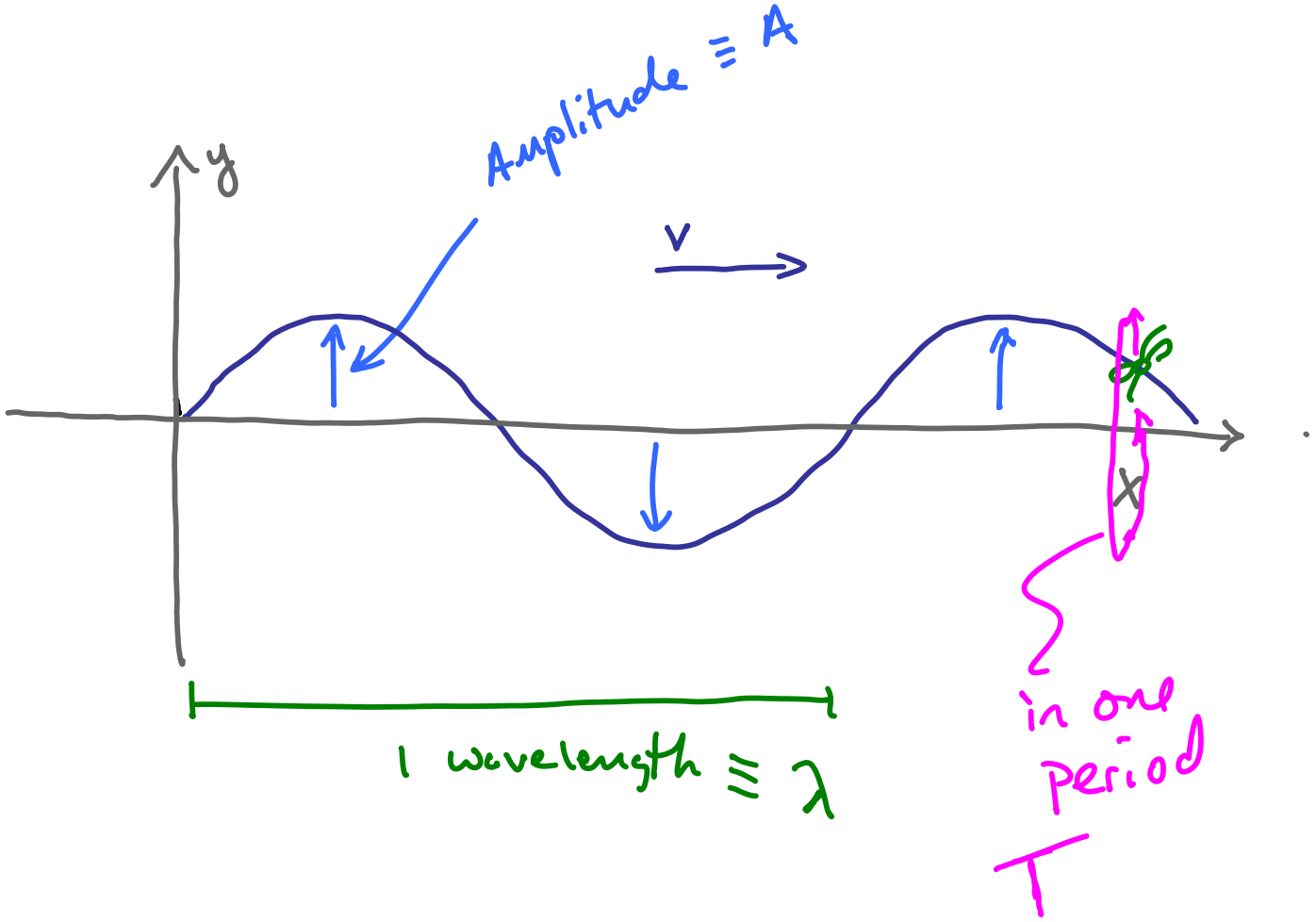
Physics 102 - February 7, 2011

Last Time

Waves



$\frac{1}{T} \equiv$ Frequency $= \nu$ or f

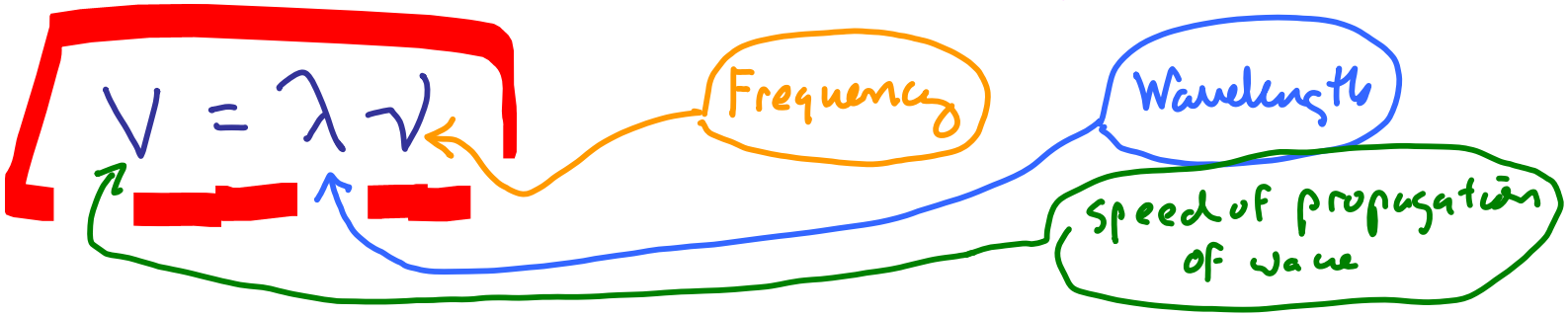
