

1. [Serway Chapter 20 Problem 2, pg 577]

An 80 kg weight watcher wishes to climb a mountain to work off the equivalent of a large piece of chocolate cake rated at 700 (food) Calories. How high must the person climb?

$$W = mgh = 700 \times 10^3 \text{ calories}$$

$$= 700 \times 10^3 \times 4.186 \text{ J}$$

$$\therefore h = \frac{700 \times 10^3 \times 4.186 \text{ J}}{80 \text{ Kg} \times 9.8 \text{ m/s}^2} = 3737.15 \text{ m.}$$

2. [Serway Chapter 20 Problem 15, pg 578]

A water heater is operated by solar power. If the solar collector has an area of 6.0 m^2 and the power delivered by sunlight is 550 W/m^2 , how long does it take to increase the temperature of 1.0 m^3 of water from 20°C to 60°C ?

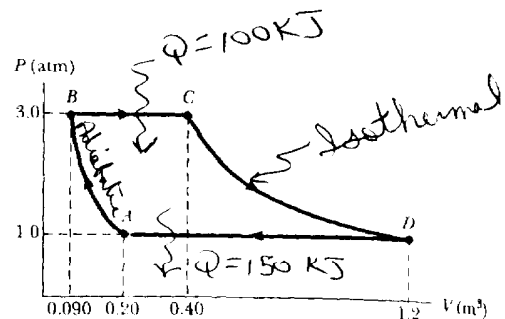
$$Q = 550 \text{ W/m}^2 \times 6 \text{ m}^2 \times t = mc \Delta T = 1 \text{ m}^3 \times \frac{1000 \text{ kg}}{\text{m}^3} \times 4186 \frac{\text{J}}{\text{kg}^\circ \text{C}} \times 40^\circ \text{C}$$

$$\therefore t = \frac{1000 \times 4186 \times 40}{550 \times 6} = 50,740 \text{ s} = 14.09 \text{ hr.}$$

3. [Serway Chapter 20 Problem 40, pg 580]

An ideal gas system goes through the process shown in the figure.

- From A to B, the process is adiabatic.
- From B to C, the process is isobaric with 100 kJ of heat flowing into the system.
- From C to D, the process is isothermal.
- From D to A, the process is isobaric with 150 kJ of heat flowing out of the system.



Determine the difference in internal energy $U_B - U_A$.

$$U_A - U_B = (Q - W)_{B \rightarrow C} + (Q - W)_{C \rightarrow D} + (Q - W)_{D \rightarrow A}$$

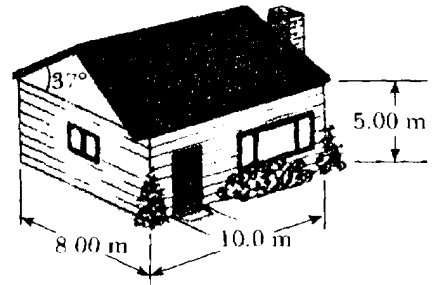
$$= 100 - (P\Delta V)_{BC} + 0 + (-150 - (P\Delta V)_{D \rightarrow A})$$

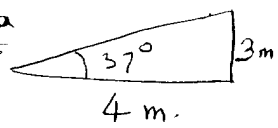
↑ heat added just compensates for expansion work, i.e. $PV = nRT = \text{constant}$

$$= 100 - (3 \times 10^5 \text{ Pa})(0.31 \text{ m}^3) - 150 \times 10^3 - (10^5 \text{ Pa})(-1.0 \text{ m}^3)$$

$$= -42.93 \text{ kJ} \quad \therefore U_B - U_A = 42.93 \text{ kJ}$$

4. [Serway Chapter 20 Problem 72, pg 583]
 The average thermal conductivity of the walls (including the windows) and roof of the house shown is $0.48 \text{ W/m}^\circ\text{C}$, and their average thickness is 21 cm . The house is heated with natural gas having a heat of combustion (heat given off per cubic meter of gas burned) of 9600 kcal/m^3 . How many cubic meters of gas must be burned each day to maintain an inside temperature of 25.0°C if the outside temperature is 0.0°C ? Disregard radiation and heat loss through the ground.



Roof area  $\cos 37^\circ = \frac{4}{L} = 0.798$ | eave height must be 3 m since it is a 3-4-5 triangle
 $\therefore L = 5.0 \text{ m}$

Heat transfer area = $2 \times 5 \times 8$ (side walls) + $2 \times 5 \times 10$ (main walls) + $2 \times 5 \times 10$ (roof) + $2 \times 3 \times 4$ (eaves)
 $= 304 \text{ m}^2$

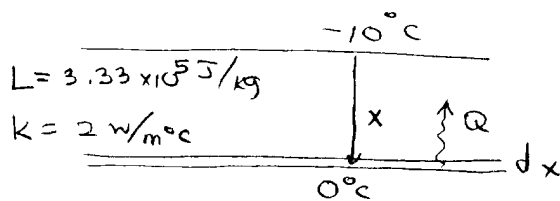
$$H = -kA \frac{\Delta T}{\Delta x} = \frac{Q}{\Delta t}$$

$$\therefore Q = -0.48 \text{ J/s m}^\circ\text{C} \times 304 \text{ m}^2 \times \frac{(-25^\circ\text{C})}{0.21 \text{ m}} \times 1 \text{ day} \times \frac{60 \times 60 \times 24 \text{ s}}{1 \text{ day}}$$

$$= 1.500 \times 10^9 \text{ J/day} \Rightarrow \therefore \text{m}^3 \text{ gas} = \frac{1.500 \times 10^9 \text{ J}}{9.6 \times 4.186 \times 10^6 \text{ J/m}^3} = 37.33 \text{ m}^3$$

5. [Serway Chapter 20 Problem 82, pg 584]

A pond of water at 0°C is covered with a layer of ice 4.0 cm thick. If the air temperature stays constant at -10°C , how long will it take before the ice thickens to 8.0 cm ? (Hint: To solve this problem, utilize $dQ/dt = kA \Delta T/x$ and note that the incremental heat dQ extracted from the water through the thickness x of ice is the amount required to freeze a thickness dx of ice. That is $dQ = L\rho A dx$, where ρ is the density of the ice, A is the area, and L is the latent heat of freezing.)



To freeze thickness dx :

$$dQ = \underbrace{\rho A dx}_{\text{mass}} \times L$$

This energy is conducted from this mass to the air through the existing layer of ice, ie $\frac{dQ}{dt} = -kA \frac{\Delta T}{x}$

$$\therefore \rho A dx L = \frac{kA(-\Delta T)}{x} dt \Rightarrow dt = \left(\frac{\rho L}{k(-\Delta T)} \right) x dx \text{ (seconds)}$$

$$\therefore t = \frac{\rho L}{k(-\Delta T)} \int_{0.04}^{0.08} x dx = \frac{\rho L}{k(-\Delta T)} \left(\frac{64}{2} - \frac{16}{2} \right) \times 10^{-4}$$

$$= \frac{917 \frac{\text{kg}}{\text{m}^3} \times 3.33 \times 10^5 \text{ J/kg} \times 24 \times 10^{-4} \text{ m}^2}{2 \text{ W/m}^\circ\text{C} \times 10^\circ\text{C}} = 3.664 \times 10^4 \text{ sec} = 10.18 \text{ hr.}$$