

Level - 0	CBSE Pattern/Solutions
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1. $T = T_C + 273.15$
2. A force which changes the size or shape of a body is called deforming force
3. The maximum stress within which the body regains its original shape and size after removal of deforming force is called its elastic limit
4. Heat is the form of energy transferred between two (or more) systems and its surroundings by virtue of temperature difference. S.I unit of heat is Joule.
5. Within elastic limit, the stress is directly proportional to strain, stress $\propto$ strain
6. Strain:- The ratio of change in any dimension produced in the body to its original dimension is called strain. Strain is a ratio, hence it has no unit.
Stress:- Restoring force per unit area of cross section of the deformed body is called stress. S.I unit of stress is Nm^{-2} .
7. Elastomer is a substance which can be stretched to cause large strains in it. It does not obey Hooke's law for most of the region and there is no well defined plastic region for it. Example of an elastomer is rubber or tissue of aorta.
8. Water exhibits an anomalous behavior as it contracts on heating between 0°C and 4°C . The volume of a given amount of water decreases as it is cooled from room temperature until it reaches 4°C . Below 4°C , the volume increases therefore density decreases. This means that water has maximum density at 4°C . Its environmental effect is that the bodies of water such as lakes and ponds freeze at the top first.
9. The temperature and pressure at which the fusion curve, the vaporization curve and the sublimation curve meet and all the three phases of a substance co exist is called the triple point of the substance. The triple point of water is at 273.16 K temperature and $6.11 \times 10^{-3}\text{ Pa}$ pressure
10. The boiling point of water is 100°C at 76cm of Hg (1atm). At the moon atmospheric pressure is extremely low nearly 0.01 cm of Hg. At such pressure, the boiling point will reach less than 0°C . It means ice straight away will convert into vapours.
11. In hills, boiling point of water is reduced due to lower atmospheric pressure. Hence vegetables cannot be heated at as high temperatures as at sea level. So they take more time in cooking.
12. A dewar flask or thermos bottle is a device to minimize heat transfer between the contents of the bottle and outside. It consists of a double walled glass vessel with inner and outer walls coated with silver. Radiation from the inner walls is reflected back into the contents of the bottle. The outer wall similarly reflects back any incoming radiation. The space between the walls is evacuated to reduce conduction and convection and the flask is supported on an insulator. The device is useful for preventing hot contents like tea from getting cold.

13. Here, compressional force, $F = 5 \times 10^4 N$

Diameter, $D = 5.0 \times 10^{-4} m$. $\therefore$ radius, $r = \frac{D}{2} = 2.5 \times 10^{-4} m$.

Area, $A = \pi r^2 = \frac{22}{7} \times (2.5 \times 10^{-4})^2 m^2$, Pressure at the tip, $P = ?$

Using the relation, $P = \frac{F}{A}$, we get, $P = \frac{5 \times 10^4}{\frac{22}{7} \times (2.5 \times 10^{-4})^2} = 0.255 \times 10^{12} Pa = 2.55 \times 10^{11} Pa$

14. $L_x = L_0(1 + \alpha_x \Delta T)$, $L_y = L_0(1 + \alpha_y \Delta T)$ and $L_z = L_0(1 + \alpha_z \Delta T)$

Thus, $V = L_x L_y L_z = L_0^3(1 + \alpha_x \Delta T)(1 + \alpha_y \Delta T)(1 + \alpha_z \Delta T)$

Neglecting higher order terms such as $\alpha_x \alpha_y$, $\alpha_y \alpha_z$, $\alpha_z \alpha_x$ and $\alpha_x \alpha_y \alpha_z$, we get

$V = V_0[1 + (\alpha_x + \alpha_y + \alpha_z) \Delta T]$ $\therefore$ Coefficient of volume expansion of the solid $= \alpha_x + \alpha_y + \alpha_z$.

15. Mass of aluminium sphere (m_1) = 0.047 kg

Initial temperature of aluminium sphere = $100^\circ C$

Final temperature = $23^\circ C$

Change in temperature (ΔT) = $(100^\circ C - 23^\circ C) = 77^\circ C$

Let specific heat capacity of aluminium be s_{Al} .

