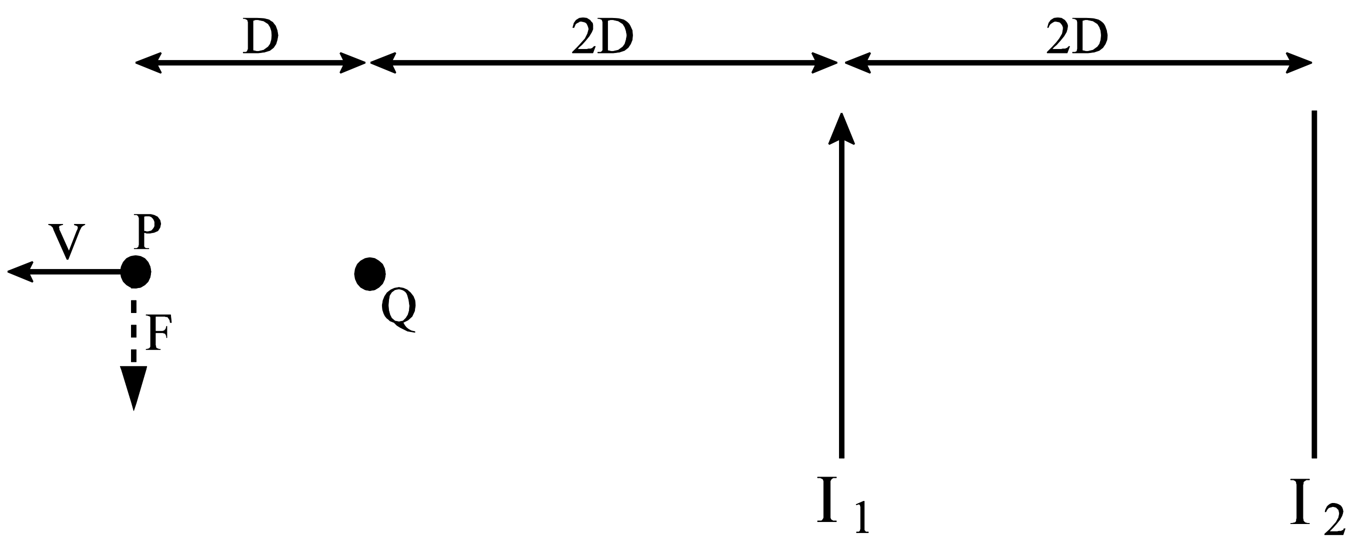
First Name: ____________________ Last Name:________________________________

The diagram (which will be used for Questions #1-6) shows two infinite line currents but you do not know the current direction for one of them. These are the only sources of magnetic field present.



1. On the diagram, draw the magnetic field due to I_1. To avoid complicating the diagram, keep your drawing confined to the region near I_1.

2. A positive charge at point P is moving to the left as shown. It experiences a downward force F. What does this tell you about the magnetic field at point P? Explain your reasoning. (You may assume that $\vec{B}$ is perpendicular to $\vec{v}$.)

3. In what direction does I_2 flow? Explain your reasoning.

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4. On the diagram, draw the magnetic field due to I_2. To avoid complicating the diagram, keep your drawing confined to the region near I_2.

5. If that same positive charge had been moving to the left at point Q, it would not have experienced any deflection. Use that information to determine I_2 in terms of I_1.

6. Are there any other points (other than point Q and any point infinitely far away) where the deflection would have also been zero? If there are, determine/describe their exact locations. If there are not, explain why not.

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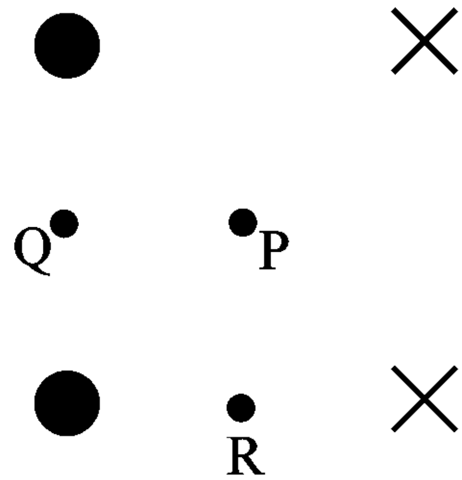
There are four infinite parallel currents arranged in a square of side L. All four currents have the same magnitude (I). Use this diagram for Questions #7-11.



