Outline for Day 1

- Attendance
- Introductions
- Syllabus and other logistics
- Lecture on EM waves
- Clicker questions on EM waves

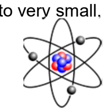
Office hours today: 2 - 4

What is Modern Physics?

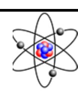
Before 1900, physicists find rules
1. that govern motion of macroscopic objects (baseballs, cannon balls) and
2. rules of electricity, magnetism and radiation.

~1900, physicists declare they understand everything there is to understand.

About 1905, physicists discover their "classical" rules don't apply to very small, very fast, or very massive things…whoops!



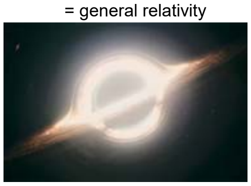
What is Modern Physics?



Study of motion & interaction of very small things (atoms,molecules &photons)
= quantum mechanics

Study of motion & interaction of very fast objects (close to the speed of light)
= special relativity

Study of motion & interaction of very massive objects (star sized)
= general relativity



All started around 1900 and continue today = "modern physics"

What is Quantum Mechanics?

Pre quantum-understood why stuff falls (gravity), a little about properties of electric and magnetic fields, gases.

Quantum- understand underlying behavior of everything you are likely to see or experience in your lifetime!

- properties of all basic materials
- properties of light and other EM radiation
- how light interacts with matter
- basis for all modern technology

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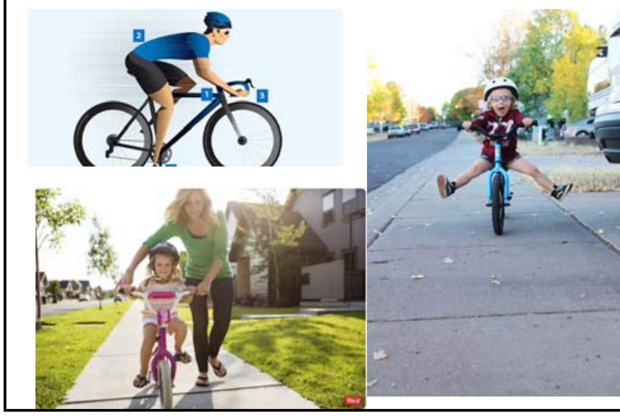
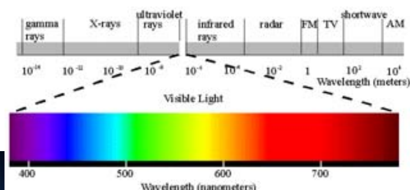
Traditional Mode of Instruction

Mode of Instruction in this Class



Today's topic: EM radiation review

Lots of modern physics has to do with light so we are going to begin with a review of this topic

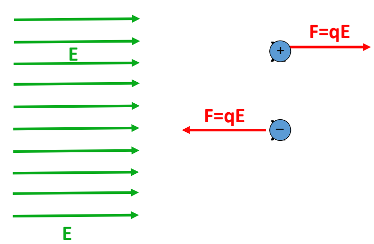


Force due to an Electric Field

Electric fields exert forces on moving or stationary charges

Force = charge * electric field

F = q **E**



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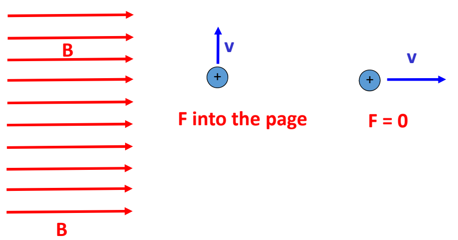
Force due to a Magnetic Field

Magnetic fields exert forces on moving charges

Force = charge* velocity* magnetic field* sin θ

F = q **v** x **B**

(use right hand rule to find direction of force)



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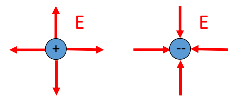
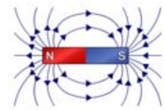
Creation of an Electric or Magnetic Field

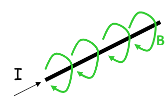
Stationary charges → E-field



Stationary magnets → B-fields



Moving charges → B-field



Moving magnets → E-fields

Phet pick up coil- move magnet

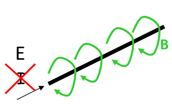
Creation of Electromagnetic Radiation

accelerating charges → changing B-field = moving magnets →

→ changing E-fields → changing B-fields → changing E-fields

→ changing B-fields → changing E-fields → changing B-fields

EM radiation!!!



Creation of Electromagnetic Radiation

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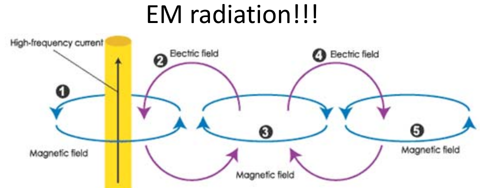
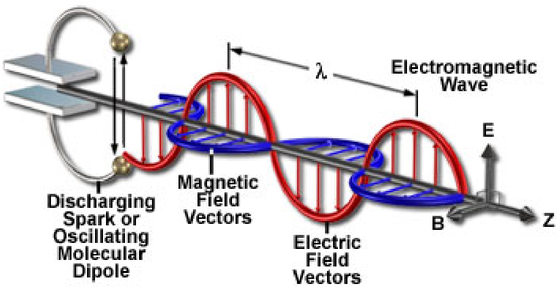
EM radiation!!!

