Fri: HW by 5pm

Supp Ex: 67, 68, 69, 70

Ch 24 Quest: 32

Ch 24 Probs 36, 37, 48

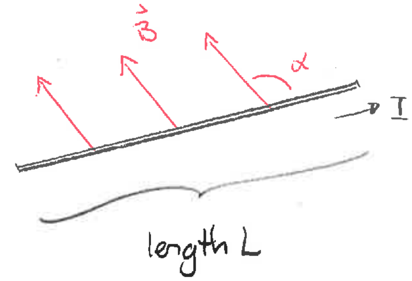
Thurs: Seminar

Mon Warm Up 8 D2L

Magnetic force on a current

The fact that a current consists of moving charged particles implies that a magnetic field can exert a force on a current. The most basic rule for such forces is:

Consider a straight current in a uniform magnetic field. Then the field exerts a force on the current with:



* magnitude

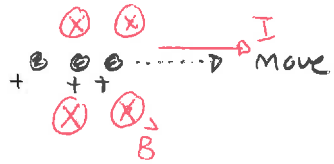
$$F = ILB\sin\alpha$$

* direction - use r h

thumb → I
index → $\vec{B}$
middle → $\vec{F}$

This rule is devised so that the direction of the force depends only on the current direction and does not require any accounting for the sign of the current carrying charge.

positive charges in current



Using force on individual charges → $\vec{F}$ is ↑

Using force on current → $\vec{F}$ is ↑

negative charges in current

Using force on individual charges → $\vec{F}$ is ↑

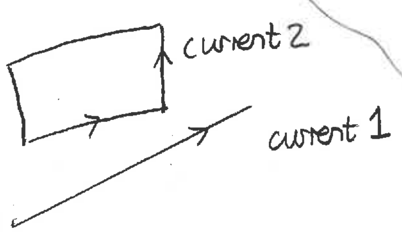
using force on current $\vec{F}$ is ↑

So

When using the force rule that involves current we do not need to account for the type of charges that constitute the current.

Force exerted by one current on another.

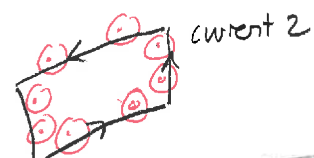
Consider two neighboring currents. We ask whether one of these exerts a force on the other.



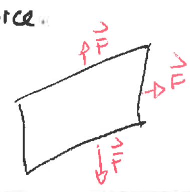
Does 1 exert a force on 2?

→

Current 1 produces a magnetic field at the location of current 2



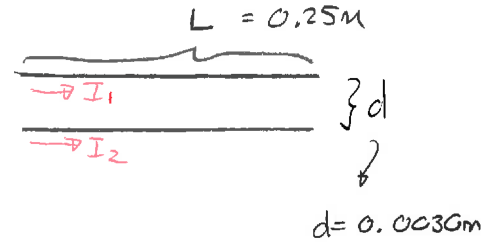
The magnetic field exerts a force on current 2. Use usual rules for this force.



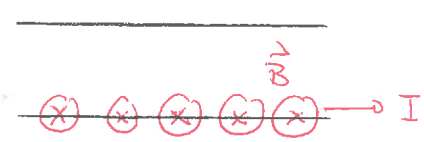
Thus we see:

In general one current will exert a force on a neighbouring current.

Example: Two closely spaced parallel wires are as illustrated. They each carry current of 4.0 A. Determine the force exerted by the upper wire on the lower.



Answer: The upper wire produces a magnetic field into the page. The magnitude of the field is



$$B = \frac{\mu_0 I_1}{2\pi d}$$ ← distance from wire 1

Then this field exerts a force with magnitude

$$F = I_2 L B \sin\alpha$$

$$= I_2 L \frac{\mu_0 I_1}{2\pi d} \quad \text{since } \alpha = 90°$$

$$F = \frac{\mu_0 I_1 I_2 L}{2\pi d}$$

$$= \frac{4\pi \times 10^{-7}\ Tm/A \times 4.0A \times 4.0A \times 0.25m}{2\pi \times 0.0030m} = 2.7 \times 10^{-4}\ N$$

The direction of the force is ↑.

This example illustrates the fact that

Parallel currents attract, opposite currents repel

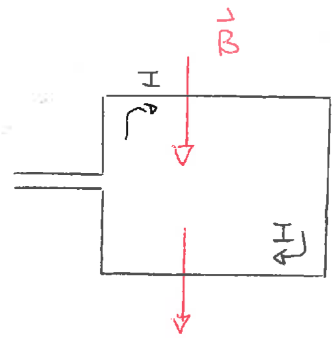
Warm Up 1

Quiz 1 Typo on option 3 10%-80%

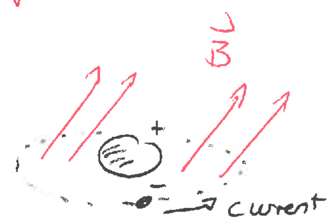
Magnetic forces on a current loop.

There are often situations in which a loop of current is situated in a magnetic field. For example:

1) loop of current in a motor and other electrical machinery

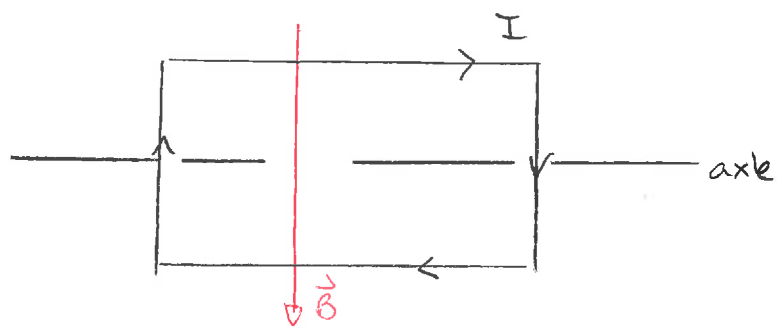


2) effective loops of current in molecular and atomic systems



We will consider a rectangular loop in a uniform magnetic field.

Quiz 2
Quiz 3
Quiz 4



By analyzing the forces on all sides we see that the loop rotates about the indicate axle.

Demo: Show PVC loop

Demo: Show PSU motor (on local page)

Demo: Show our motor.