$\frac{1}{\text{second}} = 1$ Hertz $= 1$ Hz

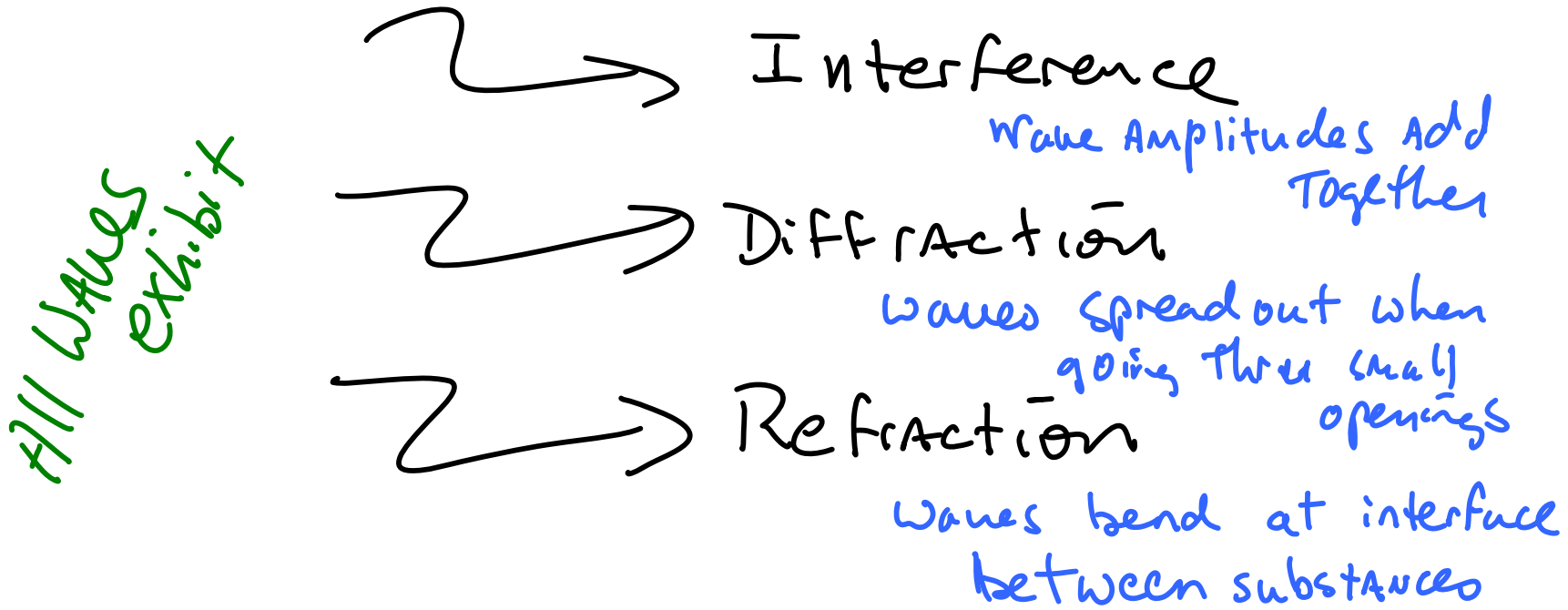
If 1 crest passes you per second
wave frequency is 1 Hz

