Chapter 6: Mechanical Properties of Solids

EXERCISES [PAGE 112]

Exercises | Q 1. (i) | Page 112

Choose the correct answer.
Change in dimensions is known as _________.

1. **deformation**
2. formation
3. contraction
4. strain

SOLUTION

Change in dimensions is known as **deformation**.

Exercises | Q 1. (ii) | Page 112

Choose the correct answer.
The point on the stress-strain curve at which strain begins to increase even without increase in stress is called ________

1. elastic point
2. **yield point**
3. breaking point
4. neck point

SOLUTION

The point on the stress-strain curve at which strain begins to increase even without increase in stress is called **yield point.**

Exercises | Q 1. (iii) | Page 112

Choose the correct answer.
Strain energy of a stretched wire is 18×10^{-3} J and strain energy per unit volume of the same wire and same cross-section is 6×10^{-3} J/m^3. Its volume will be _________.

1. 3cm^3
2. **3 m^3**
3. 6 m^3
4. 6 cm^3

SOLUTION

Strain energy of a stretched wire is 18×10^{-3} J and strain energy per unit volume of the same wire and same cross-section is 6×10^{-3} J/m^3. Its volume will be **3 m^3**

Exercises | Q 1. (iv) | Page 112

Choose the correct answer.
________ is the property of a material which enables it to resist plastic deformation.

1. elasticity
2. plasticity
3. **hardness**
4. ductility

SOLUTION

Hardness is the property of a material that enables it to resist plastic deformation.

Exercises | Q 1. (v) | Page 112

Choose the correct answer.

The ability of a material to resist fracturing when force is applied to it, is called ______.

1. **toughness**
2. hardness
3. elasticity
4. plasticity

SOLUTION

The ability of a material to resist fracturing when force is applied to it, is called **toughness.**

Exercises | Q 2. (i) | Page 112

Answer in one sentence.

Define elasticity.

SOLUTION

If a body regains its original shape and size after removal of the deforming force, it is called an elastic body and the property is called elasticity.

Exercises | Q 2. (ii) | Page 112

Answer in one sentence.

What do you mean by deformation?

SOLUTION

The change in shape or size or both of a body due to an external force is called deformation.

Exercises | Q 2. (iii) | Page 112

Answer in one sentence.

State the SI unit and dimensions of stress.

SOLUTION

1. SI unit: N m^{-2} or pascal (Pa)

2. Dimensions: $[L^{-1}M^{1}T^{-2}]$

Exercises | Q 2. (iv) | Page 112

Answer in one sentence.
Define strain.

SOLUTION

The strain is defined as the ratio of change in dimensions of the body to its original dimensions.

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

Exercises | Q 2. (v) | Page 112

Answer in one sentence.
What is Young's modulus of a rigid body?

SOLUTION

Young's modulus is the modulus of elasticity related to change in length of an object like a metal wire, rod, beam, etc., due to the applied deforming force.

Exercises | Q 2. (vi) | Page 112

Answer in one sentence.
Why bridges are unsafe after very long use?

SOLUTION

A bridge during its use undergoes recurring stress depending upon the movement of vehicles on it. When bridge is used for long time, it loses its elastic strength and ultimately may collapse. Hence, the bridges are declared unsafe after long use.

Exercises | Q 2. (vii) | Page 112

Answer in one sentence.
How should be a force applied on a body to produce shearing stress?

SOLUTION

A tangential force which is parallel to the top and the bottom surface of the body should be applied to produce shearing stress.

Exercises | Q 2. (viii) | Page 112

Answer in one sentence.
State the condition under which Hooke's law holds good.

SOLUTION

Hooke's law holds good only when a wire/body is loaded within its elastic limit.

Exercises | Q 2. (ix) | Page 112
Answer in one sentence.
Define Poisson's ratio.

SOLUTION

Within elastic limit, the ratio of lateral strain to the linear strain is called the Poisson's ratio.

Exercises | Q 2. (x) | Page 112
Answer in one sentence.
What is an elastomer?

SOLUTION

A material that can be elastically stretched to a larger value of strain is called an elastomer.

