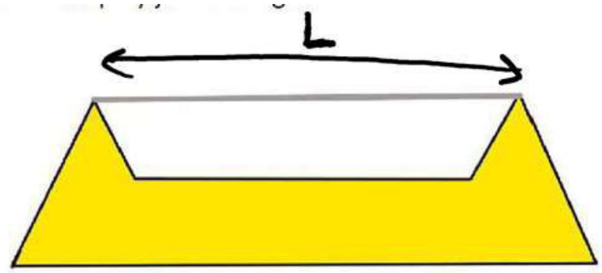
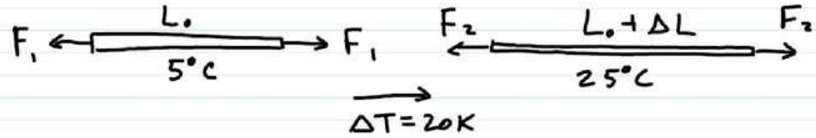
note when plucked at 2pm. To what tension should you set it?



The net expansion of the wire is fixed by how much the gold expands. We have:

$$\Delta L_{gold} = \alpha_{gold} \cdot L_0 \cdot \Delta T$$

for the distance between the points where the wire is fixed.



The wire also changes length by this amount, but this is due to the combined effects of thermal expansion and a change in tension. We have:

$$\Delta L_{wire} = \alpha_{plat.} \cdot L_0 \cdot \Delta T + \frac{\Delta F}{A} \cdot \frac{L_0}{Y_{plat.}}$$

Since $\Delta L_{wire} = \Delta L_{gold}$, we get:

$$\alpha_{gold} \cdot L_0 \cdot \Delta T = \alpha_{plat} \cdot L_0 \cdot \Delta T + \frac{\Delta F}{A} \cdot \frac{L_0}{Y_{plat.}}$$

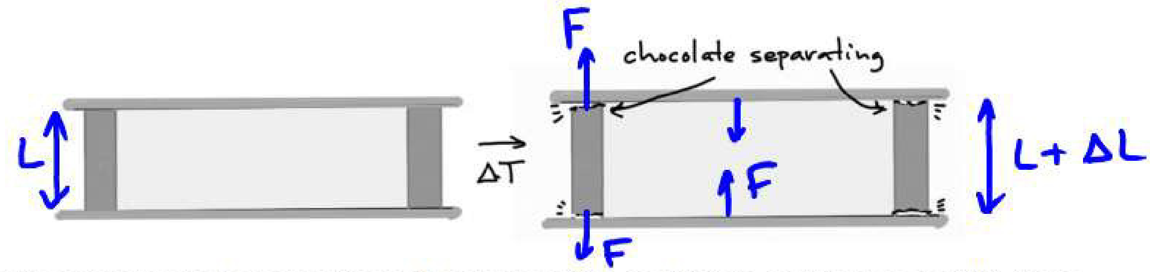
$$\Rightarrow \frac{\Delta F}{A} \cdot \frac{L_0}{Y_{plat}} = (\alpha_{gold} - \alpha_{plat.}) L_0 \Delta T$$

$$\Rightarrow \Delta F = A \cdot Y_{plat} \cdot (\alpha_{gold} - \alpha_{plat}) \Delta T$$

$$= \pi \cdot (0.5 \times 10^{-3})^2 \cdot 16 \times 10^{10} \times (0.5 \times 10^{-5}) \cdot 20 \text{ N}$$

$$= 12.6 \text{ N}$$

So you should set the tension to 787.4 N.



b) After the graham crackers are attached, and the entire cookie is in equilibrium at 10°C, there is no stress in the marshmallow or chocolate. The chocolate will separate from the graham cracker if the (vertical) tensile stress in the chocolate exceeds $1.3 \times 10^3\,Pa$. What is the maximum temperature increase the cookies can withstand without the chocolate separating?

We have $Y = 1.0 \times 10^4$ Pa and $\alpha = 0.0025K^{-1}$ for marshmallow and $Y = 1.5 \times 10^5$ Pa and $\alpha = 0.0010K^{-1}$ for the chocolate.

You can assume the graham cracker does not bend and ignore effects related to expansion in the horizontal directions.

As the cookie heats up, the marshmallow wants to expand more than the chocolate, so there will be a compressive stress on the marshmallow and a tensile stress on the chocolate keeping them the same length. We have:

$$\Delta L_m = \alpha_m L_0 \Delta T - \frac{F}{Y_m} \cdot L_0 \cdot \frac{1}{A_m}$$

$$\Delta L_c = \alpha_c L_0 \Delta T + \frac{F}{Y_c} \cdot L_0 \cdot \frac{1}{A_c}$$

$$\Delta L_m = \Delta L_c$$

Plugging in from above,

$$\alpha_m L_0 \Delta T - \frac{F}{Y_m} \cdot L_0 \frac{1}{A_m} = \alpha_c L_0 \Delta T + \frac{F}{Y_m} \cdot L_0 \frac{1}{A_m}$$

$$\Rightarrow (\alpha_m - \alpha_c)\Delta T = F \cdot \left(\frac{1}{A_m Y_m} + \frac{1}{A_c Y_c}\right)$$

We have: $A_m = \pi \cdot (0.02m)^2$ $\quad A_c = \pi\left((0.022m)^2 - (0.02m)^2\right)$

$F = 1.3 \times 10^3 Pa \times A_c = 0.34N$. Plugging in to solving for ΔT

we get $\Delta T = 24°C$