Announcements

1. Problem session this evening at 6 PM in Olin 101 – will discuss exam, homework, etc.

2. Exams will be returned at the end of class today

   Rework exam for ≤ 10 extra credit points (goes in general "extra credit" accumulation) -- due 2/14/05

   Some general comments

3. Topic for today – The physics of moving charges – Chap. 29

   - Introduce the notion of magnetic fields (sources of magnetic fields will be discussed next time)
   - Magnetic forces on moving charge particles
   - Magnetic forces on current-carrying wires

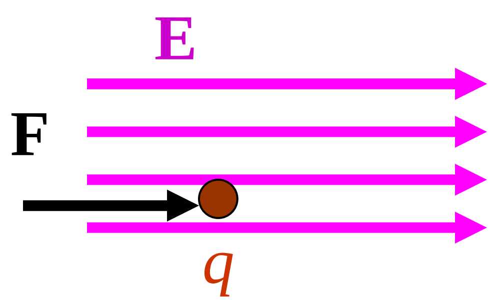
Make sure that you get your questions answered; send me email or come to see me.

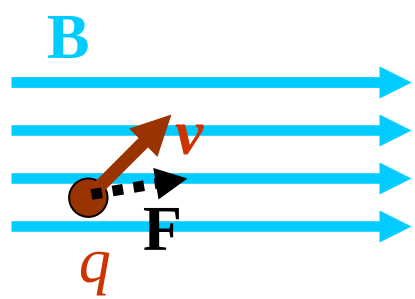
Vector quantities	Scalar quantities
$\mathbf{E} = E_x \hat{\mathbf{x}} + E_y \hat{\mathbf{y}}$ Vector addition	V Scalar addition

Arithmetic – use 3-5 digits in your calculations, especially in intermediate steps so avoid round-off error.

Electric field

Magnetic field





F = $q\mathbf{E}$

(force direction is determined by direction of **E**)

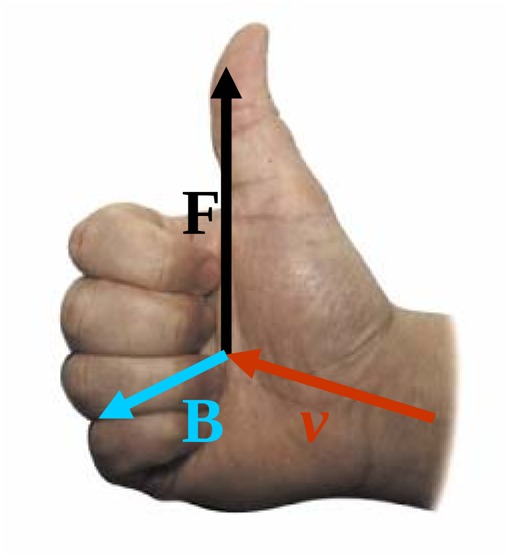
units: N = C · N/C

F = $q\, \mathbf{v} \times \mathbf{B}$

(force direction is determined by vector cross product of ***v*** and **B**)

units: N = C · m/s · Tesla

Right hand rule:

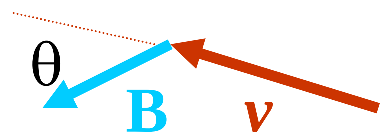


$$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$$

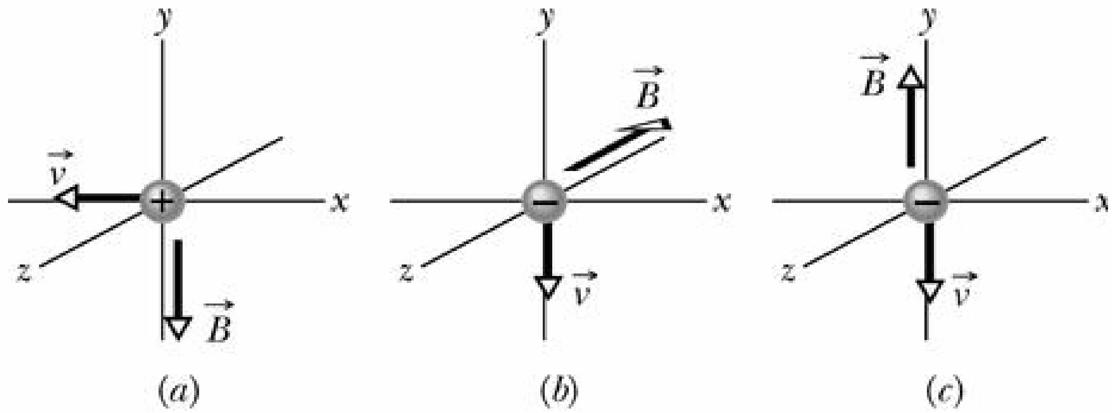
$$|\mathbf{F}| = |q||\mathbf{v}||\mathbf{B}|\sin\theta$$