7. Determine the direction of the net magnetic field at point P. You should certainly include a vector addition diagram as part of your solution.

8. Determine the magnitude of the magnetic field at point P.

9. There is a negative charge moving at point P. What velocities can it have so that the magnetic force on it is to the left? Explain your reasoning.

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10. You need to add another current so that $B_P = 0$. A classmate suggests that you run a current through point R parallel to all the others. Could this work? If it could, determine the direction of that current and its magnitude in terms of I. If it could not, explain why not.

11. Now remove any current you added as a result of Question #10. You again need to add another current so that $B_P = 0$. A different classmate suggests that you run a current through point Q parallel to all the others. Could this work? If it could, determine the direction of that current and its magnitude in terms of I. If it could not, explain why not.

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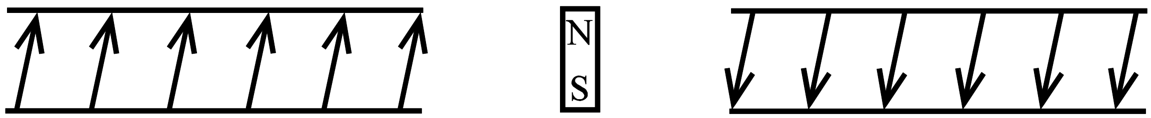
The diagram shows two finite solenoids with their symmetry axes aligned. The arrows indicate the current direction on the part of the solenoid above the page.

12. Draw the magnetic field for each solenoid. Do not let the drawings overlap.

13. If the solenoids were released from rest, would they attract each other, repel each other or stay in place? Explain your reasoning.



14. The solenoids are fixed in place and a bar magnet is placed *exactly* halfway between them and is oriented as shown. It is released from rest. Is there a net force on the bar magnet? Explain. Is there a net torque on the bar magnet? Explain. If it moves, explain its future motion as accurately as possible.

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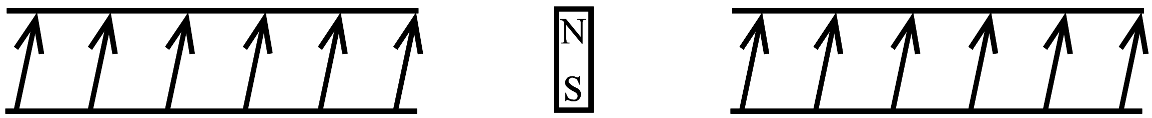

15. The same bar magnet is now placed *exactly* halfway between two solenoids with their currents in the same direction. It is released from rest. Is there a net force on the bar magnet? Explain. Is there a net torque on the bar magnet? Explain. If it moves, explain its future motion as accurately as possible.

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Comments about this Tutorial:

This can be used in either algebra-based or calculus-based courses.

This tutorial consists of three separate activities (Questions #1-6, #7-11, and #12-15). When it was used in the spring of 2016 and 2017 in calculus-based classes, the three different sets of activities were used in three consecutive regular "lecture" class periods (rather than during one of our 50 minute tutorial days).

The students (who were not so much working in groups here but were more just working with the person sitting next to them/behind them/etc.) were able to complete Questions #1-6 in less than 15 minutes.

Questions #1 and #4: I'd prefer they draw these fields just by drawing dots and X's. Many students start drawing circles around the wire and sometimes they don't have arrows on them or they're just drawn at a weird angle so you can't really tell the direction.

Question #6: Maybe 20% of the students are able to realize that there are an infinite number of solutions.

The very next "lecture" began with Questions #7-11. By this point in time, they were pretty comfortable using right hand rules but their calculation skills were still suspect. They had 15 minutes for this which worked out pretty well.

Questions #7 and #9-11: Answered pretty well.

Question #8: Definitely more problems here: Getting the radius correct. Getting the component correct, etc.

One "lecture" later I had them work on Questions #12-15. The field from a solenoid was just introduced to them immediately prior to the activity. Again, 15 minutes should be sufficient for these questions.

Questions #12-13: They performed pretty well.

Questions #14-15: These were definitely much more difficult. There are a wide variety of mistakes here.

Tutorial Source(s):

All questions were written by Drew Milsom.

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