Review for 2nd Midterm

Midterm-2

- Wednesday October 29 at 6pm
  - Section 1 – N100 BCC (Business College)
  - Section 2 – 158 NR (Natural Resources)
- Allowed one sheet of notes (both sides) and calculator
- Covers Chapters 27-31 and homework sets #5-8
- Send an email to your professor if you have a class conflict and need a make-up exam
- Review in class on Tuesday, October 28th

Current and Resistance

- Current $$i = \frac{dq}{dt}$$

- Current density $$i = \int \vec{J} \bullet d\vec{A}$$

- If *J* is uniform and parallel to *dA* $$i = JA$$

Current and Resistance

- Ohm's law $$V = iR$$
- Power lost to heat energy in a resistor $$P = iV$$

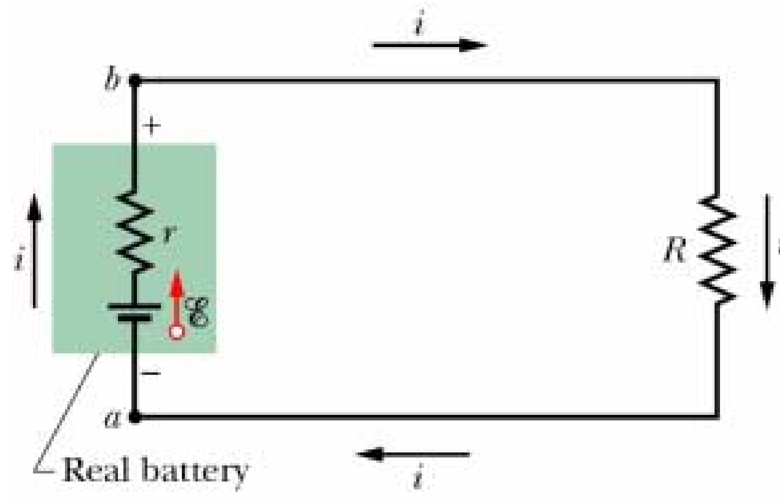
$$P = i^2 R$$

$$P = \frac{V^2}{R}$$

Loop Rule

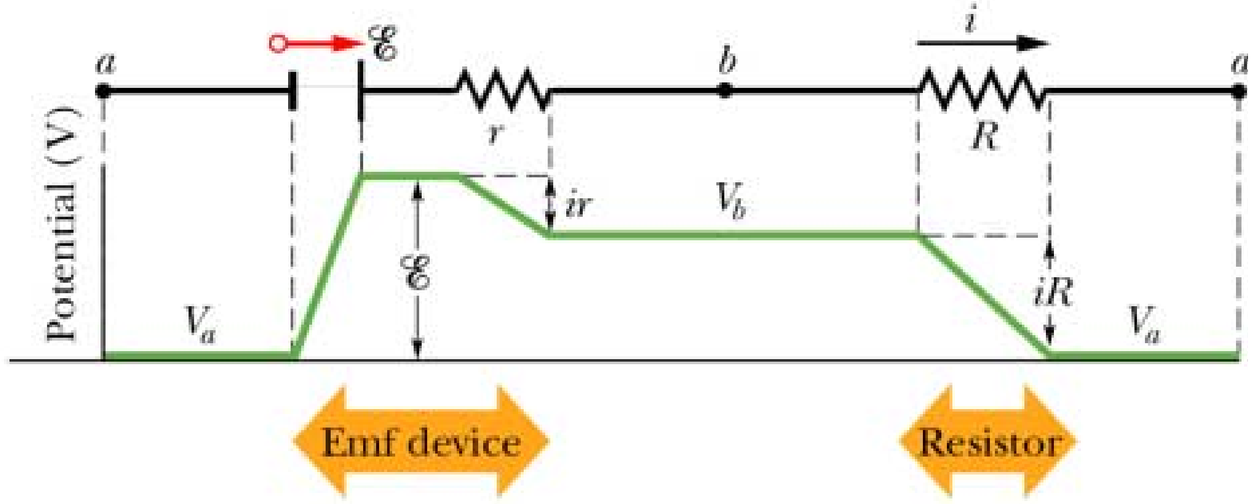
$$E - ir - iR = 0$$

$$i = \frac{E}{r + R}$$



(a)

