Physics 102 - February 19, 2014

Maxwell's Equations

1873

Wave equations
Refraction
Diffraction
Interference

James Clerk Maxwell

1831-1879 (Edinburgh)

$$\oint_s \vec{E} \bullet d\vec{a} = \frac{Q_{encl}}{\varepsilon_o}$$

$$\int_s \vec{B} \bullet d\vec{a} = 0$$

$$\int_c \vec{E} \bullet d\vec{l} = -\frac{d\int_s \vec{B} \bullet d\vec{a}}{dt}$$

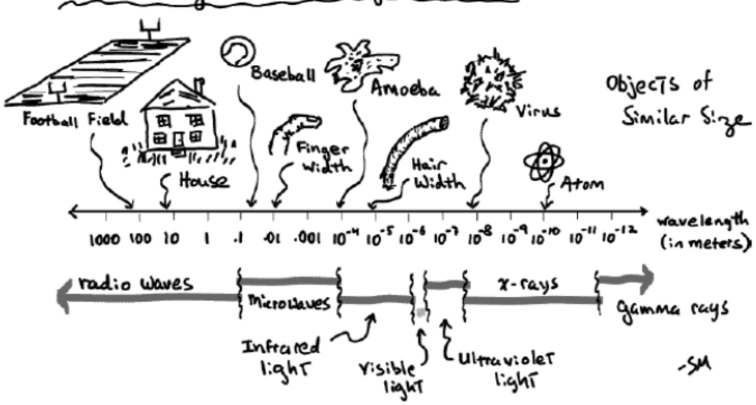
$$\int_c \vec{B} \bullet d\vec{l} = \mu_o I_{encl} + \mu_o \varepsilon_o \frac{d\int_s \vec{E} \bullet d\vec{a}}{dt}$$

ic field

netic field

light is a Wave

The variety of electromagnetic waves



Refraction of light

Speed of light in vacuum $\equiv c - 3\times10^8$ m/s

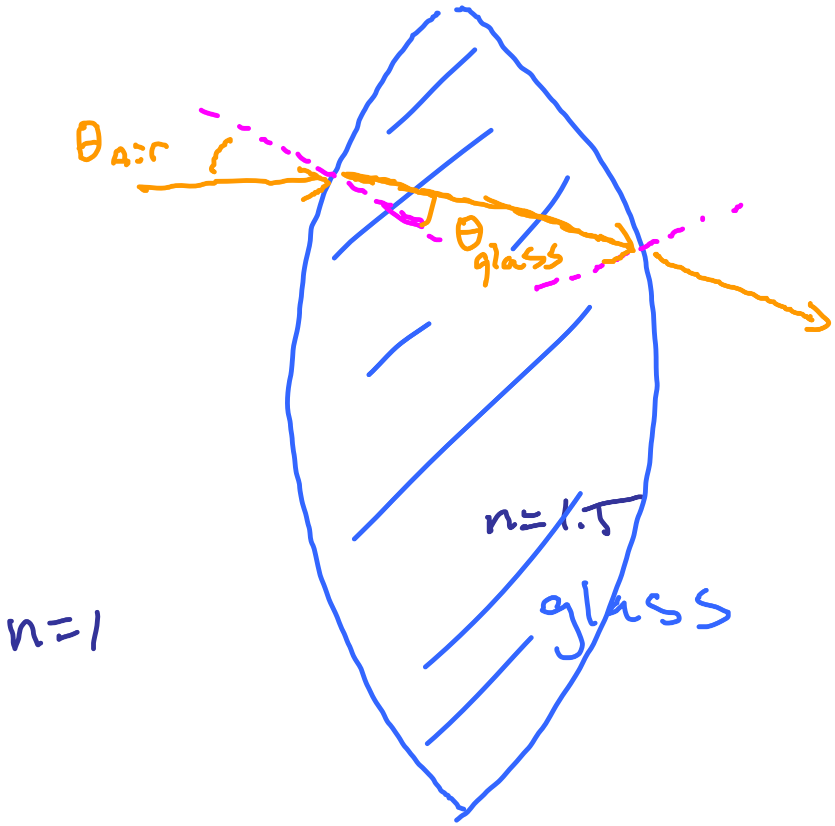
Speed of light in a medium $\equiv v < c$

