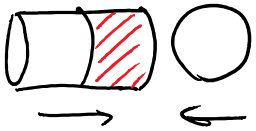
MAGNETISM:

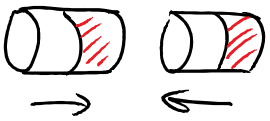
Basic phenomena w. magnets



attract certain metal objects

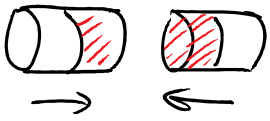
Q1

flip around: still attracts



attracted to other magnet in one orientation

Q2



but repels other magnet in opposite orientation

★ Like electric dipoles ★

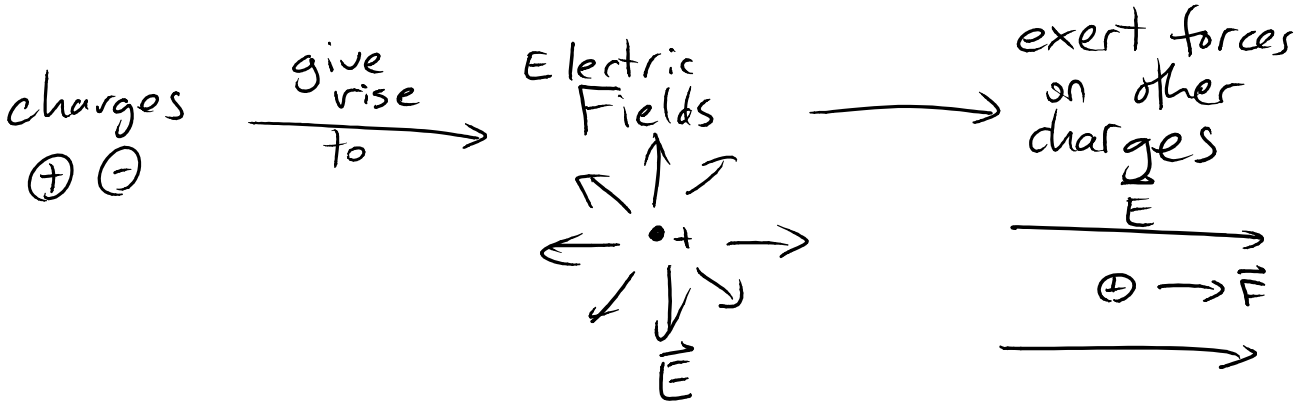
Q3

e.g.

will rotate counterclockwise & attract.

BUT: Magnetic forces different from electric forces

MODEL FOR MAGNETISM similar to model for electric forces:

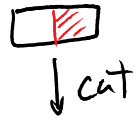


MAGNETISM:

magnets  → give rise to → Magnetic Fields $\vec{B}$ → exert forces / torques on other magnets

How can we define / measure $\vec{B}$?

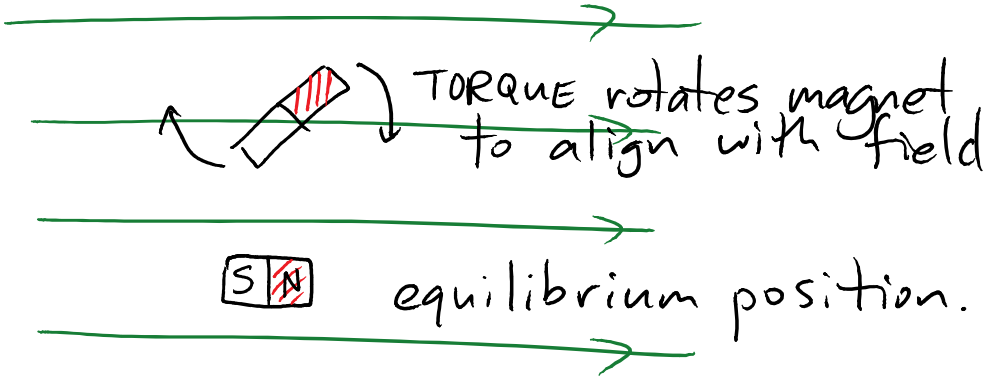
No magnetic charges:



get 2 smaller magnets

Direction of $\vec{B}$: equilibrium direction of a small magnet

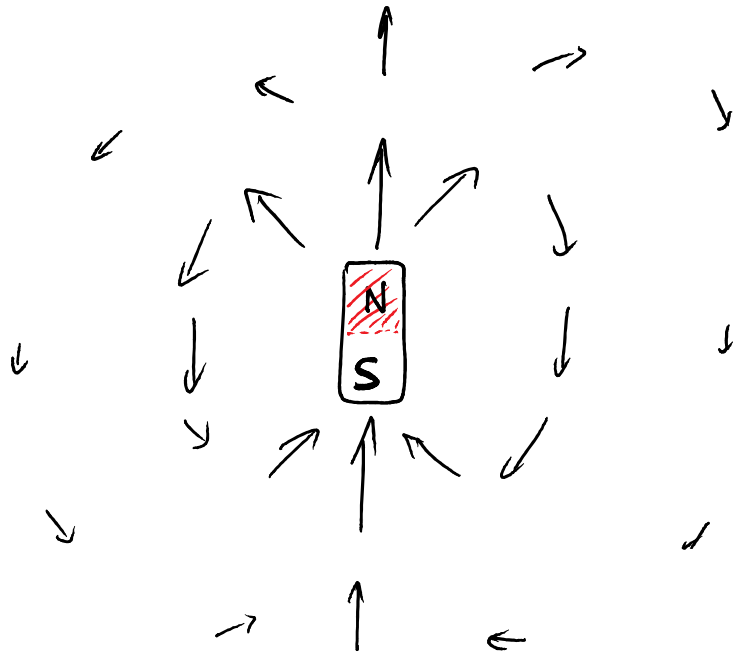
Strength of $\vec{B}$: proportional to the torque on a magnet that isn't aligned.



★ Earth has a magnetic field that points north ★

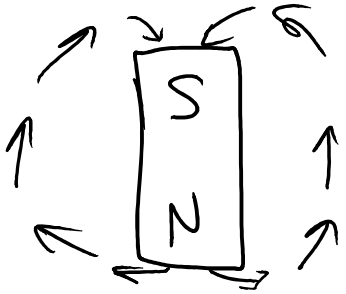
← "North" side of magnet lines up w. field.

$\vec{B}$ from magnet: like $\vec{E}$ from dipole.



Earth

acts like

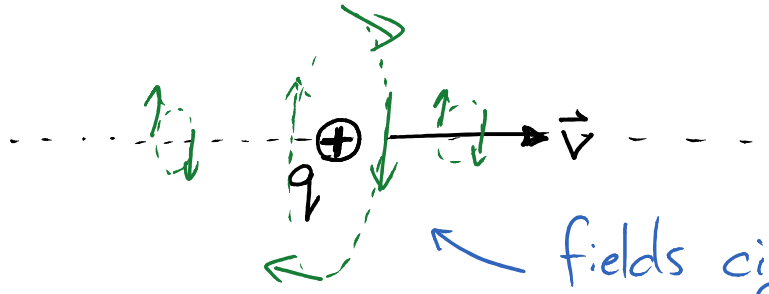


Amazing discovery (early 1800s by Ørsted or Romagnosi??)

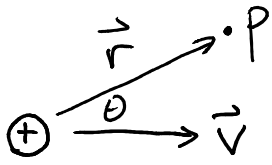
★ currents produce magnetic fields ★

DIRECT CONNECTION BETWEEN ELECTRICITY & MAGNETISM.

BASIC RESULT: moving charges produce magnetic fields



fields circulate around line of motion



P : want to know $\vec{B}$ here

* $\vec{B}$ 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 $\vec{v}$.

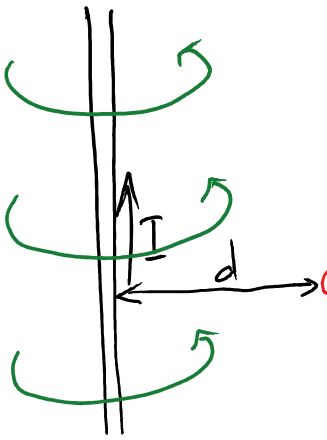
VECTOR EXPRESSION:

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

cross product.

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

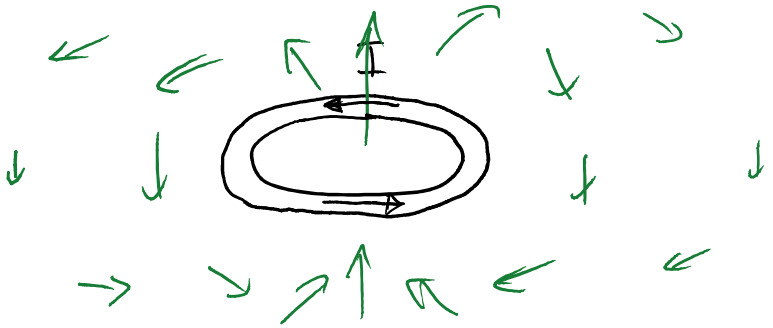
e.g. infinite wire



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

$\otimes$ $\vec{B}$: into page

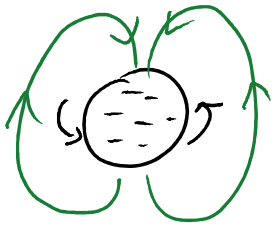
e.g. loop of current



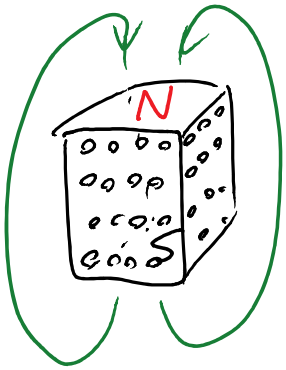
Field like dipole!

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

- imagine electron as spinning ball of charge



- like little current loop
∴ produces field like tiny magnet



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