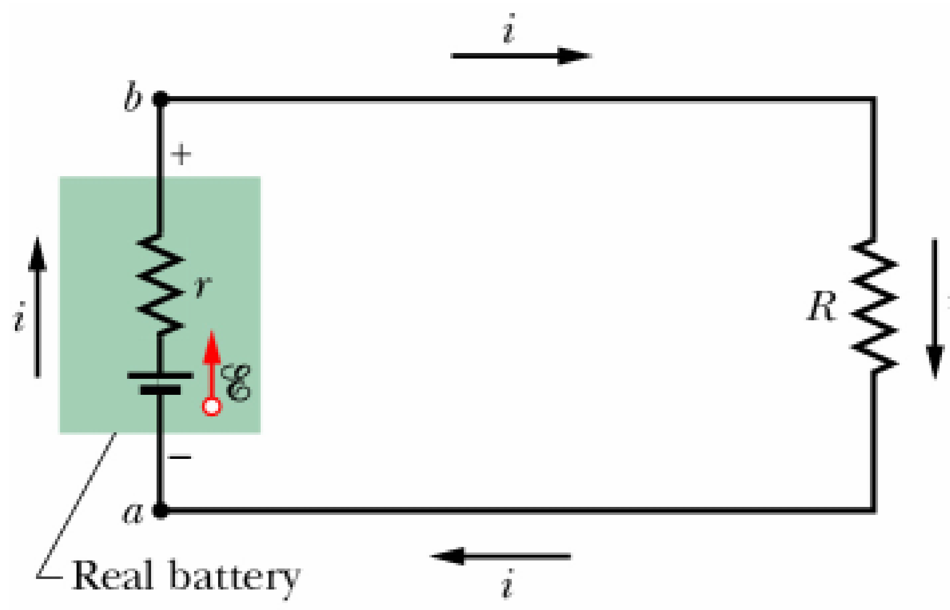
- Graphical representation



(b)

Circuits

$$V_b - V_a = iR$$



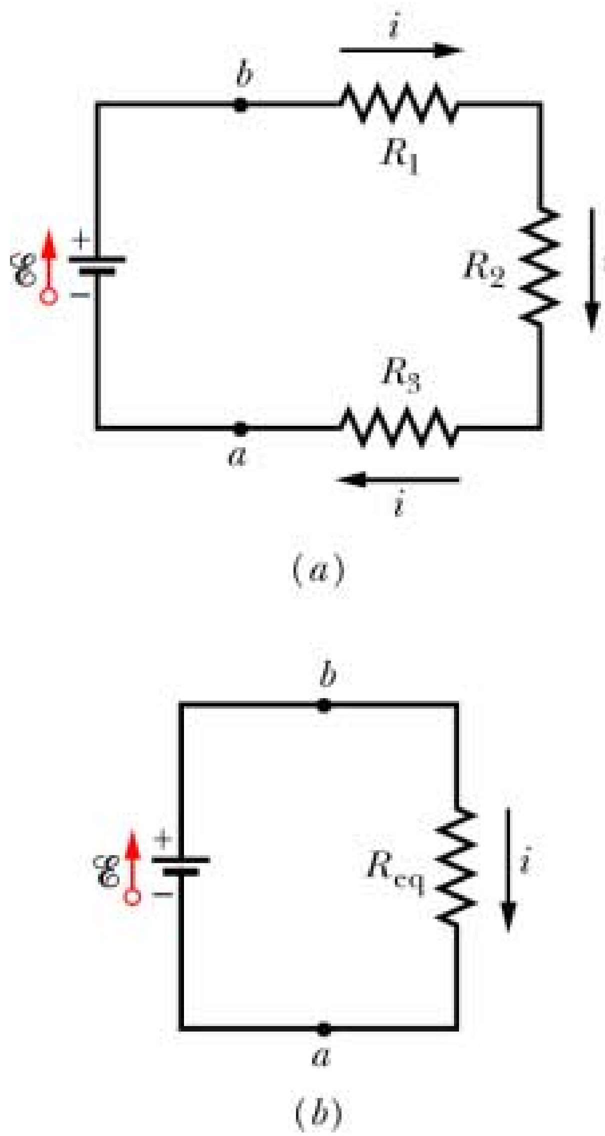
- Substituting for *i* gives

$$V_b - V_a = \mathrm{E}\frac{R}{R+r}$$

Circuits

- Resistors in series
- Resistors have identical currents, *i*
- Sum of *V*s across resistors = applied *V* = E.
- R_{eq} is sum of all resistors

