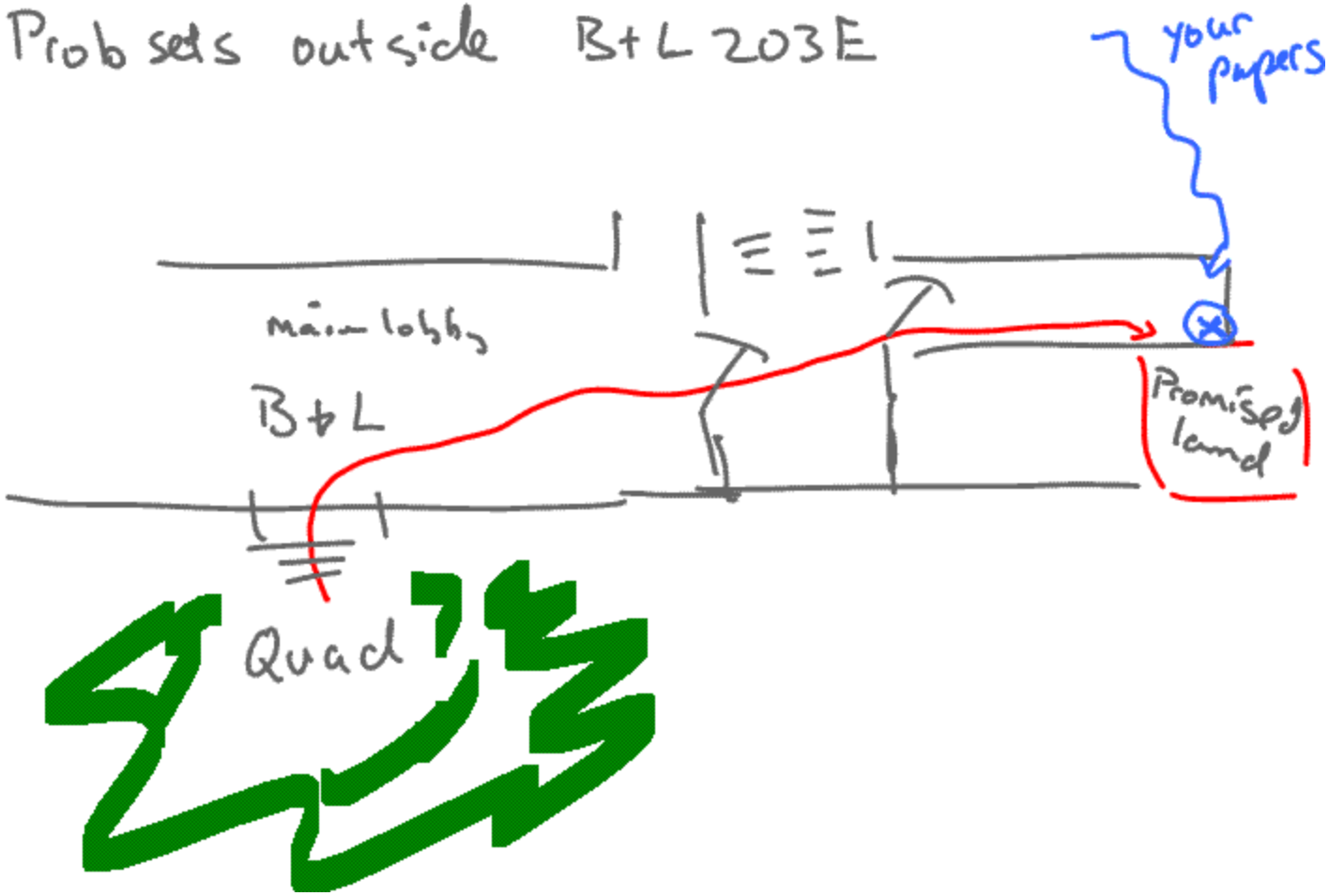
# Physics 102 - September 23, 2009

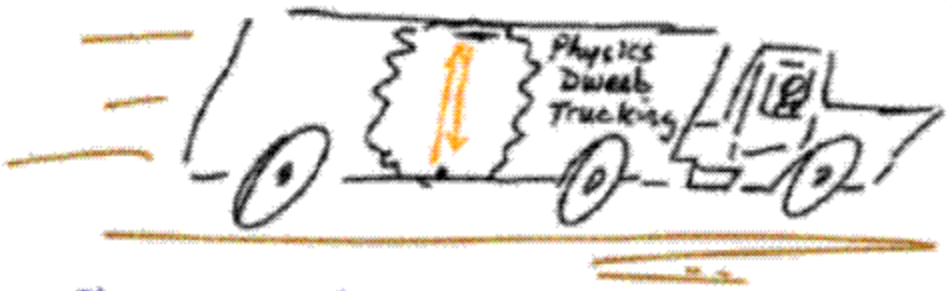
- 2 of you NOT in BlackBoard yet
  - Need to get that fixed.
- Prob sets outside B+L 203E



Speed of light CONSTANT (same) For all observers

Physics invariant

Last Time




Across all inertial Frames of Reference

Observer on truck

observer on ground

Frame of Reference

Non Accelerating

Speed of light invariant

