Physics 102 February 14, 2011

- Exam 1, Feb 23
  - Here – During normal class time
  - index cards
  - Previous exams
  - Calculators

Maxwell's Equations

1873

light is a Wave

James Clerk Maxwell

1831-1879 (Edinburgh)

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

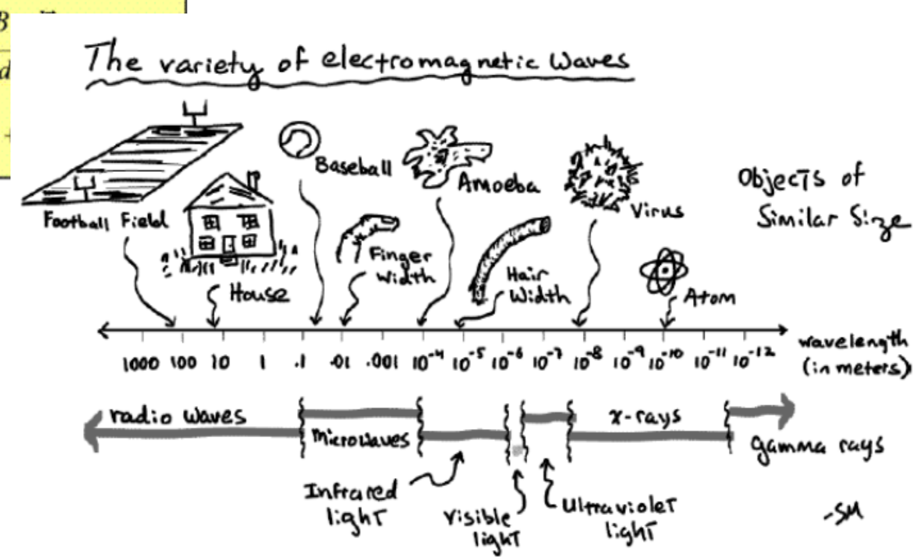
$$\int_s \vec{B} \bullet d\vec{a} = 0$$

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

$$\int_c \vec{B} \bullet d\vec{l} = \mu_o I_{encl} + \ldots$$

"E" is symbol for electric field

"B" is symbol for magnetic field



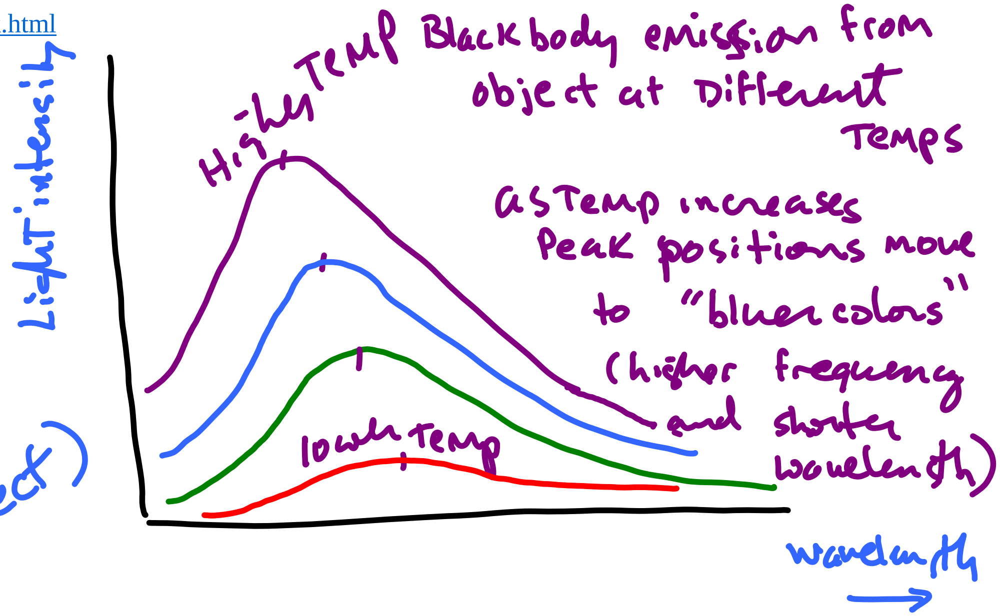
- Wave equations
- Refraction
- Diffraction
- Interference

http://www-history.mcs.st-andrews.ac.uk/Mathematicians/Planck.html

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)



