Section	Group	Name	Signature
Grade			
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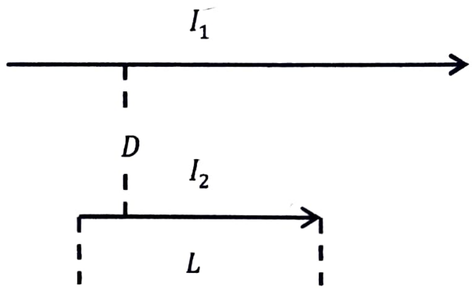
Materials: • *none*

After this activity you should know: • *Be able to combine the magnetic field of a long straight wire and the magnetic force on a current to determine the magnetic force between two long straight currents* • *Recognize when currents will attract and when they will repel.*

1. Two wires separated by a distance D carry current I_1 and current I_2 in the same direction. We want to find the magnetic force on a segment of length L of current 2.



   a. What is the direction (in/out/left/right/top/bottom) and magnitude of $\vec{B}_1$, the magnetic field generated by I_1 at location I_2? Assume that wire 1 is very long.

   $\frac{\mu_0 I}{2\pi D}$ in

   b. What is the direction of the magnetic force exerted by current 1 on current 2?

   $I_2 L \frac{\mu_0 I}{2\pi D}$

   c. What is the magnitude of the magnetic force exerted by current 1 on current 2?

   $I_2 L \frac{\mu_0 I}{2\pi D}$

   d. What is the direction of the magnetic force that current 2 exerts on current 1?

   Down

   e. Based on your results do parallel currents attract or repel each other?

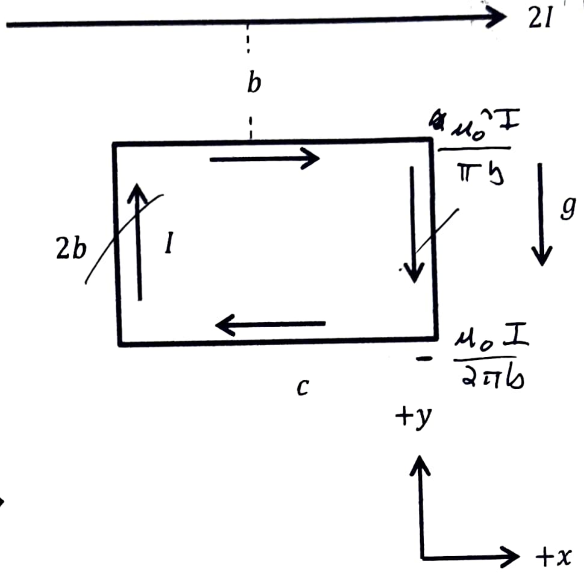
   Attract

   f. Now assume I_2 is opposite the direction of I_1. Do anti-parallel currents attract or repel each other?

   repel

2. A rectangular frame of sides $2b \times c$ has current I and mass m. It is a distance b below a very long wire carrying current $2I$. What is the acceleration of the frame? Give answer in component vector form.

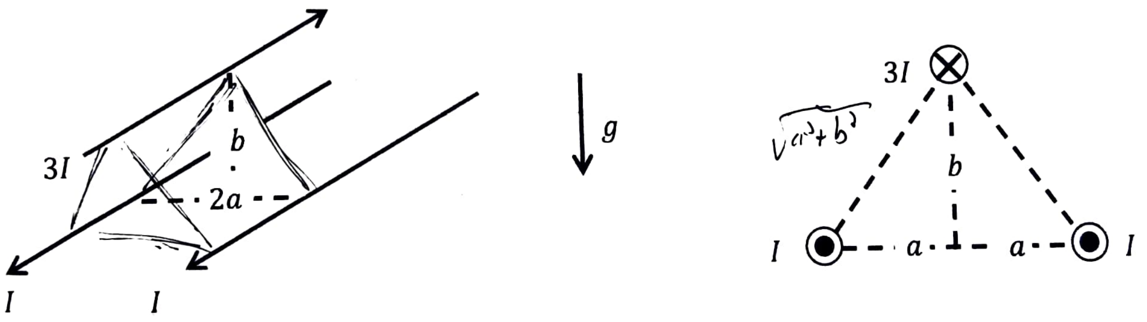
$F_y = ma = Ic\frac{\mu_0 I}{\pi b} - Ic\frac{\mu_0 I}{2\pi b} - mg$



$a = \langle 0, Ic\frac{\mu_0 I}{2\pi b}, 0\rangle \frac{1}{m}$

$a = \frac{1}{m}\langle 0, Ic\frac{\mu_0 I}{2\pi b} - mg, 0\rangle$

3. Three very long wires carries currents I and $3I$ as shown. The top wire is in instantaneous equilibrium a distance b above the midpoint between the two lower wires which are separated by a distance $2a$. The bottom wires are fixed in place. What is the mass per length μ of the top wire? *Hint: Draw a free body diagram for a length L of the top wire. When you solve for the mass per length, the length L will drop out of the answer. Use your results from the first page for the magnitude and directions of the magnetic forces between currents.*

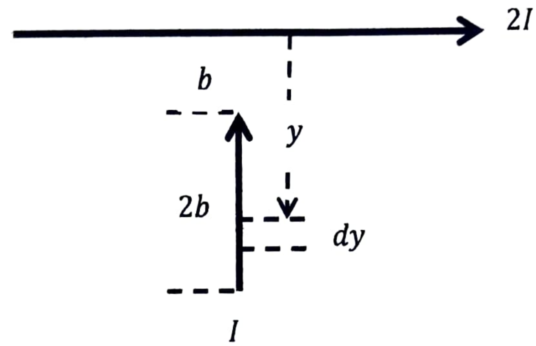


$B = 2\left(I\langle 0, \frac{\mu_0 I \cdot b}{2\pi (\sqrt{a^2+b^2})^{3/2}}, 0\rangle\right)$

$F_y = ma = IL$

4. **BONUS (3) – You must finish the rest of worksheet to receive credit on bonus:** We want to return to problem 2 and determine the magnetic force on a vertical segment of the frame due to the longer wire. The magnetic field due to the long current will be different points on the second current so we will need to integrate to find the force on the wire segment. We introduce a integration variable y defined as shown.

   a. What is the direction and magnitude of the magnetic force $d\vec{F}_B$ on the small segment dy shown?



$$I\, \vec{dL} \times B$$

$$= I\, \langle 0, dy, 0 \rangle \times \langle 0, 0, \frac{-\mu_0 I}{\pi y} \rangle$$

$$= I \langle \frac{-\mu_0 I\, dy}{\pi y}, 0, 0 \rangle$$

   b. Write the integral (including limits) that would give you the magnetic force on the entire vertical segment.

$$-\frac{\mu_0 I^2}{\pi} \int_b^{3b} \frac{dy}{y}$$

   c. Evaluate the integral. Please simplify as much as possible.

$$\boxed{\frac{-\mu_0 I^2}{\pi} (\ln(3))}$$