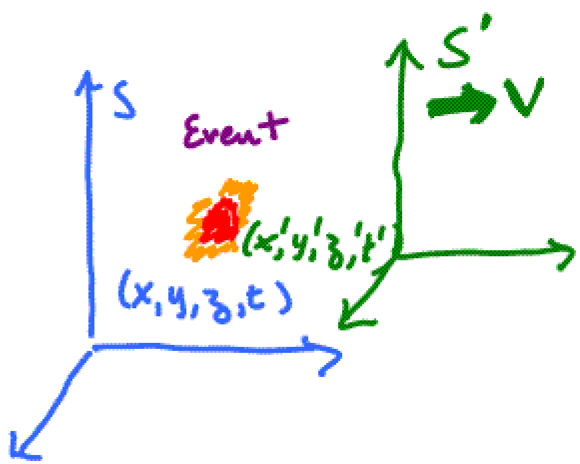
Physics 100 - September 24, 2007

- Exam I ... Oct 10   2 wks from Wed.
- Past Exams posted (w/ + w/out solns)
- Class presentations

Last Time



Special Theory of relativity relates observations ^of "Anything" between inertial reference frames

Lorentz Transformations

for space + time →

$$x = \gamma(x' + vt')$$

$$y = y'$$

$$z = z'$$

$$t = \gamma\left(t' + v\frac{x'}{c^2}\right)$$

Space + Time get all mixed up

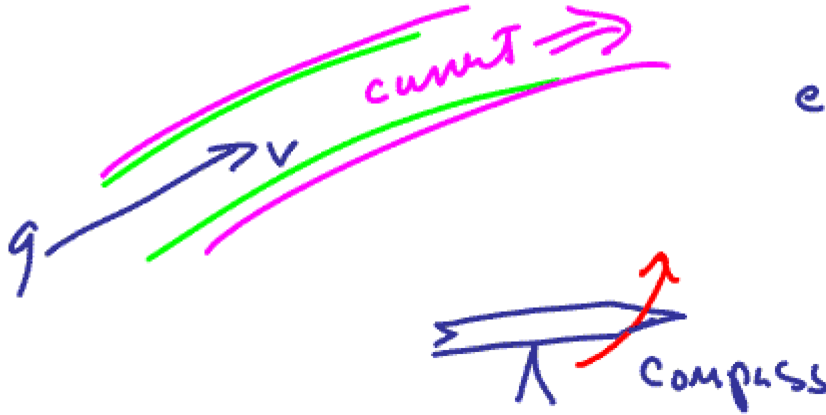
→ Spacetime

Other physical quantities ... force, energy, momentum, electric field, etc.

