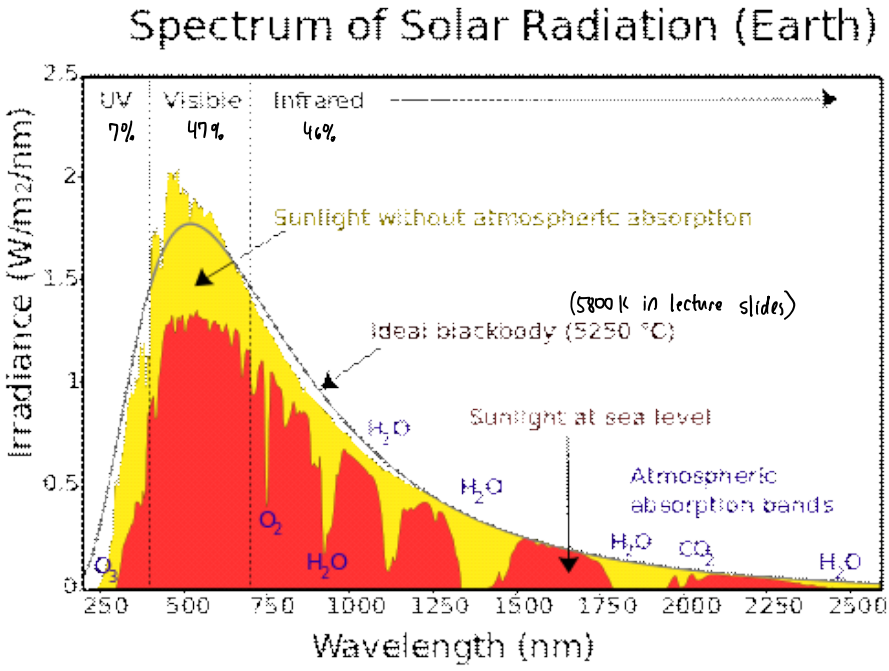
Solar Spectrum

Tuesday, January 30, 2024 4:06 PM

Solar Energy Conversion System

↳ Converting the sun's energy into electrical power

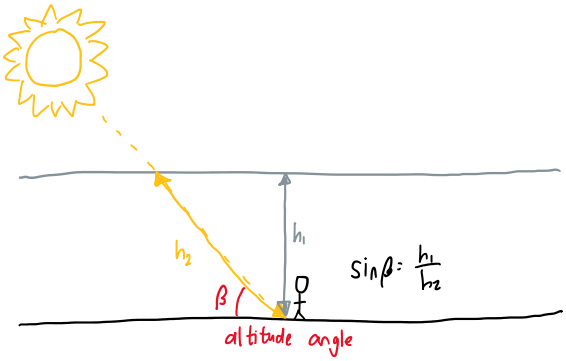
- **Insolation**
  - ↳ Incident Solar Radiation [W/m^2]
    - Goal: • Determine insolation for a particular location
      on " " day
      at " " time
    - Choose good locations and tilt angles for solar panels



- Area under curve = solar insolation just under Earth's atmosphere [W/m^2]
  = 1.37 kW/m^2

- As solar radiation makes its way to Earth's surface, it has to pass some distance thru Earth's atmosphere
  ↳ Attenuation occurs, but by how much?

- Simplifying Assumption: Earth is flat (!)

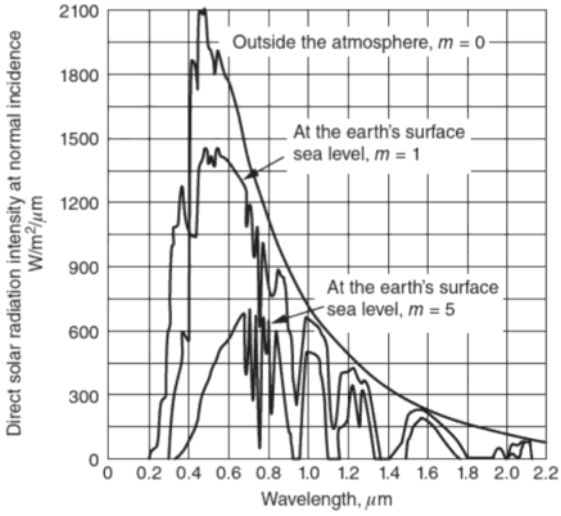


Air Mass Ratio

$$m = \frac{h_2}{h_1} = \frac{1}{\sin\beta}$$

↳ AM 0 → extraterrestrial solar spectrum

↳ AM 1.5 → average



- As m increases, spectrum attenuation overall
- Also, shift towards longer wavelength

