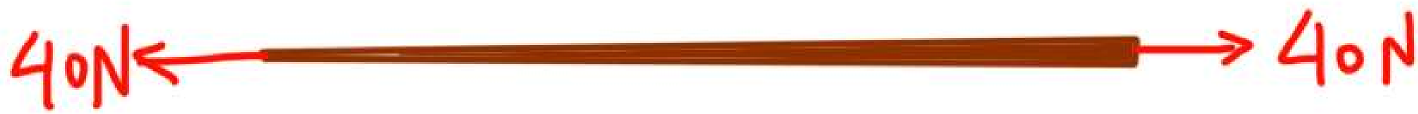
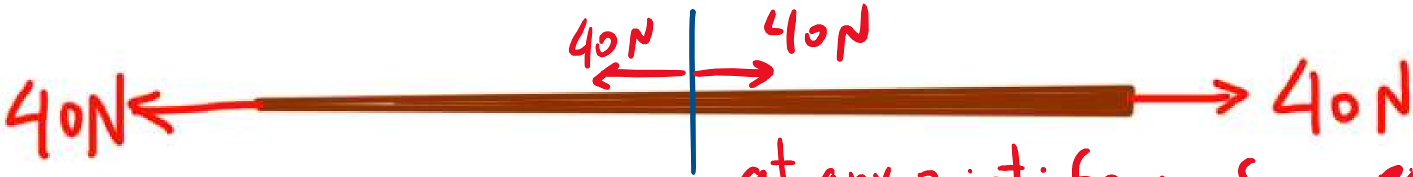


A copper wire of varying thickness is pulled at each end with a force of 40N. Which of the following statements is true?

A) The tension is a constant 80N all along the wire, and the stress is also constant along the wire.
B) The tension is a constant 40N all along the wire, and the stress is also constant along the wire.
C) The stress is constant throughout the wire but the tension varies.
D) The tension is a constant 80N all along the wire, but the stress varies along the wire.
E) The tension is a constant 40N all along the wire, but the stress varies along the wire.



at any point: force from each half on other is 40N; since net force on each side is zero.

A copper wire of varying thickness is pulled at each end with a force of 40N. Which of the following statements is true?

A) The tension is a constant 80N all along the wire, and the stress is also constant along the wire.

