5. Conservation of Energy!

\[ U = m g \Delta y = (15 \text{ kg})(9.8 \text{ m/s}^2)(1.7 \text{ m}) = 250 \text{ J} \]

This energy goes to all three, increasing their temperature and moving the air molecules around.

13. \( \Delta T = 60 \text{ C}^\circ \)

\[ m = 2.0 \text{ kg} \] (mass of 2L of water)

\[ Q = mc \Delta T = (2.0 \text{ kg})(4186 \text{ J/kg}^\circ C)(60 \text{ C}^\circ) = 5.0 \times 10^5 \text{ J} \]

14. \( Q = 100 \text{ kcal} \) (100 "food calories")

\[ = 100 \text{ kcal} \left( \frac{4186 \text{ J}}{\text{kcal}} \right) = 418600 \text{ J} \rightarrow \text{if it all goes to the mass' kinetic energy} \]

\[ 418600 \text{ J} = \frac{1}{2} m V^2 \]

\[ V = \sqrt{\frac{2(418600 \text{ J})}{83 \text{ kg}}} \approx 100 \text{ m/s} \]

Wow! So why doesn't this actually happen? Or do I need to get better bananas? Organic?

21. \( Q = mc \Delta T \)

\[ c = \frac{Q}{m \Delta T} = \left( \frac{210 \text{ cal}^\circ}{1.350 \text{ kg}^\circ C} \right) \approx 126 \frac{1}{\text{kg}^\circ C} \]
(What a great problem for a final exam in a 1st semester physics course!) This fall gives energy to the water, converting potential to internal energy (temperature). Incidentally, this is the same process that formed the sun and raised its temperature.

Energy added = \( m \cdot g \cdot \Delta y \) ... this goes into raising temperature of both masses, so

\[
\text{solve for } m_2 \left( c \cdot \Delta T \right) = m_1 \left( c \cdot \Delta T + g \cdot \Delta y \right)
\]

\[
m_2 = \frac{m_1 \left( c \cdot \Delta T + g \cdot \Delta y \right)}{c \cdot \Delta T}
\]

\[
m_2 = 1.34 \text{ kg}
\]
32. Energy from hot coffee goes into melting ice:

\[ m_c \Delta T_c = m_{ice} L + m_{ice} c \Delta T_{ice} \]

Both the coffee and original ice arrive at \( T = 60 \degree C \), both as liquid water \((c = 4186 \frac{J}{kg \cdot \degree C})\).

\[ M_{ice} = \frac{m_c c \Delta T_c \leftarrow 20 \degree C \ (80 \to 60 \degree C)}{L + c \Delta T_{ice} \leftarrow 60 \degree C \ (0 \to 60 \degree C)} \]

\[ M_{ice} = \left( \frac{1.25 \text{ kg} \times 4186 \frac{J}{kg \cdot \degree C}}{20 \degree C} \right) \left( \frac{333.7 \times 10^3 \frac{J}{kg}}{4186 \frac{J}{kg \cdot \degree C}} \right) \left( 60 \degree C \right) \]

\[ M_{ice} \approx 0.036 \text{ kg} = 36 \text{ g} \]

36. Heat from brass \((c_B = 384 \frac{J}{kg \cdot \degree C})\) goes into vaporizing liquid nitrogen:

\[ M_B c_B \Delta T = m_N L_N \]

\[ M_N = \frac{M_B c_B \Delta T}{L_N} = \left( \frac{0.25 \text{ kg}}{384 \frac{J}{kg \cdot \degree C}} \right) \left( 293.15 \degree K \right) \]

\[ M_N \approx 0.0104 \text{ kg} = 10.4 \text{ g} \]
50. \[ P = \frac{Q}{t} = \frac{m_{ice} \cdot L}{t} = \left(0.0132 \text{ kg}\right) \left(333.7 \times 10^3 \frac{\text{J}}{\text{kg} \cdot \text{C}^\circ}\right) \frac{1}{175 \text{s}} \]

\[ P = 2.517 \frac{\text{J}}{\text{s}} \]

So, the rate at which the rod needs to conduct heat:

\[ 2.517 \frac{\text{J}}{\text{s}} = kA \frac{\Delta T}{d} \]

\[ k = 2.517 \frac{\text{J}}{\text{s}} \frac{d}{A \cdot \Delta T} = 2.517 \frac{\text{J}}{\text{s}} \left(\frac{1.10 \text{ m}}{\pi \left(0.023 \text{ m}\right)^2} \left(100 \text{ C}^\circ\right)\right) \]

\[ k = 66.7 \frac{\text{W}}{\text{m} \cdot \text{C}^\circ} \]

71. \[ T = 3000 \text{ K} \]
\[ A = 10^{-4} \text{ m}^2 \]
\[ e = 0.32 \]

\[ P = \sigma e A T^4 \]

\[ = \left(5.67 \times 10^{-8} \frac{\text{J}}{\text{s} \cdot \text{m}^2 \cdot \text{K}^4}\right) \left(0.32\right) \left(10^{-4} \text{ m}^2\right) \left(3000 \text{ K}\right) \]

\[ = 150 \text{ W} \]