$F = q\, v \times \mathbf{B}$

In plane containing *v* and **B**:



Online Quiz for Lecture 9
RC circuits -- Feb. 7, 2005



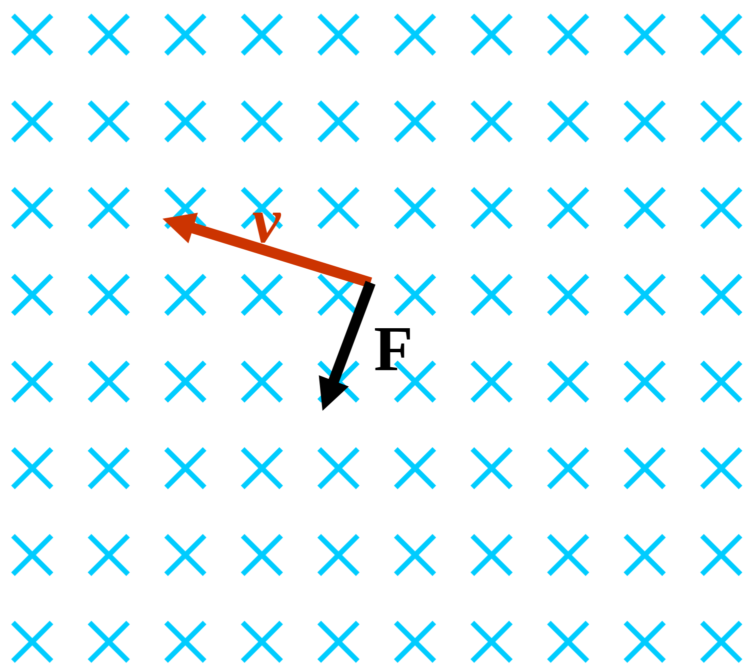
The figure shows three situations in which a charged particle with velocity **v** travels through a uniform magnetic field **B**. In each case, choose from the following answers to indicate the direction of the magnetic force on the particle:

A. + z-axis
B. - z-axis
C. + x-axis
D. - x-axis
E. Force is zero.

1. Figure (a). A
2. Figure (b). D
3. Figure (c). E

Motion of positively charged particle in magnetic field --

Field pointing into screen:



Peer instruction question:

What will happen to the trajectory of the positively charged particle?

(A) Particle will continue to move at the same velocity.

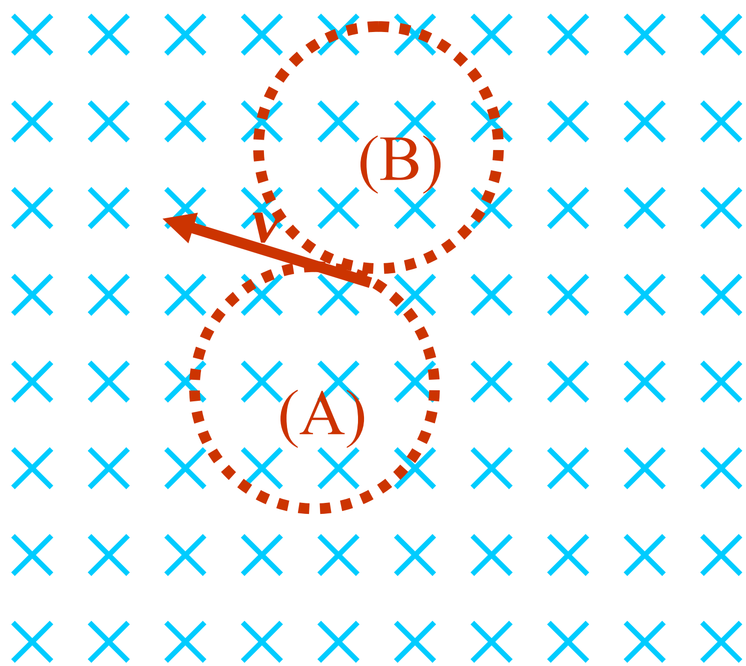
(B) Particle will accelerate in the direction of the velocity.

