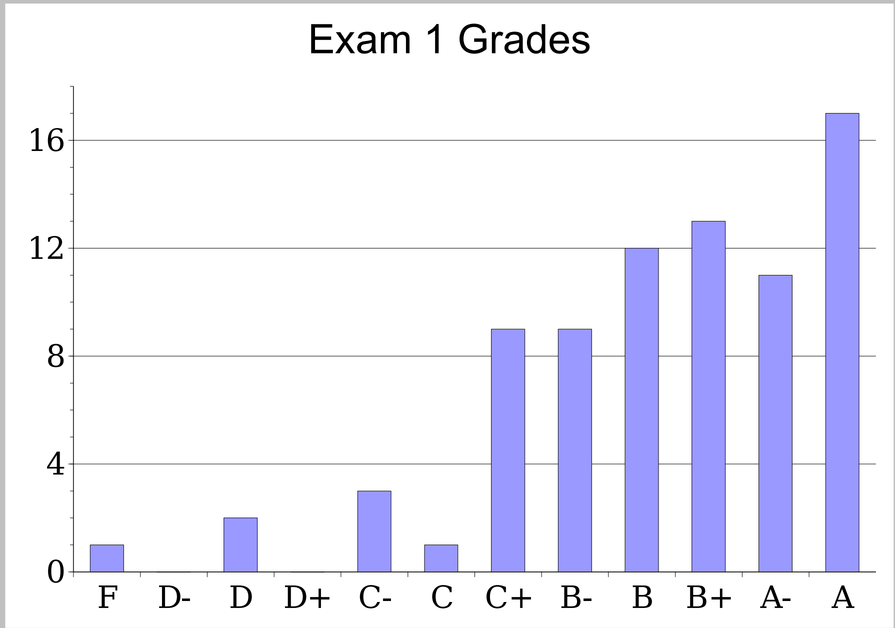
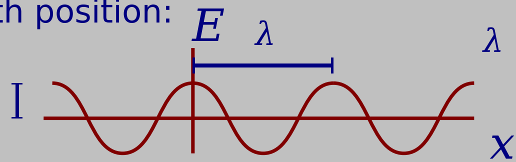


Light = Electromagnetic Wave

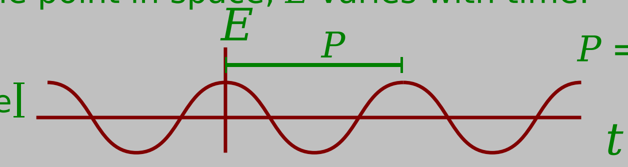
Oscillations of the Electromagnetic (E-M) Field

At one moment in time, the electric field E varies with position:



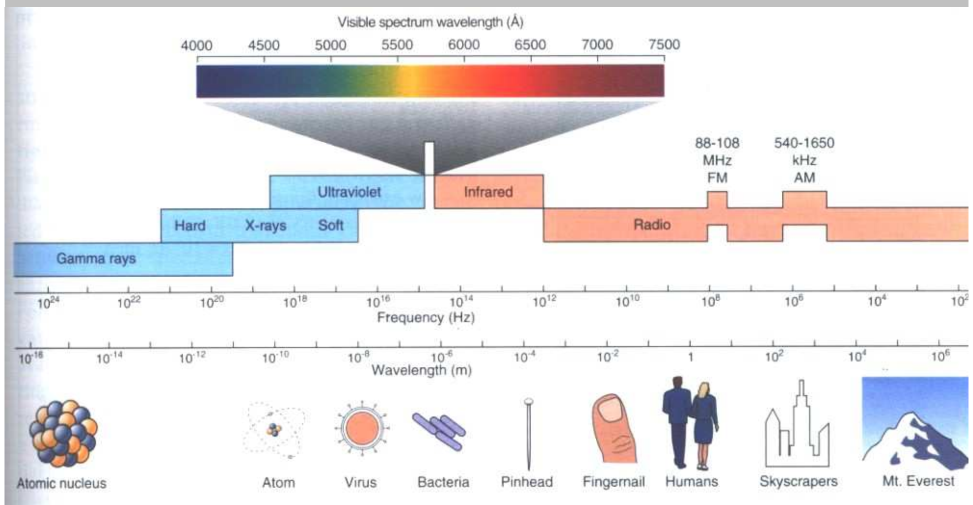
λ = Wavelength

At one point in space, E varies with time:



P = Period

$f = \frac{1}{P}$ = *Frequency*



Light : Frequency & Wavelength

$$f = \frac{1}{P}$$

$$\frac{1}{f} = \frac{\lambda}{c}$$

$$\lambda f = c \qquad f = \frac{c}{\lambda} \qquad \lambda = \frac{c}{f}$$

f = Frequency (measured in Hz ; 1 Hz = 1 s^{-1})

P = Period (measured in s)

λ = Wavelength (measured in m, nm (10^{-9}m), or Å (10^{-10}m)

c = speed of light (3.00×10^{-8} m/s)

Red light has wavelength λ = 6700 Å. What is the frequency of red light?

(1 Å = 10^{-10} m ; c = 3×10^{8} m s^{-1})

A 1.5×10^{-4} Hz

B 4.5×10^{4} Hz

C 4.5×10^{14} Hz

D It is impossible to say from the information provided.

