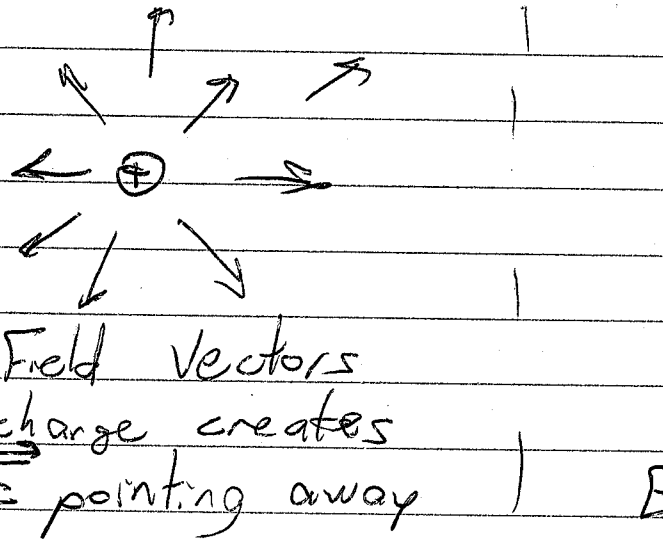
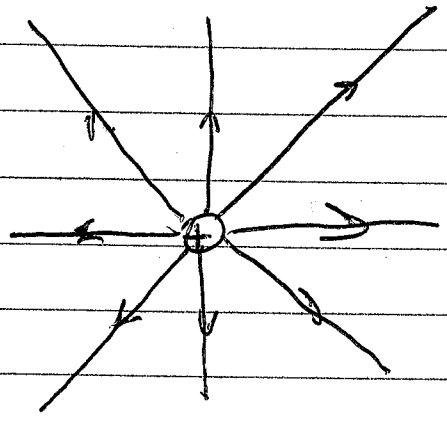
 Phys 1402 2016-09-29 Lec 11

Magnetism

Recall charges & electric fields



E-Field Vectors
⊕ charge creates $\vec{E}$ pointing away



E-Field "Lines" follow E vectors.

$\vec{E}$ causes forces on <u>other charges</u>.

Magnetic fields almost always drawn as lines (curves) rather than vectors.

Magnetic Field causes:
- Magnetic materials
- Flowing conductive liquids
- Electric currents

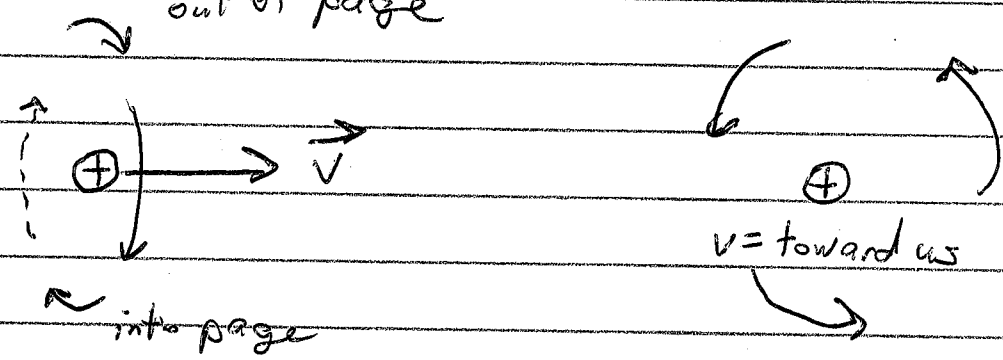
} Moving Charges

Magnetic Field Effects
- Forces
- Torques

} Affects other moving charges

- Can generate electricity

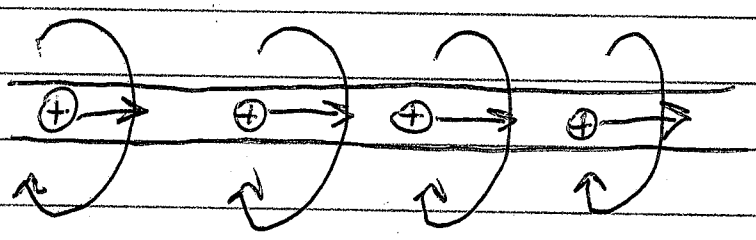
Simplest: moving charge



Side View Front View

A moving charge generates a "swirling" magnetic field. The charge "stirs" the mag. field.

A realistic situation:



There are so many charges that we don't see the "blips" of each one. We see a smooth mag field that surrounds the wire.

Magnetic Field lines always form loops!

Right hand Rule (RHR) for magnetic field of current.

- Point thumb in direction of current.
- Curl fingers around the current, and they point in the dir of the magnetic field.

Measuring magnetic fields

Magnetic field ($\vec{B}$) is measured in teslas (T).

For a long straight current:

$$B = \frac{\mu_0 I}{2\pi r} \qquad \mu_0 = 4\pi \times 10^{-7} \frac{T \cdot m}{A}$$

r = our distance from the wire.

⊕ • • • −
r_1 r_2 r_3

B_1 is strongest
B_3 is weakest

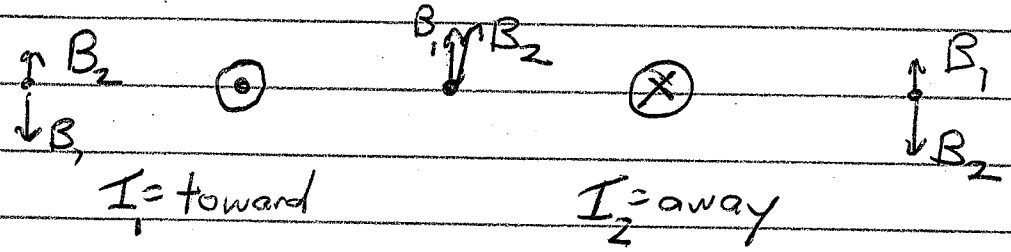
Ex: 1 cm from a 800 mA current:

$$B = \frac{(4\pi \times 10^{-7})(0.8)}{(2\pi)(0.01)} = 1.6 \times 10^{-5}\ T$$
$$= 16\ \mu T$$

Earth's mag field $B_{Earth} \approx 50\ \mu T$

Neodymium magnets ~ 1.0 T

Magnetic Field of multiple Wires



For these opposite-pointing currents:

- In Between, the mag Field is concentrated and is stronger. $B_T = B_1 + B_2$
- On either side, B_1 & B_2 partly cancel. $B_T = B_2 - B_1$

The mag field of a cell charger is actually much smaller than 16 μT because of this.

If we form a single loop of wire:

$$B = \frac{\mu_0 I}{2R}$$

2nd RHR

- Curl fingers w/ I
- Thumb points w/ B inside the loop.