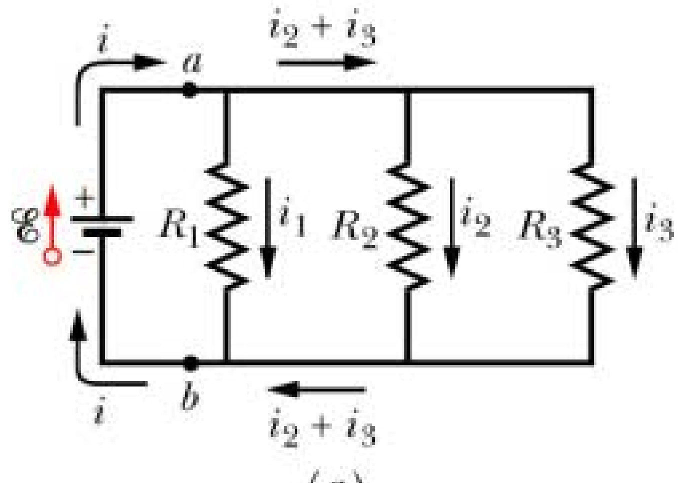
$$R_{eq} = \sum_{j=1}^{n} R_j$$



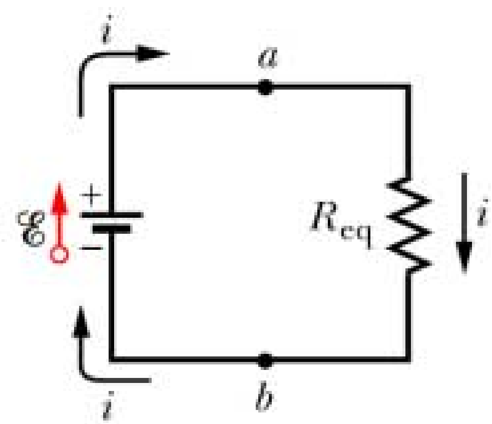
Circuits

- Resistors in parallel
- Resistors have identical $V = E$
- $i_1 = V/R_1$ etc
- R_{eq} given by

$$\frac{1}{R_{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)$$

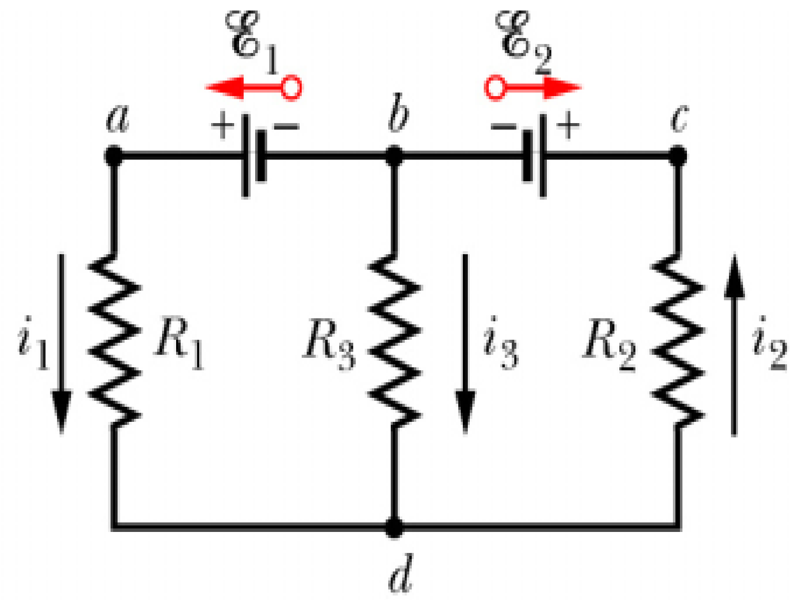


(a)



(b)

Junction Rule



- Arbitrarily label currents, using different subscript for each branch
- Using conservation of charge at each junction