distance light travels depends on point of view

⇒ light travel times differ → Time is relative

$$T_{ground} = T_{Truck} \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \qquad \gamma \geq 1$$

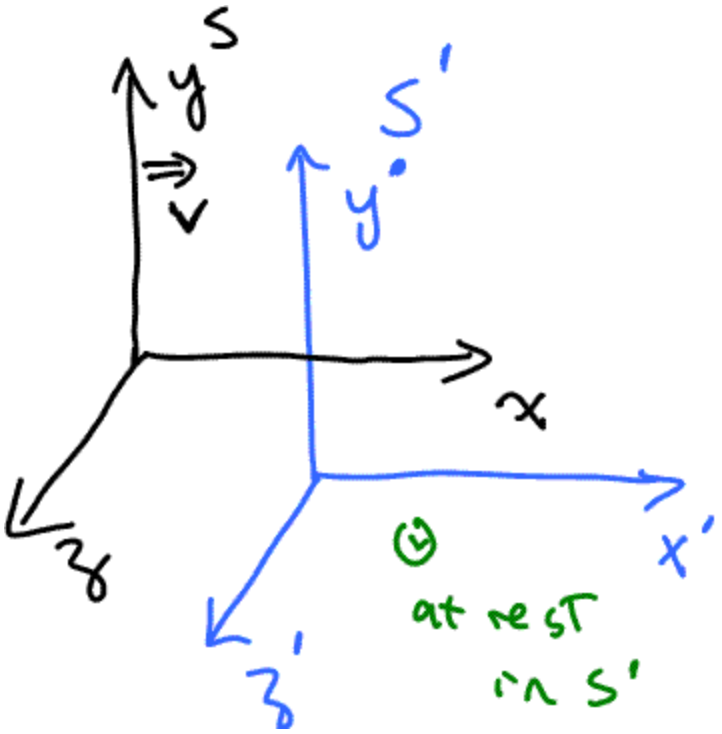
$$\gamma$$

one Special Frame of Reference
→ event happens at rest
(Truck frame)

Proper frame of Reference

In proper frame → Time is shortest

other frames Time "dilated"