(C) Particle will accelerate in the direction perpendicular to the velocity.

(D) Particle will accelerate in the direction of the magnetic field.

Motion of charged particle in magnetic field --

Field pointing into screen:

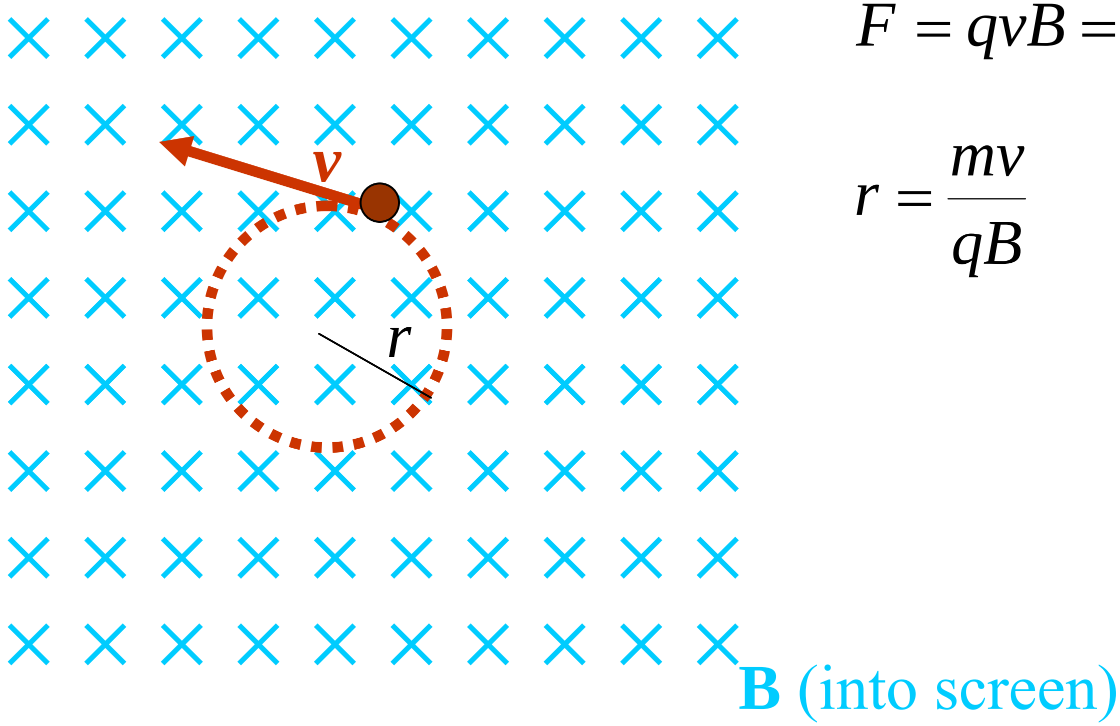


Which track is followed by + particle?

Which track is followed by – particle?

Interesting details:

If there is no component of the velocity vector ***v*** of the particle in the direction of the magnetic field, then the particle moves in a circular orbit:



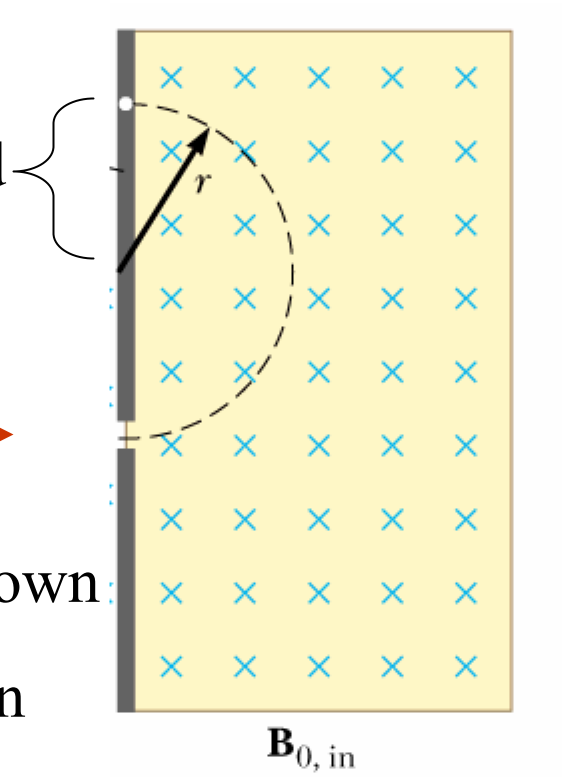
$$F = qvB = ma_r = m\frac{v^2}{r}$$

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

centripetal acceleration

Principles of the mass spectrometer:

radius r is measured

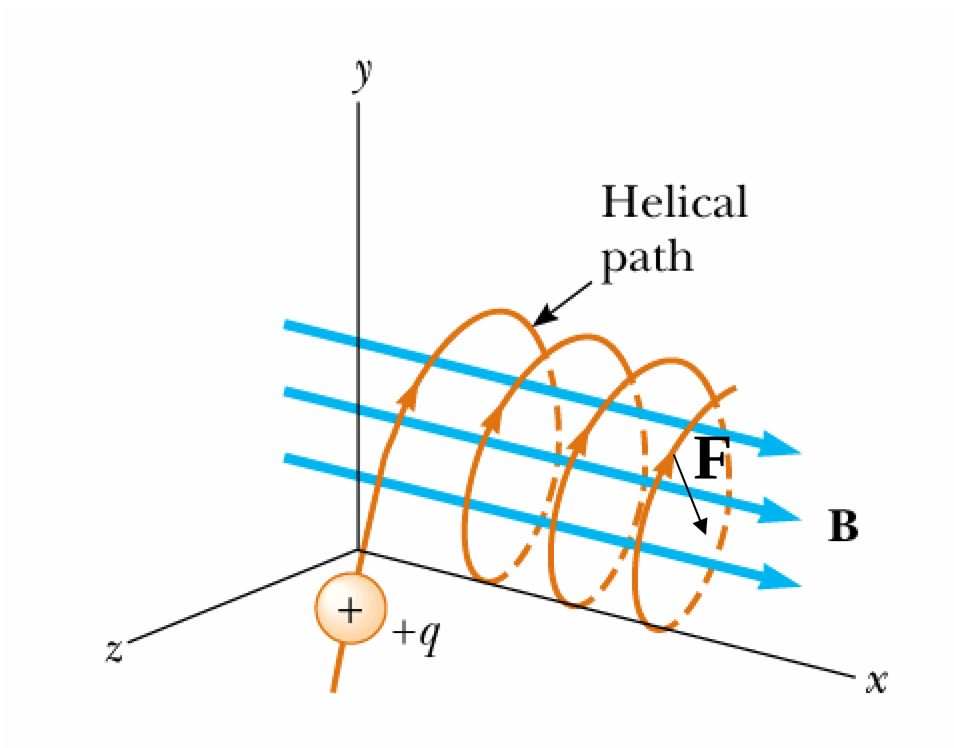


velocity $\boldsymbol{v}$ is known

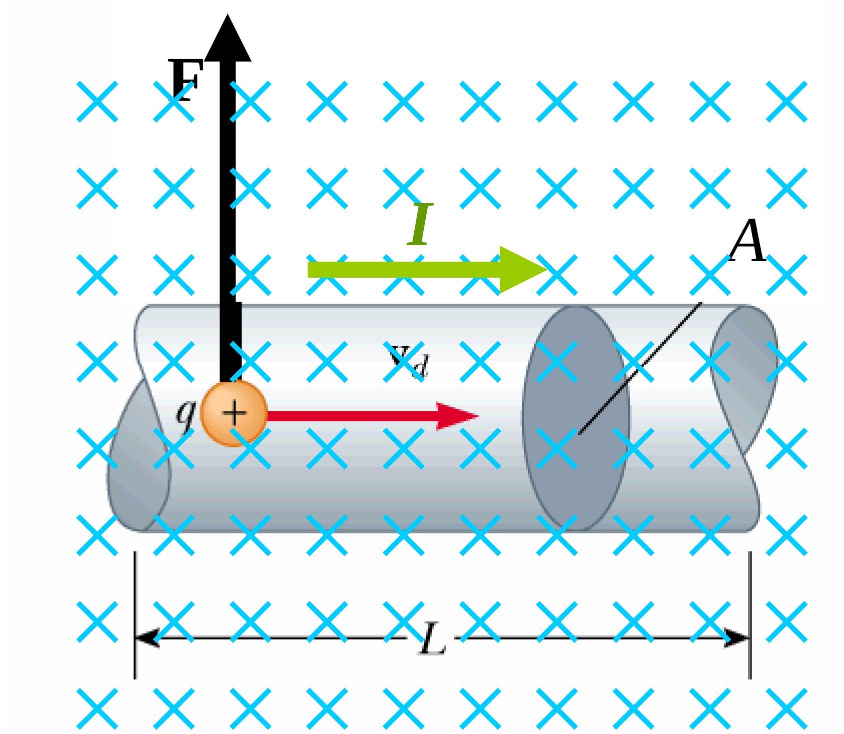
field B is known

$$r = \frac{mv}{qB} \quad \Rightarrow \frac{q}{m} = \frac{v}{Br}$$

Three-dimensional motion of particle in magnetic field



Magnetic forces acting on moving charges in a wire



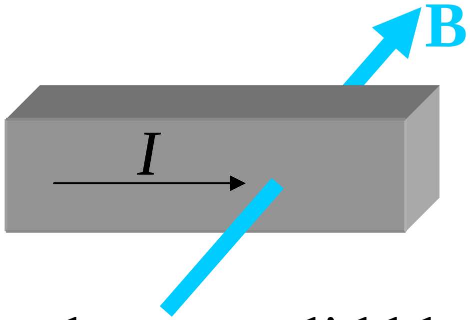
$$I = nqv_d A \qquad n = \frac{N}{AL}$$