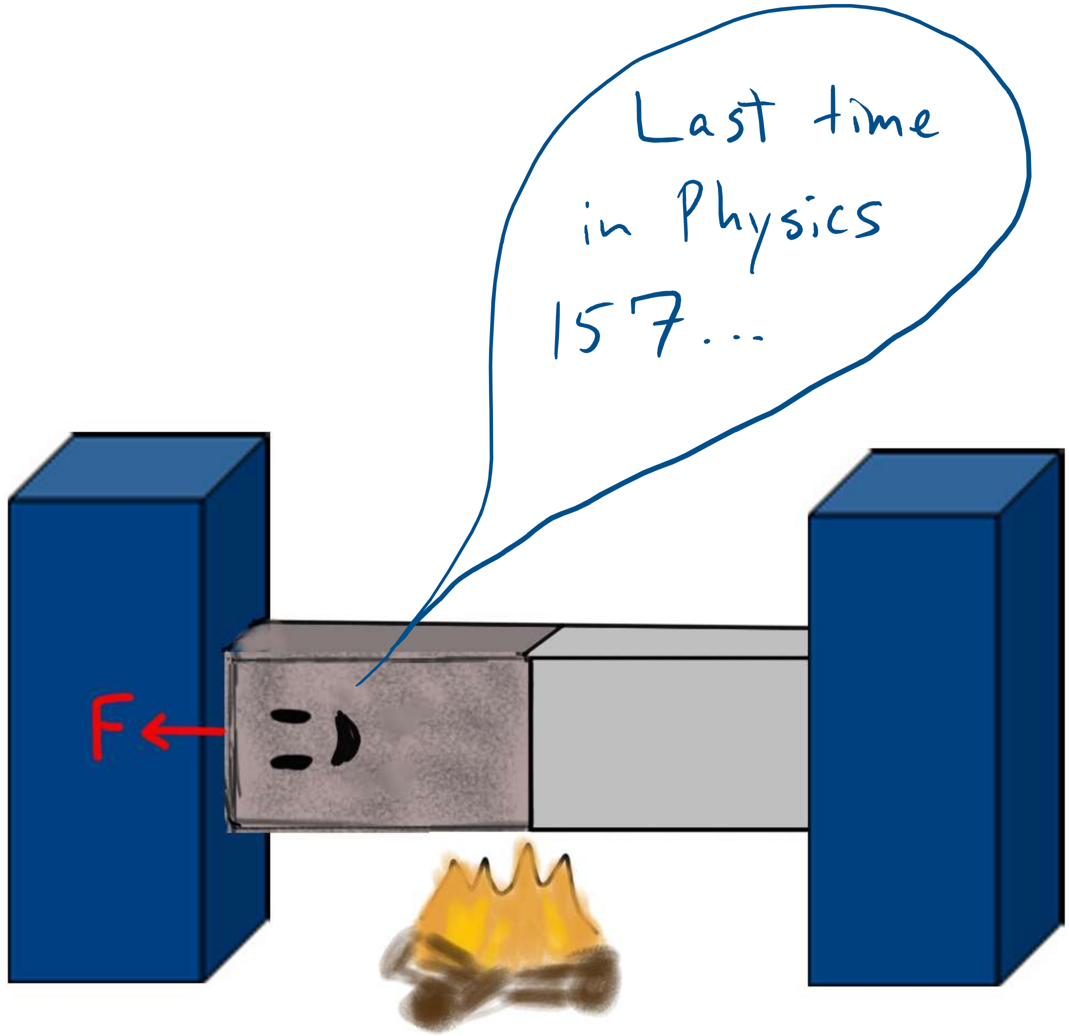
B) The tension is a constant 40N all along the wire, and the stress is also constant along the wire.

C) The stress is constant throughout the wire but the tension varies.

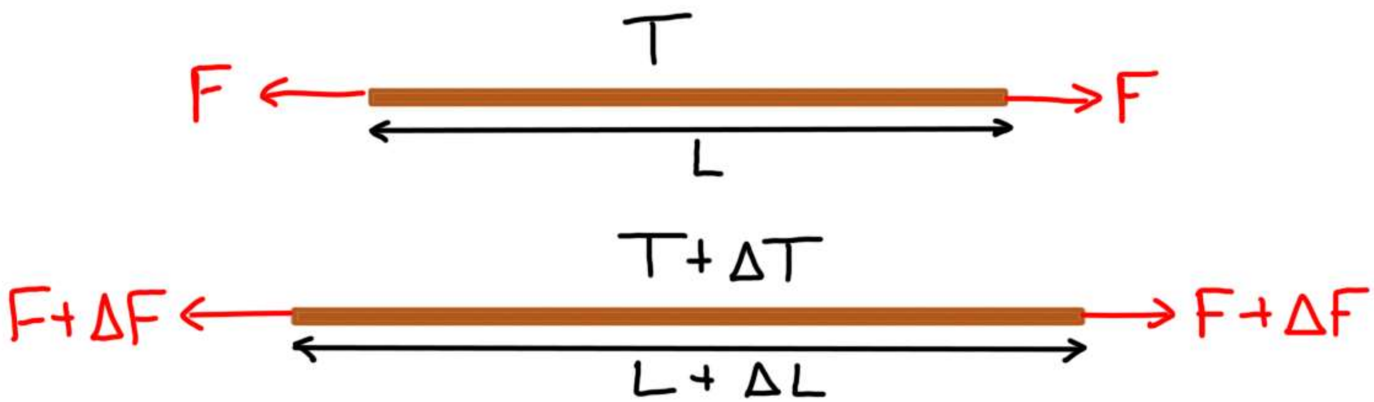
D) The tension is a constant 80N all along the wire, but the stress varies along the wire.

