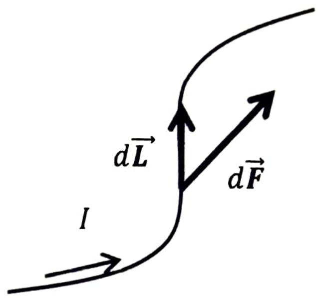
Section	Group	Name	Signature
Grade			
		Jacob Harkins	[illegible]

After this activity you should know: *• the magnetic force on an infinitesimal current segment in a magnetic field. • the magnetic force on a finite current element and how the expression simplifies if the magnetic field is uniform. • include the magnetic force and Newton's 2nd law.*

The magnetic force $d\vec{F}_B$ on a infinitesimal segment of current I is

$$d\vec{F}_B = I\, d\vec{L} \times \vec{B}$$



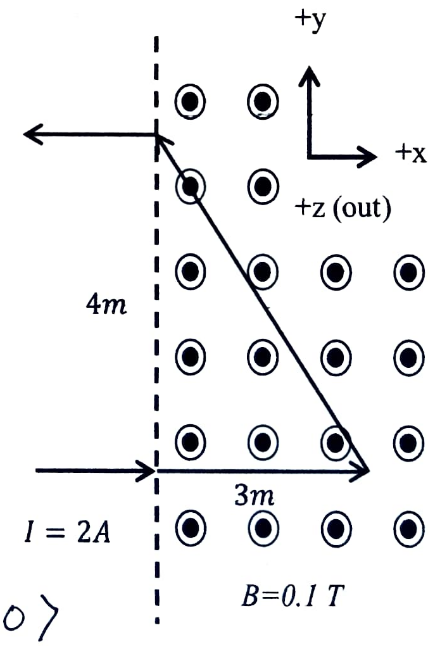
Where $d\vec{L}$ is the displacement vector of the infinitesimal current segment. The total magnetic force on a finite current segment is

$$\vec{F}_B = I \int (d\vec{L} \times \vec{B})$$

1. If the magnetic field is uniform in space the magnetic force on current simplifies to $\vec{F}_B = I\,(\vec{L} \times \vec{B})$. What is vector $\vec{L}$ in this expression? Choose one.

- $\vec{L}$ is the length of the current segment
- $\vec{L}$ is the vector from the point where the current enters the uniform field to the point where the current leaves the uniform field.
- $\vec{L}$ is the current.

2. The magnetic field is zero to the left of the dashed line. The magnetic field to the right of the dashed line is uniform outwards. A current carrying wire goes through the region as shown.



a. What is the magnetic force on the portions of the wire to the left of the dashed line?

0

b. What is the magnetic force on the bottom wire segment? Write answer in component vector form.

$\langle 3,0,0\rangle \times \langle 0,0,.1\rangle$

2(~~[illegible]~~ × $= 2\langle 0,-.3,0\rangle$

c. What is the magnetic force on the slanted wire segment? Write answer in component vector form. *Note that the displacement for this wire segment is* $\vec{L} = -3m\hat{\imath} + 4m\hat{\jmath}$.

$2\,(\langle -3,4,0\rangle \times \langle 0,0,.1\rangle) = 2\langle 0.4,0.3,0\rangle$

d. What is the total magnetic force on the wire? Answer in component vector form.

$2\langle 0.4,0,0\rangle$

e. Notice that the final answer in (d) was relativitely simple even though a relatively long calculation was required to find this answer. Often this means that there was an easier way to obtain the result. In this cases, the net magnetic force on the current is

$$\vec{F} = (I\vec{L}_1 \times \vec{B}) + (I\,\vec{L}_2 \times \vec{B}) = I(\vec{L}_1 + \vec{L}_2) \times \vec{B} = I\vec{L} \times \vec{B}$$

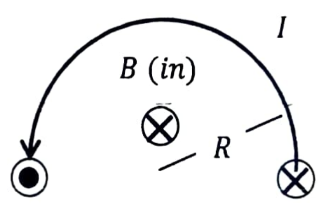
where $\vec{L} = \vec{L}_1 + \vec{L}_2$. What is $\vec{L}$ for this current segment. Write in component vector form.

$\vec{L} = \langle$ ~~m~~ , $\langle 0, 4, 0 \rangle$

f. Use your result for $\vec{L}$ to determine the net magnetic force on the wire segment. Make sure your answer agrees with (d).

