

# **Solar and Terrestrial Radiation**

## **Energy in the Atmosphere**

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## **Ch. 2: Energy in the Atmosphere**

- **Heat, Energy, Temperature**
  - **Definitions**
  - **Temperature Scales**
- **Heat Transfer**
  - **Conduction, Convection, Radiation**
- **Electromagnetic Radiation (EMR)**
  - **Types: Ultraviolet, Visible, Infrared**
  - **Blackbody Radiation**

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## **Lecture Topics, cont.**

- **Seasons**
  - **Earth's Axial Tilt**
  - **Solstices and Equinoxes**
  - **Solar Angle and Daylight Length**

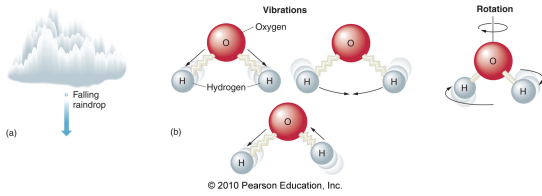
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# Heat and Temperature

• **Kinetic Energy = energy of motion**

→ **Higher speed** → **Higher KE**



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**Heat**

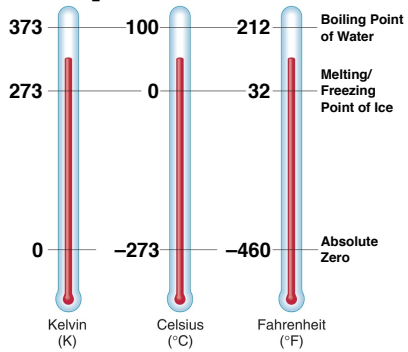
Cumulative total kinetic energy of all molecules in a substance

**Temperature**

Proportional to average kinetic energy of individual molecules in a substance

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## Temperature Scales



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## Temperature Conversion

$$K = C + 273$$

$$C = \frac{5}{9} (F - 32)$$

$$F = \frac{9}{5} C + 32$$

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## Heat Transfer

- Heat flows from regions of high heat content to regions of low heat content

→ Usual direction: high temperature regions to low temperature regions

- Conduction: heat spread by collisions between molecules

→ Slow!

→ Air is a poor conductor/is a good insulator



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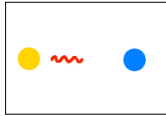
- Convection: heat transport via bulk movement of air

→ Faster than conduction; as fast as the wind

→ “Convection”: vertical movement

→ “Advection”: horizontal movement

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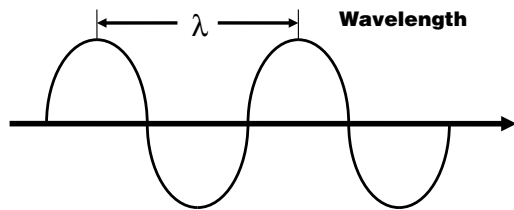


- **Radiation: energy propagating through space in the form of electromagnetic radiation**
  - Moves as fast as speed of light
  - Can travel through a vacuum

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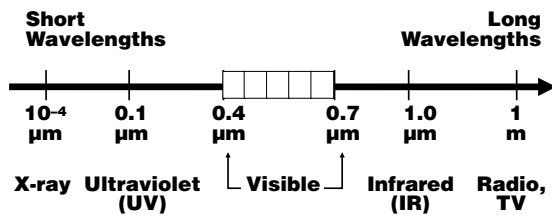
## Electromagnetic Radiation

Radiation energy propagates as a wave, in energy packets called photons



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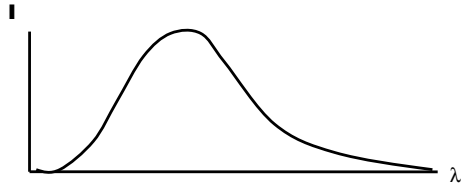
## Types of EMR



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## Blackbody Radiation

- **Blackbody: an object that absorbs all wavelengths of EMR**  
→ And emits all wavelengths of EMR (Kirchoff's Law)