E) The tension is a constant 40N all along the wire, but the stress varies along the wire.

stress = F/A varies since A varies


Last time in Physics 157...
F

Expansion from changes in temperature and stress:



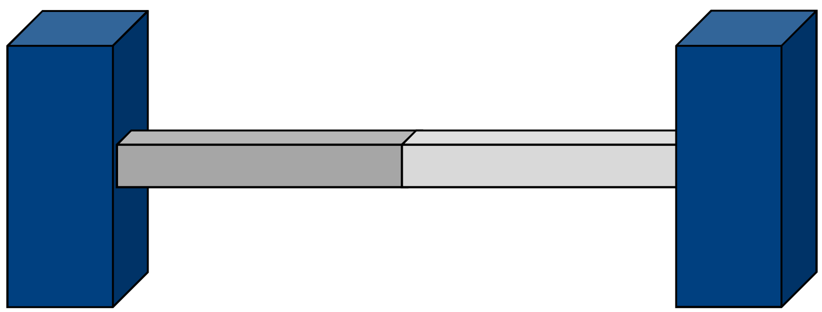
$$\Delta L = (\Delta L)_T + (\Delta L)_F$$

$$\Delta L = \alpha L \Delta T + \frac{L}{Y} \cdot \frac{\Delta F}{A}$$

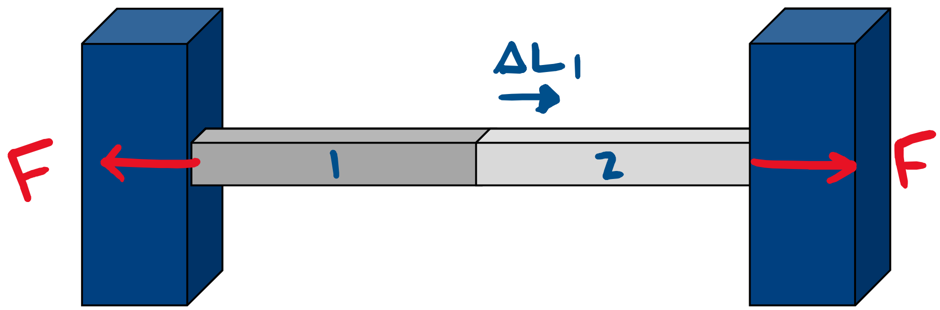
Stressed Rods

A compound bar consisting of a copper rod with a length of 1 m and cross-section area of 2.00 cm^2 placed end to end with a steel rod with length 1m and cross-section area 2.00 cm^2. The compound rod is placed between two rigid walls. Initially there is no stress in the bars at room temperature 20^o C.

Find the force on each wall at 40^o C.



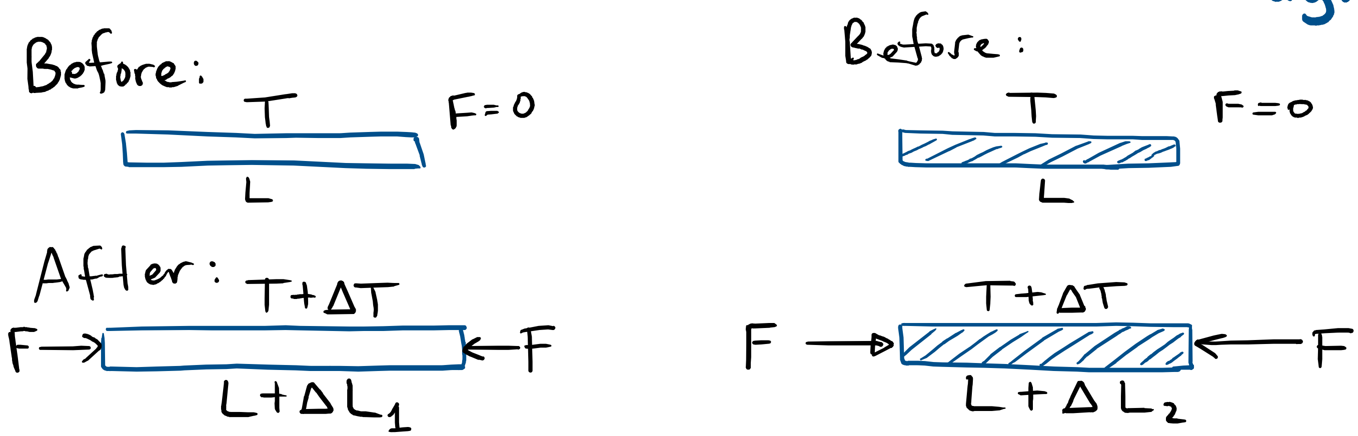
$\alpha_{steel} = 12 \times 10^{-6}\ K^{-1}$, $\alpha_{copper} = 17 \times 10^{-6}\ K^{-1}$,
$Y_{steel} = 200 \times 10^{9}\ N\ m^{-2}$, $Y_{copper} = 110 \times 10^{9}\ N\ m^{-2}$