If 10 crests pass per second → 10 Hz

If 1000 → kilo Hertz → kHz

1,000,000 → Mega Hertz → MHz





java demos – waves

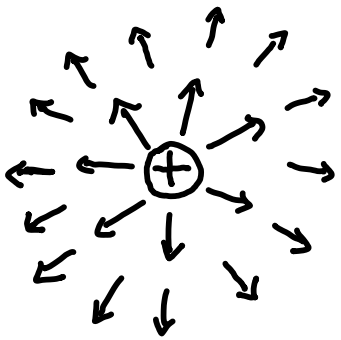
Java applet for waves interfering on string

http://mysite.verizon.net/vzeoacw1/wave_interference.html

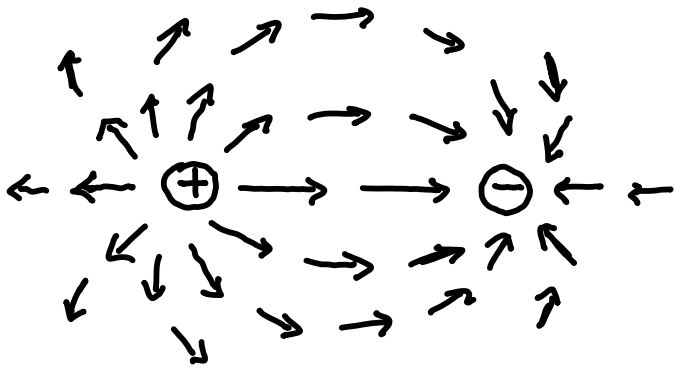
Superpostion of two waves – beats, standing waves
http://paws.kettering.edu/~drussell/Demos/superposition/superposition.html

Refraction of light at interface
http://www.physics.uoguelph.ca/applets/Intro_physics/refraction/LightRefract.html

Electric field $\vec{E}$

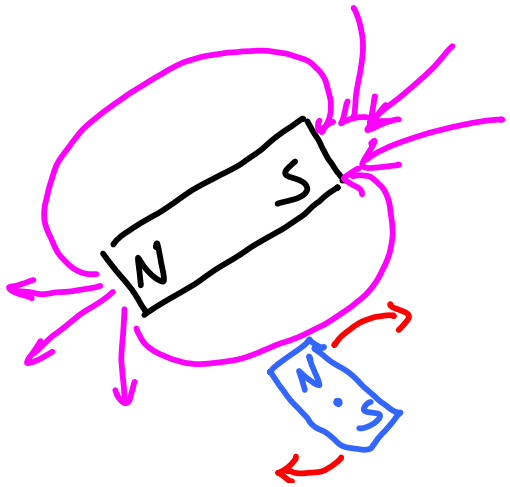


Electric field around one charged particle



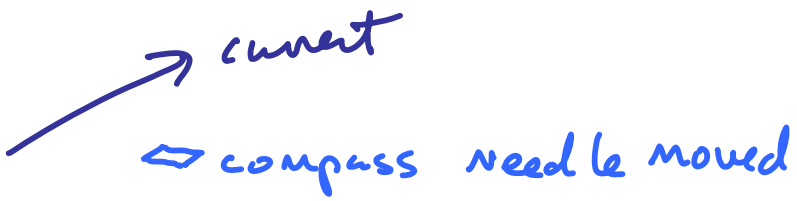
Electric field around two charges of opposite sign