$$i_{in} = i_{out}$$

- At point d

$$i_1 + i_3 = i_2$$

- At point b

$$i_1 + i_3 = i_2$$

- At point a

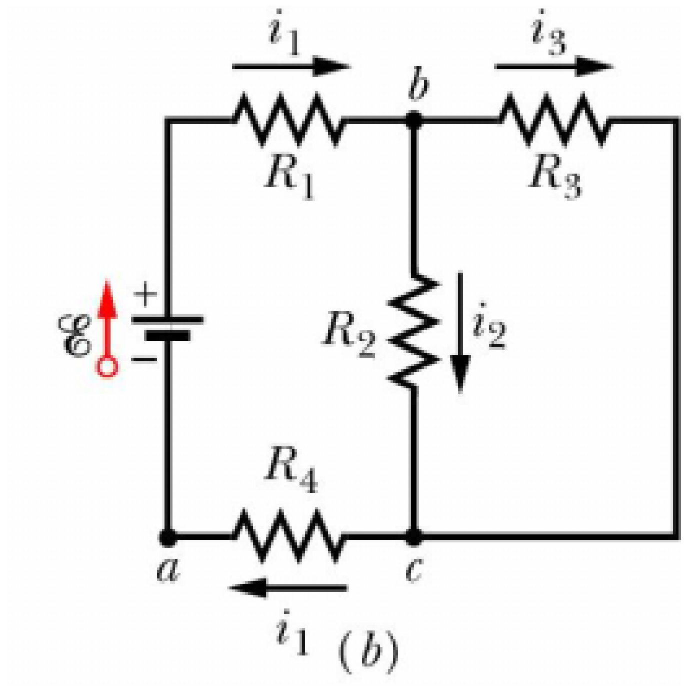
$$i_1 = i_1$$

- At point c

$$i_2 = i_2$$

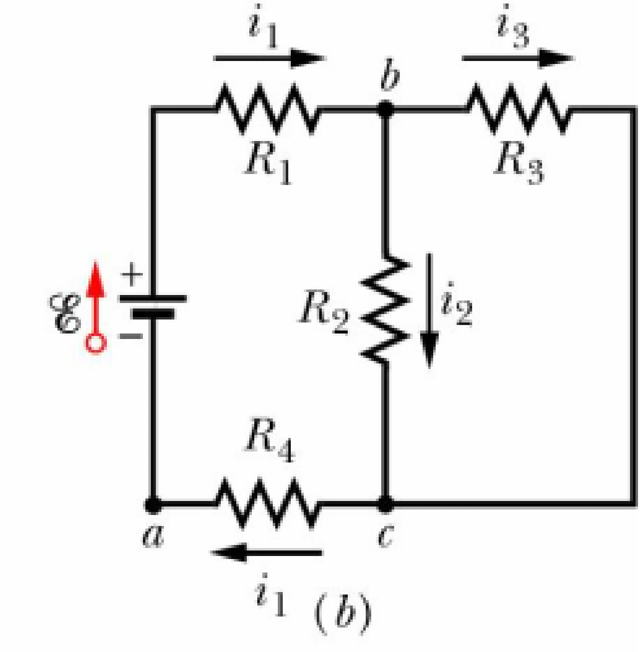
Circuits

- What is i_1 ?
- $R_1 = R_2 = R_3 = R_4 = 2$ ohm
- E=5 V



Circuits

- What is i_2 ?
- Three unknowns so we need three equations



$$\text{E} - i_1 R_1 - i_2 R_2 - i_1 R_4 = 0$$

$$-i_3 R_3 + i_2 R_2 = 0$$

$$i_1 = i_2 + i_3$$

$$i_2 = -\frac{i_1 R_3}{(R_3 + R_2)}$$

Motion in a B Field

- Force on a charged particle due to a magnetic field is

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

- F_B does not change the speed (magnitude of v) or kinetic energy of particle

- Charged particles moving with $v \perp$ to a B field move in a circular path with radius, r

$$r = \frac{mv}{qB}$$

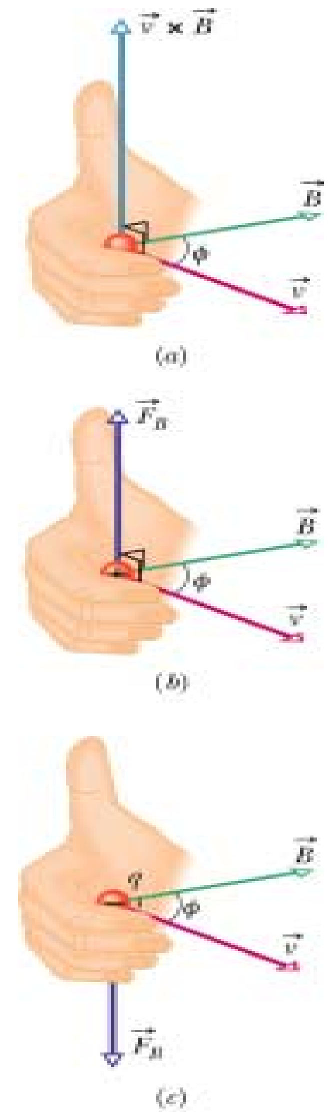
- Force on a current carrying wire due to a magnetic field is

