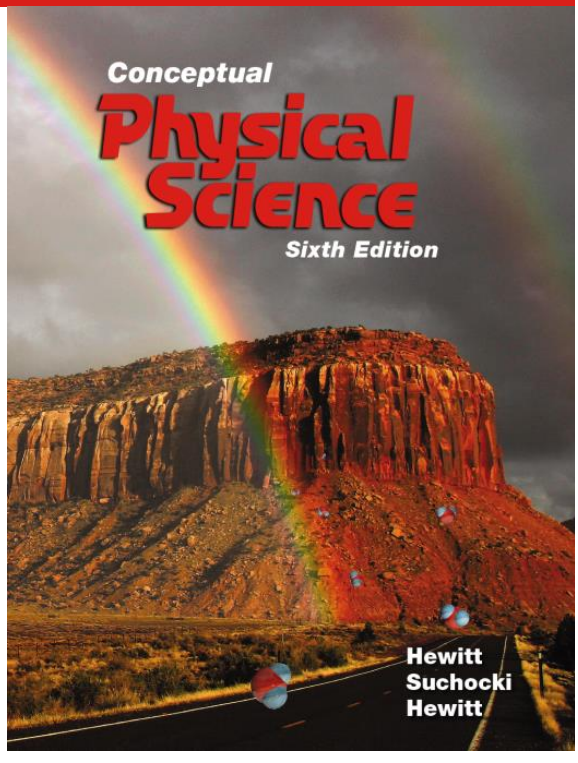
Chapter 7 Lecture

Chapter 7: Heat Transfer and Change of Phase



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Outline

- Heat Transfer → solids (poor in fluids)
  - Conduction ①
  - Convection ②
  - Radiation ③
  - } 3 methods
- Heat Transfer and Change of Phase
- Boiling
- Melting and Freezing
- Energy and Change of Phase

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Methods of Heat Transfer

- **Conduction** (solid)
  - free electrons (mobile)
- **Convection** (fluids)
  - Liquid
  - Gas
- **Radiation**
  - Vacuum

$$\rho = \frac{m}{V}$$

$T \uparrow \; V \uparrow \; D \downarrow$

hot objects → low density → floats / rise up

low temp → high density → sinks

Heat Transfer

- Processes of thermal energy transfer:
  - Conduction
  - Convection
  - Radiation

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Heat Transfer: Conduction

Conduction

- Occurs mostly in solids where the molecules remain in relatively restricted locations.
- When you stick a nail into ice, does cold flow from the ice to your hand, or heat from your hand to the ice?

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Heat Transfer: Conduction
CHECK YOUR NEIGHBOR

If you hold one end of a metal bar against a piece of ice, the end in your hand will soon become cold. Does cold flow from the ice to your hand?

A. Yes.
B. In some cases, yes.
C. No.
D. In some cases, no.

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Heat Transfer: Conduction
CHECK YOUR ANSWER

If you hold one end of a metal bar against a piece of ice, the end in your hand will soon become cold. Does cold flow from the ice to your hand?

A. Yes.
B. In some cases, yes.
C. No.
D. In some cases, no.

***Explanation*:**

Cold does not flow from the ice to your hand. Heat flows from your hand to the ice. The metal is cold to your touch, because you are transferring heat to the metal.

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Heat Transfer: Conduction

Conductors:

- Solids whose atoms and molecules have loosely bound electrons are good conductors of heat.
- These mobile electrons move quickly and transfer energy to other electrons which migrate quickly through out the solid.
- Examples: iron, copper

Insulators (poor conductors):

- Are made of atoms/molecules that hold their electrons tightly. Here, the molecules vibrate in place, and transfer energy through interaction with their neighbors.
- Examples: glass, wool, wood, paper, foam, air

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Heat Transfer: Conduction

Examples:

- Wood is used to make cookware handles
- You can put your hand briefly in a pizza oven without harm (air is a poor conductor)
- Some animals make holes in the snow and use it as a shelter from the cold (snowflakes are made of crystals that trap air and provide insulation)

