Light

Light

- *light* is an ***electromagnetic wave***
- *also* has *particle-like* properties!

- ***speed of light*** in a ***vacuum***:

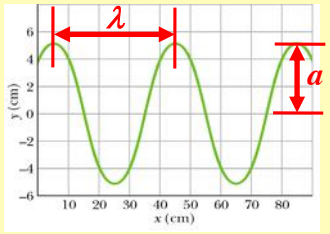
  $c = 3 \times 10^8$ *m/s*

- ~ *one billion* km/h

(eg) light could travel **8 times around Earth *in 1 s***
(eg) light from Sun takes ~**8 minutes to reach Earth**

- ***wavelength*** (**λ**): distance from one peak to the next

- ***amplitude*** (**a**): *"height"* of the *peaks* of a wave

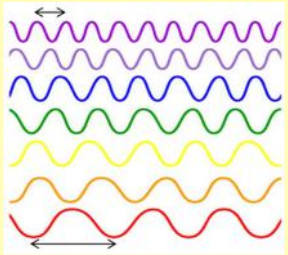


CLICKER: **λ** *for the wave shown above is:*
(a) 10cm (b) 20cm (c) 30cm (d) 40cm (e) 50cm

(eg) *wavelengths* vary ***tremendously***:
- **radio** waves: λ ~ *km*
- waves on pond: λ ~ *cm*
- **visible light**: λ ~ *nm*

- ***frequency*** *(f):* how *often* wave peaks pass by
(eg) *number of wavelengths per second*

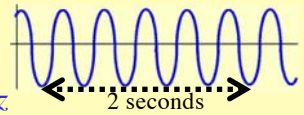
- ***frequency*** has units of *cycles/sec* or ***hertz*** (*Hz*)
(eg) *1 Hz = 1 wave (peak-to-peak) per second*



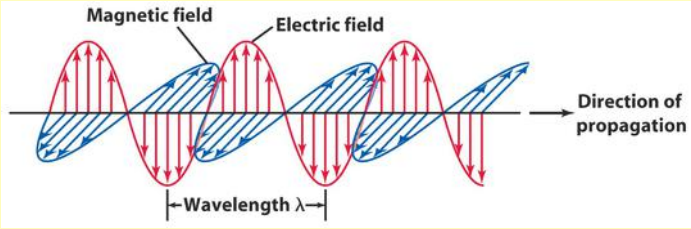
Q: Have you heard of ***hertz***?

DEMO: *wave generator & speaker*

CLICKER: *What is the* ***f*** *of the wave to the right?*
(a) 1Hz (b) 2Hz (c) 2.5Hz (d) 5Hz



• ***radiation***: energy transmitted via an ***EM wave***



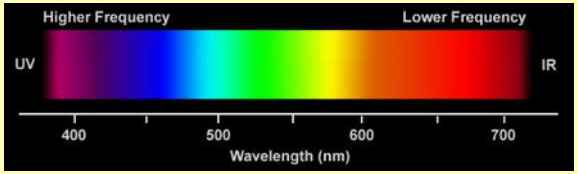
• *light* is ***self-propagating***

Q: *How does this compare to* ***sound waves****?*

Q: *What if light* ***wasn't*** *self-propagating?*

EM Spectrum

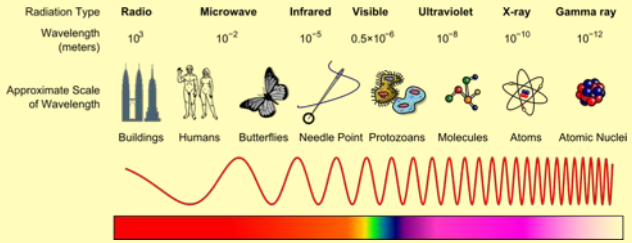
• *colours* vary **only** in their *wavelength*



• ***spectrum***: split light into *component* wavelengths

(eg) *a prism & ROYGBIV*

• *classify* light based on ***wavelength***



• ***visible light*** is only a ***tiny*** part of *EM spectrum*

• *smallest* λ: gamma rays (10^{-15} m)

• *visible* λ: 400 nm - 700 nm

• *largest* λ: *radio* (~km)