$$\vec{F}_B = i\vec{L} \times \vec{B}$$

Motion in a B Field

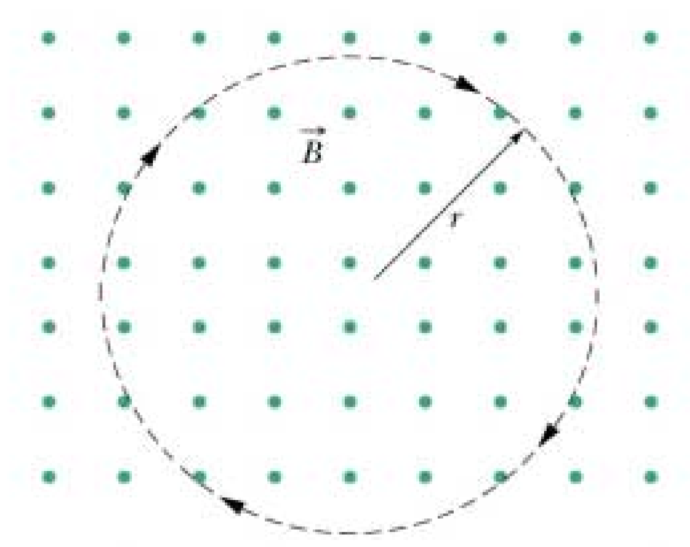
- Right-hand rule – For positive charges - when the fingers sweep v into B through the smaller angle ϕ the thumb will be pointing in the direction of F_B

- For negative charges F_B points in opposite direction



Motion in a B Field

- Circular motion $$r = \frac{mv}{qB}$$
- Period (time for one revolution) $$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$$

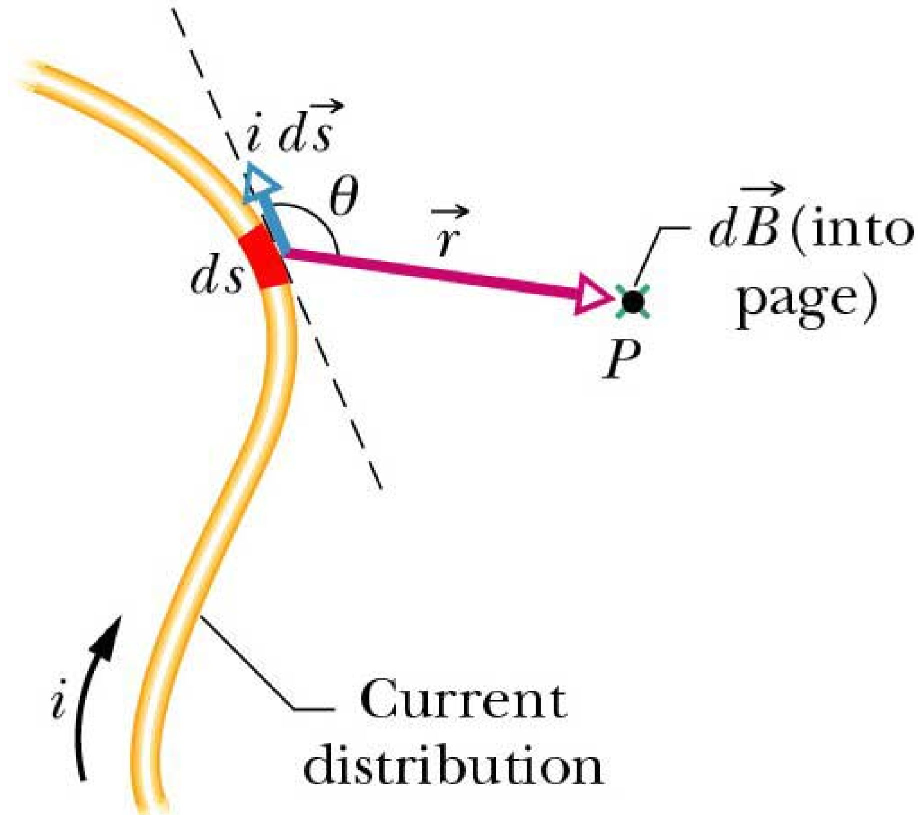


- Frequency (the number of revolutions per unit time) $$f = \frac{1}{T}$$
- Angular frequency: $$\omega = 2\pi f$$

B Fields from Currents

- Biot-Savart law

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i\, d\vec{s} \times \vec{r}}{r^3}$$