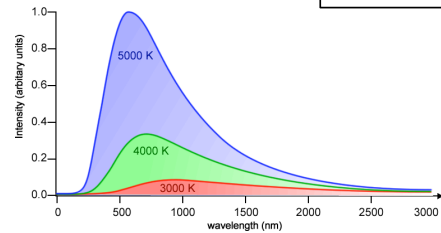


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## Stefan-Boltzmann Law

- **Radiation power flux emitted by a blackbody is directly proportional to its temperature**

$$E = \sigma T^4$$

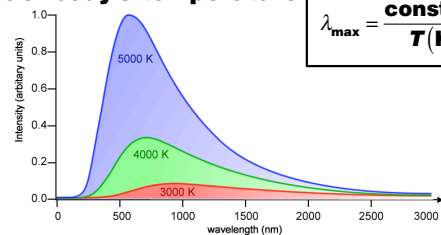


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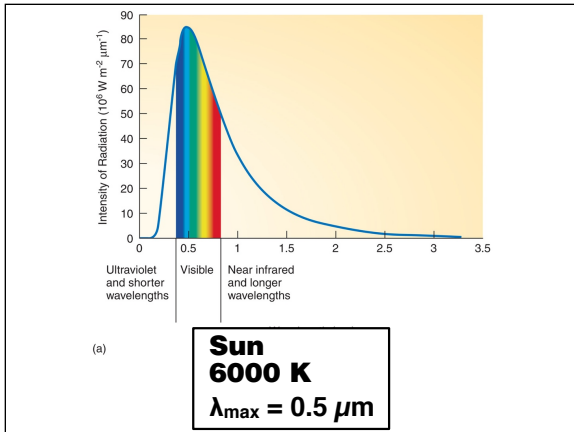
## Wien's Law

- **A blackbody emits EMR such that the wavelength of maximum intensity ( $\lambda_{\max}$ ) is inversely proportional to the blackbody's temperature**

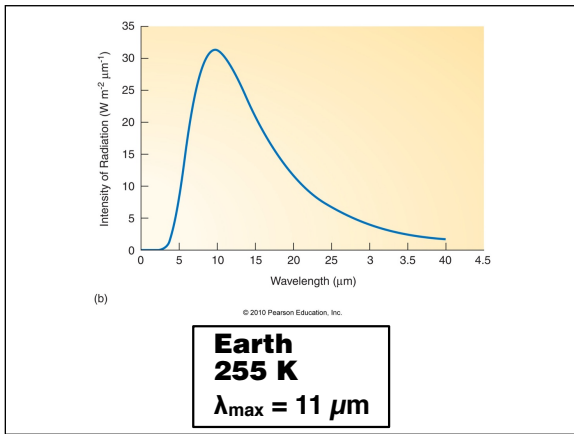
$$\lambda_{\max} = \frac{\text{constant}}{T(\text{K})}$$



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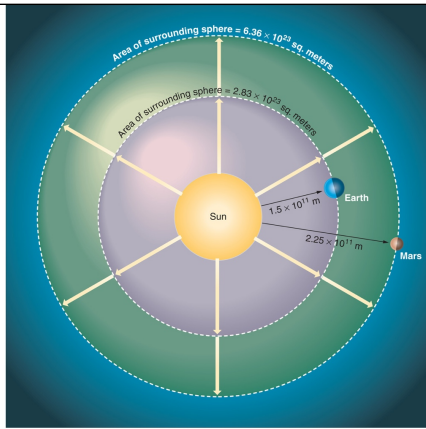


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## Inverse Square Law

- **Radiation power flux from an object decreases as the square of the distance from the object**

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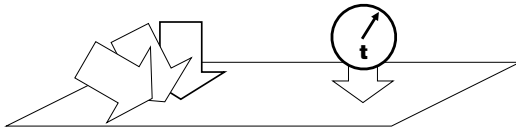
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## Insolation and Earth Seasons