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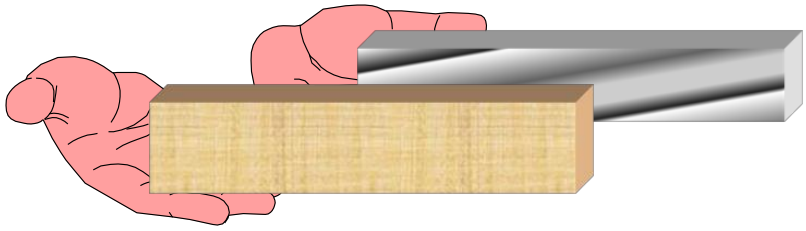
Heat Transfer: Conduction

- Why does metal feel colder than wood, if they are both at room temperature?
  - Metal is a conductor, wood is an insulator. Metal conducts the heat away from your hands. Wood does not conduct the heat away from your hands as well as the metal, so the wood feels warmer than the metal.



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Heat Transfer: Convection

Convection

- Transfer of heat by the motion of fluid as it rises or sinks .
- Unlike conduction, convection occurs only in fluids (liquids and gases).
- Convection transfers heat vertically. rise/ sink

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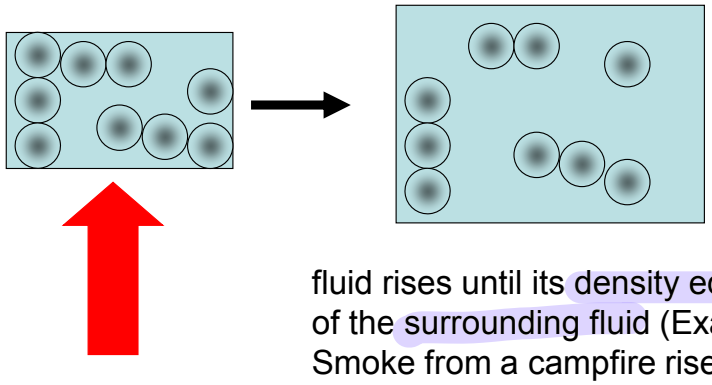
Heat Transfer: Convection

- What happens to the particles in a liquid or a gas when you heat them?

The particles spread out and the fluid become less dense.



fluid rises until its density equals that of the surrounding fluid (Example: Smoke from a campfire rises)

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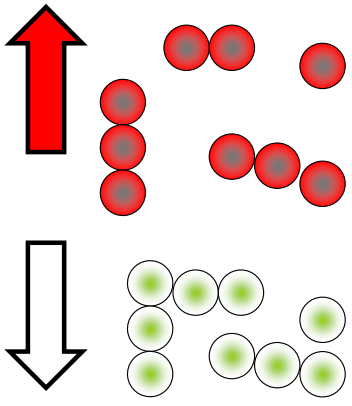
Heat Transfer: Convection

- Cooler (more dense) fluids sink through warmer (less dense) fluids.
- In effect, warmer liquids and gases rise and cooler liquids and gases sink.



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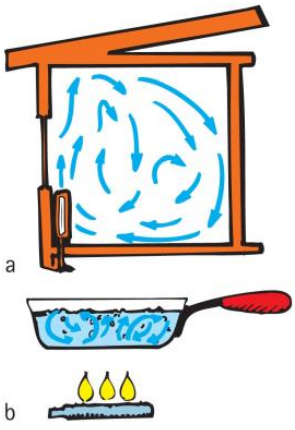
Heat Transfer: Convection



- Convection currents in (a) a gas (air) and (b) a liquid. Convection transfers heat vertically.

- The tip of a heater element submerged in water produces convection currents, which are revealed as shadows (caused by deflections of light in water of different temperatures).

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Heat Transfer: Convection

- Explain why you can keep your fingers beside the candle flame without harm, but not above the flame?

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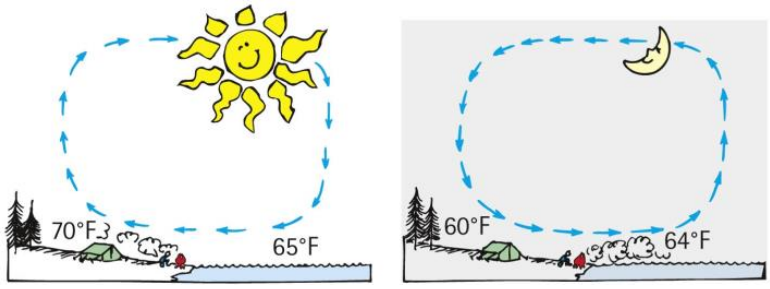
Convection Currents

- Convection currents produced by unequal heating of land and water.
- During the day, warm air above the land rises, and cooler air over the water moves in to replace it.
- At night, the direction of air flow is reversed.



