

## Physics 202, Lecture 13

### Today's Topics

- Sources of the Magnetic Field (Ch. 30)
  - Calculating the B field due to currents
    - Biot-Savart Law
      - Examples: ring, straight wire
      - Force between parallel wires
    - Ampere's Law: infinite wire, solenoid, toroid
  - Displacement Current: Ampere-Maxwell
  - Magnetism in Matter

On WebAssign Tonight: Homework #6: due 10/22 ,10 PM.  
Optional reading quiz: due 10/19, 7 PM

## Magnetic Fields of Current Distributions

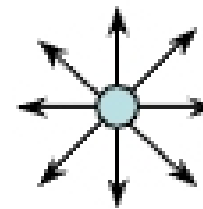
First, review: back to electrostatics:

Two ways to calculate the electric field directly:

– Coulomb's Law

$$d\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{dq}{r^2} \hat{r}$$

"Brute force"



– Gauss' Law

$$\int \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$$

"High symmetry"

$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/(\text{N m}^2)$ :  
permittivity of free space

## Magnetic Fields of Current Distributions

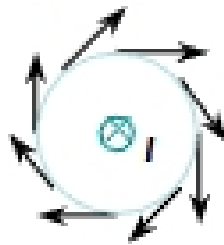
Two Ways to calculate the magnetic field:

– Biot-Savart Law  
("Brute force")

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{l} \times \hat{r}}{r^2}$$

– Ampere's Law  
("high symmetry")

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{enclosed}}$$



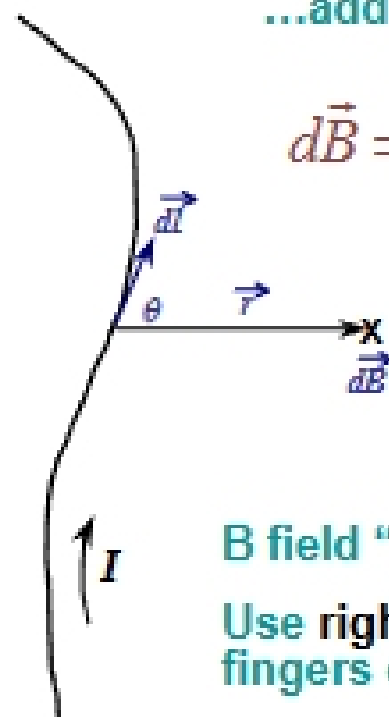
–AMPERIAN LOOP

$\mu_0 = 4\pi \times 10^{-7}$  T·m/A:  
permeability of free space

## Biot-Savart Law...

...add up the pieces

$$d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{l} \times \hat{r}}{r^2} = \frac{\mu_0 I}{4\pi} \frac{d\vec{l} \times \vec{r}}{r^3}$$



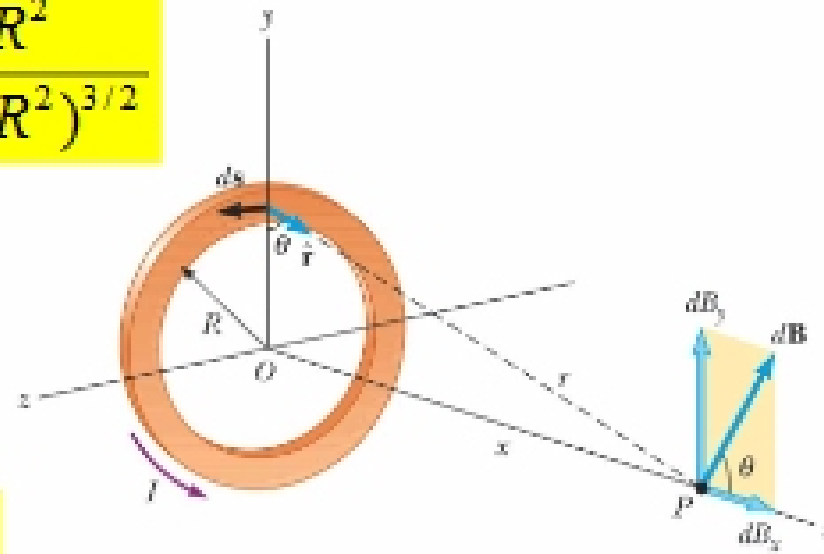
B field "circulates" around the wire

Use right-hand rule: thumb along I,  
fingers curl in direction of B.

## B Field of Circular Current Loop on Axis

□ (Text example 30.3) B field on axis of current loop is:

$$B_x = \frac{\mu_0 I R^2}{2(x^2 + R^2)^{3/2}}$$



$$B_{\text{center}} = \frac{\mu_0 I}{2R}$$

See also: center of arc (text example 30.2)

## B of Circular Current Loop: Field Lines