Magnetic field $\vec{B}$



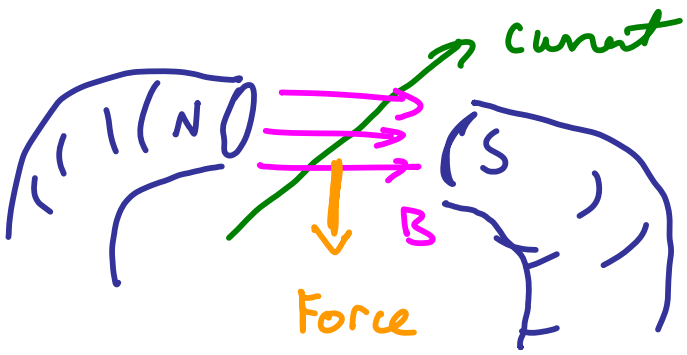
There is an intimate relationship between electricity and magnetism

We saw this with demo

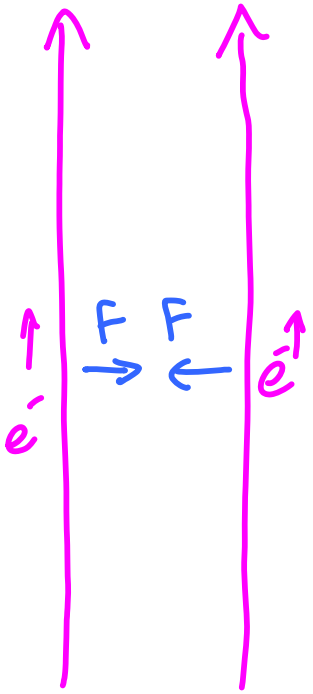


Moving electric charge creates a magnetic field

Also magnetic field causes force on moving charged particles



Saw this in demo with current-carrying wire in strong magnetic field



DEMO: Current in two wires

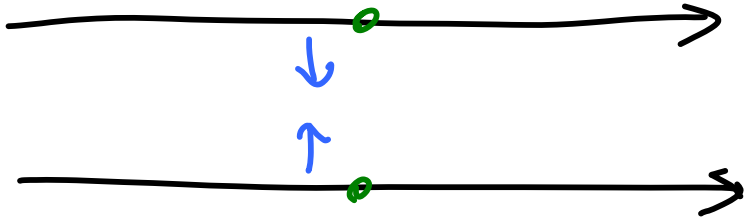
wires are attracted to each other (Repelled if current in two wires in Different Directions)

↝ Due to magnetic field

Charges viewed at rest

Force thought to be due to electric field

View same thing while running past charges very fast



Now charges look like currents!

force ATTRACTIVE and thought to be due to Magnetic field!

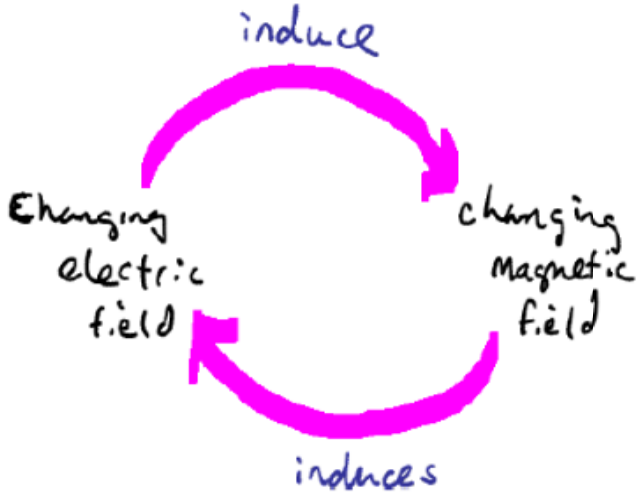
All that changes is the point of view of observer