Exercises | Q 2. (xi) | Page 112
Answer in one sentence.
What do you mean by elastic hysteresis?

SOLUTION

In case of some materials like vulcanized rubber, when the stress applied on a body decreases to zero, the strain does not return to zero immediately. The strain lags behind the stress. This lagging of strain behind the stress is called elastic hysteresis.

Exercises | Q 2. (xii) | Page 112
Answer in one sentence.
State the names of the hardest material and the softest material.

SOLUTION

Hardest material: Diamond

Softest material: Aluminium

Exercises | Q 2. (xiii) | Page 112
Answer in one sentence.
Define friction.

SOLUTION

The property which resists the relative motion between two surfaces in contact is called friction.

Exercises | Q 2. (xiv) | Page 112
Answer in one sentence.
Why force of static friction is known as 'self-adjusting force'?

SOLUTION

The force of static friction varies in accordance with applied force. Hence, it is called a self-adjusting force.

Exercises | Q 2. (xv) | Page 112

Answer in one sentence.

Name two factors on which the coefficient of friction depends.

SOLUTION

The coefficient of friction depends upon:

1. The materials of the surfaces in contact.
2. The nature of the surfaces.

Exercises | Q 3. (i) | Page 112

Answer in short.

Distinguish between elasticity and plasticity.

SOLUTION

No.	Elasticity		Plasticity
1.	Body regains its original shape or size after removal of deforming force	1.	Body does not regain its original shape or size after removal of deforming force.
2.	Restoring forces are strong enough to bring the displaced molecules to their original positions.	2.	Restoring forces are not strong enough to bring the molecules back to their original positions.
3.	Examples of elastic materials: metals, rubber, quartz, etc	3.	Examples of plastic materials: clay, putty, plasticine, thick mud, etc

Exercises | Q 3. (ii) | Page 112

Answer in short.

State any four methods to reduce friction.

SOLUTION

Friction can be reduced by using polished surfaces, using lubricants, using grease and using ball bearings.

Exercises | Q 3. (iii) | Page 112

Answer in short.
What is rolling friction? How does it arise?

SOLUTION

1. Friction between two bodies in contact when one body is rolling over the other is called rolling friction.
2. Rolling friction arises as the point of contact of the body with the surface keeps changing continuously.

Exercises | Q 3. (iv) | Page 112

Answer in short.
Explain how lubricants help in reducing friction.

SOLUTION

1. The friction between lubricant to surface is much less than the friction between the two same surfaces. Hence using lubricants reduces the friction between the two surfaces.
2. When the lubricant is applied to machine parts, it fills the depression present on the surface in contact. Thus, less friction occurs between machine parts.
3. The application of lubricants also reduces wear and tear of machine parts which in turn reduces friction.

Exercises | Q 3. (v) | Page 112

Answer in short.
State the laws of static friction.

SOLUTION

1. **First law:** The limiting force of static friction (F_L) is directly proportional to the normal reaction (N) between the two surfaces in contact.
   $F_L \propto N$

   $\therefore F_L = \mu_S N$

where, μ_s = constant called the coefficient of static friction.

2. **Second law:** The limiting force of friction is independent of the apparent area between the surfaces in contact, so long as the normal reaction remains the same.

3. **Third law:** The limiting force of friction depends upon materials in contact and the nature of their surfaces.

Exercises | Q 3. (vi) | Page 112

Answer in short.
State the laws of kinetic friction.

SOLUTION

1. **First law:** The force of kinetic friction (F_k) is directly proportional to the normal reaction (N) between two surfaces in contact.

   $F_k \propto N$
   $\therefore Fk = \mu_k N$
   where, μ_k = constant called the coefficient of kinetic friction.

2. **Second law:** Force of kinetic friction is independent of shape and apparent area of the surfaces in contact.

3. **Third law:** Force of kinetic friction depends upon the nature and material of the surfaces in contact.

4. **Fourth law:** The magnitude of the force of kinetic friction is independent of the relative velocity between the object and the surface provided that the relative velocity is neither too large nor too small.