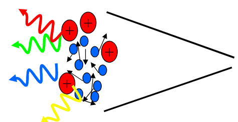


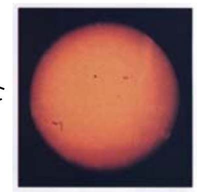
https://www.olympus-lifescience.com/en/microscope-resource/primer/java/polarizedlight/emwave/

Creation of Electromagnetic Radiation



Why the Sun Shines





Surface of sun = very hot →
Lots of free electrons whizzing around crazily (i.e. accelerating)
→ EM radiation.

(Equal number of protons, but heavier so moving slower, so less EM waves generated from those.)

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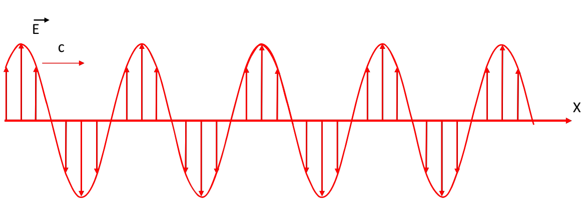
Electromagnetic Radiation Basics

oscillating electric and magnetic field traveling to the right at speed of light (c) } Electromagnetic radiation

Snap shot of E-field in time

Length of vector represents strength of E-field
Orientation represents direction of E-field



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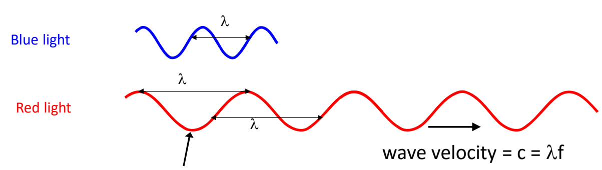
Electromagnetic Wave Properties

wavelength (λ) = distance (Δx) until wave repeats



frequency (f) = # of times per second E-field at a point changes through complete cycle as wave passes

period (T) = amount of time for one complete oscillation at a given point = 1/f

Phet wave on a string

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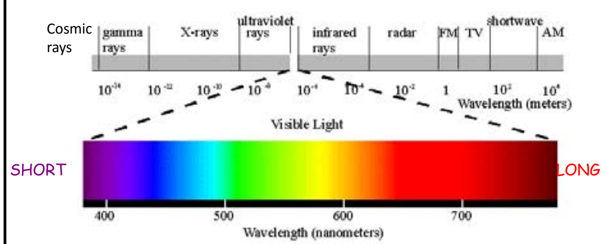
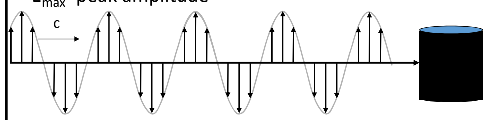
Electromagnetic Spectrum



Electromagnetic Waves Carry Energy

E_{max}=peak amplitude



Light shines on black tank full of water.
How much energy absorbed?

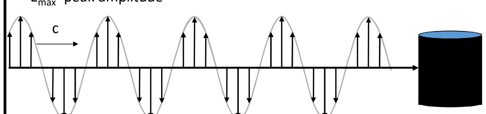
$E(x,t) = E_{max}\sin(ax-bt)$

$$\text{intensity} = \frac{\text{power}}{\text{area}} = \frac{\text{energy/time}}{\text{area}} \propto (E_{max})^2$$

$$\propto (\text{amplitude of wave})^2$$

Electromagnetic Waves Carry Energy

E_{max}=peak amplitude

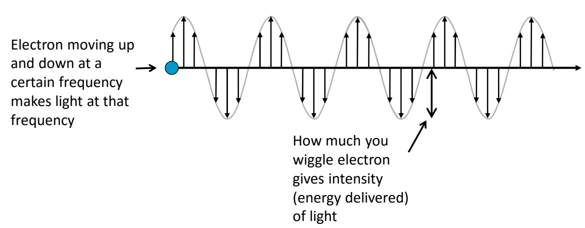


Light shines on black tank full of water.
How much energy absorbed?

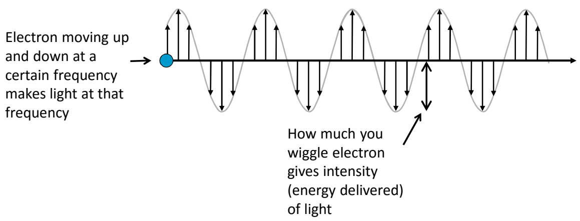
$E(x,t) = E_{max}\sin(ax-bt)$

$$I_{avg} = 0.5\epsilon_o c E_{max}^2$$

Wave View of Light



Wave View of Light



How **fast** the electron is wiggled is independent of how **much** the electron is wiggled

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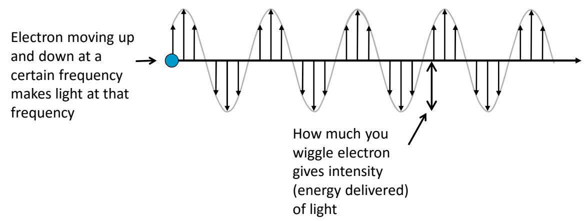
Wave View of Light



How **fast** the electron is wiggled is independent of how **much** the electron is wiggled

or in fancier words

The frequency of light is independent of its energy delivered
(but we will see this isn't true in quantum mechanics).

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