Text Book Exercise

Q1. Select the correct answer of the following questions.

(i) A wire is stretched to double of its length. Its strain is:

(a) 2   **(b)** 1   **(c)** 0   **(d)** 0.5

(ii) Which of the modulus of elasticity is involved in compressing a rod of decrease its length?

(a) Young's modulus **(b)** Bulk modulus   **(c)** Modulus of elasticity   **(d)** None

(iii) Which one is ferromagnetic in nature?

(a) Soft iron   **(b)** Nickle   **(c)** Copper   **(d)** None of these

(iv) If both the length and radius of the rod are doubled, then the modulus of elasticity will:

(a) increase   **(b)** decrease   **(c)** remain the same   **(d)** doubled

(v) Curie temperature is a point where:

(a) diamagnetism changes to paramagnetism

(b) paramagnetism changes to diamagnetism

(c) ferromagnetism changes to paramagnetism

(d) paramagnetism changes to ferromagnetism

(vi) A cable breaks if stretched by more than 2mm. it is cut into two equal parts. How much either part can be stretched without breaking?

(a) 25 m   **(b)** 1mm   **(c)** 2mm   **(d)** 0.5m

No.	Option	Answer	Explanation
(i)	(b)	1	$\varepsilon = \frac{\Delta l}{l} = \frac{l}{l} = 1$ ($\because \Delta l = 2l - l = l$)
(ii)	(a)	Young's modulus	$Y = \frac{\sigma}{\varepsilon} = \frac{\sigma}{\Delta l / l}$
(iii)	(a, b)	Soft iron	Both Nickle and soft iron (low carbon content iron) are ferromagnetic in nature
(iv)	(c)	Remain the same	Young's modulus is the characteristic of material and independent of its dimensions
(v)	(c)	ferromagnetism changes to paramagnetism	At this temperature the domain loses their alignment
(vi)	(b)	1mm	As $\Delta l = \frac{fl}{Y\pi r^2}$ And $\Delta l' = \frac{F\frac{l}{2}}{Y\pi r^2}$ $\left(l' = \frac{l}{2}\right)$ $= \frac{\Delta l}{2} = \frac{2mm}{2} = 1mm$

Comprehensive Questions

Q.2 Write short answers of the following questions.

1. Explain the differences between tensile and compressive forces and how they affect equilibrium within a structure.

Ans: See Theory

2. Draw and describe a stress/strain graph and identify the elastic region, plastic flow region, yield stress and ultimate tensile stress.

Ans: See Theory Question No. 3

3. Describe the valence band, conduction band and forbidden energy gap with the help of energy level diagram.

Ans: See Theory Question No. 6

4. Discuss the superconductivity of a conductor with the help of a curve.

Ans: See Theory Question No. 7

5. Describe the mechanical properties of solids?

Ans: See Theory Question No. 4

6. Describe Hysteresis loop a ferromagnetic material by drawing its curve for iron.

Ans: See Theory Question No. 9

7. Explain strain energy in a deformed wire by drawing its graph.

Ans: See Theory Question No. 5

Conceptual Questions

1. Evaluate the importance of strength and stiffness in a design contact.

Ans: Strength and stiffness are the mechanical properties of solids.

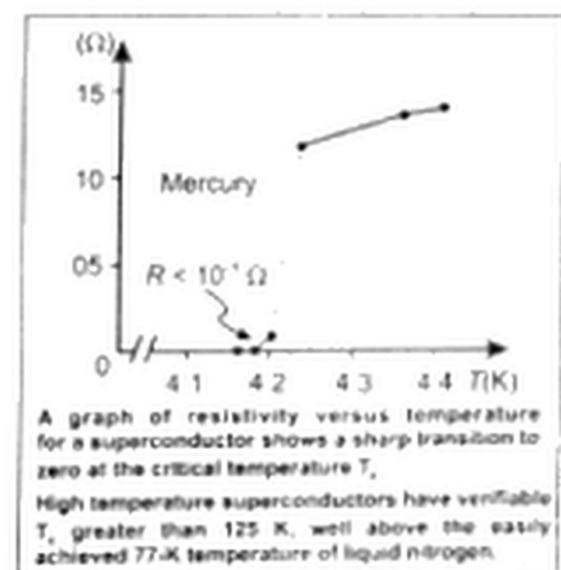**Strength:** The general ability of a material to withstand an applied force.

Stiffness: the ability to resist bending.

Importance: Variety of materials are used in our daily life for designating cupboards, window frames, guarders, gates and also for industrial properties like strength and stiffness hence their key importance.

2. Discuss the superconductivity of a conductor with the help of a curve.

Ans: A superconductor is material that can conduct electricity or transport electrons from one atom to another with no resistance.