Exercises | Q 3. (vii) | Page 112

Answer in short.
State advantages of friction.

SOLUTION

1. We can walk due to friction between ground and feet.
2. We can hold objects in hand due to static friction.
3. Brakes of vehicles work due to friction; hence we can reduce speed or stop vehicles.
4. Climbing on a tree is possible due to friction.

Exercises | Q 3. (viii) | Page 112

Answer in short.
State disadvantages of friction.

SOLUTION

1. Friction opposes motion.
2. Friction produces heat in different parts of machines. It also produces noise.
3. Automobile engines consume more fuel due to friction.

Exercises | Q 3. (ix) | Page 112

Answer in short.
What do you mean by brittle substance? Give any two examples.

SOLUTION

1. Substances which breaks within the elastic limit are called brittle substances.
2. Examples: Glass, ceramics.

Exercises | Q 4. (i) | Page 112

Long answer type question.
Distinguish between Young's modulus, bulk modulus, and modulus of rigidity.

SOLUTION

	Young's modulus	Bulk modulus	Modulus of rigidity
1.	It is the ratio of longitudinal stress to longitudinal strain.	It is the ratio of volume stress to volume strain.	It is the ratio of shearing stress to shearing strain.
2.	It is given by, Y = $\frac{\mathrm{MgL}}{\pi \mathrm{r}^1 l}$	It is given by, K = $\frac{\mathrm{VdP}}{\mathrm{dV}}$	It is given by, $\eta = \frac{\mathrm{F}}{\mathrm{A}\theta}$
3.	It exists in solids.	It exists in solid, liquid and gases.	It exists in solids.
4.	It relates to change in the length of a body.	It relates to the change in volume of a body.	It relates to change in shape of a body.

Exercises | Q 4. (ii) | Page 112

Long answer type question.
Define stress and strain. What are their different types?

SOLUTION

- **Stress:**

1. The internal restoring force per unit area of a body is called stress.

   Stress = $\frac{\text{deforming force}}{\text{area}} = \frac{|\vec{F}|}{A}$

   where $\vec{F}$ is internal restoring force or external applied deforming force.

2. **Types of stress:**

   i. Longitudinal stress,

   ii. Volume stress,

   iii. Shearing stress

- **Strain:**

1. Strain is defined as the ratio of change in dimensions of the body to its original dimensions.

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

2. **Types of strain:**

   i. Longitudinal strain,

   ii. Volume strain,

   iii. Shearing strain.

Exercises | Q 4. (iii) | Page 112

Answer the following:
What is Young's modulus?

SOLUTION

Young's modulus is the ratio of longitudinal stress to longitudinal strain. It is denoted by Y.
Unit: N/m^2 or Pa in SI system.
Dimensions: $[L^{-1}M^{1}T^{-2}]$

Exercises | Q 4. (iv) | Page 112

Long answer type question.
Derive an expression for strain energy per unit volume of the material of a wire.

SOLUTION

The expression for strain energy per unit volume:

1. Consider a wire of original length L and cross-sectional area A stretched by a force F acting along its length. The wire gets stretched and elongation l is produced in it.

2. If the wire is perfectly elastic then,

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

   Longitudinal strain = $\frac{l}{L}$

   Young's modulus (Y) = $\frac{\text{longitudinal stress}}{\text{longitudinal strain}}$

   Y = $\frac{F/A}{l/L} = \frac{F}{A} \times \frac{L}{l}$

   ∴ F = $\frac{YAl}{L}$ ....(1)

3. The magnitude of stretching force increases from zero to F during elongation of wire. Let 'f' be the restoring force and 'x' be its corresponding extension at certain instant during the process of extension.

