Unit 10 · Thermal Expansion

HARDER PRACTICE QUESTIONS

Full marks 28

Write your answers on separate paper. Show your working. Linear expansivity α (K^{-1}): steel 1.1×10^{-5}, iron 1.2×10^{-5}, copper 1.7×10^{-5}, brass 1.9×10^{-5}, aluminium 2.3×10^{-5}. Young's modulus of steel 2.0×10^{11} N/m^2.

1 Spot the error [3]

Find the mistake and correct it.

An aluminium sheet has an area of 2.0 m^2 at 20 °C. Sabina finds its area at 70 °C:
"$A_2 = A_1(1 + \alpha\Delta\theta) = 2.0 \times (1 + 2.3 \times 10^{-5} \times 50) = \mathbf{2.0023\ m^2}$."

2 Read the data [4]

Answer from the table.

In Pullinger's apparatus a rod 0.500 m long is heated from 20 °C. The micrometer measures its expansion:

Temperature (°C)	20	40	60	80	100
Expansion (mm)	0.00	0.12	0.24	0.36	0.48

i. Is the expansion proportional to the rise in temperature? Show how you know.
ii. Find the linear expansivity of the rod.
iii. Which metal in the note is it?

3 A rail with no gap [4]

The numbers are made up.

A steel rail, of cross-sectional area 60 cm^2, is laid on a cool morning and held at both ends so that it can't expand. By afternoon it is 30 K warmer.

i. Find the thermal stress in the rail and the force it pushes on its ends with.
ii. A longer rail, laid the same way, is twice as long. Would the force be larger? Explain.

4 A clock in the Terai [3]

The numbers are made up.

A pendulum clock with a brass pendulum keeps correct time at 20 °C. It is taken to a town in the Terai where the summer temperature is 35 °C. Does it gain or lose, and by how many seconds a day?

5 Show that [3]

A liquid of density ρ_1 is heated through $\Delta\theta$. Show that its new density is $\rho_2 = \dfrac{\rho_1}{1 + \gamma\Delta\theta} \approx \rho_1(1 - \gamma\Delta\theta)$. Why does a hot-air balloon or warm water rise?

6 Predict, then explain [3]

Write your prediction first, then explain it.

A bimetallic strip of brass and steel is straight at room temperature. It is put in a freezer.

i. Predict which way it bends.
ii. Explain why.

7 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

> Rabin wrote: "A metal expands on heating because its atoms get bigger. If a metal plate with a hole is heated, the hole gets smaller, because the metal expands into it. And a liquid in a flask rises the moment the flask is put in hot water."

8 Think [3]

On a very hot day Mohan measures a steel rod with a steel tape that is accurate at 20 °C. Later he measures an aluminium rod with the same tape. Which reading gives the rod's length at 20 °C? Does the other read more or less than its rod's length at 20 °C?

9 Make your own [2]

Design a steel rod and a brass rod whose lengths always differ by exactly 10 cm, whatever the temperature. Find the length of each, and show that it works.