also transform and can get mixed together

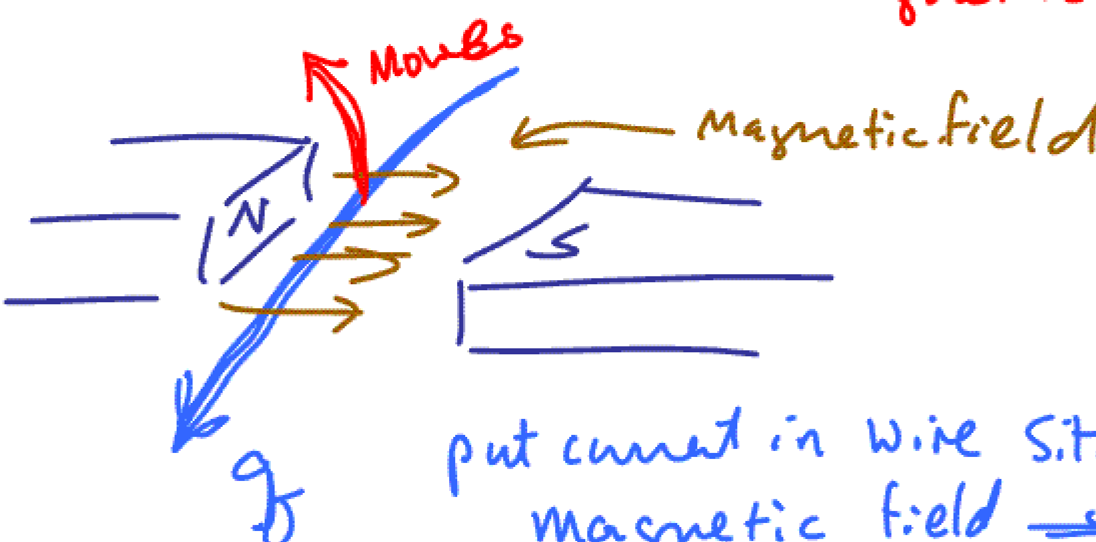
Energy + Momentum → $E = mc^2$

Electric + Magnetic fields



electric current
→ moving charge
causes compass
to move

→ moving electric charge creates
a magnetic field

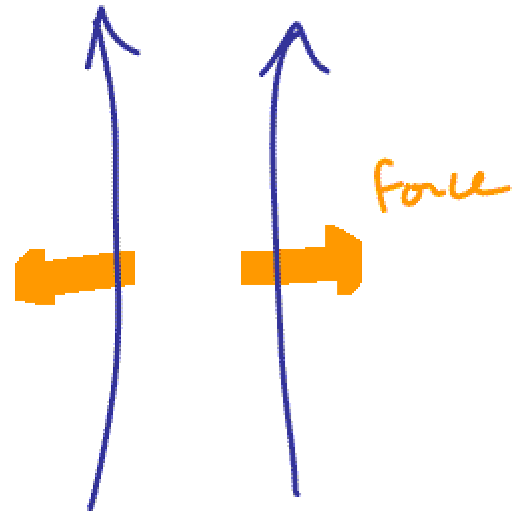


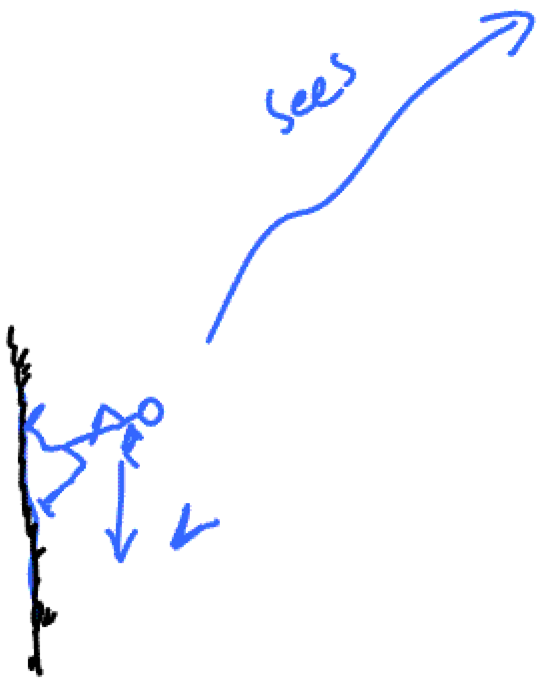
put current in wire sitting in
magnetic field → it moves!

→ magnetic field exerts force on moving charge!

Force between two currents
⇝ magnetic

... or is it?





stationary q's

Q Q

Relationship between electric + magnetic fields very deep

Maxwell's Equations

1873

James Clerk Maxwell

1831 - 1879 (Edinburgh)