$$I = \frac{Nqv_d}{L} \qquad \Rightarrow Nqv_d = IL$$

$$\mathbf{F} = L\mathbf{I} \times \mathbf{B}$$

B (into screen)

Peer instruction question

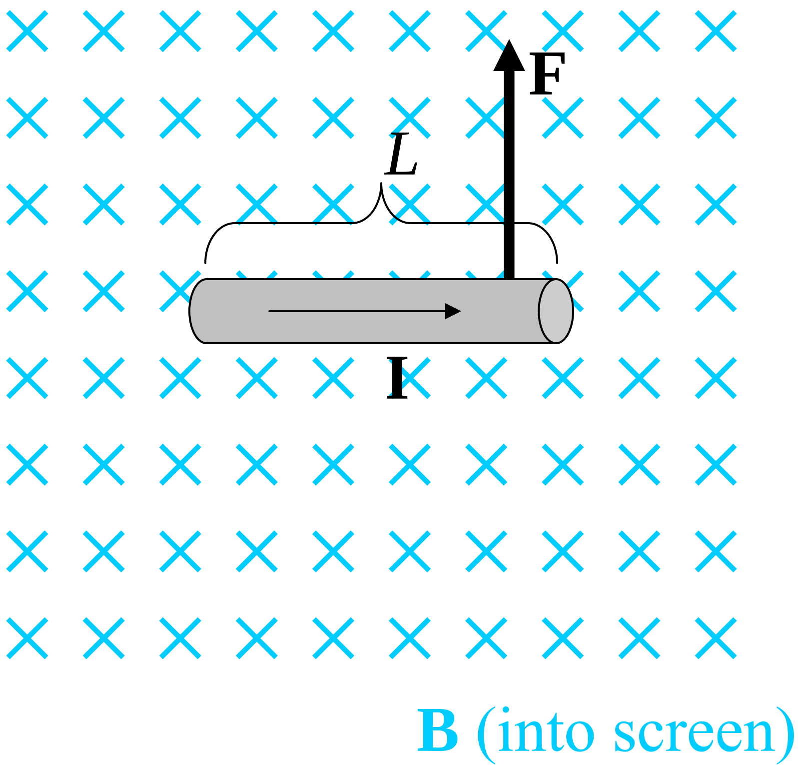


Suppose you have a solid block of metal with a current *I* and uniform magnetic field as shown. Which of the following statements are true.

(A) Mobile charges within the wire will not be effected by the magnetic field because they are confined within the metal.