**Insolation: cumulative amount of solar radiation energy received by the Earth's surface in one day**

**Intensity**

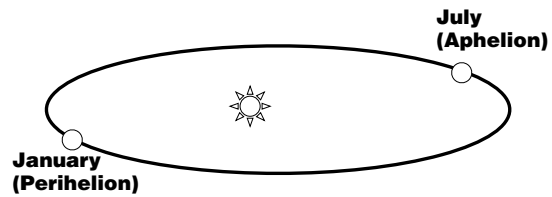
**Duration**



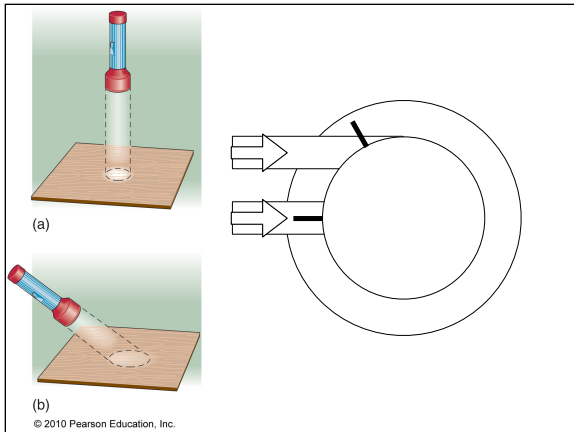
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• **Seasons are regular, annual variations in temperature and/or climate**

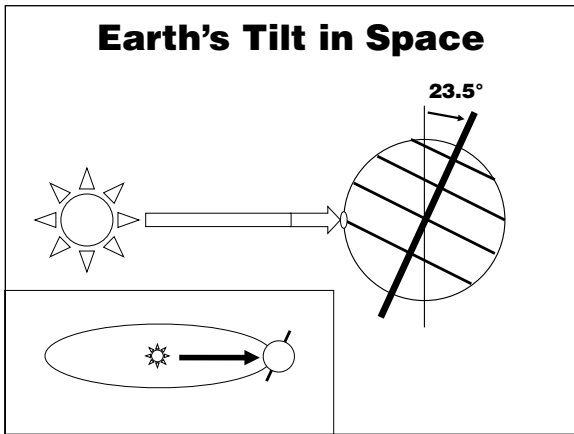
→ **Results from variation of insolation during the course of a year**



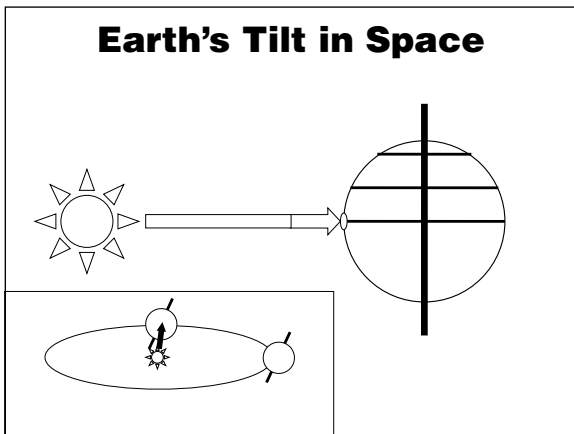
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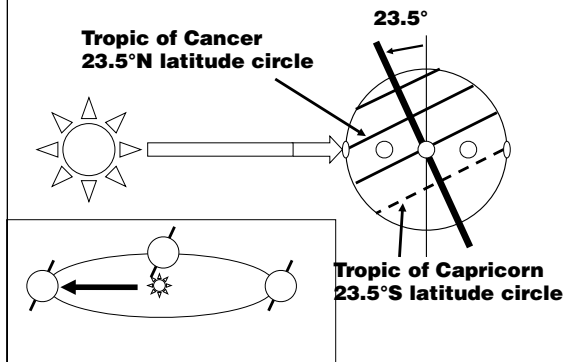
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## Earth's Tilt in Space