index of refraction $n \geq 1$ $\quad n = \frac{c}{v}$

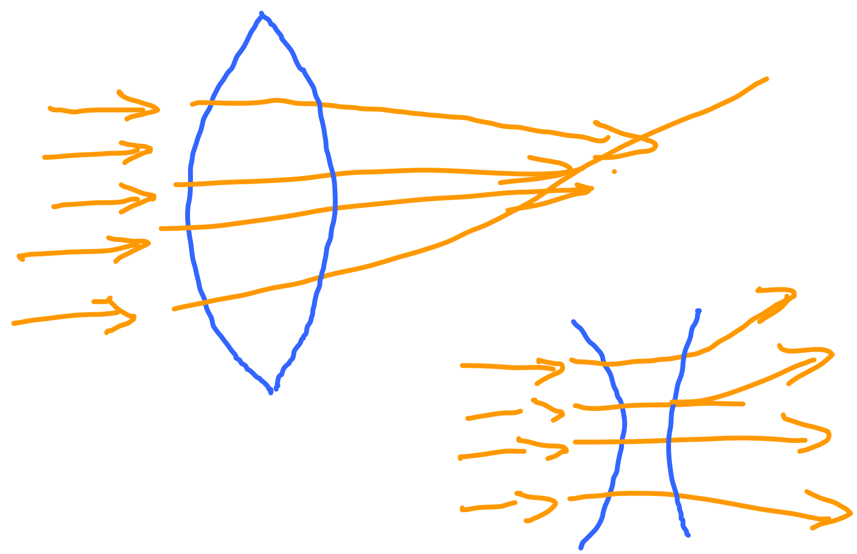
Air has $n \sim 1$

glass has $n \sim 1.5$

water has $n \sim 1.33$



$$n_{air} \sin\theta_{air} = n_{glass} \sin\theta_{glass}$$



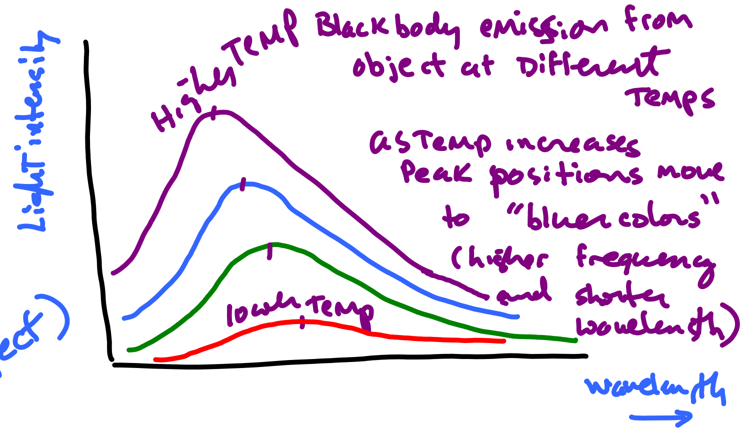
http://www-history.mcs.st-

Max Planck
(1858 - 1947)