This means no heat, sound or any other form of energy would be released from the material when it has reached "critical temperature" (T_c), or the temperature at which the material becomes superconductive. Unfortunately, most materials must be in an extremely low energy state (very cold) in order to become superconductive. The resistance of a superconductor is zero, since,

A graph of resistivity versus temperature for a superconductor shows a sharp transition to zero at the critical temperature T, High temperature superconductors have verifiable T, greater than 125 K, well above the easily achieved 77-K temperature of liquid nitrogen.

there are no heat losses for currents through them; they are used in magnets needing high currents, such as in MRI machines, and it does not offer resistance to transmission line. In the past decade, tremendous advances have been made in producing materials that become superconductors at relatively high temperatures. There is hope that room temperature superconductors may someday be manufacture.

3. Distinguish between crystalline, amorphous and polymer solids.

Ans: Crystalline Solids

Crystalline solids are those in which there is a regular arrangement of atoms and molecules.

Their structure is studied by x-rays diffraction techniques.

Some examples of crystalline solids are iron, sodium chloride, zirconia etc.

The cohesive forces arc responsible for strict long-range order inside of atomic vibrations.

Crystalline structure has a definite melting point.

Amorphous or Glassy Solids

Amorphous solids have no regular arrangement of molecules.

They are also known as solid liquids. (liquids in frozen)

Thus, amorphous solids are also called glassy solids.

Amorphous solids have no definite melting point.

Polymeric Solids

They are more or less solid materials with a structure which is intermediate between order and disorder.

They may be formed by polymerization process.

Natural rubber is composed in the pure state entirely hydrocarbon with the formula $(C_5H_6)_n$.

These materials have rather low specific gravity compared with even the lightest of metals

They exhibit good strength to weight ratio.

4. Define unit cell, basis and space lattice.

Ans: Unit cell:

The group of atom, molecules or ions that repeat itself in three-dimensional space is called unit cell.

It may be cubic, tetragonal, orthorhombic, hereagonal, monoclinic, triclinic.

Basis:

A group of atoms repeated at regular intervals along all directions in a crystal is called basis or unit cell. Sparc lattice:

A spare lattice is the repeating pattern of mathematical points that extends throughout the space.

When the basis is associated with each lattice site, the crystal structure is obtained

Crystal lattice + Basis structure = Crystal

5. Differentiate between paramagnetic diamagnetic and ferromagnetic material with suitable examples.

Ans: Paramagnetic material:

In these substances the orbital and spin axis of the electrons in an atom are so oriented that their field support each other and the atom behaves like a tiny magnet. These substances are called paramagnetic materials.

When a paramagnetic substance (e.g. aluminum, antimony etc.) is placed in a magnetic field, the substance is weakly magnetized in the direction of the applied field. Therefore, a paramagnetic substance is weakly attracted by a strong magnet.

Ferromagnetic material:

In these substances the group of atoms act like tiny magnets. The interaction between these tiny atomic magnets is so strong that it lines up parallel to each other even when no external magnetic fields is present. Such substances are called ferromagnetic material. These tiny magnets are called magnetic domains. The size of these domains is very small of the order of millimeters or less but large enough to contain atoms from 10^{12} to 10^{16} Each domain acts like a small magnet with its own north and South pole. The coupling or interaction between the neighboring tiny magnets is reduced by increasing the temperature of a substance. The temperature at which a ferromagnetic material becomes paramagnetic is called its curie temperature.
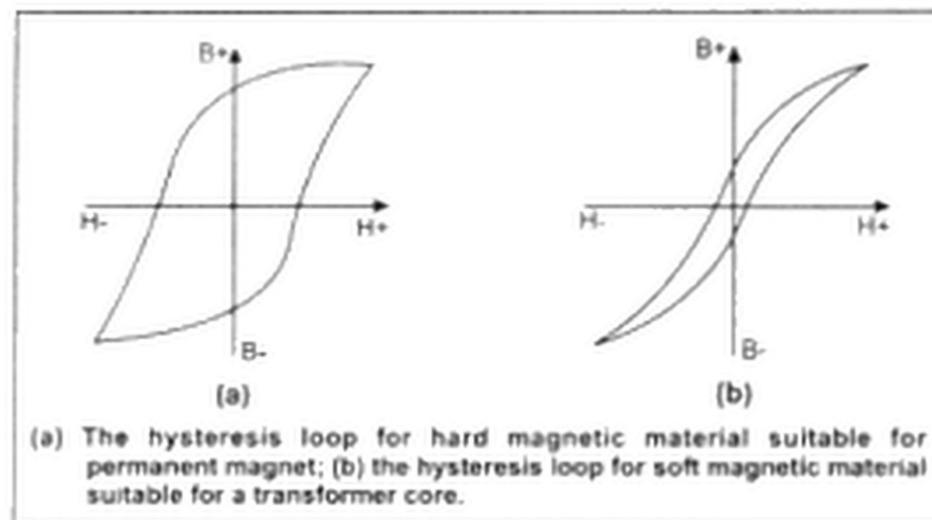
6. Distinguish between soft and hard substance by drawing its curves.

