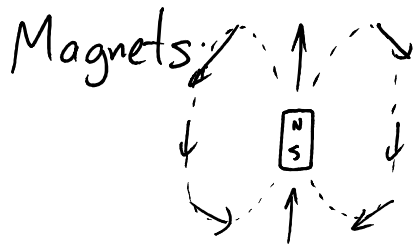
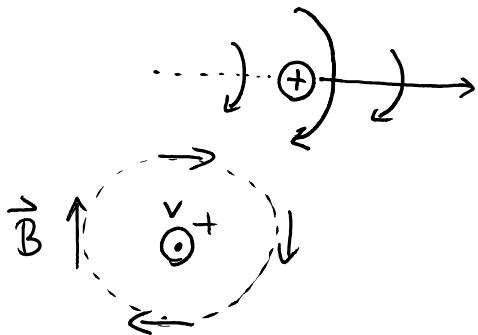


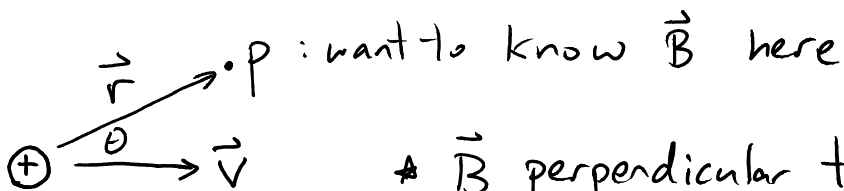
# LAST TIME:

Sources for magnetic fields:

Moving charges:



\*  $\vec{B}$  from Magnet like  $\vec{E}$  from dipole \*



\*  $\vec{B}$  perpendicular to  $\vec{r}$  and  $\vec{v}$

\* magnitude is

$$\frac{\mu_0}{4\pi} q \cdot v \cdot \frac{1}{r^2} \cdot \sin\theta$$

proportional  
to charge  
& to velocity

stronger closer  
to charge  
(same as Coulomb)

zero on path  
of motion &  
biggest in  
direction  $\perp$   
to  $\vec{v}$ .

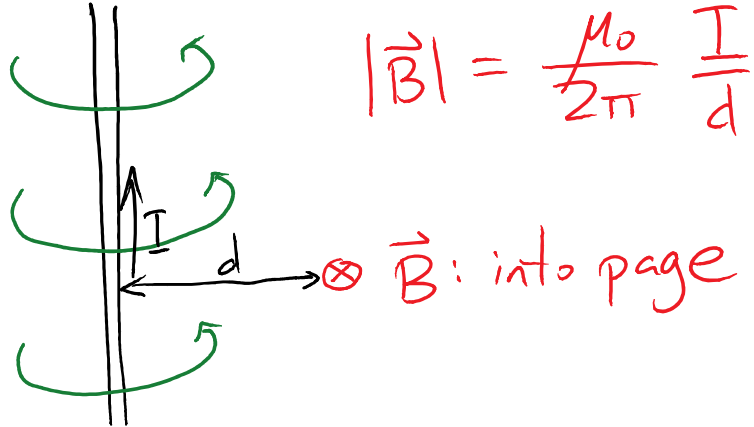
VECTOR EXPRESSION:

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q}{r^3} \vec{v} \times \vec{r}$$

↑  
cross product.

★ Get  $\vec{B}$  for collection of moving charges via  
SUPERPOSITION PRINCIPLE ★