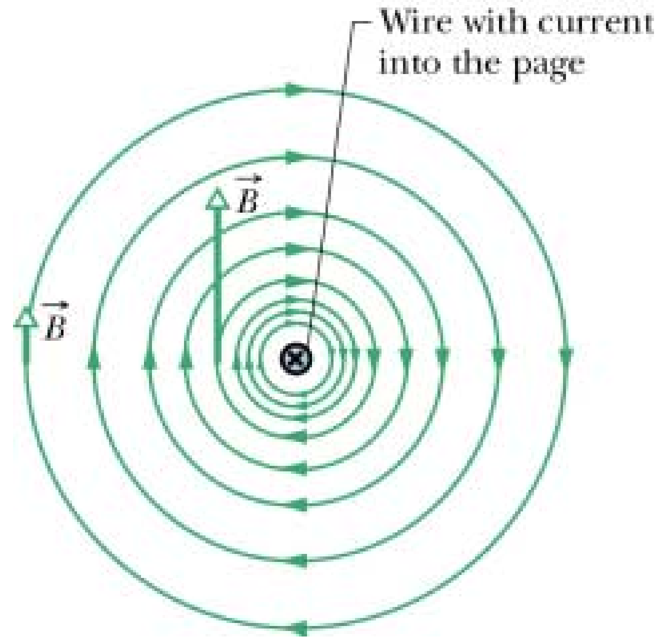


B Fields from Currents

- *B* field a distance *R* from a long straight wire carrying current *i*

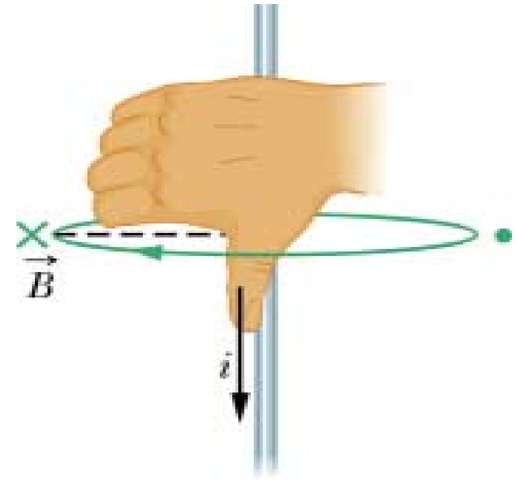
$$B = \frac{\mu_0 i}{2\pi R}$$

- *B* field is tangent to magnetic field lines

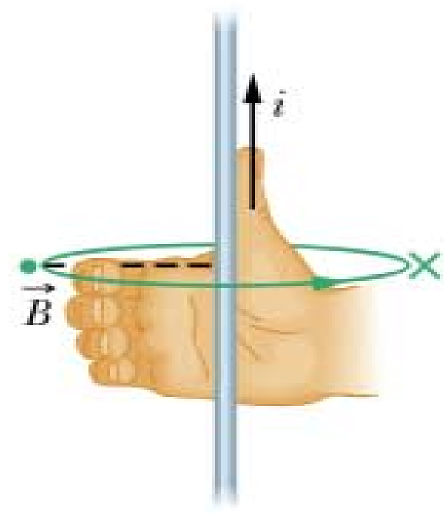


B Fields from Currents

- right-hand rule
- Point thumb in direction of current flow
- Fingers will curl in the direction of the magnetic field lines due to current



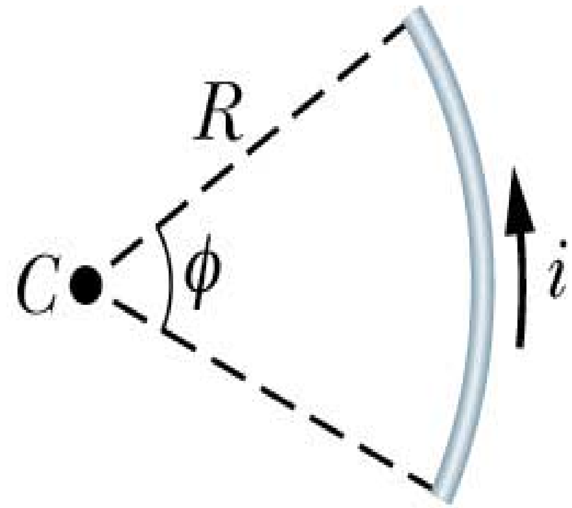
(a)



B Fields from Currents

- B field at the center of an arc is

$$B = \frac{\mu_0 i \phi}{4\pi R}$$



- Express ϕ in radians

- For a complete loop ($\phi = 2\pi$) then B is

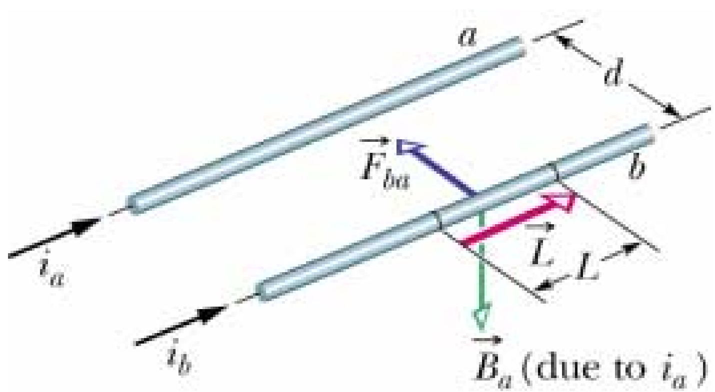
$$B = \frac{\mu_0 i}{2R}$$

B Fields from Currents

- Force on a wire carrying current, i_1, due to *B* of another parallel wire with current i_2