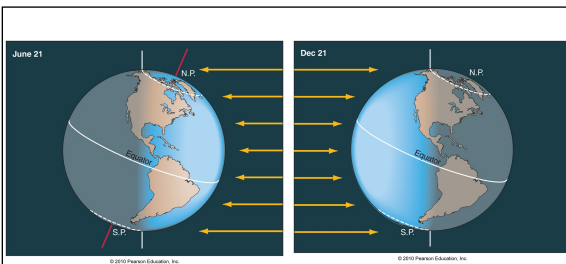


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## Solstices

- **North/South Poles are pointed most toward or away from the Sun**
- **Subsolar point is Tropic of Cancer or Capricorn**
  - **June Solstice: ~June 21, subsolar point Tropic of Cancer**
  - **December Solstice: ~December 21, subsolar point Tropic of Capricorn**

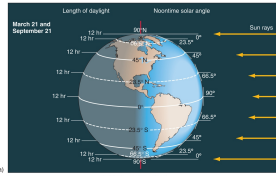
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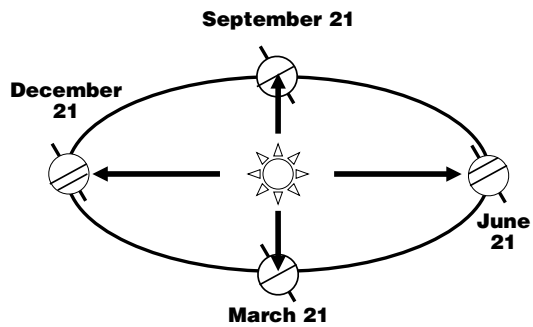
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## Equinoxes

- **Subsolar point = 0° latitude (the Equator)**
- **Directly between solstices**
- **12 hours daylight, 12 hours night**

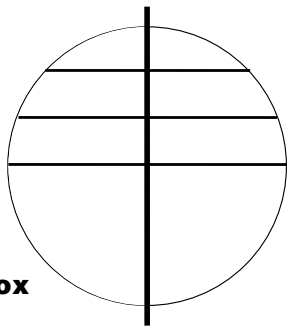


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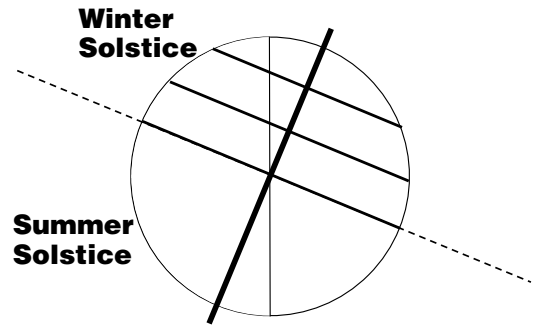
## Seasons and Daylight Length



Equinox

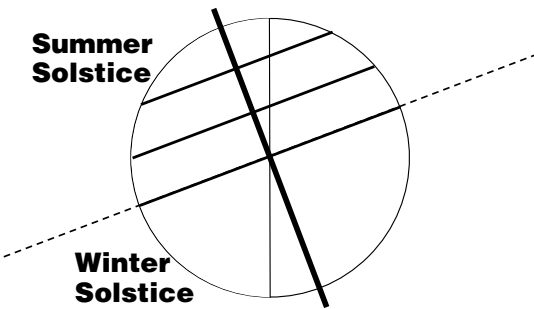
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## Seasons and Daylight Length



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## Seasons and Daylight Length



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**TABLE 2-2** Variations in Solar Angle and Daylength

	Solar Angle at Noon	Length of Day	Total Radiation for Day (Megajoules/m <sup>2</sup> )
December 21			
Winnipeg (50 °N)	16.5°	7 hr, 50 min	7.1
Austin (30 °N)	36.5°	10 hr, 04 min	18.6
June 21			
Winnipeg (50 °N)	63.5°	16 hr, 10 min	44.5
Austin (30 °N)	83.5°	13 hr, 56 min	43.9

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# Seasons and Solar Altitude