$2\langle 0.4, 0, 0 \rangle$

3. A wire carries current I into the page on the right, through a half circle of radius R and out of the page on the left. A uniform external field B points inward as shown.



a. What is the direction (in/out/left/right/top/bottom/zero) and magnitude of the force exerted by the external magnetic field on the portion of the current going into the page?

~~Down $\frac{\mu_0 I}{4\pi R}$~~ 0

b. What is the direction and magnitude of the force exerted by the external magnetic field on the portion of the current going out of the page?

0

? c. What is the direction and magnitude of the net magnetc force on the wire?

~~$\frac{\mu_0 I}{4\pi R}$~~ $I(\langle -2R, 0, 0 \rangle \times \langle 0, 0, -B \rangle)$

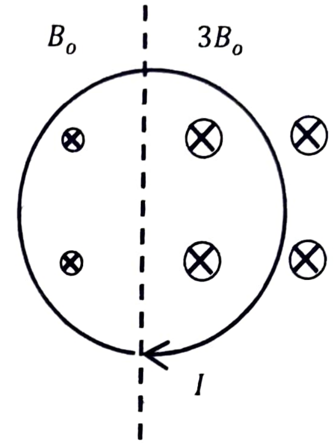
$= I\langle 0, -2RB, 0 \rangle$

*Comment: the magnitude is **not** $F_B = \pi IRB$.*

d. The magnetic field created by the outgoing current will exert a force on the incoming currrent. Why didn't we need to consider this force when we calculate the **net** force on the current?

They will cancel each other out.

4. A circular current loop of radius R carries current I. There are two region of uniform magnetic field in directions and magnitudes shown. What is the direction and magnitude of the net magnetic force on the loop?



$I(\langle 0, 2R, 0\rangle \times \langle 0, 0, B_0\rangle + \langle 0, -2R, 0\rangle \times \langle 0, 0, 3B_0\rangle)$ ⊗

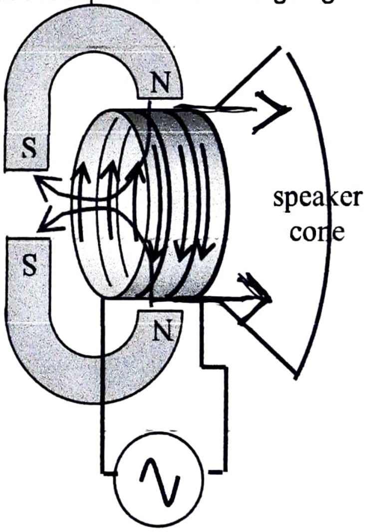
$\langle 2RB_0, 0, 0\rangle + \langle -6RB_0, 0, 0\rangle$

$I\langle -4RB_0, 0, 0\rangle$

5. A speaker consists of a coil of wire attached to a speaker cone. A permanent magnet sits behind the coil. The coil is then connected to an amplifier which is essentially an alternating current (AC) power supply. We want to understand the role of the magnet in the speaker.

   a. Open https://www.edumedia-sciences.com/en/media/356-loudspeaker to observe a simulation of a speaker. Click on the speaker to see the magnet and coil inside the speaker.

   b. The current in the speaker coil will constantly reverse directions at the frequency of the sound to be produced. Consider an instant in time when the current is coming out of the page at the top of the coil and going into the page at the bottom.



      i. Draw an arrow showing the direction of the magnetic force on the top of the coil where the current is coming out of the page. *Notice that the magnetic field lines are essentially vertical at the coil.*

      ii. Draw an arrow showing the direction of the magnetic force on the bottom of the coil where the current is going into the page.

      iii. What is the direction (in/out/left/right/top/bottom/zero) of the net magnetic force on the coil?

Right

   c. What is the direction of the net magnetic force of the coil if the current was in the opposite direction (in at the top and out at the bottom)?

Left

   d. How does the speaker produce sound at the correct frequency and why is a magnet required for it to work?

It alternates the current at proper intervals and strength to push the magnet which pushes air and create sound waves. The magnet allows the current to create a force

6. A rod hangs from two wires as shown. A current I goes down one wire, through the conducting rod into the page, and then up the second wire. The rod has a mass M and length L. The wire hangs at an angle θ from vertical and an external magnetic field B points at the same angle θ.
   a. Draw a free body diagram showing the forces acting on the rod.
   ? b. Determine the current I.