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

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

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

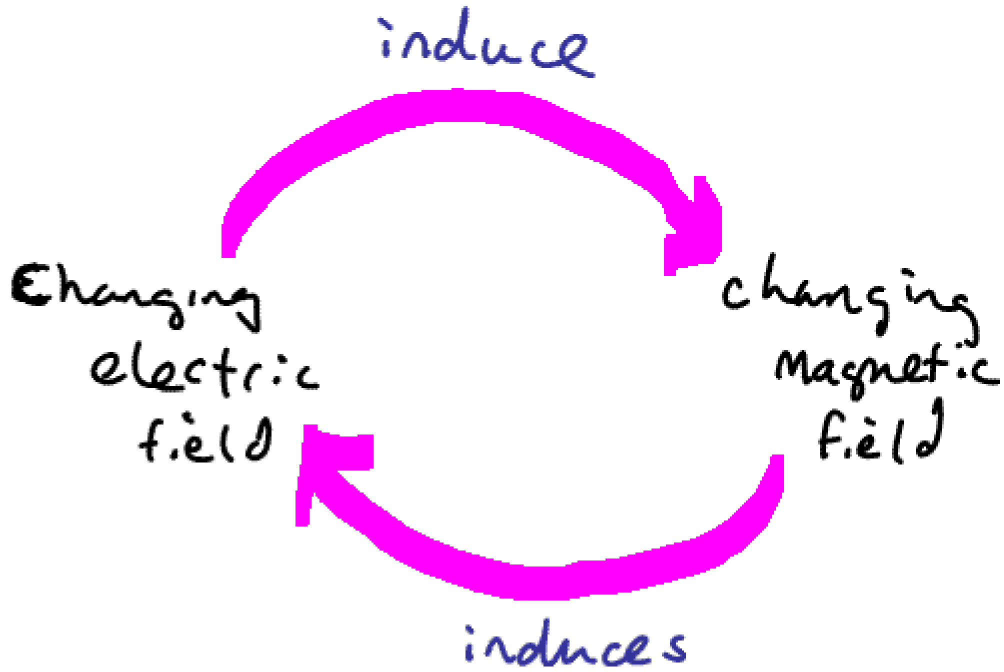
$$\int_c \vec{B} \bullet d\vec{l} = \mu_o I_{encl} + \mu_o \varepsilon_o \frac{d\int_s \vec{E} \bullet d\vec{a}}{dt}$$

"E" is symbol for electric field

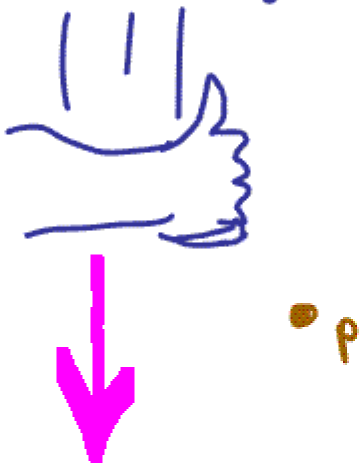
"B" is symbol for magnetic field

Maxwell unified Electric } forces
Magnetic }

into Electromagnetism



Fist full of Electric charge



At point P, as fist of charge swoops by, there is a changing electric field.

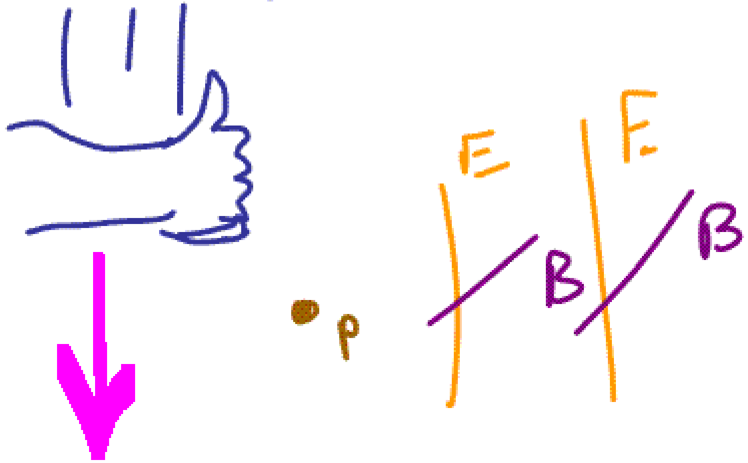
Maxwell tells us this creates (or induces) a changing magnetic field in the vicinity of P.

This produces a changing electric field . . . etc.

This cycle of electric and magnetic field creation propagates outward at the speed of light.

In fact . . . This is the essence of light.

Fist full of Electric charge → creates changing E which induces changing B which induces changing E ...