Photon

A photon is the smallest non-zero amount of light of a given frequency (color) that you can have.

A photon is the *particle* of light.

Photon equation : $E = h\,f = \dfrac{h\,c}{\lambda}$

E = energy of the photon

f = frequency of the photon

l = wavelength of the photon

h = Planck's constant = 6.626×10^{-34} J s

c = speed of light = 3.00×10^{8} m s^{-1}

What do you get if you divide a photon in half?

A A photon with half as much energy in light of the same frequency.

B Two photons each with half as much energy in light of the same frequency.

C A photon of lower frequency.

D Two photons of lower frequency.

E None of the above.

ANSWER: None of the above. You can't divide a photon in half! (You can destroy and create photons, though.)

Which has more energy, a red photon or a blue photon?

A The red photon.

B The blue photon.

C They have the same energy, since a photon represents the smallest possible energy packet for light.

D It could be either one, depending on the size of each photon.

Two monochromatic sources are emitting light. One source emits only red light, the other source emits only blue light. Which source has a higher energy output per second?

A The red source.

B The blue source.

C It could be either one.

$$\frac{\text{Energy}}{\text{second}} = \left(\frac{\text{photons}}{\text{second}}\right)\left(\frac{\text{Energy}}{\text{photon}}\right)$$

B : Both the same
C : The blue one
D : The red one
E : Can't tell

Two photons, one red, one blue

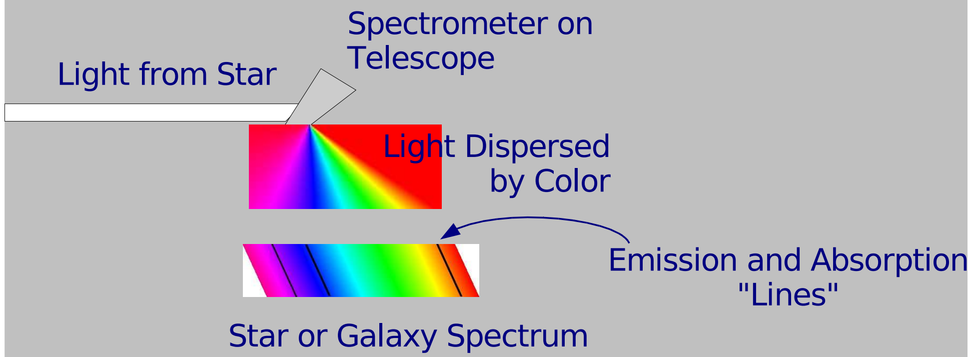
- Which one has more energy? C
- Which one has a longer wavelength? D
- Which one has a higher frequency? C
- If both are emitted from the Sun at the same time, which reaches you first? B

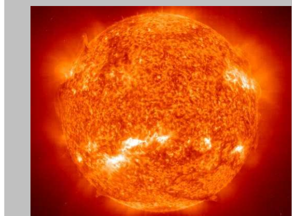
Two stars, one redder, one bluer

- Which one is more luminous? E
- Which one is bigger? E

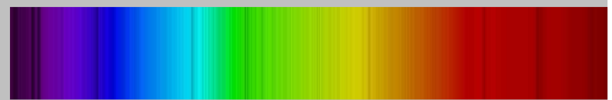
Spectroscopy

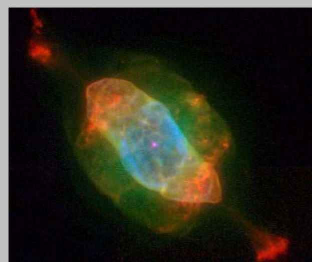
"Fingerprinting" Stars and Galaxies



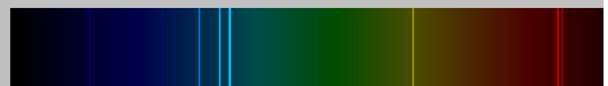


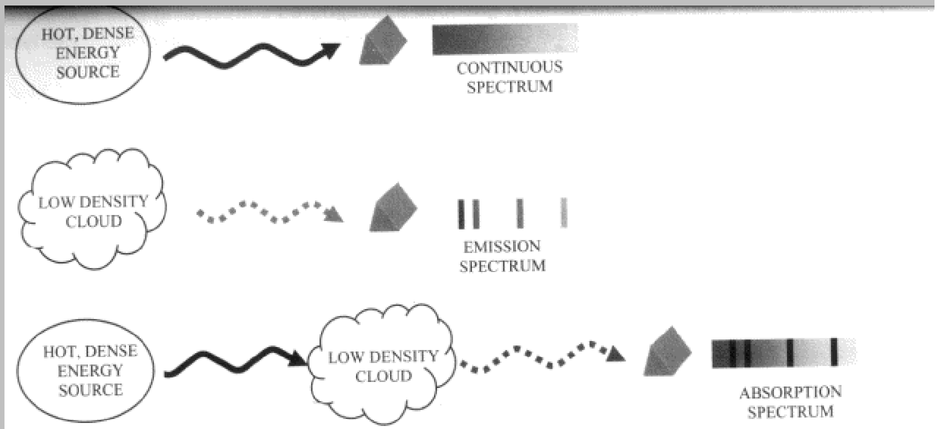
Stars: Absorption Lines





Nebulae: Emission lines





Sun's “Atmosphere”
(size exaggerated)