Phys 1402 2017-10-05 Lec 10

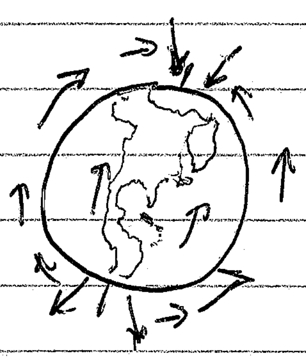
Magnetism - Magnetic Field ($\vec{B}$) in teslas (T).

- Virtual "wind" of magnetic flux.
- How do we know it's there?
    - Deflects particles
    - Makes compass needle point.
    - Generate electricity.
    - Form electromagnetic waves.

What Creates Magnetic Fields?

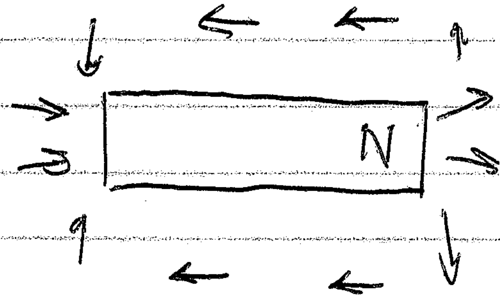
- Moving Charges - i.e. current.
- Fluctuating $\vec{E}$-field.

Earth's Magnetic Field



- On non-polar Surface, B points north.
- At geographic north, B points into ground.
- In Antarctica, B points toward sky.
- $B \sim 50\ \mu T$

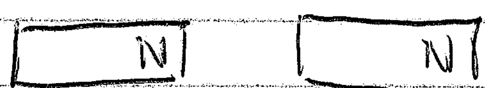
Permanent Magnets



- N tends to orient to Earth's north pole.

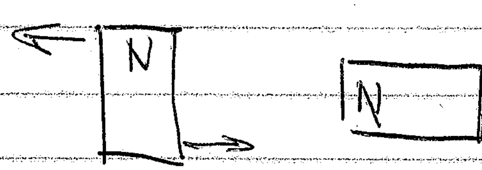
- Compass needle shows $\vec{B}$ emerging from N and pointing into S.
- Earth's geographic north pole is like a magnet's south.

- Two nearby magnets affect each other.
  - Opposite poles attract.
  - Like poles repel.



Attraction

Repulsion

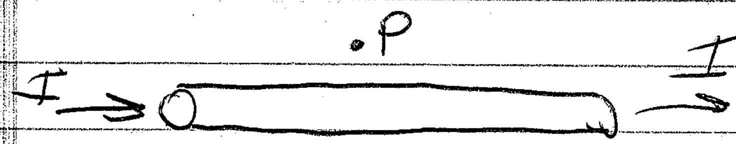


Torque

(3)

Magnetic Field of a wire:

- Long Straight Wire



At point P:

$$B = \frac{\mu_0 I}{2\pi r}$$

- $\mu_0 = 4\pi \times 10^{-7}$ T·m/A

  Type as: (π * 4E-7)

- I = current in amps (A)
- r = dist from P to center of wire.

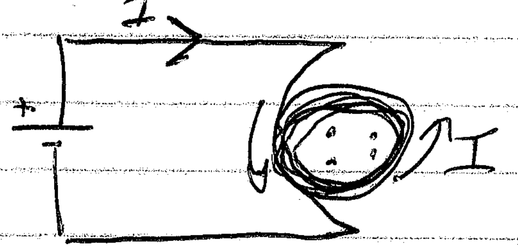
Ex: $I = 2.0$ A
$r = 2$ cm

$$B = \frac{\left(4\pi \times 10^{-7} \frac{T\cdot m}{A}\right)(2.0\ A)}{2\pi\ (0.02\ m)} = 2 \times 10^{-5}\ T$$

$$= 20\ \mu T$$

(4)