So there's a deep relationship between electric and magnetic fields. Einstein saw this. Special relativity shows how electric + magnetic fields get "mixed up" by Lorentz TRANSFORMATIONS ... a bit like what happens w/ space + time (slightly more complex)

- E, B are "unified" in one framework
  Deeper relationship understood by Einstein

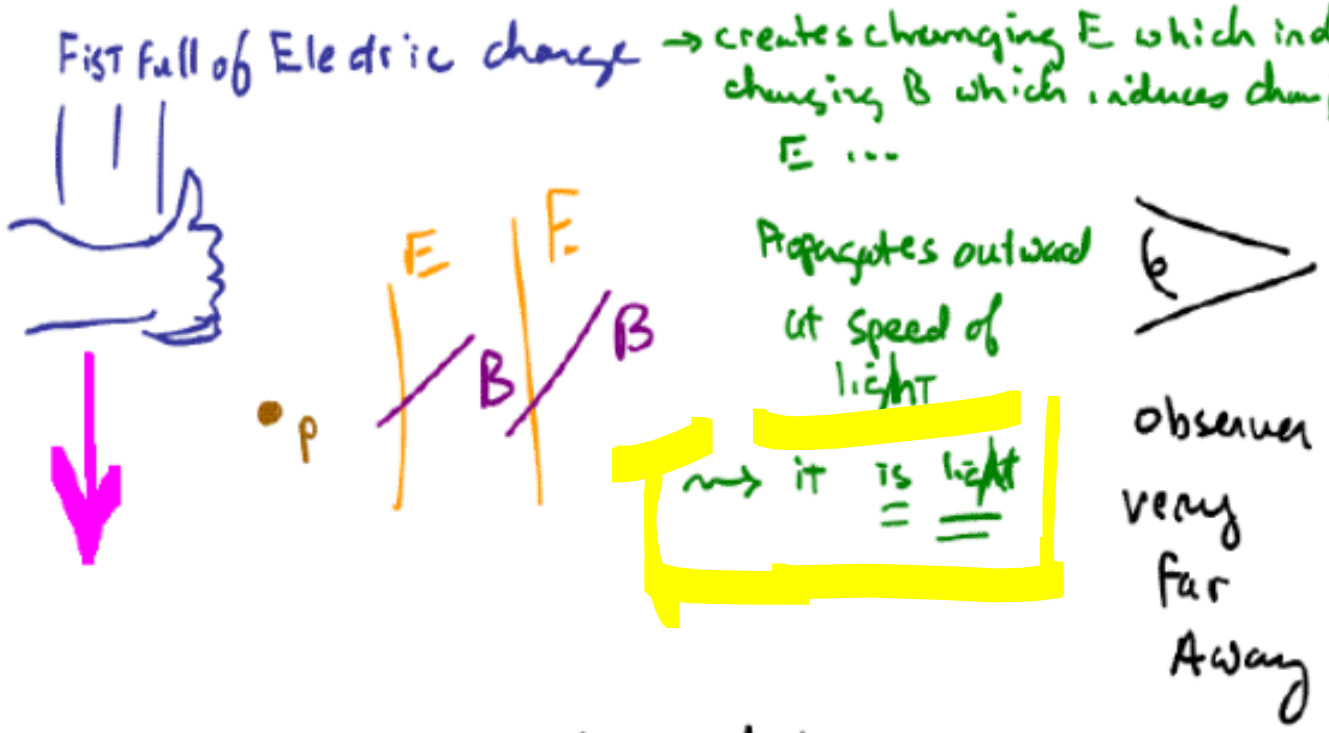
Maxwell unified Electric } forces
Magnetic }

into Electromagnetism

- 

changing E induces changing B
induces changing E
⋮

Propagates out at speed of light!



- Maxwell's eqns also tell us that E, B satisfy wave equations

Waves are a well-known mechanical phenomenon

Wave pulse traveling on a string

Maxwell's Equations

1873

James Clerk Maxwell

1831 - 1879 (Edinburgh)

integral Form of Maxwell's eqns

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

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

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

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

"E" is symbol for electric field

"B" is symbol for Magnetic Field

The variety of electromagnetic Waves