_B} = \frac{\tan 60}{\tan 30} = \frac{\sqrt{3}}{1/\sqrt{3}} = 3 \Rightarrow Y_A = 3Y_B$$

(a) 
$$l = \frac{FL}{AY} \therefore l \propto \frac{1}{r^2}$$
 (Y, L and F are constant)

*i.e.* for the same load, thickest wire will show minimum elongation. So graph D represent the thickest wire.

(a) From the graph 
$$l = 10^{-4} m$$
,  $F = 20N$ 

$$A = 10^{-6} m^2, L = 1m$$



: 
$$Y = \frac{FL}{Al} = \frac{20 \times 1}{10^{-6} \times 10^{-4}} = 20 \times 10^{10} = 2 \times 10^{11} N/m^2$$

10. (b) At point b, yielding of material starts.

- (c) Graph between applied force and extension will be straight line because in elastic range,
  - Applied force  $\propto$  extension

but the graph between extension and stored elastic energy will be parabolic in nature

As 
$$U = 1/2 kx^2$$
 or  $U \propto x^2$ 

12. (b) 
$$F = -\left(\frac{dU}{dx}\right)$$
.

In the region BC slope of the graph is positive

- $\therefore$  F = negative *i.e.* force is attractive in nature
- In the region AB slope of the graph is negative
- $\therefore$  *F* = positive *i.e.* force is repulsive in nature

**13.** (b) Force constant, K = tan  $30^{\circ} = 1 / \sqrt{3}$ 

- 14. (b) In ductile materials, yield point exist while in Brittle material, failure would occur without yielding.
- 15. (d) Young's modulus is defined only in elastic region and

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{8 \times 10^7}{4 \times 10^{-4}} = 2 \times 10^{11} \ N / m^2$$

16. (a) Elasticity of wire decreases at high temperature *i.e.* at higher temperature slope of graph will be less. So we can say that  $T_1 > T_2$ 

17. (c)

 (d) Attraction will be minimum when the distance between the molecule is maximum.

Attraction will be maximum at that point where the positive  $\frac{dU}{dU}$ 

slope is maximum because  $F = -\frac{dU}{dx}$ 

**19.** (c)  $Y = \tan \theta$ . According to figure  $\theta_A > \theta_B > \theta_C$ 

*i.e.* 
$$\tan \theta_A > \tan \theta_B > \tan \theta_C$$

or 
$$Y_A > Y_B > Y_C$$

 $\therefore$  *A*, *B*, and *C* graph are for steel, brass and rubber respectively.

#### Assertion and Reason

- (a) Because, the stretching of coil simply changes its shape without any change in the length of the wire used in coil. Due to which shear modulus of elasticity is involved.
- 2. (e) When a spring balance has been used for a long time, the spring in the balance fatigued and there is loss of strength of the spring. In such a case, the extension in the spring is more for a given load and hence the balance gives wrong readings.
- (a) Elasticity is a measure of tendency of the body to regain its original configuration. As steel is deformed less than rubber therefore steel is more elastic than rubber.
- 4. (d) In a glassy solid (*i.e.*, amorphous solid) the various bonds between the atoms or ions or molecules of a solid are not equally strong. Different bonds are broken at different temperatures. Hence there is no sharp melting point for a glassy solid.

**5.** (a)

6.

7.

8.

9.

11.

12.

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(a) Bulk modulus of elasticity measures how good the body is to regain its original volume on being compressed. Therefore, it represents incompressibility of the material.  $K = \frac{-PV}{\Delta V}$  where

*P* is increase in pressure,  $\Delta V$  is change in volume.

- (c) Strain is the ratio of change in dimensions of the body to the original dimensions. Because this is a ratio, therefore it is dimensionless quantity.
- (a) A bridge during its use undergoes alternating strains for a large number of times each day, depending upon the movement of vehicles on it when a bridge is used for long time, it losses its elastic strength. Due to which the amount of strain in the bridge for a given stress will become large and ultimately, the bridge may collapse. This may not happen, if the bridges are declared unsafe after long use.
- (d) Ivory is more elastic than wet-clay. Hence the ball of ivory will rise to a greater height. In fact the ball of wet-clay will not rise at all, it will be somewhat flattened permanently.