   ∴ f = $\frac{YAx}{L}$ .....(2)

4. Let 'dW' be the work done for the further small extension 'dx'.

   Work = force × displacement

   ∴ dW = fdx

   ∴ dW = $\frac{YAx}{L}$dx .....(3) [From (2)]

5. The total amount of work done in stretching the wire from x = 0 to x = l can be found out by integrating equation (3).

$$W = \int_0^l dW = \int_0^l \frac{YAx}{L} dx = \frac{YA}{L} \int_0^l x dx$$

$$\therefore W = \frac{YA}{L} \left[\frac{x^2}{2} \right]_0^l$$

$$\therefore W = \frac{YA}{L} \left[\frac{l^2}{2} - \frac{0^2}{2} \right]$$

$$\therefore W = \frac{YAl}{L} \times \frac{l}{2}$$

But, $\frac{YAl}{L} = F$ .....[From (1)]

$$W = \frac{1}{2} \times F \times l$$

W = $\frac{1}{2} \times \text{load} \times \text{extension}$

6. Work done by stretching force is equal to strain energy gained by the wire.

   ∴ Strain energy = $\frac{1}{2} \times \text{load} \times \text{extension}$

7. Work done per unit volume = $\frac{\text{workdone instretching wire}}{\text{volume of wire}}$

   $= \frac{1}{2} \times \frac{F \times l}{V}$

   $= \frac{1}{2} \times \frac{F \times l}{A \times L}$

   $= \frac{1}{2} \times \frac{F}{A} \times \frac{l}{L}$

   $= \frac{1}{2} \times \text{stress} \times \text{strain}$

   ∴ Strainenergy per unitvolume = $\frac{1}{2} \times \text{stress} \times \text{strain}$

8. **Other forms:**

   Since, Y = $\frac{\text{stress}}{\text{strain}}$

- Strain energy per unit volume

  $= \frac{1}{2} \times \text{stress} \times \frac{\text{stress}}{Y} = \frac{1}{2} \times \frac{(\text{stress})^2}{Y}$

- Strain energy per unit volume

  $= \frac{1}{2} \times Y \times \text{strain} \times \text{strain} = \frac{1}{2} \times Y \times (\text{strain})^2$

Exercises | Q 4. (v) | Page 112

Answer in one sentence.

Define friction.

SOLUTION

The property which resists the relative motion between two surfaces in contact is called friction.

Exercises | Q 4. (vi) | Page 112

Long answer type question.

State Hooke's law.

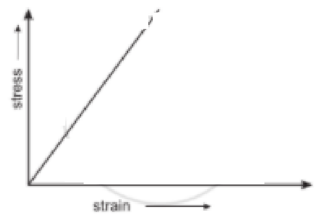
SOLUTION

Statement:

Within the elastic limit, stress is directly proportional to strain.

Explanation:

1. According to Hooke's law,
   Stress ∝ Strain
   $\therefore \frac{\text{Stress}}{\text{Strain}} = \text{constant}$
   This constant of proportionality is called modulus of elasticity.
2. Modulus of elasticity of a material is the slope of the stress-strain curve inelastic deformation region and depends on the nature of the material.
3. The graph of strain (on X-axis) and stress (on Y-axis) within elastic limit is shown in the figure.



Stress versus strain graph within elastic limit for an elastic body

Exercises | Q 5. (i) | Page 113

Answer the following.

Calculate the coefficient of static friction for an object of mass 50 kg placed on a horizontal table pulled by attaching a spring balance. The force is increased gradually, it is observed that the object just moves when spring balance shows 50 N.

SOLUTION

Given: m = 50 kg, F_L = 50 N, g = 9.8 m/s^2

To find: Coefficient of static friction (μ_S)

Formula: $\mu_S = \frac{F_L}{N} = \frac{F_L}{mg}$

Calculation: From formula,

$$\mu_S = \frac{50}{50 \times 9.8} = 0.102$$

The coefficient of static friction is 0.102.

Exercises | Q 5. (ii) | Page 113

Answer the following.

A block of mass 37 kg rests on a rough horizontal plane having coefficient of static friction 0.3. Find out the least force required to just move the block horizontally.

SOLUTION

Given: m = 37 kg, S = 0.3, g = 9.8 m/s^2

To find: Limiting force (F_L)

Formula: $F_L = \mu_S N = \mu_S mg$

Calculation: From formula,

$F_L = 0.3 \times 37 \times 9.8 =$ **108.8 N**

Exercises | Q 5. (iii) | Page 113

Answer the following.

