

3.4

Rate in Thermal Systems

Heat Flow Rate

Heat is thermal energy transferred from one body to another because of temperature difference.

Amount of heat transferred from one body to another in a time interval is heat flow rate

$$\text{Heat flow rate} = \frac{\text{heat transferred}}{\text{time interval}}$$

$$\dot{Q} = \frac{Q}{\Delta t}$$

Heat is measured in cal Joules Btu or ft·lb

Example 3.13 pg. 158

Heat Conduction

is the transfer of thermal energy within the same body caused by a temperature difference

* example of heating a pot.

Not all substances have the same ability to conduct heat.

- Metals have the greatest ability to conduct heat

* gases are poor conductors of heat

Thermal conductivity (k) is a measure of a materials ability to conduct heat

$$\text{Heat conduction rate} = \frac{\text{thermal conductivity} \times A \times \Delta T}{\text{thickness}}$$

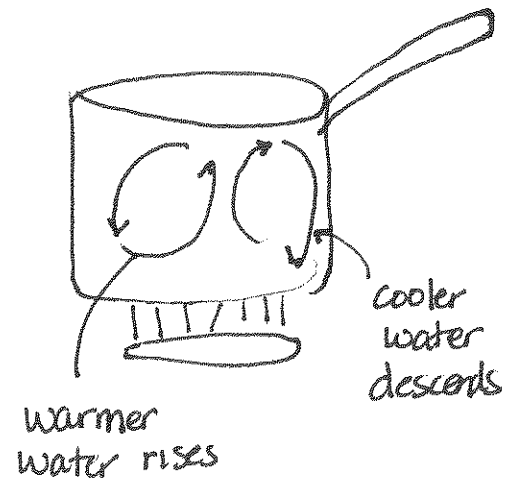
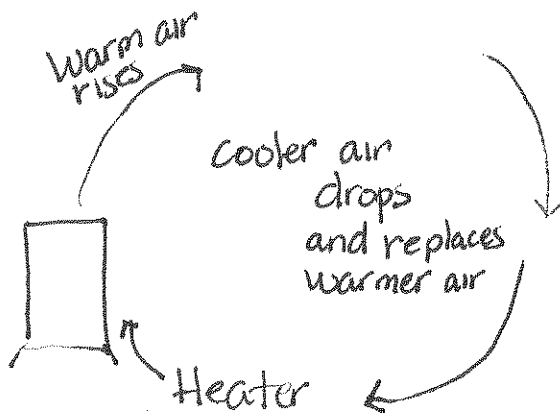
$$\dot{Q} = \frac{-kA\Delta T}{\Delta x}$$

Units of heat flow rate are the same as heat conduction rate.

* Example 3.14 pg. 161

Convection

transfer of heat by movement of fluid



Forced convection

a fan or pump creates a pressure difference in a heated or cooled fluid which forces the fluid to circulate.

human body is an example of forced convection.

blood is circulated by the heart (pump)

Natural Convection

the sun heats the surface of the earth, energy is transferred from the surface to the air, air rises and cools at higher altitudes

* energy is transferred from a high-temperature body to the fluid (air)

3.4

Radiation (transfer of energy by electromagnetic waves)

all objects radiate energy in the form of electromagnetic radiation

- radiation is not visible
- rate of energy radiated by an object depends on
 - temperature
 - surface area
 - material composition

Hot objects radiate more energy than an identical cooler object

* Radiation is the most common means of energy transfer

Reminder from chapter 1.

$$Q = m C \Delta T$$

heat transferred = objects mass \times specific heat \times temperature change