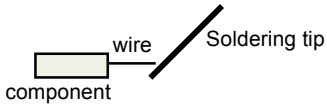
Physics 213 **Problem 3** **Week 3**

Soldering

One of the real-world thermodynamic issues that arise when assembling electronic circuits is the need to prevent heat damage to the components. Specifically, one needs to take care not to leave the tip of the soldering* iron too long on the connection, lest the attached component heat up too much. Here we make some simple estimates involving this problem. Assume:

- the soldering iron temperature is $T_{iron} = 250°C$ (assumed constant)
- the thermal conductivity of copper wire is ($\kappa = 400$ W/m-K)
- the length of the wire is L = 5 mm, and its diameter is d = 0.5 mm
- the initial temperature of the component is 20°C
- the specific heat of the component is 1200 J/kg·K
- the mass of the component is 0.5 grams
- the component will "die" when its temperature reaches $T_{death} = 200°C$



1) What is the heat capacity of the component?

$C = mc = (5\times10^{-4}\ kg)(1200\ J/kg\cdot K) = 0.6\ J/K$

2) How many joules must be deposited to raise the temperature of the component from 20°C to 200°C?

$Q = C\Delta T = 108\ J$

3) What is the thermal resistance R_{th} of the wire?

$R_{th} = (L/\kappa A) = 63.7\ K/W$

4) What is the initial heat flow (*i.e.*, before the component temperature has changed much)?

$H = \Delta T/R_{th} = 3.61\ W$ (Note: $\Delta T = 250-20$)

5) Assuming the heat flow stays constant, calculate how long it would take to heat the component to 200°C. What *actually* happens to the heat flow as it heats up, and what is the effect (qualitatively) of this on the time?

$t = Q/H = 30$ sec
In reality, H decreases as the component warms up, so the time is larger.

6) If we want to double the time we have to solder before overheating the component, what should we do to the length of the wire?

L only appears in the expression for R_{th}, so we need to double the length of the wire.

* Note: The "l" is silent in this oft-mispronounced word. Its first syllable is pronounced "sod".