rigid ends:

$$\Delta L_1 + \Delta L_2 = 0$$

Newton's Laws: all forces have magnitude F



Length change from ΔT and ΔF:

$$\Delta L_1 = \alpha_1 L \Delta T - \frac{F}{A} \cdot \frac{L}{Y_1}$$

$$\Delta L_2 = \alpha_2 L \Delta T - \frac{F}{A} \cdot \frac{L}{Y_2}$$

$$\Delta L_1 + \Delta L_2 = 0 \qquad (1)$$

$$\Delta L_1 = \alpha_1 L \Delta T - \frac{F}{A} \cdot \frac{L}{Y_1} \qquad (2)$$

$$\Delta L_2 = \alpha_2 L \Delta T - \frac{F}{A} \cdot \frac{L}{Y_2} \qquad (3)$$

Plug (2) and (3) into (1):

$$\alpha_1 L \Delta T + \alpha_2 L \Delta T - \frac{F}{A} \frac{L}{Y_1} - \frac{F}{A} \frac{L}{Y_2} = 0$$

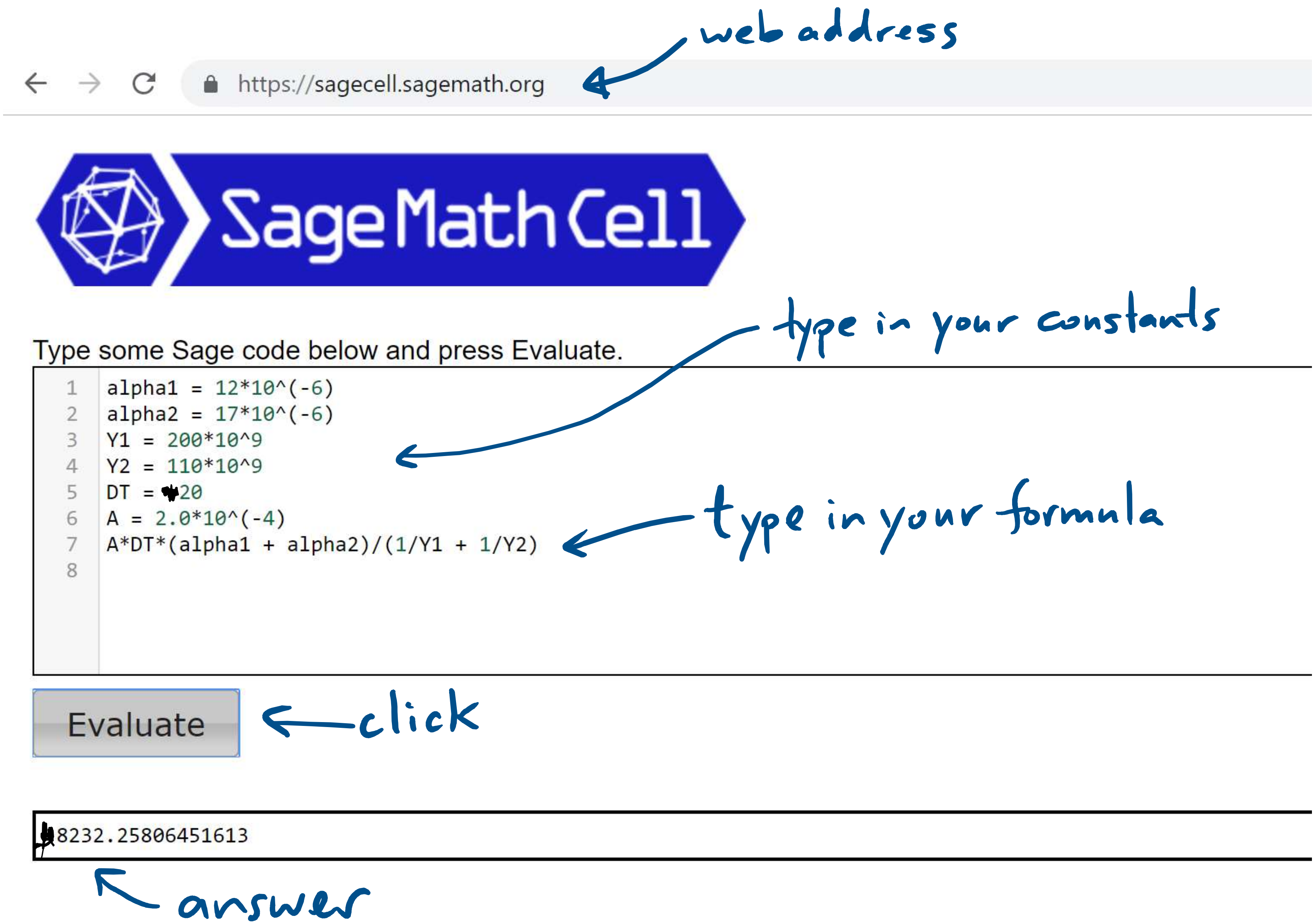
Isolate terms with F:

$$\frac{F \cdot L}{A} \left(\frac{1}{Y_1} + \frac{1}{Y_2} \right) = (\alpha_1 + \alpha_2) L \Delta T$$

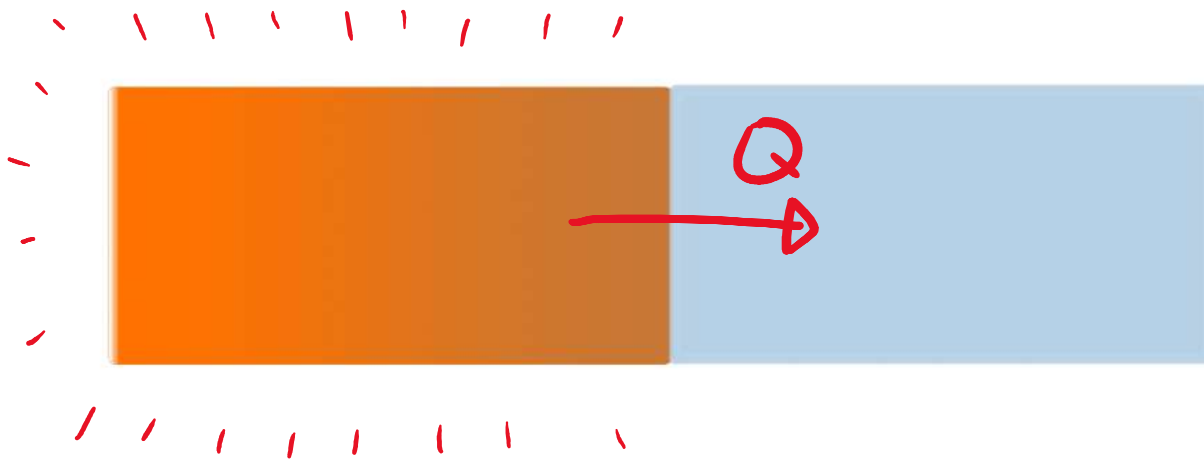
Solve:

$$F = \frac{(\alpha_1 + \alpha_2) \Delta T}{\left(\frac{1}{Y_1} + \frac{1}{Y_2} \right)} \cdot A = 8.2 \times 10^3 \, N$$

If you find it annoying to use your calculator...