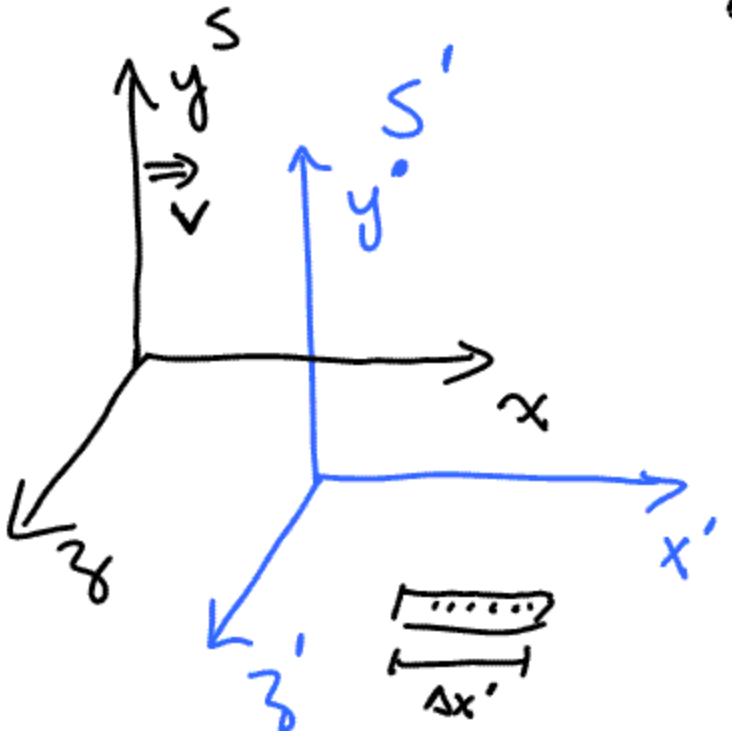



$$t = \gamma t'$$

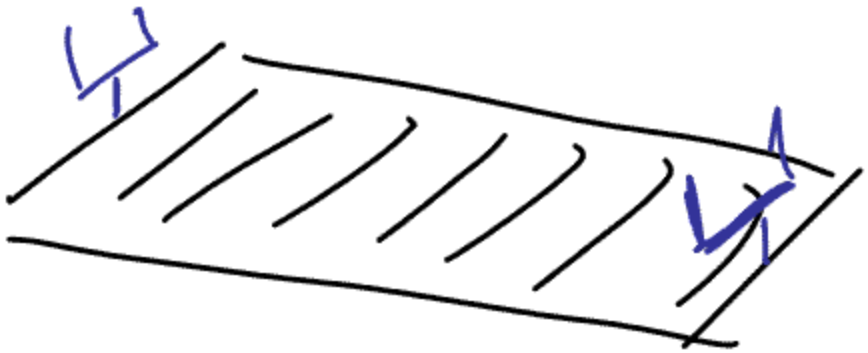
# Length contraction

(only in direction of relative motion)

$$\Delta x = \frac{\Delta x'}{\gamma}$$



$v = 0.98c$



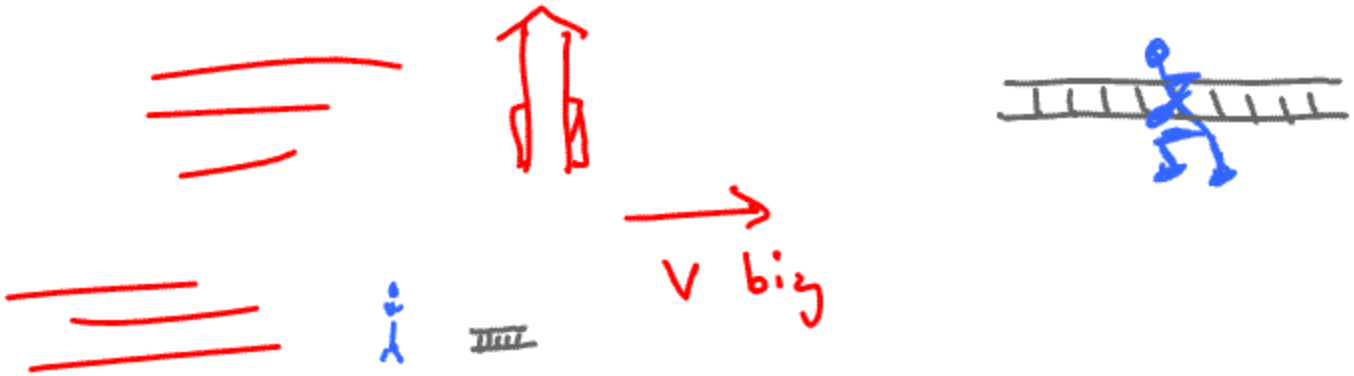
How long is the football field to observers in spacecraft