Planck succeeded in describing
Black body radiation

light exists in packets of energy
Discrete
Particle

"photons"

Planck's constant

$$E = h\nu$$

Energy

frequency

Planck's Theory worked perfectly ... but physicists thought it was a fortuitous accident ... after all, light is a wave.

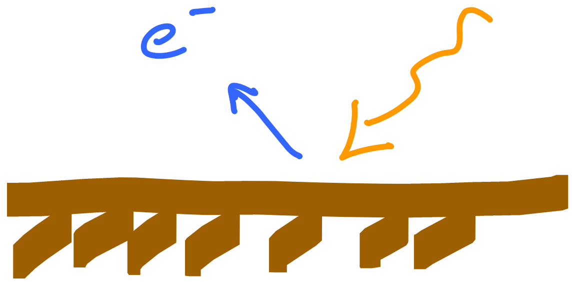
Classical wave theory was unable to
account for the shape of the blackbody spectrum.

Planck's theory fit the data perfectly but made
the outlandish assumption that light comes
in little packets.

Fantastic Blackbody radiation applet
From PhET, Interactive Simulations
Univ. of Colorado, Boulder

http://phet.colorado.edu/sims/blackbody-spectrum_en.html

Photoelectric effect



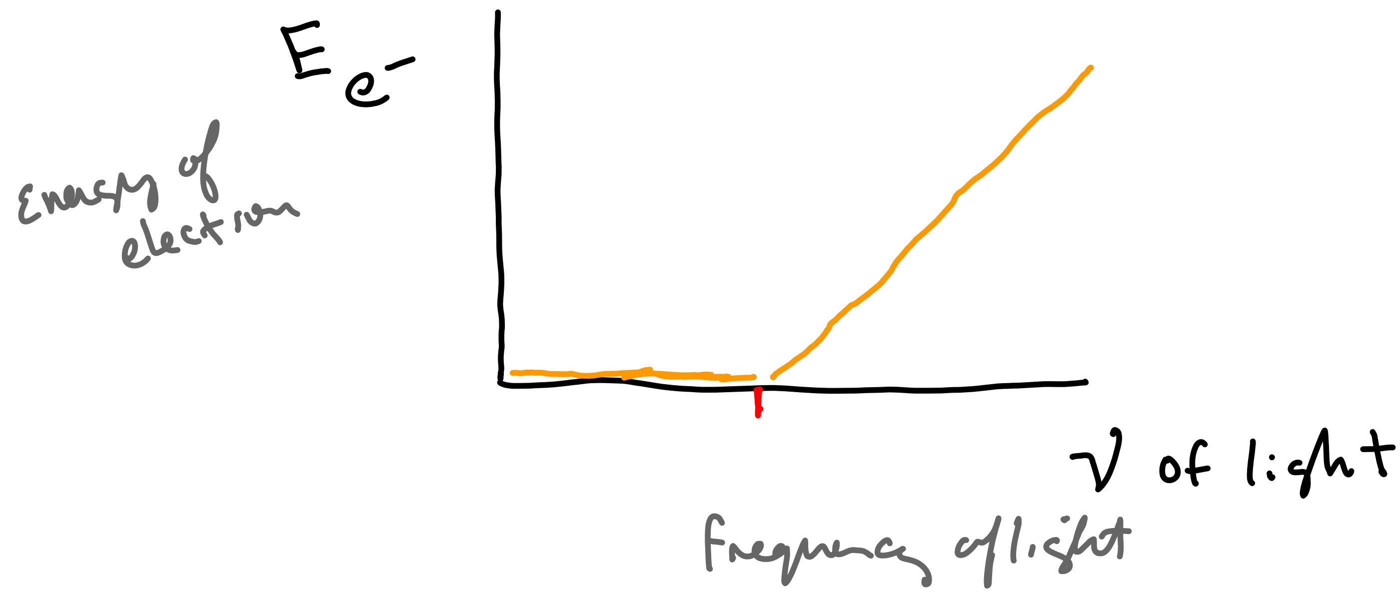
light incident on a metal surface ejects electrons