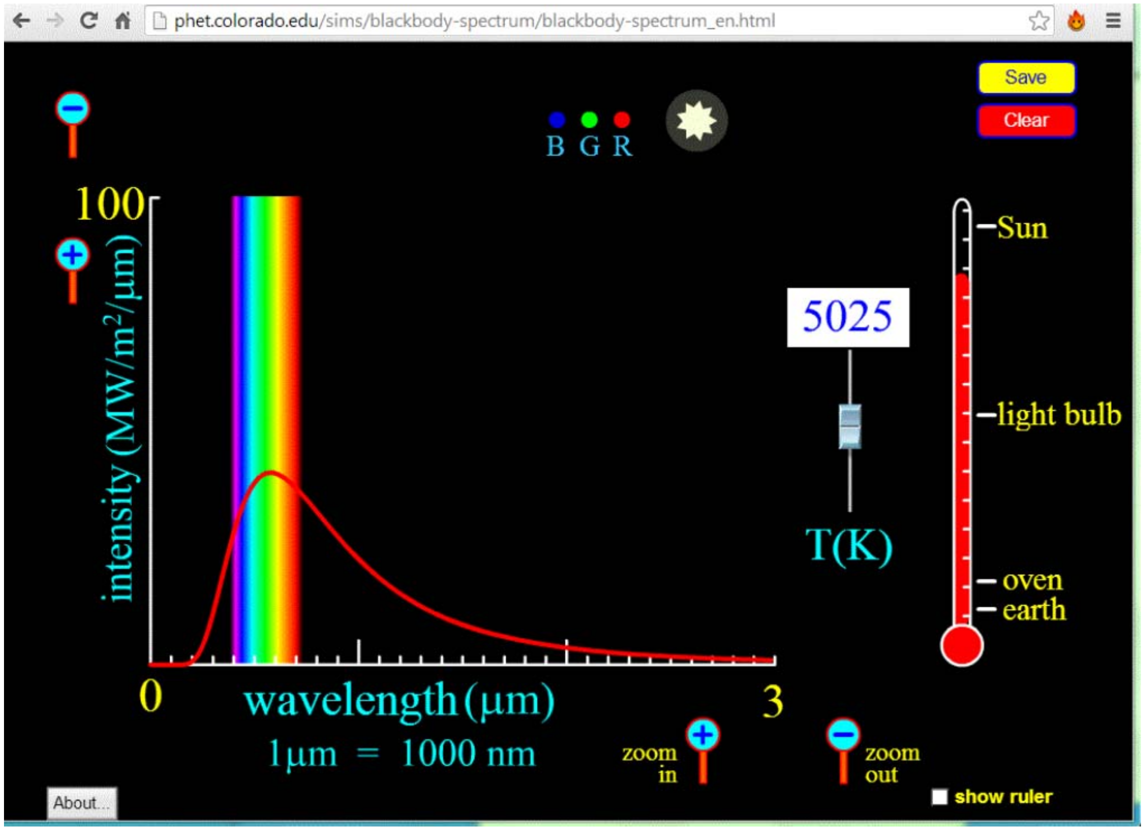
German national

Awarded 1918 Nobel Prize in physics for analysis of blackbody radiation which contributed to rise of quantum Mechanics

"Blackbody" radiation (emitted by object)



Fantastic java applet for Blackbody radiation
http://phet.colorado.edu/sims/blackbody-spectrum/blackbody-spectrum_en.html