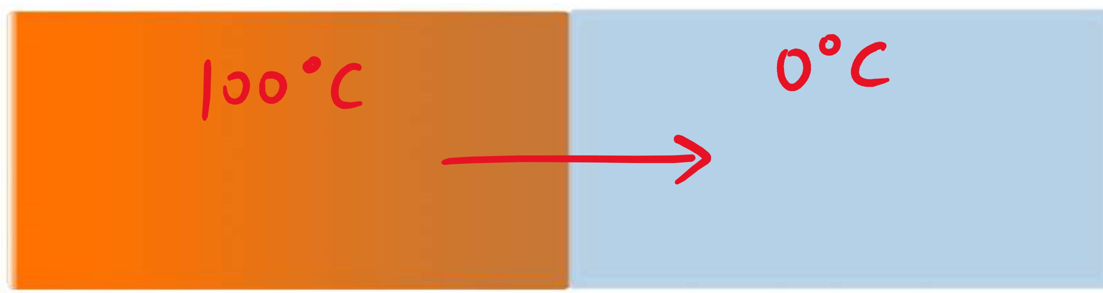
HEAT:



Q = heat : amount of energy transfered due to temperature differences
(Joules)

Clicker: two objects with the same mass are put in thermal contact but insulated from their environment. If the initial temperatures are 100°C and 0°C, the final equilibrium temperature will be

A) 50°C
B) Somewhere between 0°C and 100°C but not necessarily 50°C
C) Not necessarily between 0°C and 100°C

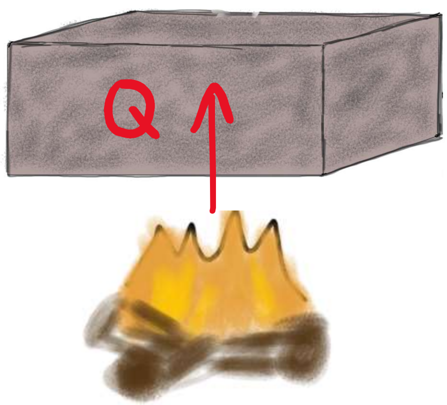


Clicker: two objects with the same mass are put in thermal contact but insulated from their environment. If the initial temperatures are 100ºC and 0ºC, the final equilibrium temperature will be

A) 50ºC
B) Somewhere between 0ºC and 100ºC but not necessarily 50ºC
C) Not necessarily between 0ºC and 100ºC

- Heat flows from the hotter object to the cooler
- Temperature of the hot object decreases & the cold object increases, until they are the same temperature, between 0° and 100°.
- Not necessarily 50° since some materials require more energy for a given temperature change

Heat required to raise the temperature of a material determined by its SPECIFIC HEAT c:



$$Q = m\,c\,\Delta T$$

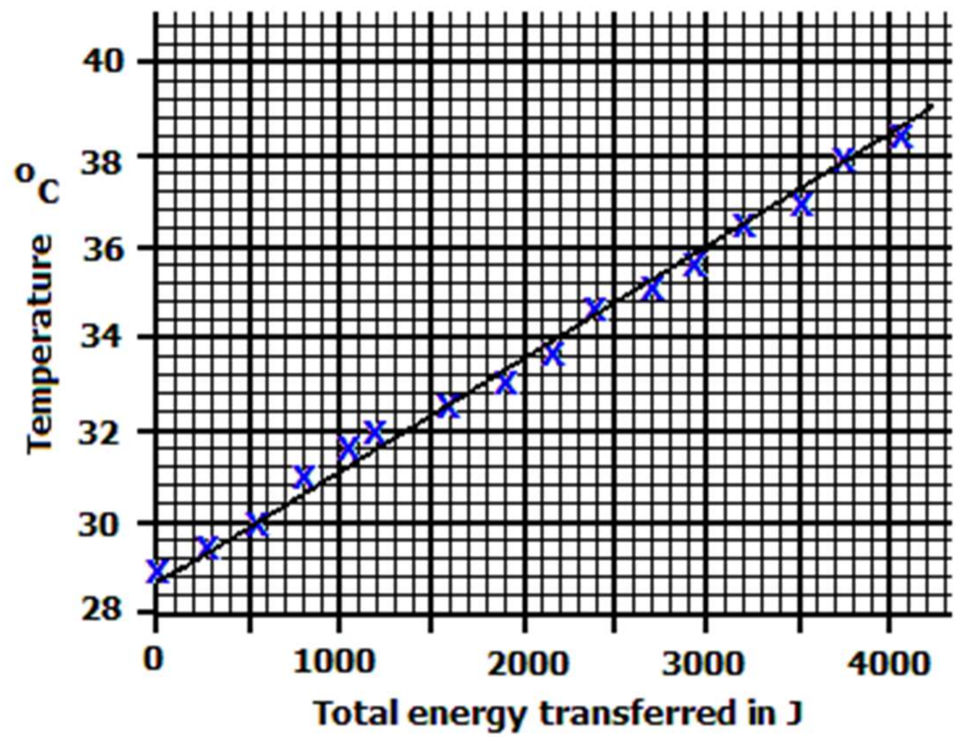
- Q: heat added
- m: mass
- ΔT: change in temperature