$$F = \frac{\mu_0 L i_1 i_2}{2\pi d}$$

- Force is attractive if current in both wires are in the same directions
- Force is repulsive if current in both wires are in the opposite directions

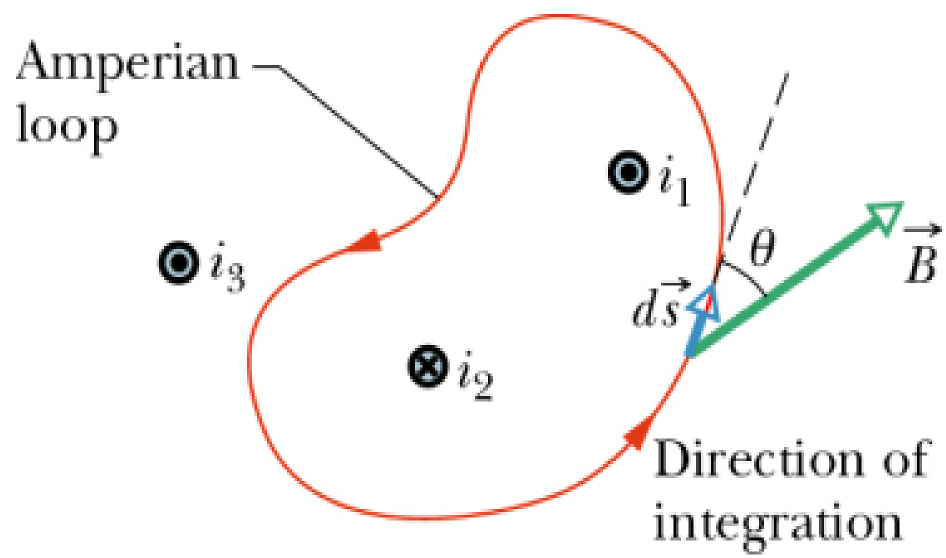


B Fields from Currents

- For symmetric distributions of charge use Ampere's law to calculate *B* field

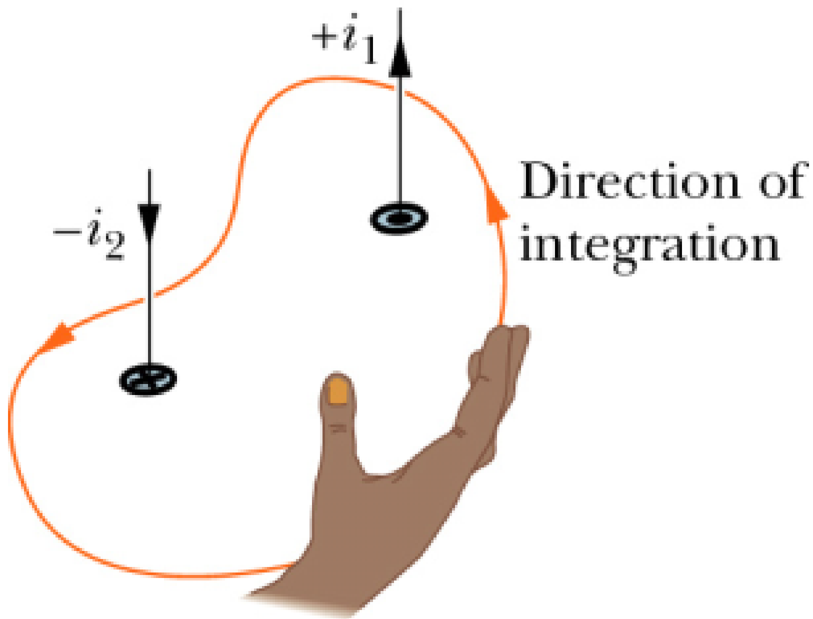
$$\oint \vec{B} \bullet d\vec{s} = \mu_0 i_{enc}$$

