temperature and heat, problem set #2

1) An aluminum tea kettle with mass $m_{\mathrm{Al}} = 1.5$ kg and containing $m_{\mathrm{W}} = 1.8$ kg of water is placed on a stove. The specific heat capacity of water, ice, and aluminum are $c_{\mathrm{W}} = 4.2$ kJ/kg $\cdot$ K, $c_{\mathrm{I}} = 2.1$ kJ/kg $\cdot$ K, and $c_{\mathrm{Al}} = 0.91$ kJ/kg $\cdot$ K, respectively. The latent heat of fusion for water is $L_{\mathrm{f}} = 334$ kJ/kg.
a) If no heat is lost to the surrounding, how much heat must be added to raise the temperature from 20°C to 85°C?
b) Now if we throw a piece of ice with mass $m_{\mathrm{I}} = 0.5$ kg and temperature -20°C inside this hot water, what would be the final temperature of the system?

2) Consider an aluminum bar with $\alpha_1 = 2.4 \times 10^{-5}$ /K and $Y_1 = 70$ GPa, and a steel bar with $\alpha_2 = 1.2 \times 10^{-5}$ /K and $Y_2 = 210$ GPa. As shown in fig. 1 these two bars are sitting between two solid walls with a gap $D = 1.96$ m. If there is no tension the length of the bars are $L = 1$ m at 20°C and their area is $A = 1.0 \times 10^{-3}$ m^2. We call the joint point position x, so the aluminum bar's length is x and the steel bar's length is $D - x = 1.96\text{ m} - x$. Remember the force formula for a change in length ΔL and a change in temperature ΔT is given by, $F = YA(\Delta L/L_0 - \alpha\Delta T)$. As $\alpha\Delta T \ll 1$ and $\Delta L \ll L_0$, use the same number for A which is given. The walls will not move if temperature changes, in other words, D is constant.

a) Use $\Delta T = 0$ and write down mechanical equilibrium condition for the bars and find x at 20°C.
b) Write the equilibrium condition at temperature $T = 400$°C and find x at 400°C.

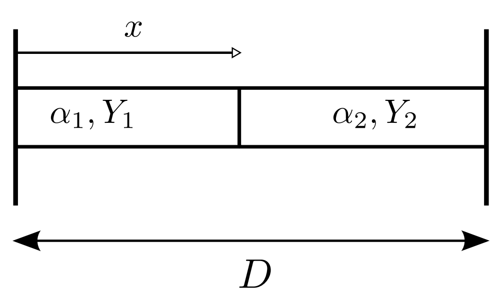

Figure 1: Bars between two solid walls.