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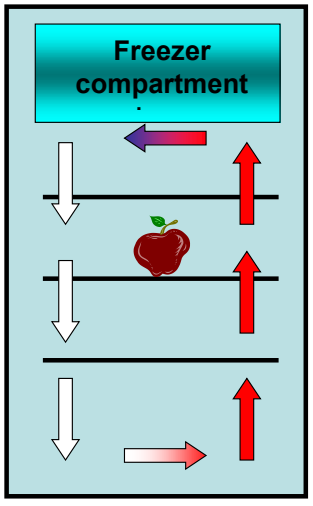
Heat Transfer: Convection

- Where is the freezer compartment put in a fridge?
  - It is put at the top, because cool air sinks, so it cools the food on the way down.
  - It is warmer at the bottom, so this warmer air rises, and a convection current is set up



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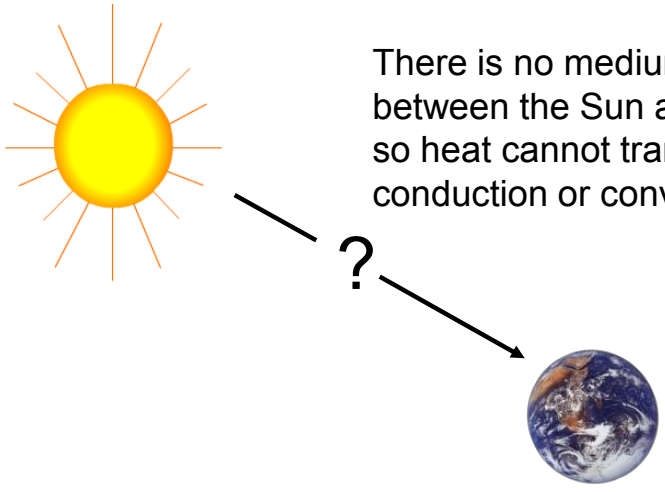
Heat Transfer: Radiation

through radiation

How does heat energy get from the Sun to the Earth?



There is no medium (particles) between the Sun and Earth, so heat cannot transfer by conduction or convection.

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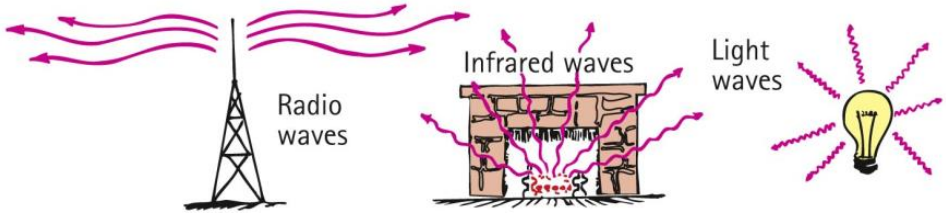
Heat Transfer: Radiation

- Radiation
  - Transfer of energy via electromagnetic waves that can travel through empty space



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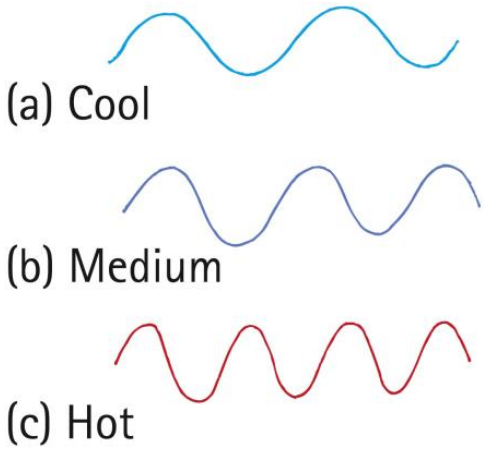
Wave Frequency - Temperature