A body of mass 37 kg rests on a rough horizontal surface. The minimum horizontal force required to just start the motion is 68.5 N. In order to keep the body moving with constant velocity, a force of 43 N is needed. What is the value of

i. coefficient of static friction? and

ii. coefficient of kinetic friction?

SOLUTION

Given: F_L = 68.5 N, F_k = 43 N, m = 37 kg, g = 9.8 m/s^2

To find: i. Coefficient of static friction (μ_S)

ii. Coefficient of kinetic friction (μ_k)

Formulae: From formula (i),

$$\therefore \mu_S = \frac{F_S}{N} = \frac{68.5}{37 \times 9.8} = 0.1889$$

From formula (ii),

$$\therefore \mu_k = \frac{F_k}{N} = \frac{43}{37 \times 9.8} = 0.1186$$

i. The coefficient of static friction is **0.1889**.

ii. The coefficient of kinetic friction is **0.1186**.

Exercises | Q 5. (iv) | Page 113

Answer the following.

A wire gets stretched by 4 mm due to a certain load. If the same load is applied to a wire of same material with half the length and double the diameter of the first wire, what will be the change in its length?

SOLUTION

Given: $l_1 = 4 \text{ mm} = 4 \times 10^{-3}$ m

$L_2 = \frac{L_1}{2}$, $D_2 = 2D$, $r_2 = 2r_1$

To find: Change in length (l_2)

Formula: $Y = \frac{FL}{Al} = \frac{FL}{\pi r^2 l}$

Calculation: From formula,

$$Y_1 = \frac{F_1 L_1}{\pi r_1^2 l_1} \quad .....(i)$$

$$Y_2 = \frac{F_2 L_2}{\pi r_2^2 l_2} \quad .....(ii)$$

Dividing equation (ii) by equation (i),

$$\frac{Y_2}{Y_1} = \frac{\frac{F_2 L_2}{\pi r_2^2 l_2}}{\frac{F_1 L_1}{\pi r_1^2 l_1}} \quad .....(iii)$$

Since same load is applied on same wire, $Y_1 = Y_2$ and $F_1 = F_2$

$$\therefore \frac{L_1}{r_1^2 l_1} = \frac{L_2}{r_2^2 l_2} \quad .....[\text{From (iii)}]$$

$$l_2 = \frac{L_2 \times r_1^2 \times l_1}{r_2^2 \times L_1}$$

$$= \frac{L_2 \times r_1^2 \times l_1}{4r_1^2 \times 2 \times L_2} \quad \ldots..(\because L_1 = 2L_2, r_2 = 2r_1)$$

$$= \frac{l_1}{8}$$

$$= \frac{4 \times 10^{-3}}{8}$$

= 0.5×10^{-3} m

= **0.5 mm**

Exercises | Q 5. (v) | Page 113

Answer the following.

Calculate the work done in stretching a steel wire of length 2 m and cross-sectional area 0.0225 mm^2 when a load of 100 N is slowly applied to its free end. (Young's modulus of steel = 2×10^{11} N/m^2)

SOLUTION

Given: L = 2 m, F = 100 N, A = 0.0225 mm^2 = 2.25×10^{-8} m^2, Y = 2×10^{11} N/m^2

To find: Work (W)

Formula: W = $\frac{1}{2} \times F \times l$

Calculation: Since, Y = $\frac{FL}{Al}$

$\therefore$ l = $\frac{FL}{AY}$

From formula,

$$W = \frac{1}{2} \times \frac{F \times FL}{AY} = \frac{1}{2}\frac{F^2L}{AY}$$

$$= \frac{1}{2} \times \frac{100 \times 100 \times 2}{2.25 \times 10^{-8} \times 2 \times 10^{11}}$$

$$= \frac{10^4 \times 10^{-11} \times 10^8}{2.25 \times 2}$$

$$= \frac{10}{4.5}$$

= antilog [log 10 – log 4.5]

= antilog [1.0000 – 0.6532]

= antilog [0.3468]

∴ W = **2.222 J**

The work done in stretching the steel wire is **2.222 J**.