$$\gamma = \frac{1}{\sqrt{1-\left(\frac{.98c}{c}\right)^2}} \cong 5$$

$$\left(\text{Football field length}\right)_{\text{space ship}} = \frac{100 \text{ yds}}{\gamma}$$

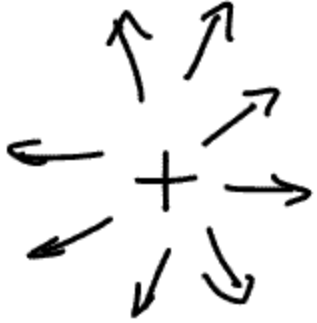
$$= 20 \text{ yds}$$


Son's perspective



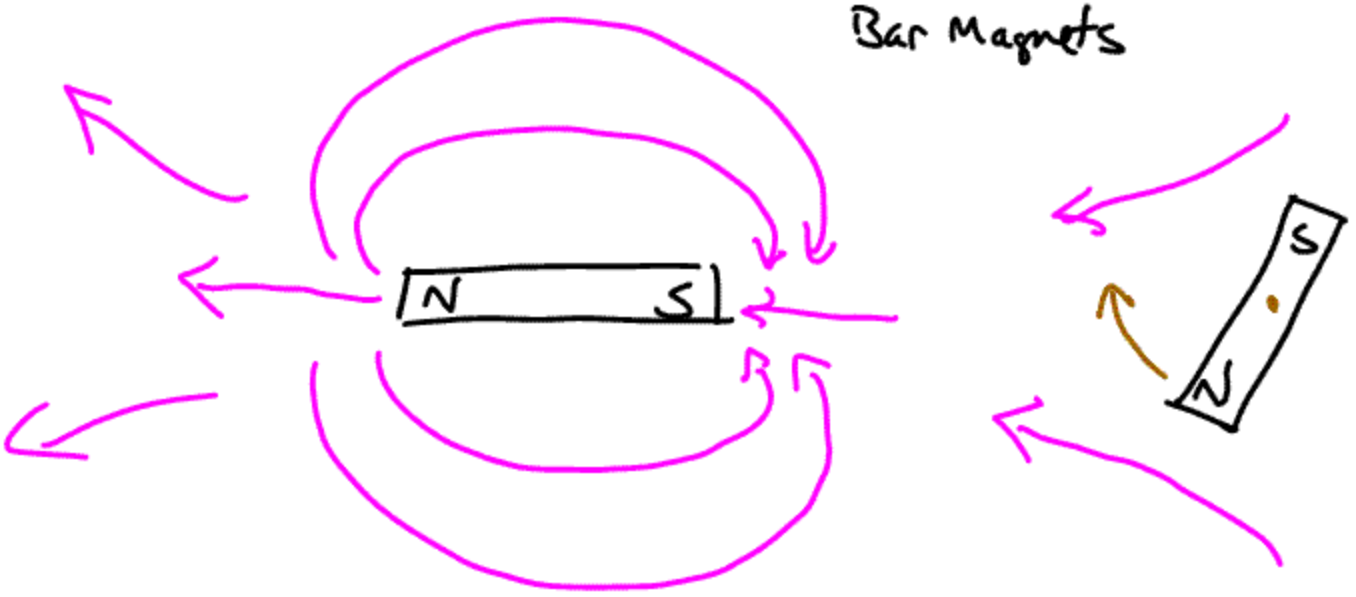

What does it mean for two events to be simultaneous?