short-wavelength – high freq, vice versa



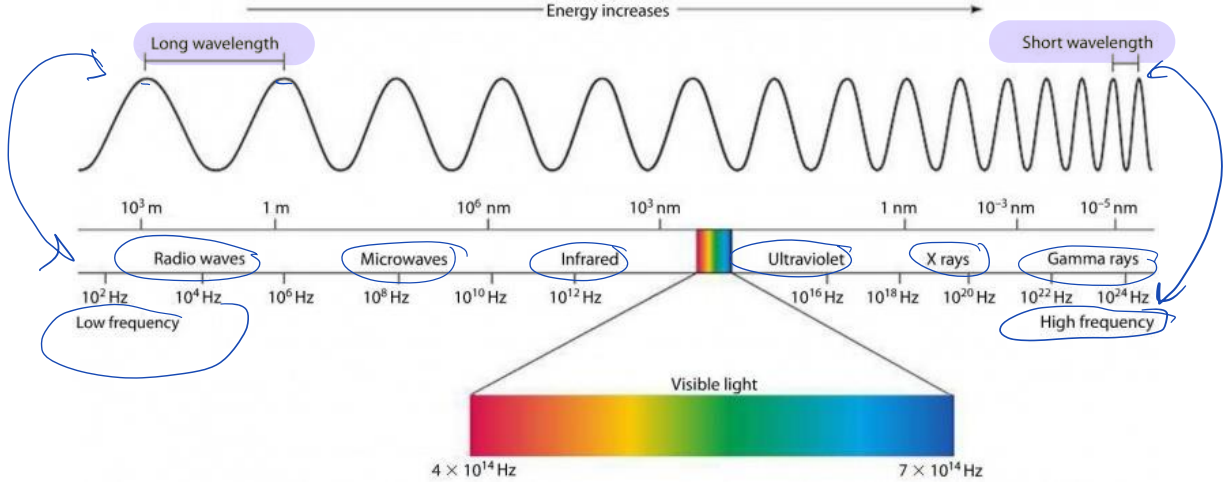
a) A low-temperature (cool) source emits primarily low-frequency, long wavelength waves.

b) A medium-temperature source emits primarily medium-frequency.

c) A high-temperature source emits primarily high-frequency, short wavelength waves.

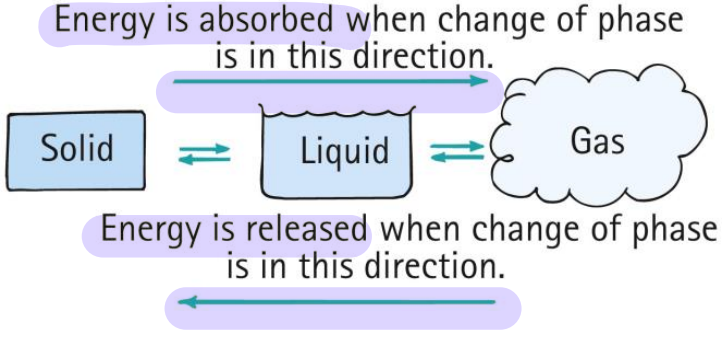
Heat Transfer: Radiation

- Examples of electromagnetic radiation



Phases of Matter

- Matter exists in the three common phases: *solid*, *liquid*, and *gas* (a fourth phase of matter is *plasma*).
- When matter changes from one phase to another, energy is transferred.



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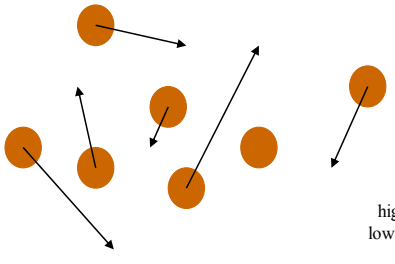
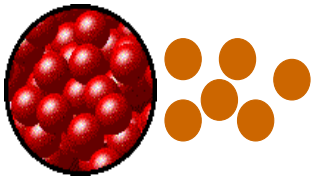
Phases of Matter

Gas - very weak intermolecular forces, rapid random motion

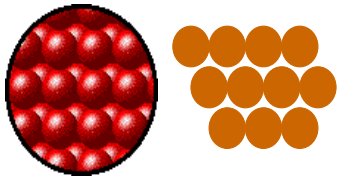


high temp
low pressure

Liquid - intermolecular forces bind closest neighbours



Solid - strong intermolecular forces



low temp
high pressure

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Heat Transfer and Change of Phase

When a liquid changes phase to a gas, it

A. absorbs energy.
B. emits energy.
C. neither absorbs nor emits energy.
D. becomes more conducting.

Heat Transfer and Change of Phase

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