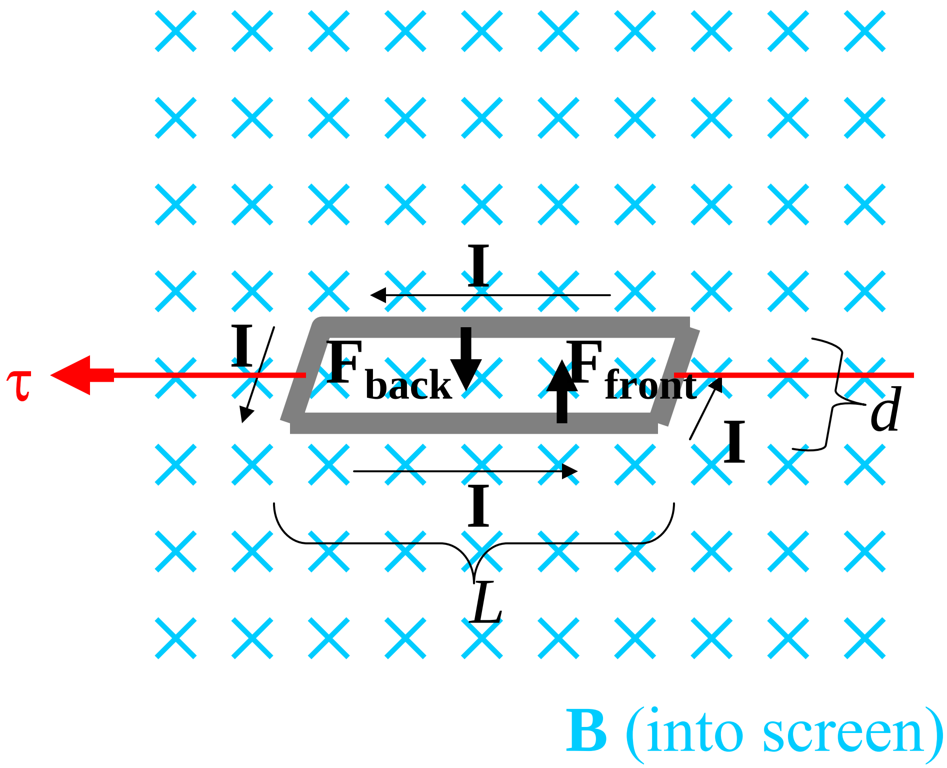
(B) Mobile charges within the wire will respond to magnetic forces and will move until they come to equilibrium.

Net forces on a current-carrying wire:



$$\mathbf{F} = L\mathbf{I} \times \mathbf{B}$$

Net forces on a current loop:



$\mathbf{F}_{\mathbf{front}}\mathbf{=}$ *L* **IB (up)**

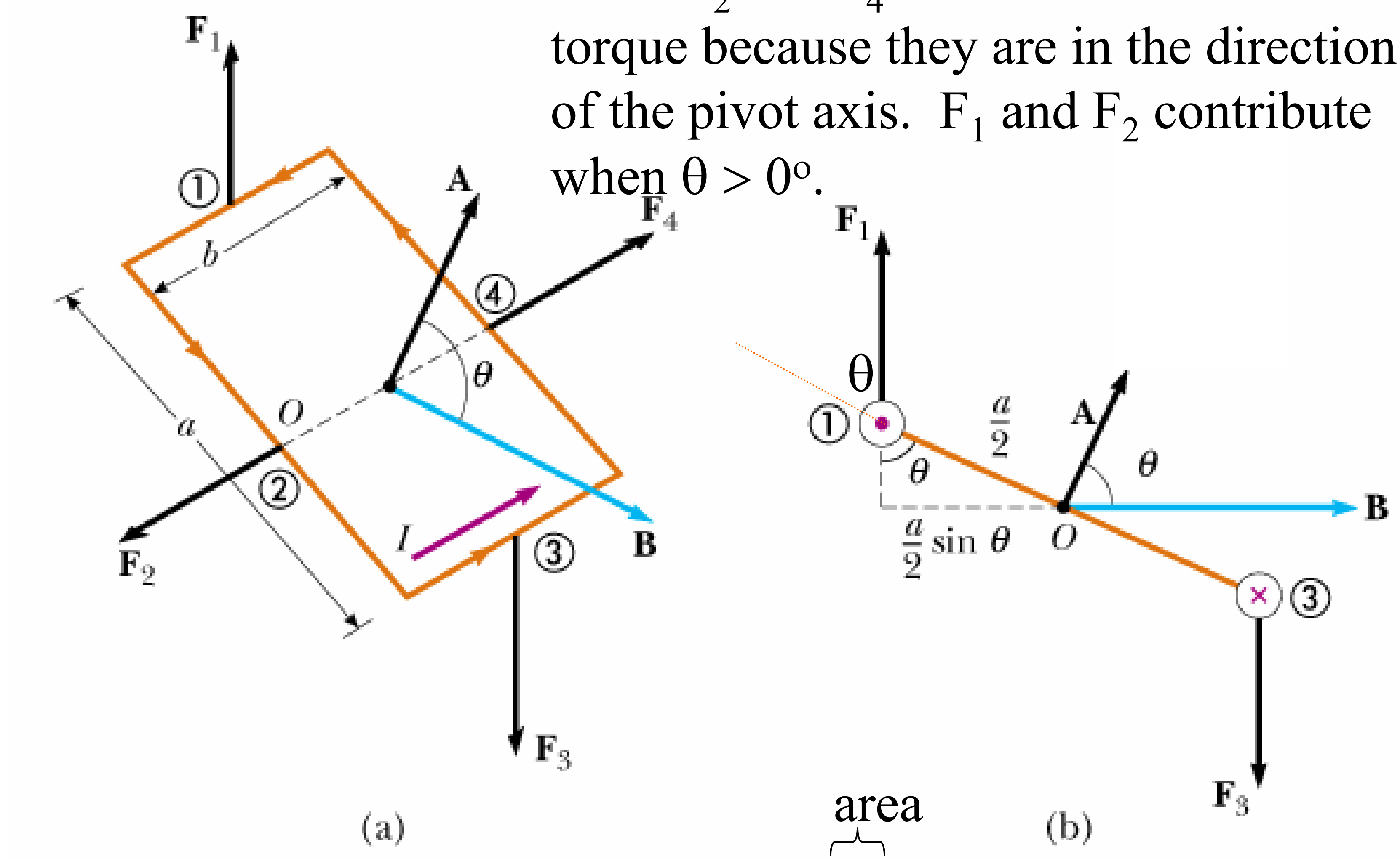
$\mathbf{F}_{\mathbf{back}}\mathbf{=}$ *L* **IB (down)**