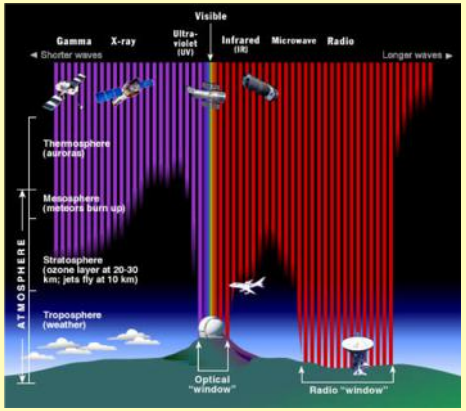
• ***higher frequency*** corresponds to *more energy*

• ***wavelength*** affects *interaction with matter*

• ***gamma*** & ***X- rays*** mostly *absorbed*

• ***UV*** *absorbed* by* O_3

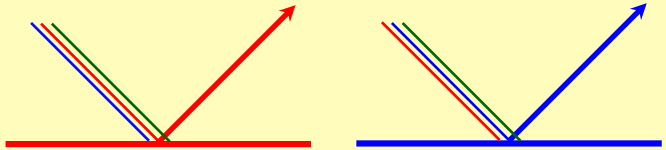
• ***infrared*** *absorbed* by CO_2, CH_4 & H_2O *vapor*



• ***visible light*** & ***radio waves*** reach the ground

Colour

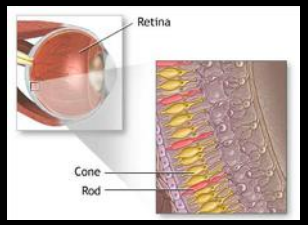
- see *colour* due to *reflected wavelengths*
- other *wavelengths* are *absorbed*

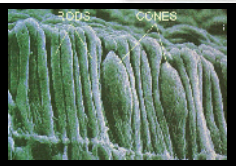


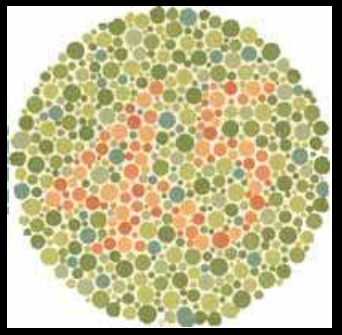
DEMO: laser pointer & coloured plastic

CLICKER: *An object appears* ***black*** *if it*
(a) absorbs all wavelengths (b) reflects all wavelengths

Q: *How do we actually see colour?*





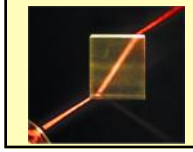


- ***rods*** see dim light; ***cones*** see in bright light & RGB
- ***cones*** concentrated in center of retina, ***rods*** on edges
- "***averted vision***"

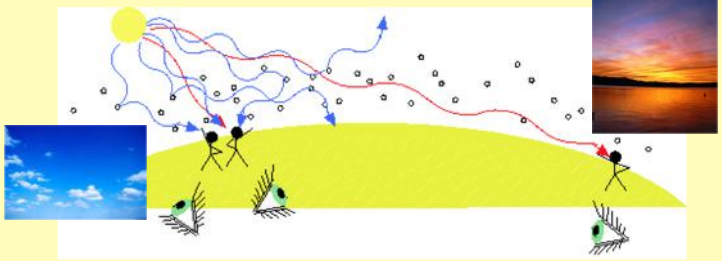
Reflection & Refraction

- *waves* ***reflect*** off ***opaque***, ***smooth*** surfaces
(eg) *reflecting telescope*

- *light* ***refracts***
(*slows* and/or *bends*)
as it moves from *one material into another*
- ***different*** *wavelengths* are *refracted* by ***different amounts***



- *shorter wavelengths* more easily bent (*scattered*), so *blue light* scattered *more* than *red light*



(eg) *Why is the Moon a (dim) red colour during a* ***total lunar eclipse****?*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CLICKER: Which of the following is correct?
(a) radio waves have the lowest frequency
(b) reflection of sunlight causes our blue skies
(c) visible light, radio and X-rays readily pass through Earth's atmosphere
(d) visible light is a large part of the EM spectrum
LIGHT