- Coil or Loop



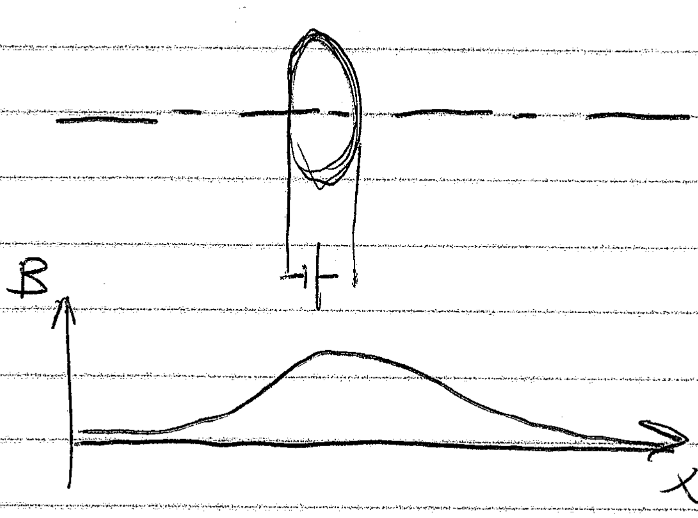
- In loop, I is CCW.
- Inside loop, B points out of page.

RHR for Loops: Curl fingers with current.
Thumb is $\vec{B}$ inside loop.

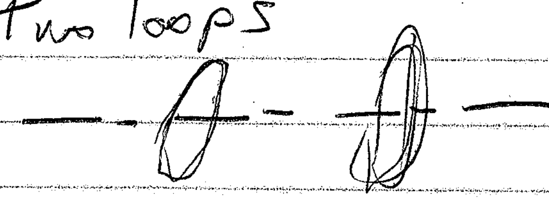
How Strong? $|\vec{B}| = \frac{\mu_0 I}{2R} N$ at center.

Ex: $I = 2.0\ A$ $N = 100$
$R = 2\ cm$

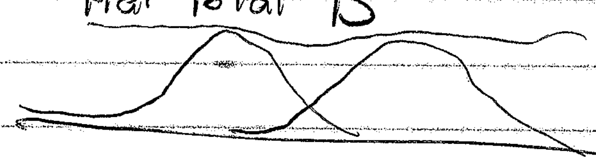
$$B = \frac{\mu_0 (2.0\ A)}{2(0.02\ m)}(100) = 0.006\ T = 6\ mT$$



Two loops

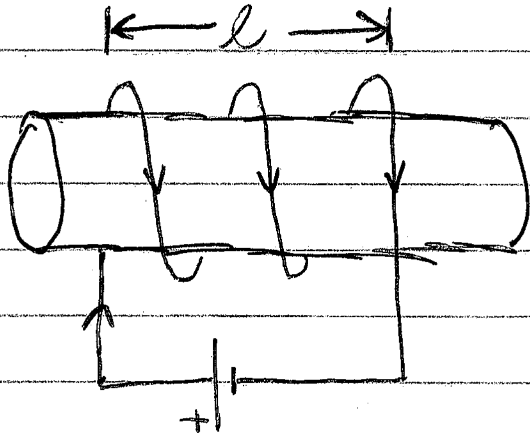


Flat Total B



Helmholz Coil

- Solenoid Coil



Inside, $\vec{B}$ is uniform.

$$B = \frac{\mu_0 N I}{l}$$

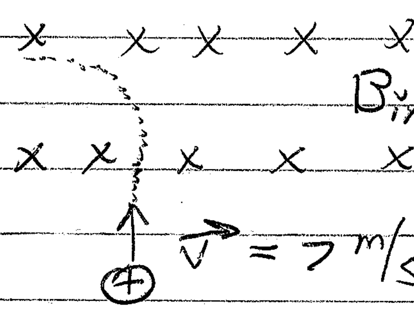
Ex: $I = 2.0\ A$
$N = 1000$
$l = 10\ cm$

$$B = \frac{\mu_0 (1000)(2.0 A)}{0.1\ m}$$

$$= 0.025\ T = 25\ mT$$

Magnetic Effects

- Deflect moving charges sideways.



$B_{in} = 0.05\ T$

$F = q v_{\perp} B$

$\vec{v} = 7\ m/s$

$q = 2\ \mu C$

RHR for force: Thumb = F
Index = v
Middle = B