maximum torque on loop:

$\tau = dL\ IB$

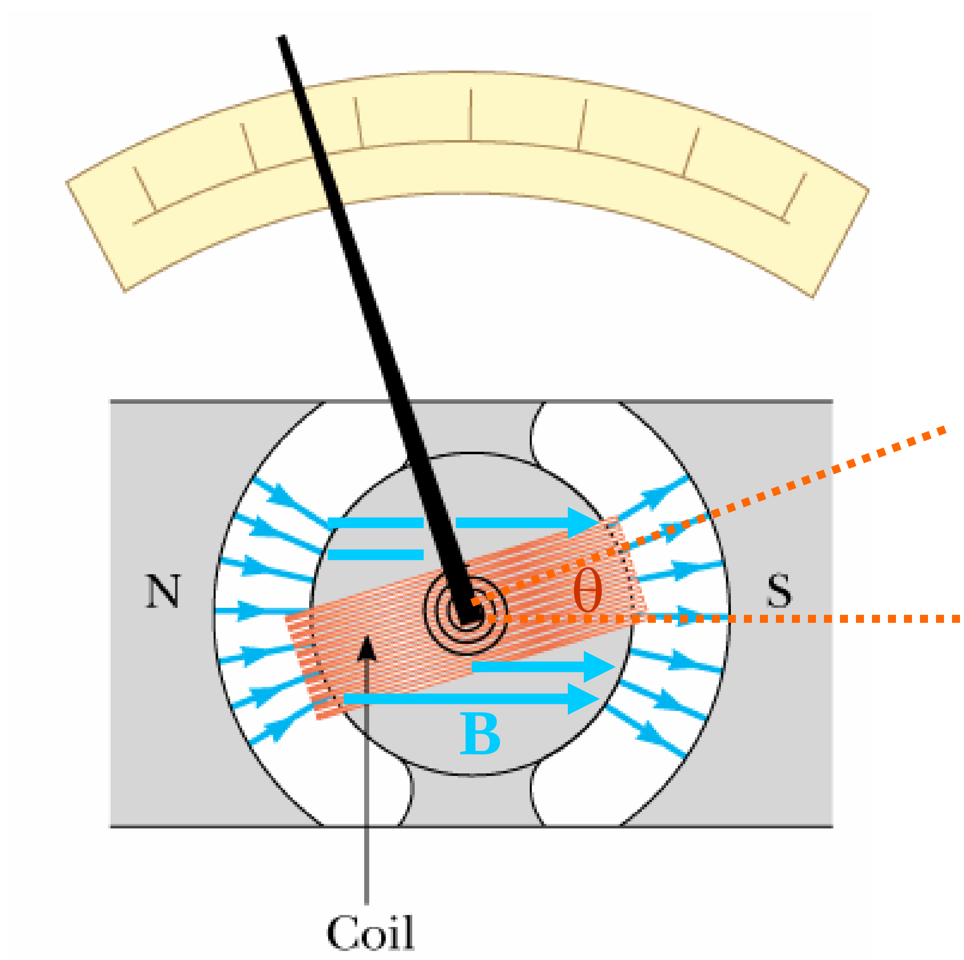
More diagrams of current loop in a magnetic field