$$E = h\nu$$

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

W: Meas. of tightness e^- held

γ = photon



Again — classical wave theory unable to describe photoelectric effect data

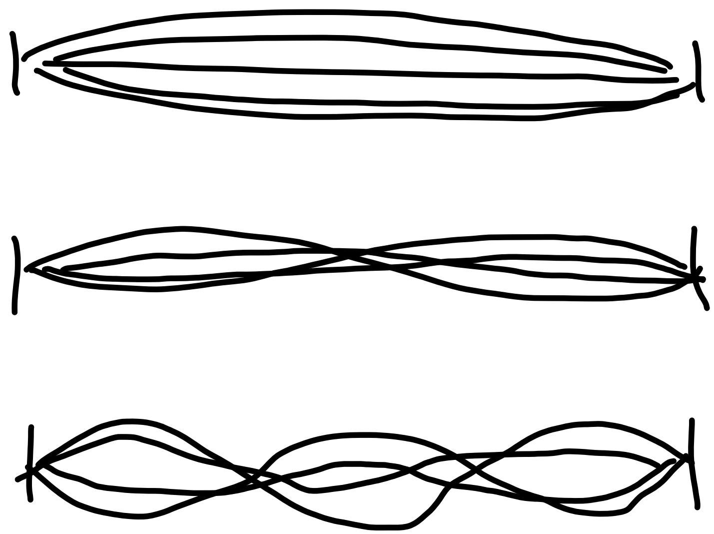
Einstein - in 1905 - proposed a model that accounted for the data — Assumed light comes in little packets of energy

$E = h\nu$ ... just like Planck's Assumption!

Fantastic Photoelectric effect applet from PhET, Interactive Simulations Univ. of Colorado, Boulder

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

STANDING WAVES DEMO



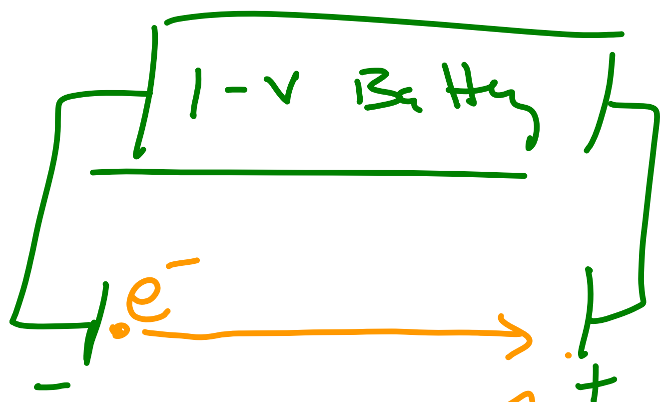
... discussed at length in recitation 4

Slight detour

MKS system → energy Joule

Power 1 WaTT = 1 Joule/second

"Normal" unit



has an energy of 1 electron-Volt

1 electron-Volt ≡ 1 eV = 1.6×10^{-19} Joules

eV	electron volt
keV	Thousand eV
MeV	Million eV
GeV	Billion eV
TeV	Thousands of Billions of eV

$E = mc^2$ mass = eV/c^2

Mass e^- 0.511 MeV/c^2 → 0.511 MeV

Mass proton ~ 1 GeV/c^2 → 1 GeV

Mid-1920's

Louis de Broglie

hypothesized particles might have wavelike properties

Wavelength of particle → $$\lambda = \frac{h}{p} = \frac{h}{mv}$$

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

$v = \lambda\nu$

$c = \lambda\nu$

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

$m = 0$

photon

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

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