The amount of heat lost by the aluminium sphere = $m_1 s_{Al} \Delta T = 0.047 kg \times s_{Al} \times 77^\circ C$

Mass of water (m_2) = 0.25 kg

Mass of calorimeter (m_3) = 0.14 kg

Initial temperature of water and calorimeter = $20^\circ C$

Final temperature of the mixture = $23^\circ C$

Change in temperature (ΔT_2) = $23^\circ C - 20^\circ C = 3^\circ C$

Specific heat capacity of water (s_w) = $4.18 \times 10^3 J kg^{-1} K^{-1}$

Specific heat capacity of copper calorimeter = $0.386 \times 10^3 J kg^{-1} K^{-1}$

The amount of heat gained by water and calorimeter = $m_2 s_w \Delta T_2 + m_3 s_{Cu} \Delta T_2$

$= (m_2 s_w + m_3 s_{Cu})(\Delta T_2) = (0.25 \times 4.18 \times 10^3 + 0.14 \times 0.386 \times 10^3)(3)$

In the steady state, heat lost by the aluminium sphere = heat gained by water + heat gained by calorimeter

$\therefore 0.047 \times s_{Al} \times 77 = (0.25 \times 4.18 \times 10^3 + 0.14 \times 0.386 \times 10^3)(3) \Rightarrow$

$s_{Al} = 0.911 kJ kg^{-1} K^{-1}$.

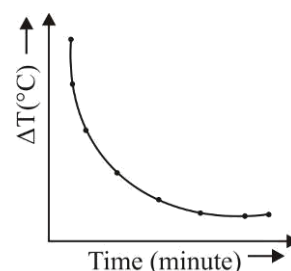
16. Stefan's law, $P \propto AT^4$

When's law, $\lambda_m T = \text{constant}$

$\therefore P \propto \frac{A}{(\lambda_m)^4} \propto \frac{r^2}{\lambda_m^4}$, $P_A : P_B : P_C = \frac{2^2}{3^4} : \frac{4^2}{4^4} : \frac{6^2}{5^4} = \frac{4}{81} : \frac{1}{16} : \frac{36}{625} = 0.0494 : 0.0625 : 0.0576$

17. Newton's law of cooling. The rate of cooling (or rate of loss of heat) of a body is directly proportional to the temperature difference between the body and its surroundings, provided the temperature difference is small. The rate at which a body loses heat by radiation depends on

- (i) The temperature of the body
- (ii) The temperature of the surrounding medium
- (iii) The nature and extent of the exposed surface



18. As the heat capacities are equal, so $m_1c_1 = m_2c_2$. Let c be the specific heat of the composite body. Then

$$(m_1 + m_2)c = m_1c_1 + m_2c_2 = m_1c_1 + m_1c_1 = 2m_1c_1 \quad \text{or} \quad c = \frac{2m_1c_1}{m_1 + m_2} = \frac{2m_1c_1}{m_1 + m_1 \frac{c_1}{c_2}} = \frac{2c_1c_2}{c_1 + c_2}$$

19. (a) Black bodies absorb and emit radiant energy better than bodies of lighter colours. During winter, we use dark coloured clothes which absorb heat from the sun and keep our body warm. However we wear white or light coloured clothes in summer so that they absorb the least heat from the sun. The bottoms of the utensils for cooking food are blackened so that they absorb maximum heat from the fire and give it to the vegetables to be cooked.

(b)	Steam point	373.15 K	100.00°C	212.00°F
	Ice point	273.15 K	0.00°C	32.00°F
	Absolute zero	0.00 K	-273.15°C	-459.69°F

20. (a) The stress-strain curves for rubber differ from the stress – strain curve for a metal in following respects;

- (i) Hooke's law is not obeyed even for small stresses.
- (ii) There is no permanent set (residual strain) even for large stress.
- (iii) There is large elastic region for both types of rubber.
- (iv) Neither material retraces the curve during unloading. Thus both materials exhibit elastic hysteresis.

- (b) The area of the hysteresis loop is proportional to the energy dissipated by the material as heat when the material undergoes loading and unloading. A material for which the hysteresis loop has larger area would absorb more energy when subjected to vibrations. Therefore to absorb vibrations, we would prefer rubber B.

- (c) In car tyre, the energy dissipation must be minimized to avoid excessive heating of the car tyre. As rubber A has smaller hysteresis loop area (and hence smaller energy loss), so it is preferred for a car tyre.