Note: F_2 and F_4 do not contribute to the torque because they are in the direction of the pivot axis. F_1 and F_2 contribute when $\theta > 0^o$.



$$\tau = 2 \times a/2\ b\ IB \sin\theta = \overbrace{ab}^{\text{area}}\ IB \sin\theta$$

Current loop in galvanometer mechanism



area of coil

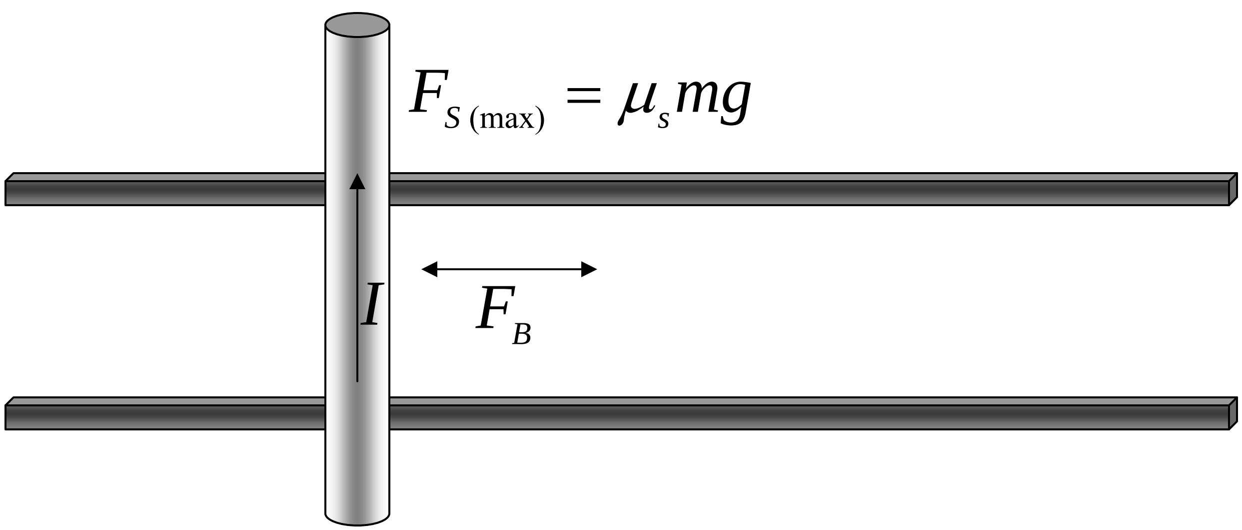
$\tau = NA\, IB \sin\theta$

number of turns in coil.

3. [HRW6 29.P.037.] A 2.4 kg copper rod rests on two horizontal rails 2.4 m apart and carries a current of 41 A from one rail to the other. The coefficient of static friction between rod and rails is 0.47. What is the smallest magnetic field (not necessarily vertical) that would cause the rod to slide?

[ ] T

Top view



4. [HRW6 29.P.039.] Figure 29-36 shows a rectangular, 30-turn coil of wire, 10 cm by 5.0 cm. It carries a current of 0.40 A and is hinged along one long side. It is mounted in the *xy* plane, at an angle of 30° to the direction of a uniform magnetic field of 0.80 T. Find the magnitude and direction of the torque acting on the coil about the hinge line.

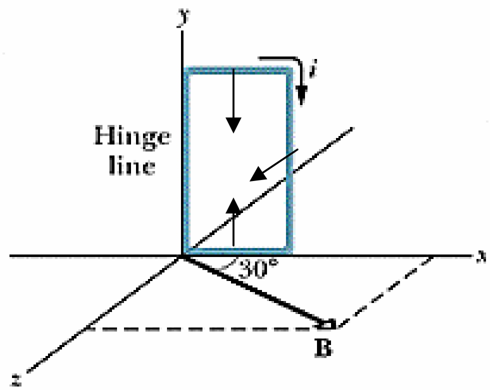


Figure 29-36

Magnitude

[ ] N · m

Direction

- ○ to the left (clockwise)
- ○ downward
- ○ to the right (counterclockwise)
- ○ upward