Ans: Soft ferromagnetic materials such as iron or silicon steel have very narrow magnetic hysteresis loops resulting in very small amounts of residual magnetism making them ideal for use in relays, solenoids and transformers as they can be easily magnetized and de-magnetized.

Since a coercive force must be applied to overcome this residual magnetism, work must be done in closing the hysteresis loop with the energy being used being dissipated as heat in the magnetic material. This heat is known as

hysteresis loss, the amount of loss depends on the material's value of coercive force.

By adding silicon, to iron a material with a very small coercive force can be made, such materials typically contain 5% silicon and have very narrow hysteresis loop.

(a) The hysteresis loop for hard magnetic material suitable for permanent magnet; (b) the hysteresis loop for soft magnetic material suitable for a transformer core.

Materials with narrow hysteresis loops are easily magnetized and de-magnetized and known as soft magnetic materials. '

Magnetic Hysteresis results in the dissipation of wasted energy in the form of heat with the energy wasted being in proportion to the area of the magnetic hysteresis loop. Hysteresis losses will always be problem in AC transformers where the current is constantly changing direction and thus the magnetic poles in the core will cause losses because they constantly reverse direction.

7. Explain Hook's Law and Modulus of Elasticity.

Ans: Hook's law:

Hook's law states that within elastic limit stress is directly proportional to strain.

Stress ∝ stain (with in elastic limit)

Modules of Elasticity:

In hook's law, the constant of proportionality is called modules of elasticity.

Which can be defined as the ratio of stress and strain

i.e.   stress = E strain

$$E = \frac{Stress}{Strain}$$

Its unit is Pa = Nm^{-2} and it is the property of given material.

8. Is there any difference in the length of a 20-meter steel girder when standing vertically and horizontally?

Ans: Yes, there is a difference in length of steel girder in vertical and horizontal positions.

Explanation:

As the stress can be defined as the deforming force per unit area, i.e

$$\sigma = \frac{F}{A}$$

This shows that for definite force, the stress varies inversely with the area of cross-section.

As the force in that case is weight, so when the steel girder is placed in horizontal position, then the force acting on it will, distribute itself on the wider area of girder and so there will be no change in the length of the steel girder. But when it is placed vertically, then the same force will act along its length on its cross-section area which is smaller than that of horizontal. So, the difference of length becomes greater in this case.

9. Steel reinforcing is used in concrete beams to prevent cracking. Explain where the steel reinforcing should be placed in a concrete beam?

Ans: The well combination of steel and concrete is called Reinforced Concrete.

Explanation:

The reinforcing steel rods are very significant in huge structures. Only concrete is not sufficient to provide the shear strength. Reinforcement steel provides the greater strength and safety.

Steel reinforcement should be used in concrete beams due to their structural difference in design. It provides the resistance to cracking, shrinkage, temperature changes and impacts necessary for a long-strengthened life of the structure.

10. (a) What is meant by the elastic limit of material.

(b) In what way does a material behave 8f it obeys Hook's Law?

Ans: a) Elastic limit:

Elastic limit can be defined as the maximum stress which a material can endure without any permanent change in shape or dimension. It is denoted by σ_e

The elastic limit point in stress strain graph is also called yield point.

b) Hook's Law:

Hook law can state as "up to proportional limit the stress is directly proportional to strain."

i.e.   stress $\propto$ strain

stress = E (strain)

$$E = \frac{stress}{strain}$$

It means that stress and strain vary in same proportion so their ratio will remain constant (i.e. elastic modulus).

11. Cast-iron beams are used in bridge and building construction. The lower part of the beam is thicker than the upper part. Why is it better for the lower part of

the beam to be thicker than the upper part? Given reasons for your answer including reference to the tensile and compressive strength.

Ans: A hard, brittle, nonmalleable iron-carbon alloy, cast into shape containing 2 to 4.5 percent carbon 0.5 to 3 percent silicon and lesser amount of sulfur, manganese and phosphorus is called cast iron.

Explanation

Making the lower part of the beam made thicker to increases the surface area of the beam, therefore the compressive stress decreases on the lower part of the cast iron. As,

$$\sigma = \frac{F}{A}$$

It will help to increase the compressive strength of the solenoid