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**10.** (a) Young's modulus of a material, 
$$Y = \frac{\text{Stress}}{\text{Strain}}$$

$$re, stress = \frac{Restoring force}{Area}$$

Her

As restoring force is zero  $\therefore Y = 0$ .

(a) Work done 
$$= \frac{1}{2} \times \text{Stress} \times \text{Strain} = \frac{1}{2} \times Y \times (\text{Strain})^2$$
.

Since, elasticity of steel is more than copper, hence more work has to be done in order to stretch the steel.

(b) Stress is defined as internal force (restoring force) per unit area of a body. Also, rubber is less elastic than steel, because restoring force is less for rubber than steel.

ET Self Evaluation Test -9

wo writes /1 and D of same length, same area of cross-section having the same Young's modulus are heated to the same range of temperature. If the coefficient of linear expansion of A is 3/2 times of that of wire B. The ratio of the forces produced in two wires will be

- (a) 2/3 (b) 9/4
- (d) 3/2 (c) 4/9
- A wire of area of cross-section  $10^{-6}m^2$  is increased in length by 2. 0.1%. The tension produced is 1000 N. The Young's modulus of wire
  - $10^{12} N/m^2$ (b)  $10^{11} N/m^2$ (a)

(c) 
$$10^{10} N/m^2$$
 (d)  $10^9 N/m^2$ 

- To break a wire of one meter length, minimum 40 kg wt. is 3. required. Then the wire of the same material of double radius and 6 m length will require breaking weight
  - (a) 80 kg-wt (b) 240 kg-wt
  - (c) 200 kg-wt (d) 160 kg-wt
- The breaking stress of a wire of length L and radius r is 5 4.  $kg - wt / m^2$ . The wire of length 2/ and radius 2r of the same

material will have breaking stress in  $kg - wt / m^2$ 

- (b) 10 (a) 5 (d) 80
- (c) 20
- The increase in length on stretching a wire is 0.05%. If its Poisson's 5. ratio is 0.4, then its diameter
  - (a) Reduce by 0.02% (b) Reduce by 0.1%
  - (c) Increase by 0.02% (d) Decrease by 0.4%
- If Poission's ratio  $\sigma$  is  $-\frac{1}{2}$  for a material, then the material is 6.
  - (a) Uncompressible (b) Elastic fatigue (c) Compressible (d) None of the above
- If the breaking force for a given wire is F, then the breaking force of 7. two wires of same magnitude will be

(a)	F	(b)	4F

- (d) 2F (c) 8F
- If the thickness of the wire is doubled, then the breaking force in the 8. above question will be
  - (a) 6F (b) 4F
  - (c) 8F (d) F
- On all the six surfaces of a unit cube, equal tensile force of F is 9. applied. The increase in length of each side will be (Y = Young's)modulus,  $\sigma$  = Poission's ratio)

(a) 
$$\frac{F}{Y(1-\sigma)}$$
 (b)  $\frac{F}{Y(1+\sigma)}$ 

(c) 
$$\frac{F(1-2\sigma)}{Y}$$
 (d)  $\frac{F}{Y(1+2\sigma)}$ 

The mass and length of a write are manu b respectively. The density of the material of the wire is d. On applying the force F on the wire, the increase in length is *l*, then the Young's modulus of the material of the wire will be

) 
$$\frac{Fdl}{Ml}$$
 (b)  $\frac{FL}{Mdl}$ 

$$\frac{FMl}{dl} \qquad \qquad (d) \quad \frac{FdL}{Ml}$$

Two exactly similar wires of steel and copper are stretched by equal forces. If the difference in their elongations is 0.5 cm, the elongation (1) of each wire is

 $Y_{\rm s}(\text{steel}) = 2.0 \times 10^{11} N/m^2$ 

(a

(c)

11.

12.