21. (i) For steel, $Y_S = \frac{\text{Stress}}{\text{Strain}}$

$$\text{Stress} = \frac{4Mg}{\pi D^2} = \frac{4W_S}{\pi D_S^2}$$

$$\text{Strain} = \frac{\Delta L_S}{L_S} \quad \therefore \quad \Delta L_S = \frac{4W_S L_S}{\pi Y_S D_S^2}$$

Putting values and simplifying we get, $\Delta L_S = \frac{4 \times 10 \times 9.8 \times 1.5}{3.14 \times 2.0 \times 10^{11} \times (2.5 \times 10^{-3})^2}$, where

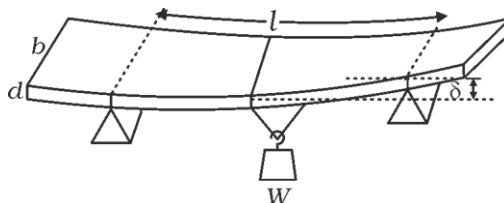
$$W_S = (4 + 6)9.8N \quad \text{or} \quad \Delta L_S = 1.5 \times 10^{-4} m$$

- (ii) Similarly, for brass

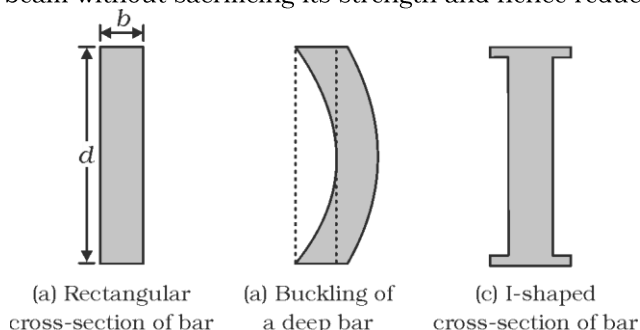
$$\Delta L_b = \frac{4 \times 6 \times 9.8 \times 1.0}{3.14 \times (2.5 \times 10^{-3})^2 \times 9.1 \times 10^{10}}, \text{ where } W_S = 6 \times 9.8N \quad \text{or} \quad \Delta L_b = 1.3 \times 10^{-4} m$$

- 22. (i)** The knowledge of elasticity is applied in designing a bridge such that it does not bend too much or break under the load of traffic, the force of wind and under its own weight. Consider a rectangular bar length l , breadth b and thickness d supported at both ends, as shown in figure. When a load W is suspended at its middle, the bar gets depressed by an amount given by

$$\delta = \frac{Wl^3}{4Ybd^3}$$



- (ii)** Bending can be reduced by using a material with a large Young's modulus Y . As δ is proportional to d^{-3} and only to b^{-1} , so depression can be decreased more effectively by increasing the depth d rather than the breadth b . But a deep bar has tendency to bend under the weight of a moving traffic, as shown in figure (b). This bending is called buckling. Hence a better choice is to have a bar of I-shaped cross-section, as shown in figure (c). This section provides a large load bearing surface and enough depth to prevent bending. Also, this shape reduces the weight of the beam without sacrificing its strength and hence reduces of cost.



- 23.** From figure, $x^2 = \left(\frac{L + \Delta L}{2}\right)^2 - \left(\frac{L}{2}\right)^2$

$$\Rightarrow x = \sqrt{\left(\frac{L + \Delta L}{2}\right)^2 - \left(\frac{L}{2}\right)^2} = \sqrt{\left(\frac{L}{2}\right)^2 + \frac{2L\Delta L}{4} + \left(\frac{\Delta L}{2}\right)^2 - \left(\frac{L}{2}\right)^2}$$

Since ΔL is a small quantity, the term with $(\Delta L)^2$ being very small can be neglected.

$$\therefore x = \sqrt{\frac{L\Delta L}{2}} = \sqrt{\frac{L(L\alpha\Delta T)}{2}} = L\sqrt{\frac{\alpha\Delta T}{2}}$$

Given, $L = 10m$, $\alpha = 1.2 \times 10^{-5} \text{ } ^\circ\text{C}^{-1}$, $\Delta T = 20^\circ\text{C}$

$$\text{Hence, } x = 10\sqrt{\frac{1.2 \times 10^{-5} \times 20}{2}} = 10 \times 1.1 \times 10^{-2}m = 0.11m = 11cm$$

