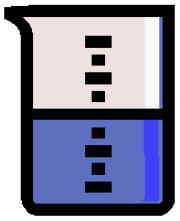
# *Critical Experiment 1*


If we have equal amounts of the same kinds of materials at different temperatures and put them together, what happens?

200 g of water at 80 °C



200 g of water at 20 °C

A. pretty close to 50 C
B. pretty close to 80 C
C. pretty close to 20 C
D. greater than 80 C
E. less than 20 C


$$Q = mc\Delta T$$

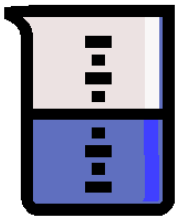
# *Real-World Intuition* 2
# How do objects exchange hot and cold?

- When two amounts of water at different temperatures are combined, they come to a temperature somewhere in between.
- We expect that the amount of each kind of water determines the final temperature.
- Try it!
  - Case 1: Equal amounts of water
  - Case 2: Different amounts of water

# *Critical Experiment 2*


If we have unequal amounts of the same kinds of materials at different temperatures and put them together, what happens?

100 g of water at 80 °C



200 g of water at 20 °C

A. pretty close to 40 C
B. pretty close to 80 C
C. pretty close to 20 C
D. greater than 60 C
E. something else


$$Q = mc\Delta T$$

# Two Objects of the Same Kind but Different Temperatures

Physical idea:
The bigger mass changes its temp less in proportion.

$$\frac{m_1}{m_2} = \frac{\Delta T_2}{\Delta T_1}$$

the changes in temp are opposite—one goes up the other goes down

$$m_1 \Delta T_1 = -m_2 \Delta T_2$$

$$m_1 (T_f - T_1) = m_2 (T_2 - T_f)$$

$$m_1 T_f - m_1 T_1 = m_2 T_2 - m_2 T_f$$

$$m_1 T_f + m_2 T_f = m_1 T_1 + m_2 T_2$$

$$T_f = \frac{m_1 T_1 + m_2 T_2}{m_1 + m_2} = \left(\frac{m_1}{M}\right) T_1 + \left(\frac{m_2}{M}\right) T_2$$

# Implications

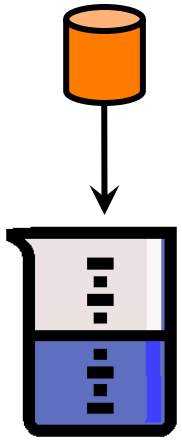
- From the equation $m_1 \Delta T_1 = -m_2 \Delta T_2$
  - it looks like something is being transferred from the hot object to the cold object
  - it looks like temperature is kind of a "density of hotness." You have to multiply by the mass to get the "amount of hotness" transferred.
- We will call the thing being transferred "thermal energy."

# What if we have different kinds of stuff?

- What happens if we have equal masses of water and something else — a copper cylinder, say?
- What's your intuition here?
  - Will the temperature settle down to halfway between?
  - Will it be closer to the water's temperature?
  - Will it be closer to the copper's temperature?
- Try it!

# *Critical Experiment 3*

If we have equal masses of different kinds of materials at different temperatures and put them together, what happens?



200 g of copper at 80 °C

200 g of water at 20 °C

A. pretty close to 50 C
B. pretty close to 80 C
C. pretty close to 20 C
D. greater than 80 C
E. less than 20 C


$$Q = mc\Delta T$$