See last few pages of relativity slides $\Rightarrow$ Lorentz transformations



recall electric field

Bar Magnets




Magnetic field

unlike poles attract ... say that one bar magnet creates a condition in space called a "magnetic field" that causes force on the other bar magnet.

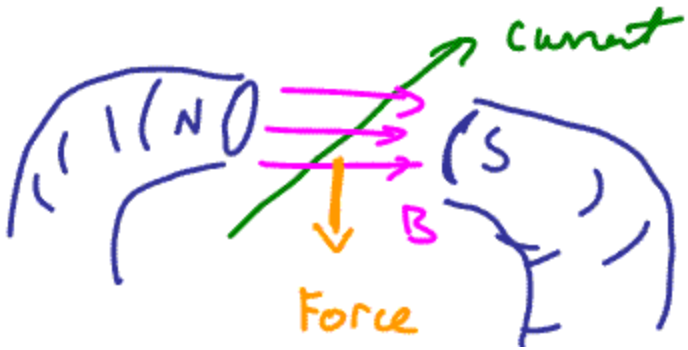
We saw this with demo

current

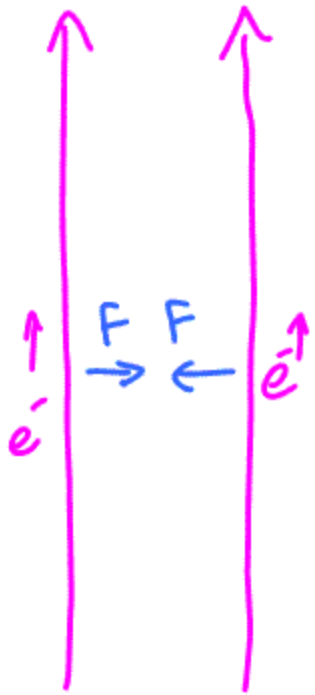
⇔ compass needle moved

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

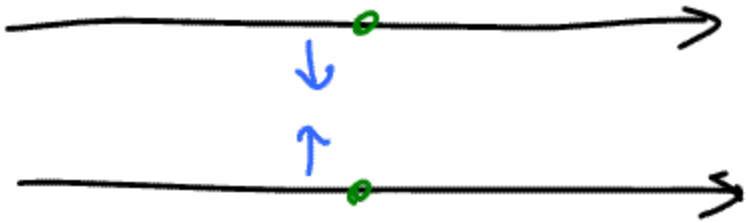
wires are attracted to each other (Repelled if current in two wires in Different Directions)

↝ 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 is 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)

Before Einstein it had been shown that electric + Magnetic fields are different faces of the same force.

# Maxwell's Equations

1873

James Clerk Maxwell

1831 - 1879 (Edinburgh)