- Integral around closed loop called Amperian loop



B Fields from Currents

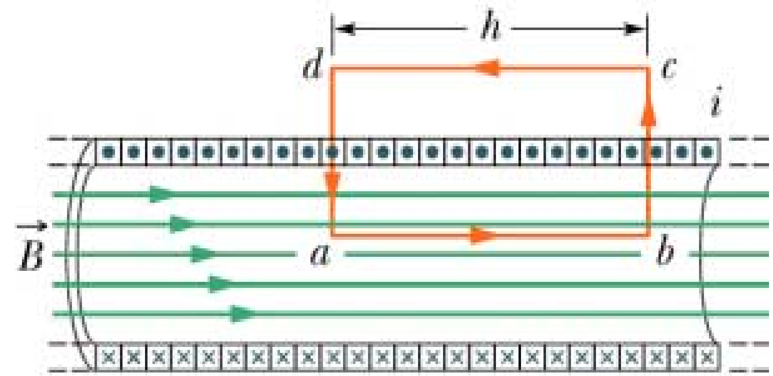
- Use the right-hand rule to determine the signs for the currents encircled by the Amperian loop
- Curl right hand around Amperian loop with fingers pointing in direction of integration
- Current going through loop in the same direction as thumb is positive.
- Current going in the opposite direction is negative.



B Fields from Currents

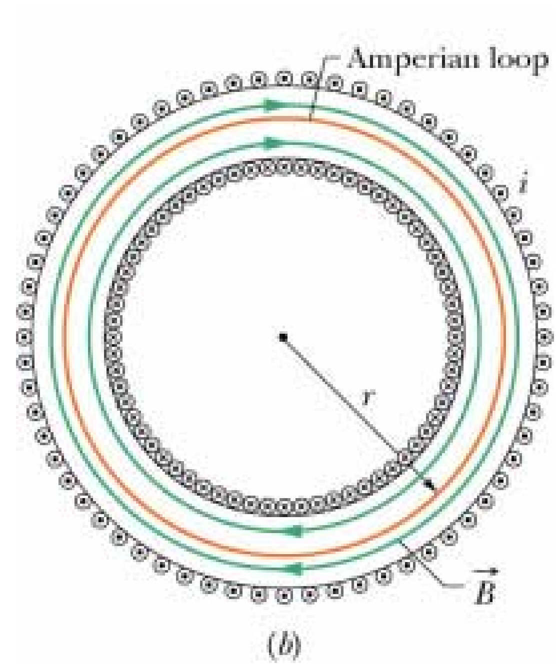
- For ideal solenoid:

$$B = \mu_0 i n$$



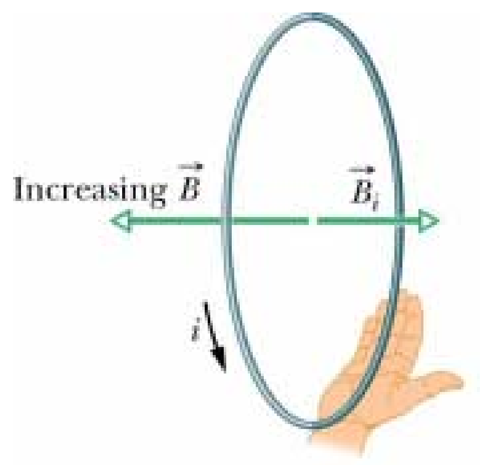
- n is # turns/length
- For toroid

$$B = \frac{\mu_0 i N}{2\pi r}$$



Currents from B Fields

- Magnetic flux $$\Phi_B = \int \vec{B} \bullet d\vec{A}$$
- Faraday's law (N loops) $$\mathcal{E} = -N \frac{d\Phi_B}{dt}$$
- Lenz's law – induced emf gives rise to a current whose *B* field opposes the change in flux that produced it



Faraday's law

$$\Phi_B = \int \vec{B} \bullet d\vec{A} = BA\cos\theta$$

$$\mathcal{E} = -N\frac{d\Phi_B}{dt}$$

- We can change the magnetic flux through a loop (or coil) by:
  - Changing magnitude of *B* field within coil
  - Changing area of coil, or portion of area within *B* field
  - Changing angle between *B* field and area of coil (e.g. rotating coil)

$$\mathcal{E} = -NA\cos\theta\frac{dB}{dt}$$

$$\mathcal{E} = -NB\cos\theta\frac{dA}{dt}$$

$$\mathcal{E} = -NBA\frac{d(\cos\theta)}{dt}$$

Generators

- Generator with N turns of area A and rotating with constant angular velocity, ω
- Magnetic flux is

$$\Phi_B = BA\cos\omega t$$

- Emf is

$$\mathcal{E} = NBA\omega\sin\omega t$$