Propagates outward at speed of light

⇝ it is light

observer very far away

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

other examples:

Sound waves traveling in air

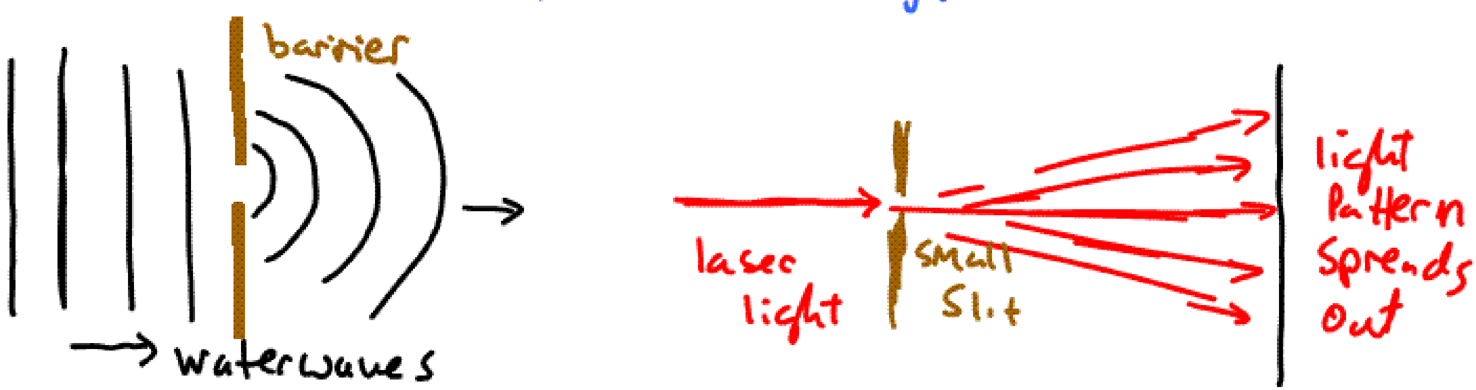
Water waves traveling on the surface of lake or ocean

When I say E, B satisfy wave equations — it means Maxwell's equations can be written in a form similar to other equations whose solutions yield waves.

Light is a wave!

This is important because all waves share many basic properties ...