c in $\frac{J}{kg \cdot K}$: energy required to heat 1 kg of material by 1 K

Heat is added to two kilograms of a liquid, and data for the temperature vs energy transfer is shown.

If we took data for another liquid with the same mass but a larger specific heat, the slope of this graph would be

A) Larger
B) Smaller
C) The same
D) Any of the above are possible.



$Q = mc\Delta T$

EXTRA: what is the specific heat of the original liquid?

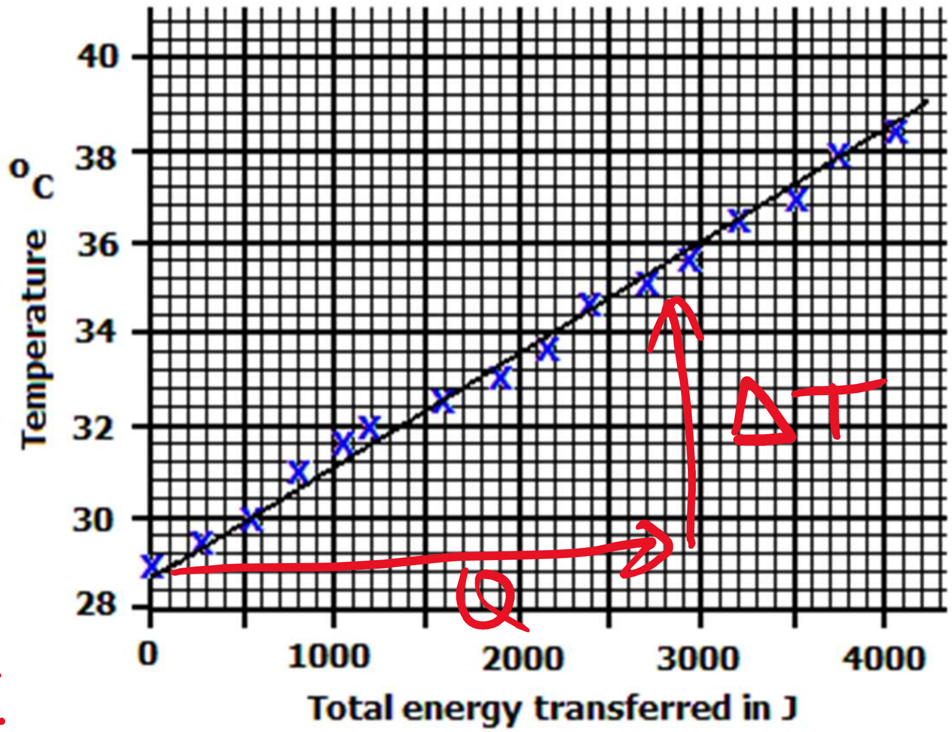
Heat is added to two kilograms of a liquid, and data for the temperature vs energy transfer is shown.

If we took data for another liquid with the same mass but a larger specific heat, the slope of this graph would be

Smaller ΔT for same Q

A) Larger
B) Smaller
C) The same
D) Any of the above are possible.