integral Form of Maxwell's eqns

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

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

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

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

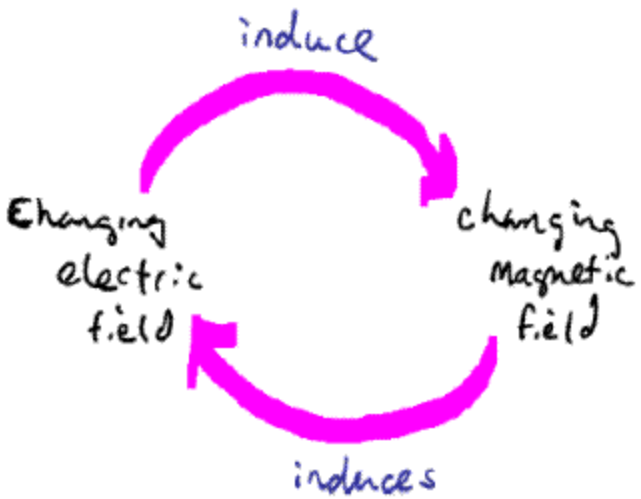
"E" is symbol for electric field

"B" is symbol for Magnetic field

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

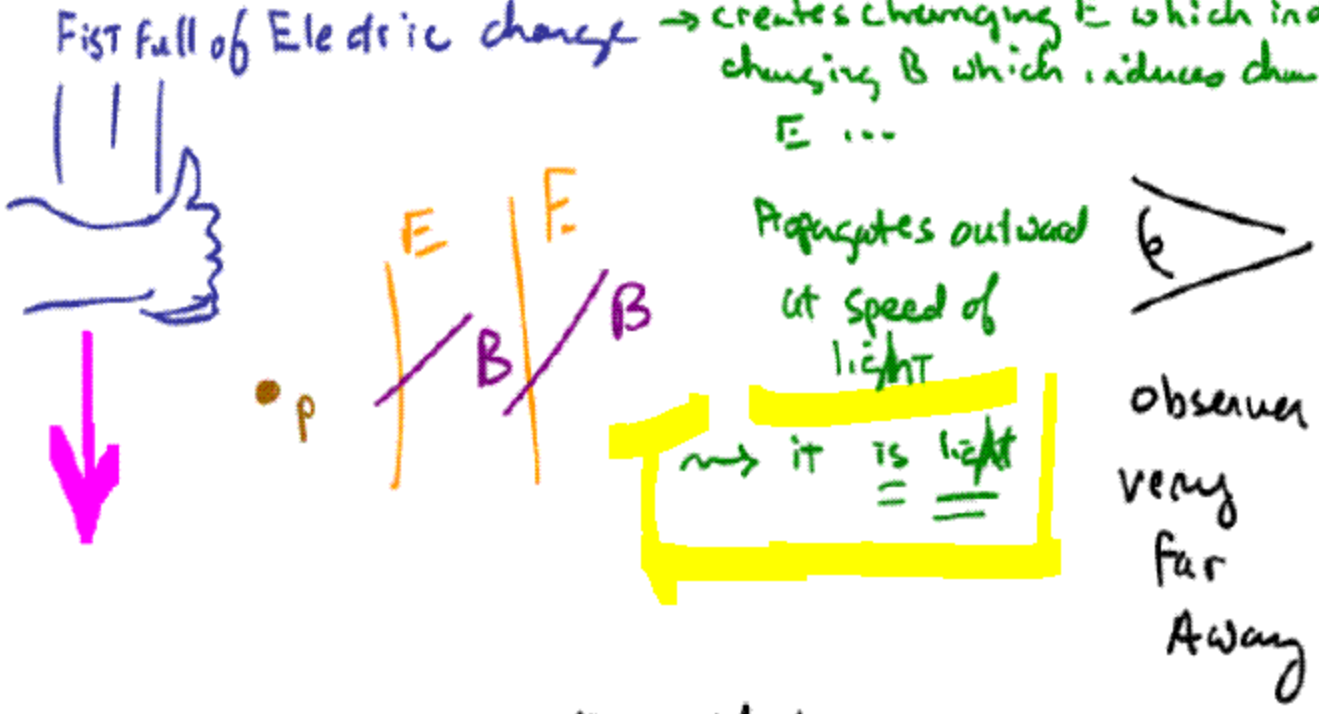
Maxwell united Electric } forces
Magnetic }

into Electromagnetism




changing E induces changing B
induces changing E
⋮

Propagates out at speed of light!