Exercises | Q 5. (vi) | Page 113

Answer the following.

A solid metal sphere of volume 0.31 m^3 is dropped in an ocean where water pressure is 2×10^7 N/m^2. Calculate change in volume of the sphere if the bulk modulus of the metal is 6.1×10^{10} N/m^2.

SOLUTION

Given: V = 0.31 m^3, dP = 2×10^7 N/m^2, K = 6.1×10^{10} N/m^2

To find: Change in volume (dV)

Formula: $K = V \times \frac{dP}{dV}$

Calculation: From formula,

$$dV = \frac{V \times dP}{K}$$

$$\therefore dV = \frac{0.31 \times 2 \times 10^7}{6.1 \times 10^{10}} \approx 10^{-4} m^3$$

The change in volume of the sphere is **10^{-4} m^3**.

Exercises | Q 5. (vii) | Page 113

Answer the following.

A wire of mild steel having an initial length 1.5 m and diameter 0.60 mm gets extended by 6.3 mm when a certain force is applied to it. If Young's modulus of mild steel is 2.1×10^{11} N/m^2, calculate force applied.

SOLUTION

Given: L = 1.5 m, d = 0.60 mm,

r = $\frac{d}{2} = 0.30$mm = 3×10^{-4} m,

Y = 2.1×10^{11} N/m^2,

l = 6.3 mm = 6.3×10^{-3} m

To find: Force (F)

Formula: Y = $\frac{FL}{Al}$

Calculation: From formula,

F = $\frac{YAl}{L}$

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

$= \frac{2.1 \times 10^{11} \times 3.142 \times (3 \times 10^{-4})^2 \times 6.3 \times 10^{-3}}{1.5}$

$= \frac{2.1 \times 3.142 \times 9 \times 6.3 \times 10^{11} \times 10^{-8} \times 10^{-3}}{1.5}$

= 2.1 × 3.142 × 6 × 6.3

= antilog [log 2.1 + log 3.142 + log 6 + log 6.3]

= antilog [0.3222 + 0.4972 + 0.7782 + 0.7993]

= antilog [2.3969]

= 2.494×10^2

≈ **250 N**

The force applied on wire is **250 N**.

Exercises | Q 5. (viii) | Page 113

Answer the following.

A composite wire is prepared by joining a tungsten wire and steel wire end to end. Both the wires are of the same length and the same area of cross-section. If this composite wire is suspended to a rigid support and a force is applied to its free end, it gets extended by 3.25 mm. Calculate the increase in the length of tungsten wire and steel wire separately.

($Y_{Tungsten} = 4.1 \times 10^{11}$ Pa. $Y_{Steel} = 2 \times 10^{11}$ Pa)

SOLUTION

Given: $l_S + l_T = 3.25$ mm, $Y_T = 4.11 \times 10^{11}$ Pa, $Y_s = 2 \times 10^{11}$ Pa

To find: Extension in tungsten wire (l_T)

Extension in steel wire (l_S)

Formula: $Y = \frac{FL}{Al}$

Calculation: From formula,

$$Y \propto \frac{1}{l} \quad .....(\because \text{F, L and A are same for both the wires})$$

$$\therefore Y_S = \frac{l_T}{l_S}$$

$$\therefore \frac{2 \times 10^{11}}{4.11 \times 10^{11}} = \frac{l_T}{l_S}$$

$$\therefore \frac{l_T}{l_S} = 0.487$$

But $l_S + l_T = 3.25$

$l_S + 0.487\ l_S = 3.25$

$l_S\ (1 + 0.487) = 3.25$

$l_S = 2.186$ mm

$\therefore l_T = 3.25 - 2.186 = 1.064$ mm

The extension in tungsten wire is **1.064 mm** and the extension in steel wire is **2.186 mm**.

Exercises | Q 5. (ix) | Page 113

Answer the following.