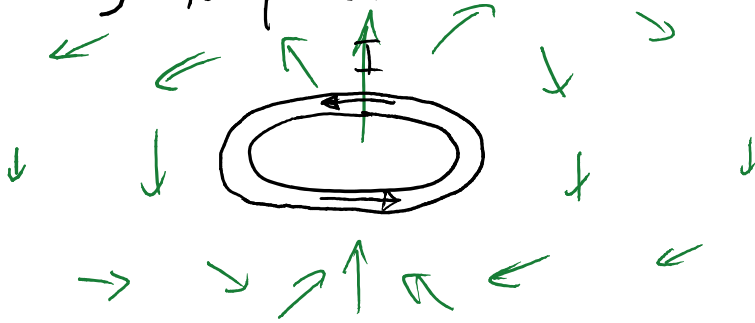
e.g. infinite wire



$$|\vec{B}| = \frac{\mu_0}{2\pi} \frac{I}{d}$$

$\vec{B}$ : into page

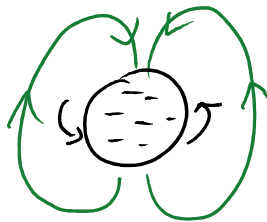
e.g. loop of current



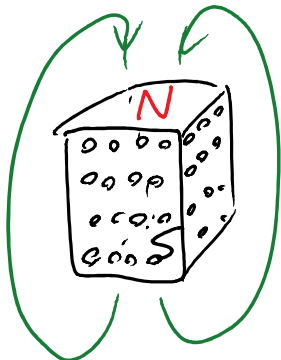
Field like dipole!

ORIGIN OF  $\vec{B}$  IN MAGNETS:

- imagine electron as spinning ball of charge



- like little current loop  
 $\therefore$  produces field like tiny magnet



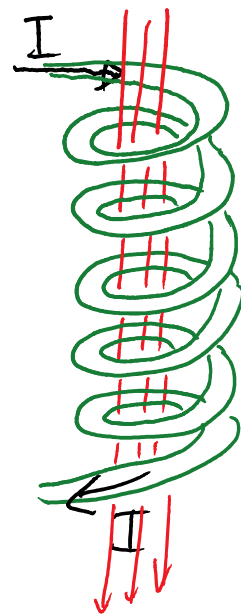
PERMANENT MAGNET: electron spins are aligned so these fields add up!

Field from solenoid:

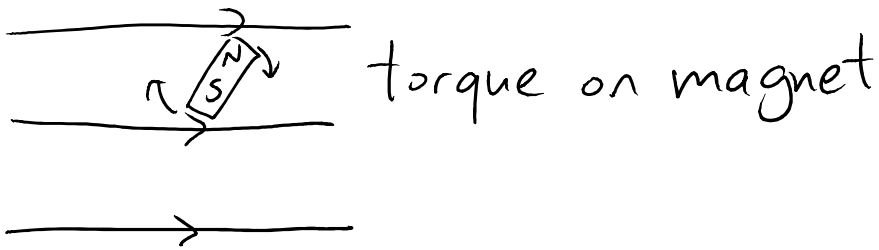
uniform  $\vec{B}$  inside

$$\vec{B} = \mu_0 I \cdot \frac{N}{L}$$

↑  
coils per  
length.



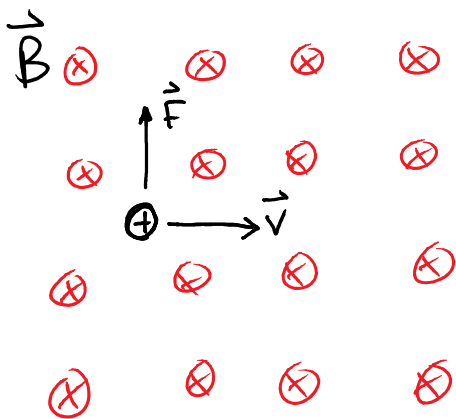
EFFECTS OF MAGNETIC FIELDS:



★ Force on moving charge ★

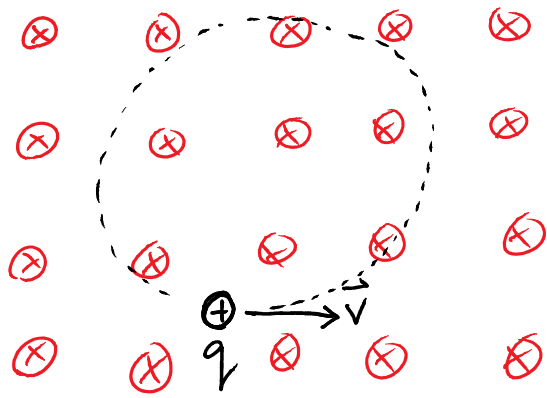
$$\vec{F} = q \vec{v} \times \vec{B}$$

→ perpendicular to  
both field and  
velocity



→ changes direction  
of  $\vec{v}$  but not  
magnitude

$$\vec{F} \cdot d\vec{x} = 0 \quad \therefore \text{no work done}$$



★ Circular orbit for  
charged particle  
moving perpendicular  
to constant  $\vec{B}$  field★