$$E = h\nu$$

Energy

constant

Planck's constant

frequency

Energy is quantized

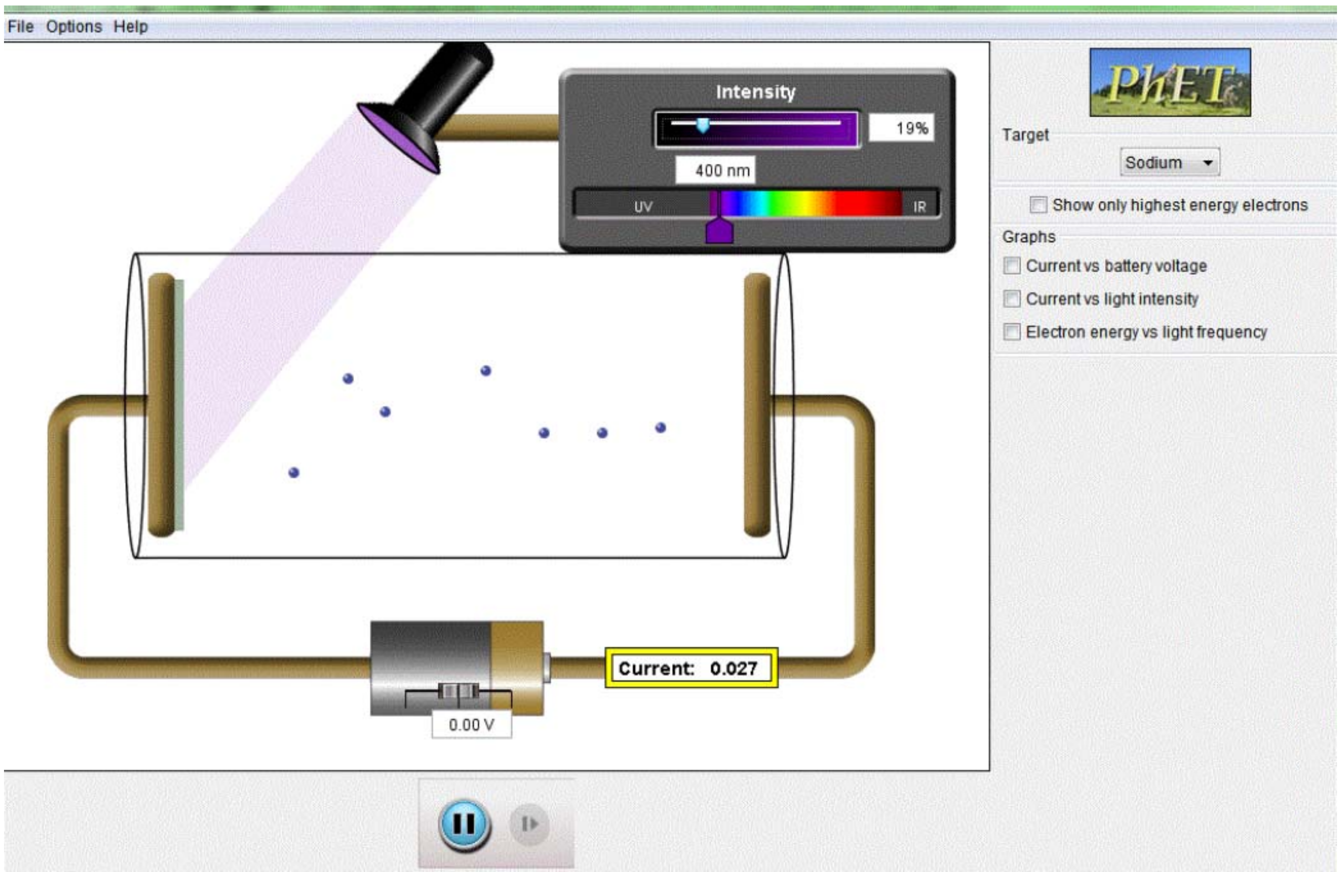
light comes as discrete particles

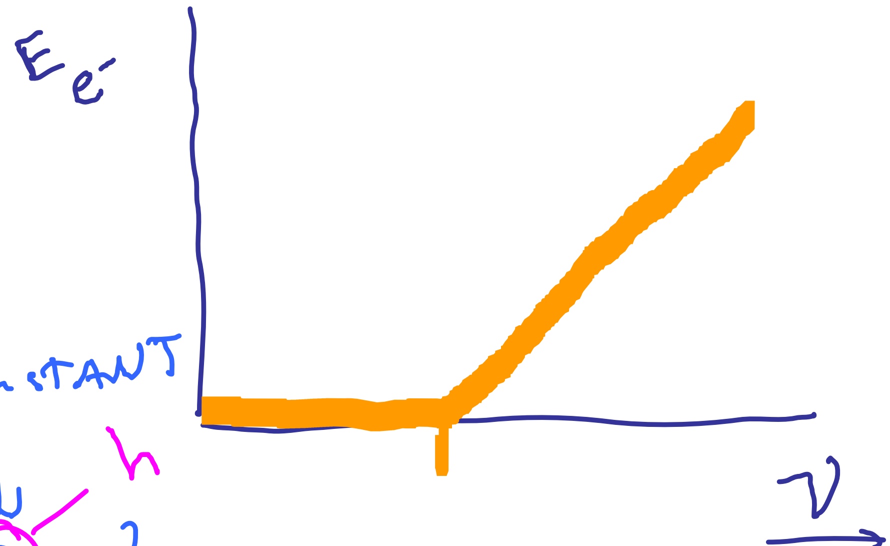
"photons"