$\therefore$ smaller $\frac{\text{rise}}{\text{run}}$

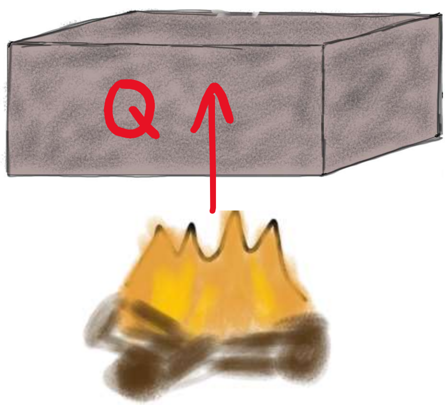


EXTRA: what is the specific heat of the original liquid?

$c \approx \frac{3000}{7.2} \approx 200\ \text{J/kg K}$

$Q = mc\Delta T$

Heat required to raise the temperature of a material determined by its SPECIFIC HEAT c:



mass → m, SPECIFIC HEAT → c

$$Q = m c \Delta T$$

OR:

$$Q = n C \Delta T$$

moles → n

MOLAR SPECIFIC HEAT → C

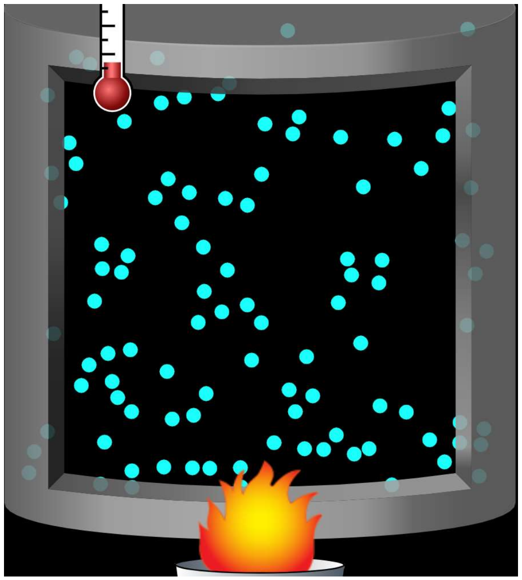
= MOLAR HEAT CAPACITY

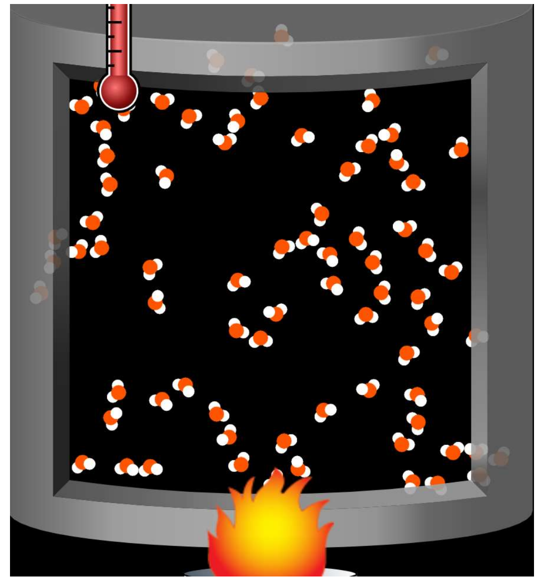
c in $\frac{J}{kg \cdot K}$: energy required to heat 1 kg of material by 1 K

C in $\frac{J}{mol \cdot K}$: energy required to heat 1 mole of material by 1 K

Why is heat capacity higher for some materials?

will see: temperature proportional to average kinetic energy of molecules





for more complicated materials, part of added energy added goes to rotations/vibrations etc..., so it takes more Q to increase the kinetic energy.

From PHET: states of matter simulation, https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html

Exercise: two objects with the same mass are put in thermal contact but insulated from their environment. If the initial temperatures are 100ºC and 0ºC, and the specific heats are c_1 = 300 J/kg·K and c_2 = 900 J/kg ·K, calculate the final equilibrium temperature.

Hint: isolate the parts and think of what is happening to each part separately. Draw a picture and label it.

Click A if you are finished, B if you are totally stuck.

$$Q = mc\Delta T$$