A steel wire having a cross-sectional area of 1.2 mm^2 is stretched by a force of 120 N. If a lateral strain of 1.455×10^{-4} is produced in the wire, calculate the Poisson's ratio. (Given: $Y_{Steel} = 2 \times 10^{11}\ N/m^2$)

SOLUTION

Given: $A = 1.2\ mm^2 = 1.2 \times 10^{-6}\ m^2$, F = 120 N, $Y_{steel} = 2 \times 10^{11}\ N/m^2$, Lateral strain = 1.455×10^{-4}

To find: Poisson's ratio (σ)

Formulae:

i. Longitudinal stress = $\frac{F}{A}$

ii. $Y = \frac{\text{longitudinal stress}}{\text{longitudinal strain}}$

iii. $\sigma = \frac{\text{lateral strain}}{\text{longitudinal strain}}$

Calculation: From formula (i),

longitudinal stress = $\frac{F}{A} = \frac{120}{1.2 \times 10^{-6}} = 10^8 N/m^2$

From formula (ii),

longitudinal strain = $\frac{\text{longitudinal stress}}{Y}$

$= \frac{10^8}{2 \times 10^{11}} = 5 \times 10^{-4}$

From formula (iii),

$\sigma = \frac{\text{lateral strain}}{\text{longitudinal strain}} = \frac{1.455 \times 10^{-4}}{5 \times 10^{-4}}$

= 0.291

The Poisson's ratio of steel is **0.291**.

Exercises | Q 5. (x) | Page 113

Answer the following.

A telephone wire 125 m long and 1 mm in radius is stretched to a length 125.25 m when a force of 800 N is applied. What is the value of Young's modulus for the material of wire?

SOLUTION

Given: L = 125 m, r = 1 mm = 1×10^{-3} m,

l = 125.25 - 125 = 0.25 m, F = 800 N

To find: Young's modulus (Y)

Formula: $Y = \frac{FL}{Al} = \frac{FL}{\pi r^2 l}$

Calculation: From formula,

$$Y = \frac{800 \times 125}{3.142 \times 10^{-6} \times 0.25}$$

= {antilog [log 800 + log 125 – log 3.142 – log 0.25]} × 10^6

= {antilog [2.9031 + 2.0969 – 0.4972 – $\bar{1}$.3979]} × 10^6

= {antilog [5.1049]} × 10^6

= 1.274×10^5

=1.274 × 1011N/m^2

The Young's modulus of telephone wire is **1.274×10^{11} N/m^2**.

Exercises | Q 5. (xi) | Page 113

Answer the following.

A rubber band originally 30 cm long is stretched to a length of 32 cm by a certain load. What is the strain produced?

SOLUTION

Given: L = 30 cm = 30 $\times 10^{-2}$ m, Δl = 32 cm - 30 cm = 2 cm = 2 $\times 10^{-2}$

To find: Strain

Formula: Strain = $\frac{\Delta l}{L}$

Calculation: From formula,

Strain = $\frac{2 \times 10^{-2}}{30 \times 10^{-2}} = 6.667 \times 10^{-2}$

The strain produced in the wire is **6.667×10^{-2}**.

Exercises | Q 5. (xii) | Page 113

Answer the following.
What is the stress in a wire which is 50m long and 0.01cm^2 in cross-section, if the wire bears a load of 100 kg?

SOLUTION

Given: M = 100 kg, L = 50 m, A = 0.01 $\times 10^{-4}$ m

To find: Stress

Formula: Stress = $\frac{F}{A} = \frac{Mg}{A}$

Stress = $\frac{100 \times 9.8}{0.01 \times 10^{-4}} = 9.8 \times 10^{8} N/m^2$

The stress in the wire is **9.8×10^{8} N/m^2**.

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Answer the following.
What is the strain in a wire cable of the original length 50 m whose length increases by 2.5 cm when a load is lifted?

SOLUTION

Given: L = 50 m, Δl = 2.5 cm = 2.5×10^{-2} m

To find: Strain

Formula: Strain = $\frac{\Delta l}{L}$

Calculation: From the formula,

Strain = $\frac{2.5 \times 10^{-2}}{50} = 5 \times 10^{-4}$

The strain produced in wire is **5×10^{-4}**.