Photoelectric effect

Fantastic java applet for the photoelectric effect

http://phet.colorado.edu/en/simulation/photoelectric





Could NOT be understood thru classical wave theory

ν Frequency → bluer

constant ↓ (h)

$$E_\gamma = h\nu$$

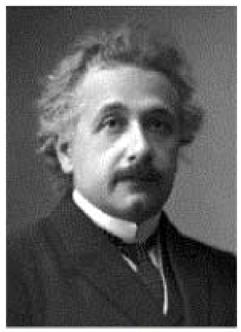
$$E_{e^-} = E_\gamma - W$$

↑ work function

Metal dependent . . . binding energy of e^- to Metal

The Nobel Prize in Physics 1921
Albert Einstein

The Nobel Prize in Physics 1921



Albert Einstein

The Nobel Prize in Physics 1921 was awarded to Albert Einstein ***"for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect".***

Slight detour →

units of energy and mass

mks (metric) → unit of energy Joule

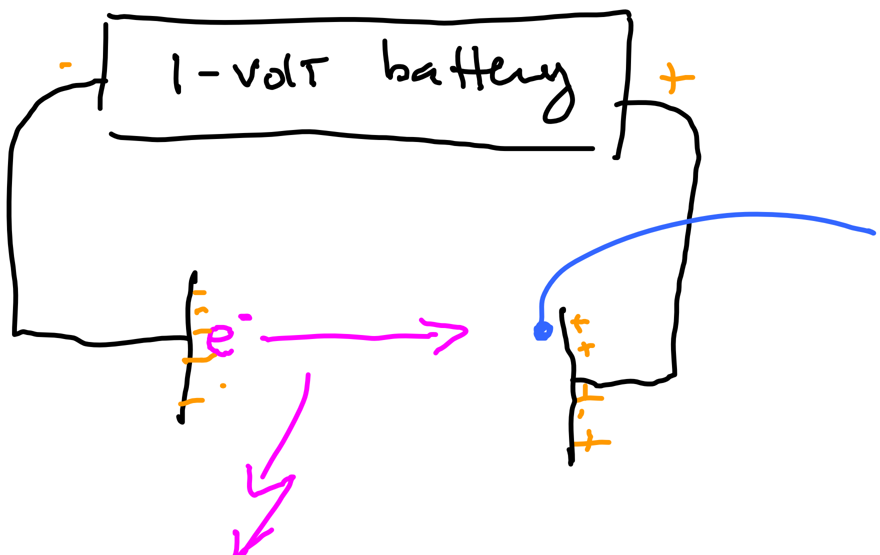
- meter
- kg
- second

Power is measure of energy/time

100 watt lightbulb

emits 100 Joules/second of energy

Energy of light or other particles



force Accelerates electron

at this point electron has an energy of 1 electron-volt

1 eV

$= 1.6 \times 10^{-19}$ Joules

eV — electron Volt

keV — Thousands of eV

MeV — Millions of eV

GeV — billions of eV

TeV — Thousand of billions of eV

Large hadron collider

$E \sim 14$ TeV

$E = mc^2$ — mass of particles in eV/c^2

mass of electron 0.511 $MeV/c^2 \longrightarrow 0.511$ MeV

mass of proton ~ 1 $GeV/c^2 \longrightarrow 1$ GeV mid-1920's

Louis de Broglie

hypothesized particles might have wavelike properties

$$\boxed{\lambda = \frac{h}{p} = \frac{h}{mv}}$$

$E = h\nu$ → $E = \frac{hc}{\lambda}$ → $\frac{h}{\lambda} = E/c$ → $\frac{h}{\lambda} = p$

$v = \lambda\nu$

$c = \lambda\nu$

$E = \sqrt{p^2c^2 + m^2c^4}$

$m = 0$ photon → $E = pc$ $\quad p = E/c$