- 24. (i)** Rekha is a helpful girl. She also has presence of mind as she thought of an excellent idea to help cartman.
(ii) Linear expansion of solids i.e., increase in length of solid on heating.
(iii) $L_{T2} = L_{T1}[1 + \alpha(T_2 - T_1)]$
 $6.243 = 6.231[1 + 1.20 \times 10^{-5}(T_2 - 27)]$
 $T_2 = 187.5^\circ\text{C}$

- 25.**
- (i) Hooke's law is obeyed upto the point P , because upto this point, stress $\propto$ strain.
 - (ii) Point E corresponds to elastic limit (yield point) because the wire returns to original state O along EPO as it is gradually unloaded.
 - (iii) The elastic region is from O to E and the plastic region is from E to B .
 - (iv) Upto point P , stress is proportional to strain. Between P and E strain increases more rapidly than stress and Hooke's law is not obeyed. When the wire is unloaded at any point A beyond E , the wire does not retrace the curve $AEPO$ but follows the dashed curve AO' . When the stress becomes zero, a residual strain OO' is left in the wire.
 - (v) Between C and B , the wire virtually flows out, i.e., the strain increases even the wire is being unloaded.
- 26.**
- (i) Radius of the ball, $r = 0.5\text{m}$ $\sigma = 5.67 \times 10^{-8} \text{Wm}^{-2}\text{K}^{-4}$, $T = 10^6 \text{K}$
 Surface area of nuclear weapon, $A = 4\pi r^2 = 4 \times 3.14 \times (0.5)^2 = 3.14\text{m}^2$
 $\therefore$ Power radiated, $P = (\sigma T^4)A = 5.67 \times 10^{-8} \times (10^6)^4 \times 3.14 = 1.8 \times 10^{17} \text{W}$
 - (ii) Energy radiated, $E = P \times t$
 $= 1.8 \times 10^{17} \text{W} \times 1\text{s} = 1.8 \times 10^{17} \text{J}$
 $Q = 10\% \text{ of } E = 1.8 \times 10^{16} \text{J}$
 Also, $Q = mc_w \Delta T + mL_v = m(c_w \Delta T + L_v)$
 Here, $c_w = 4186 \text{J kg}^{-1}\text{K}^{-1}$
 $L_v = 22.6 \times 10^5 \text{J kg}^{-1}$; $\Delta T = 100 - 30 = 70^\circ\text{C} = 70\text{K}$
 $\therefore m = \frac{Q}{(c_w \Delta T + L_v)} = \frac{1.8 \times 10^{16}}{4186 \times 70 + 22.6 \times 10^5} = \frac{1.8 \times 10^{16}}{25.53 \times 10^5} = 7 \times 10^9 \text{kg}$
 - (iii) $\therefore p = \frac{U}{c}$
 The radiation spread in an area of $4\pi r^2$
 Here, $r = 1\text{km} = 10^3 \text{m}$
 Momentum imparted per unit time on a unit area at a distance r ,

$$= \frac{(U/c)}{4\pi r^2 t} = \frac{U}{4\pi c r^2 t} = 4\pi c r^2 = \frac{1.8 \times 10^{17}}{4 \times 3.14 \times 3 \times 10^8 \times 10^6} = 47.7 \text{N m}^{-2}$$
- 27.**
- (i) The resolved part of F along the normal is the tensile force on this plane and the resolved part parallel to the plane is the shearing force on the plane.
 $\therefore$ Area of plane section $= A \sec \theta$
 Tensile stress $= \frac{\text{Force}}{\text{Area}} = \frac{F \cos \theta}{A \sec \theta} = \frac{F}{A} \cos^2 \theta$
 - (ii) Shearing stress applied on the plane
 So, $F = F \sin \theta$
 Shearing stress $= \frac{\text{Force}}{\text{Area}} = \frac{F \sin \theta}{A \sec \theta} = \frac{F}{A} \sin \theta \cos \theta$
 $= \frac{F}{2A} \sin 2\theta$ $[\because \sin 2\theta = 2 \sin \theta \cos \theta]$
 - (iii) Tensile stress will be maximum when $\cos^2 \theta$ is maximum i.e., $\cos \theta = 1$ or $\theta = 0^\circ$
 - (iv) Shearing stress will be maximum when $\sin 2\theta$ is maximum i.e. $\sin 2\theta = 1$
 or $2\theta = 90^\circ$ or $\theta = 45^\circ$.