13.

$$Y_{c}(\text{copper}) = 1.2 \times 10^{11} N/m^{2}$$

- (a)  $l_s = 0.75 \, cm, l_c = 1.25 \, cm$
- (b)  $l_s = 1.25 \ cm, l_c = 0.75 \ cm$
- (c)  $l_s = 0.25 \, cm, l_c = 0.75 \, cm$
- (d)  $l_s = 0.75 \ cm, l_c = 0.25 \ cm$
- If the compressibility of water is  $\,\sigma\,$  per unit atmospheric pressure, then the decrease in volume V due to P atmospheric pressure will be

(a)	$\sigma P / V$	(b)	$\sigma PV$
( )	= / DV	(1)	-V/D

- (c)  $\sigma/PV$ (d)  $\sigma V / F$
- A rectangular block of size  $10 \text{ cm} \times 8 \text{ cm} \times 5 \text{ cm}$  is kept in three different positions P, Q and R in turn as shown in the figure. In each case, the shaded area is rigidly fixed and a definite force F is applied tangentially to the opposite face to deform the block. The displacement of the upper face will be



- (d) Maximum in R position

Answers and Solutions

(SET - 9)

 $I. (d) F = YA \ \alpha \Delta \theta$ 

If *Y*, *A* and  $\Delta \theta$  are constant then  $\frac{F_A}{F_B} = \frac{\alpha_A}{\alpha_B} = \frac{3}{2}$ 

**2.** (a)  $Y = \frac{FL}{Al} = \frac{1000 \times 100}{10^{-6} \times 0.1} = 10^{12} N/m^2$ 

 $\textbf{3.} \qquad (d) \quad \text{Breaking force} = \text{Breaking stress} \times \text{Area of cross}$ 

section of wire

∴ Breaking force  $\propto r$  (Breaking distance is constant) If radius becomes doubled then breaking force will become 4 times *i.e.* 40 × 4 = 160 kg wt

4. (a) Breaking stress depends on the material of wire.

5. (a) Poisson's ratio = 
$$\frac{\text{Lateral strain}}{\text{Longitudinal strian}}$$

$$\therefore$$
 Lateral strain =  $0.4 \times \frac{0.05}{100}$ 

So reduced by 0.02%.

6. (a) 
$$\frac{dV}{V} = (1+2\sigma)\frac{dL}{dL}$$
  
if  $\sigma = -\frac{1}{2}$  then  $\frac{dV}{V} = 0$  i.e.  $K = \infty$ 

7. (d) Breaking force  $\infty$  Area of cross section

If area is double then breaking force will become two times.

**8.** (b) Breaking force  $\propto \pi r^2$ 

If thickness (radius) of wire is doubled then breaking force will become four times.

\*\*\*

12.

10. (d)  $Y = \frac{F}{A} \frac{L}{l} = \frac{F dL^2}{M l}$ 

As M = volume × density =  $A \times L \times d$   $\therefore$   $A = \frac{M}{Ld}$ 

**n.** (a) 
$$l \propto \frac{1}{Y} \Rightarrow \frac{Y_s}{Y_c} = \frac{l_c}{l_s} \Rightarrow \frac{l_c}{l_s} = \frac{2 \times 10^{11}}{1.2 \times 10^{11}} = \frac{5}{3}$$
 ...(i)  
Also  $l_s = -l_s = 0.5$  ...(ii)

On solving (i) and (ii)  $l_c = 1.25 \ cm$  and  $l_s = 0.75 \ cm$ .

(b) Compressibility = 
$$\frac{\Delta V/V}{P} \Rightarrow \sigma = \frac{\Delta V}{PV} \Rightarrow \Delta V = \sigma PV$$

**13.** (d) 
$$\eta = \frac{F/A}{x/L} \Rightarrow x = \frac{L}{\eta} \times \frac{F}{A}$$
  
If  $\eta$  and  $F$  are constant then  $x \propto \frac{L}{A}$ 

For maximum displacement area at which force applied should be minimum and vertical side should be maximum, this is given in the R position of rectangular block.

**9.** (c) Tensile strain on each face =  $\frac{F}{Y}$ 

Lateral strain due to the other two forces acting on perpendicular faces =  $\frac{-2\sigma F}{Y}$ Total increase in length =  $(1 - 2\sigma)\frac{F}{Y}$ 

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