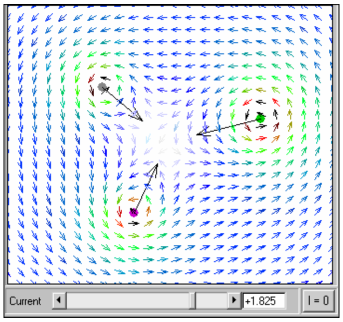
Worksheet for Exploration 28.3: Wire Configurations for a Net Force of Zero



The purple wire and the green wires have fixed currents and fixed positions. You can change the current in the gray wire by using the slider and you can also drag the gray wire around to new positions. The animation shows the magnetic field vectors as well as the force on the wires. You can also add field lines by double-clicking.

a. What are the directions of the currents in the green and purple wires?

Direction Green_________________

Direction Purple_________________

b. Which one carries a larger magnitude of current? Explain.

Keep the current in the gray wire at zero (you can use the *I = 0* button to set the current to zero). Move the gray wire to a spot where the magnetic field is zero. (You will need to measure where B is zero and then place the gray wire there). Now increase the current in the gray wire.

c. Why is the force on the gray wire zero?
   i. Identify all objects that may exert a force on the gray wire.

d. Why isn't the force on the other wires zero?
   i. Identify all objects that may exert a force on the purple wire,
   ii. the green wire.

e. Is the force on the other wires different from the force on those wires before the current was turned on in the gray wire? Explain.

With current in the gray wire, move it to some point where the force is nonzero. The force on the wire is due to the current in the gray wire and the magnetic field it sits in (due to the other wires), $\mathbf{F} = q\, \mathbf{v} \times \mathbf{B} = I\, \mathbf{L} \times \mathbf{B}$, where $\mathbf{L}$ is the length of the wire and points in the direction of the current in the wire. (that "x" means cross product here) To determine the direction of the force, then, you use the right hand rule. Turn the current off in the gray wire.

f. What is the direction of the net magnetic field (make a sketch)?

Direction of magnetic field at your chosen location____________

g. Positive current comes straight out of the computer screen (negative current is into the screen). Therefore, in what direction is $I\, \mathbf{L} \times \mathbf{B}$ for negative current (indicate this on your sketch). Try it and verify your answer.
   i. Your sketch should have the same view as the simulation screen (top down). Quantities into paper is usually indicated with an "X" out of the paper by a dot "•". Also include direction for B and the direction of the force on the gray wire.

h. With a negative current, where does the gray wire need to be located so that the force on the purple wire is zero? So that the force on the green wire is zero? Explain.
   i. After you find these positions, you should be able to use the known current in the gray wire, and the positions to determine the currents in each of the other wires. Do so.

Purple wire: Zero position: x=_______ y=_______

Green wire: Zero position: x=_______ y=_______

Purple Current=_______

Green Current=_______

ii. You are able to use the position of the gray wire with current running through it to help determine the currents through either of the other wires. If you make the current in the gray wire zero, then you can still use the simulation to determine each of the other currents. Discuss how to make such measurements (just describe the procedure needed to find I's).

i. If you change the current, how does your answer to Part (h) (positions) change? Explain.

Try a different configuration.

j. Where will the force be zero on the gray wire when it has a current flowing in it?

k. If the gray current has a current of about -1A, where do you have to put it in order to get the force on the green wire to be zero? Where do you have to put it in order to get the force on the purple wire to be zero? Where do you have to put it in order to get the force on the yellow wire to be zero? Explain.