[HRK 5e, 39-1]

Electromagnetic spectrum

EM waves can exist w/ any wavelength λ

[from millions of km, to < fm (size of nucleus)]

and frequency f.

All EM waves travel (in vacuum) w/ speed $c = 3 \times 10^8 \frac{m}{s}$

Exact: $c = 299,792,458 \frac{m}{s}$ (by definition)

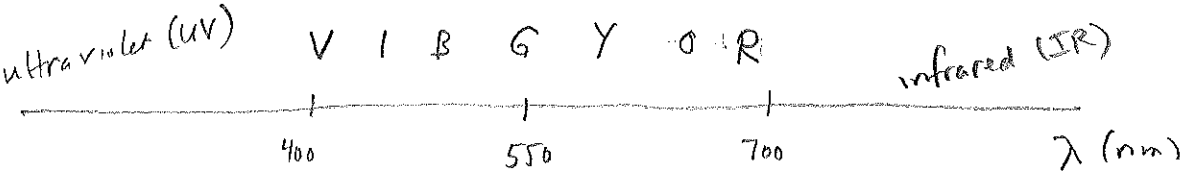
$\Rightarrow f = \frac{c}{\lambda}$ [smaller $\lambda \Rightarrow$ higher f]

Visible light: $\lambda \approx 0.5 \mu m = 500 nm$ [size of small cell]

$(1\ nm = 10^{-9} m)$

Ranges from ~ $\lambda = 400 nm$ to $700 nm$

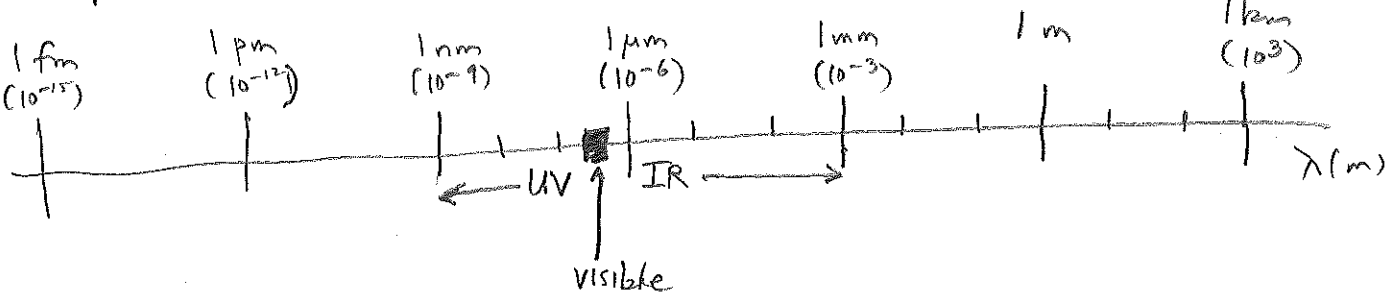
[Demo: OH projector w/ slit from sheet of paper + prism/grating]



monochromatic $\Rightarrow$ single wavelength ("one color")

White = mixture of wavelengths

spectrum (log scale!)



Radio waves AM $f \approx 1000\ kHz = 10^6 \frac{cyc}{sec}$ [generated by oscillating charges in transmission antennas]

$$\lambda = \frac{c}{f} = \frac{3\times10^8 \frac{m}{s}}{10^6 \frac{cyc}{sec}} = 300\ m$$ [put on diagram]

FM: $f \approx 100\ MHz = 10^8 \frac{cyc}{sec}$

$$\lambda = \frac{3\times10^8 \frac{m}{s}}{10^8 \frac{cyc}{s}} = 3\ m$$ [put on diagram]

Shortwave

wireless $f \sim 1-60\ GHz$

$\lambda = 5\ mm - 30\ cm$ (microwaves)

microwave oven $f \approx 2.5\ GHz$

$\Rightarrow \lambda = 12\ cm$

[standing waves. Try marshmallows on a plate. Why rotating plate?]

[XM radio 2332.5 – 2345.0 MHz]

Infrared: $400\,nm < \lambda < 1\,mm$ [warmth on skin, night vision goggles, remote control]

Visible: $400\,nm < \lambda < 700\,nm$

$f = \frac{c}{\lambda} \sim 5 \times 10^{14}\,Hz$ [approx freq of electrons in Bohr orbits; electronic transitions]

Ultraviolet: $100\,nm < \lambda < 400\,nm$ [sun burns, skin cancer; absorbed by O_2, N_2 + by ozone in atmosphere]

UVA	320 - 400
UVB	290 - 320
UVC	100 - 290

[but actually down to ~10 nm]

X-rays: $0.01\,nm \leq \lambda < 10\,nm$ [deceleration of electrons]

[~size of atoms used for determining molecular structure, DNA]

γ-rays: $\lambda < 10^{-11}\,m$ [emitted by nuclei, radioactivity, cosmic rays, matter/antimatter $e^+e^- \rightarrow \gamma\gamma$]