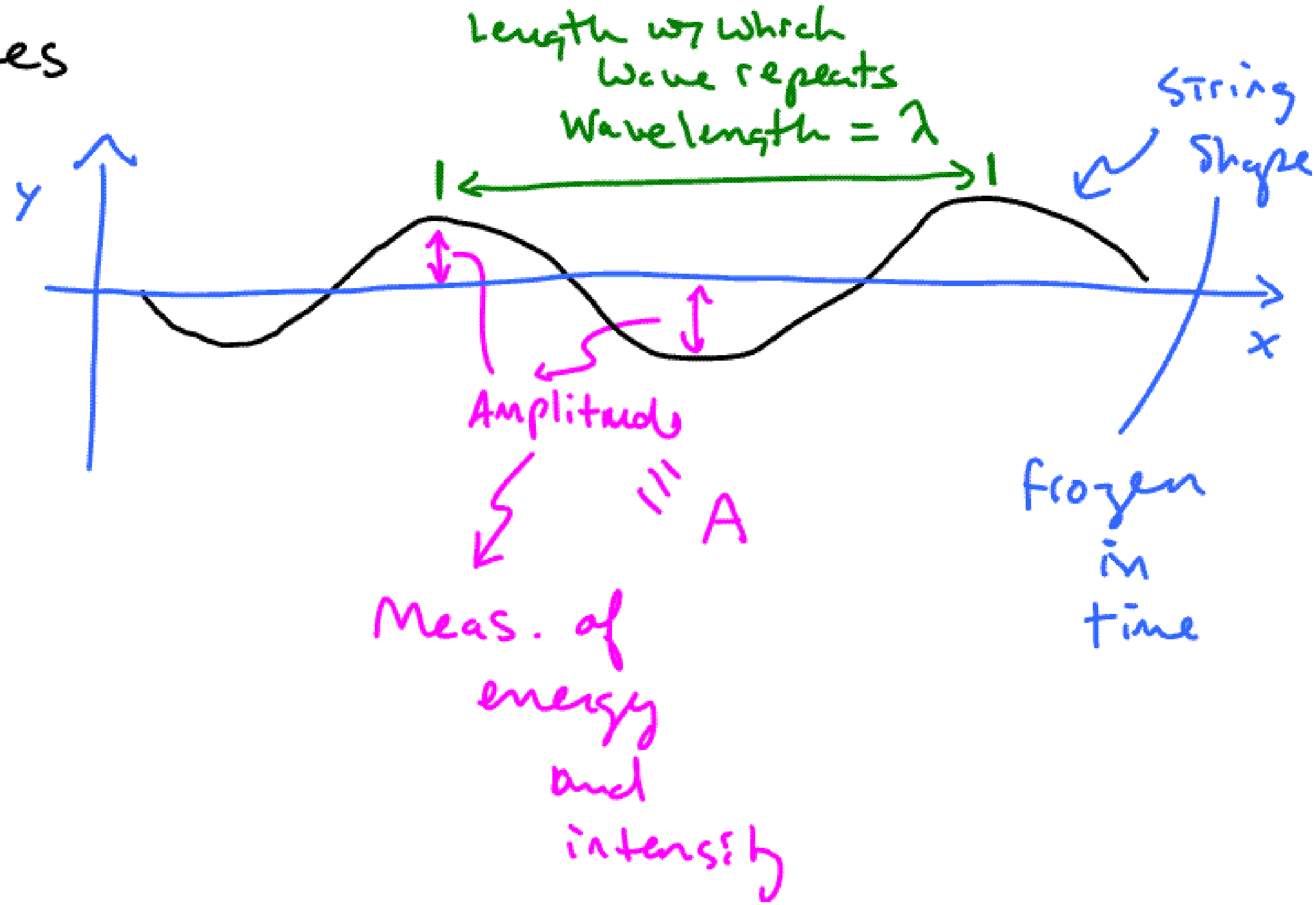
Diffraction — waves spread out passing thru small hole

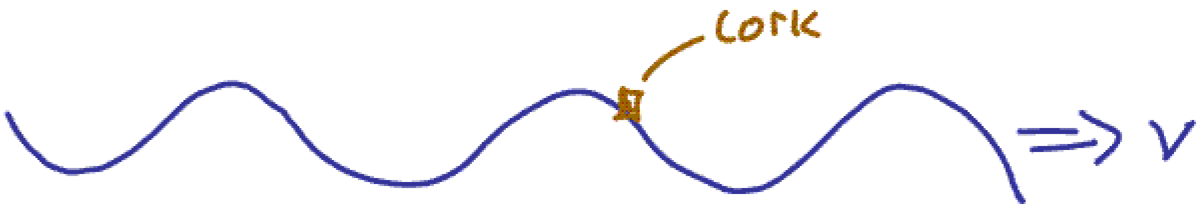


Other properties waves share

interference } will discuss next class
Refraction }

Waves





imagine wave traveling on surface of water with cork floating on surface

As wave moves past, the cork bobs up and down without moving to the right or left.
The amount of time it takes the cork to bob through one full cycle of its up and down motion is called a period. The symbol for the period of a wave is T.
T is measured in seconds.

The period is the amount of time it takes a wave to move a distance of one wavelength.

$$\text{frequency of wave} = \frac{1}{T} = \frac{1}{\text{seconds}} \equiv \text{Hertz} \quad (\text{Hz})$$

Sound waves at high frequency → you perceive as having high pitch

low frequency → low pitch

frequency corresponds to pitch in sound waves.

light waves ~ high frequency more blue

low frequency more red

frequency corresponds to color in light waves frequency $= \frac{1}{T} = f$ ~ sound (music)

$= \nu$

$v = \lambda f$

$$v = \frac{\lambda}{T} = \lambda f = \lambda \nu$$

light in vacuum $c = \lambda \nu$