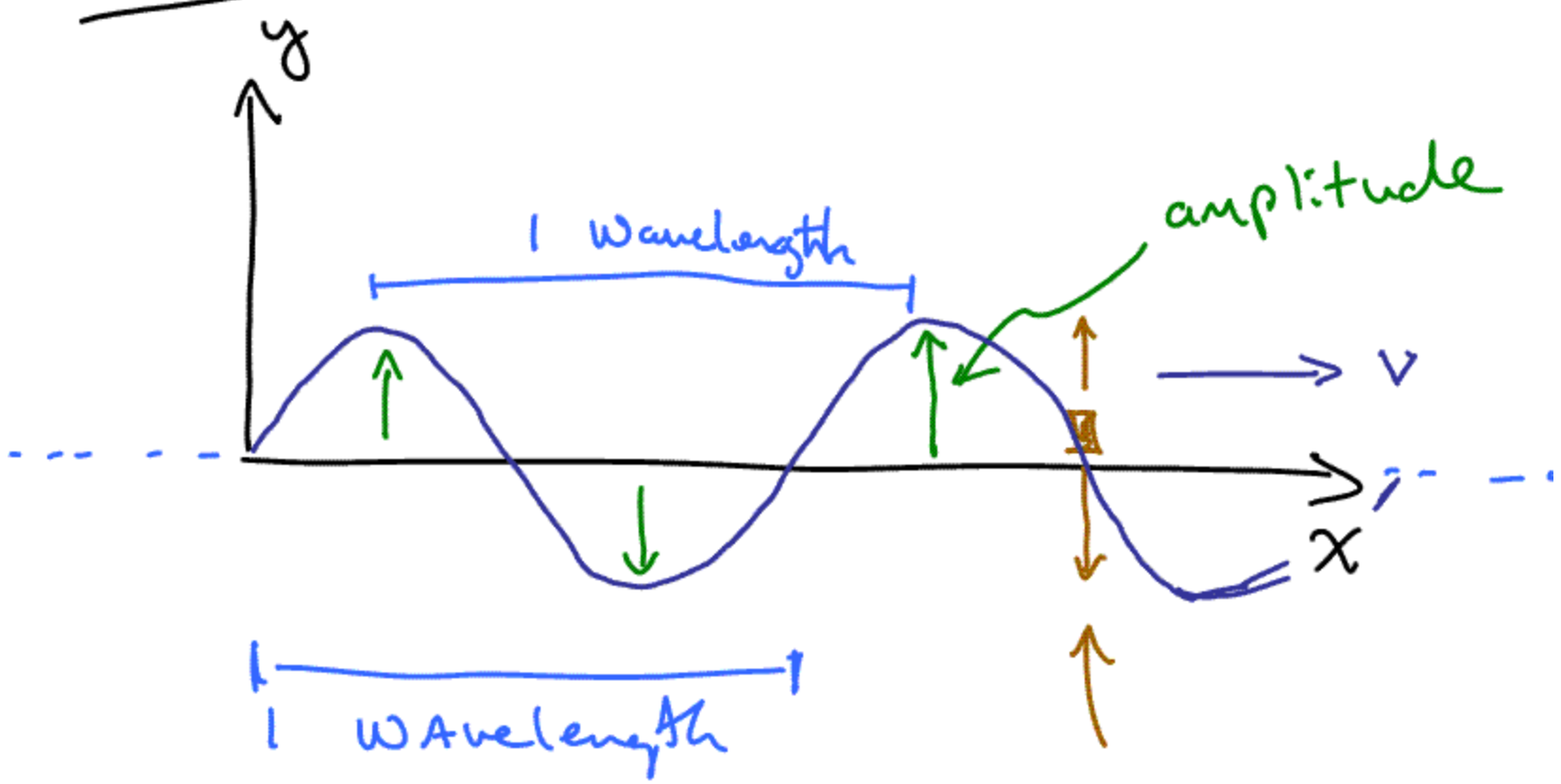



- Maxwell's eqns also tell us that E, B satisfy wave equations

Waves are a well-known mechanical phenomenon

Wave pulse traveling on a string

# WAVES




cork goes thru 1 complete oscillation in one "period" T

$$\lambda$$

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

$\lambda$ ← distance

$T$ ← time

Frequency, $\nu$ (light) $f$ (sound) $\equiv \frac{1}{T}$ $(s^{-1})$ / units

$v = \lambda \nu$

$v = \lambda f$