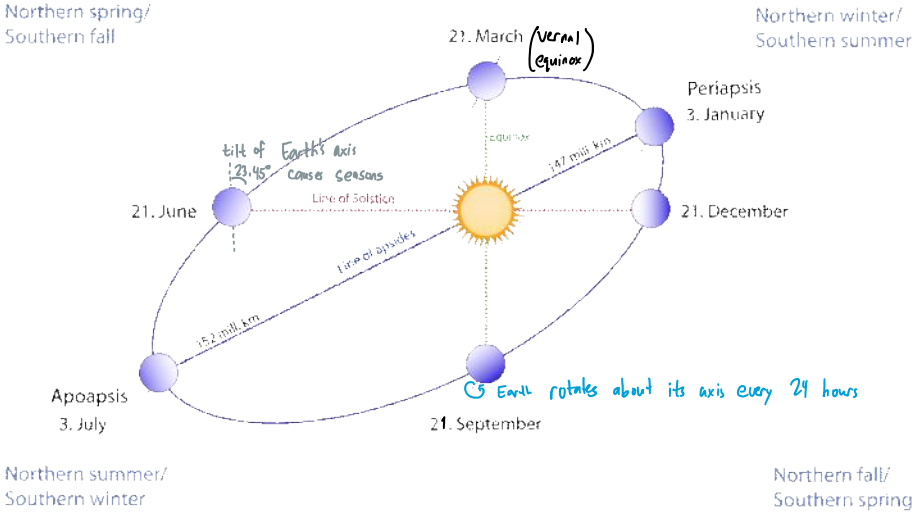
$$E = \frac{hc}{\lambda}$$ photon energy

- This is why sunsets look red

- To compute m without the flat earth assumption, need to know more about Earth's orbit

Earth's Orbit

- Elliptical orbit around the sun 365.25 days/yr



- Variation in distance:

$$d = 1.5 \times 10^8 \left(1 + 0.017 \sin\left(\frac{360(n-93)}{365}\right)\right) \text{ [km]}$$

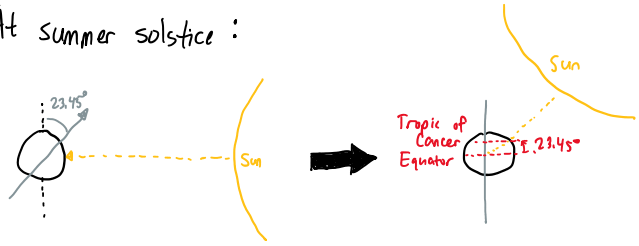
d: distance away from the sun

n: day number. {Jan 1 = 1, .., Dec 31 = 365}

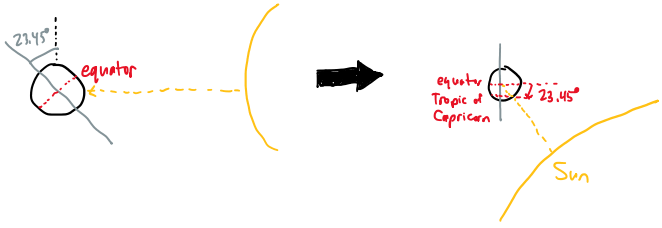
$\frac{360(n-93)}{365}$: in degrees

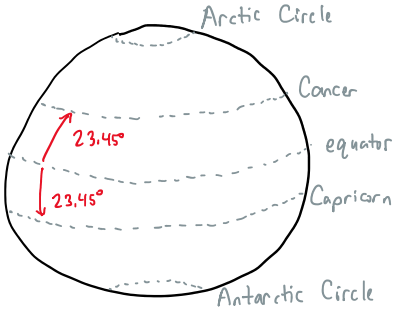
- Sun rises in the East, sets in the West

- Try alternate frame of reference (stationary Earth)
  - At summer solstice:



  - At winter solstice:



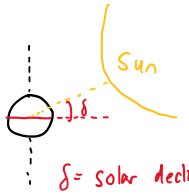


Can we use this information to find a good tilt angle for solar collector?
See next lecture

- In this new frame of reference, the sun moves around!

In general:

Solar Declination Angle (δ)



- angle formed between plane of equator and line drawn from centre of the sun

$$\delta = 23.45^\circ \sin\left(\frac{360}{365}(n-81)\right)$$

(n → day number)

$\delta \in [-23.45^\circ, +23.45^\circ]$

winter solstice — summer solstice

$\frac{360}{365}(n-81) = 0^\circ$ or $180^\circ \rightarrow \delta = 0$

$n = 81$: Spring equinox

$n = 264$: fall equinox