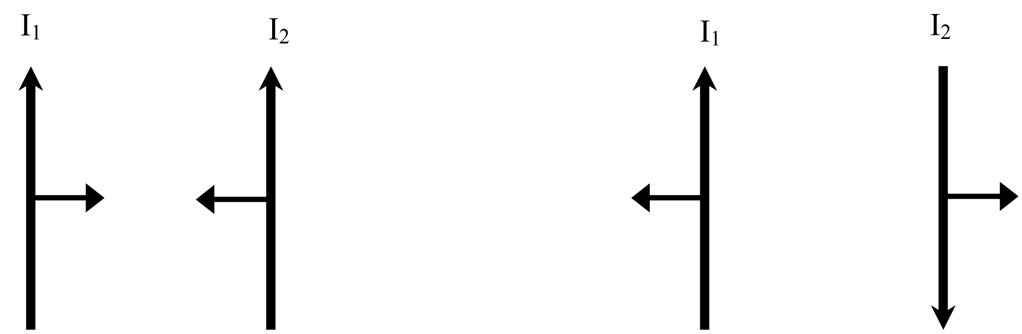
Chapter 9 Magnetic Forces and Magnetism

In-Class Questions

Introduction: We already know that charged particles exert forces on each other – pushes and pulls – even when they are not moving. It turns out that when they *are* moving, a different sort of force arises. We will discuss the forces that electric *currents* – that is, charges in motion – exert on each other.

Suppose we have two long straight wires of equal length, parallel to each other, each carrying an electric current as shown in the diagram. It can be shown in a simple experiment that if the currents flow in the *same* direction, the wires attract each other. However, if the currents in the wires flow in *opposite* directions, the wires repel each other. This is indicated in the diagram by force vectors. Let's make some "educated guesses" about how we might make those forces stronger, or weaker.



1. Suppose we keep the currents flowing in the wires the same, but we pull the wires farther apart. Do you think the magnitude of the forces acting on the wires will:
    A. increase
    B. decrease
    C. remain the same
    D. first get larger, then get smaller
    E. first get smaller, then get larger

2. Now suppose we keep the distance between the wires the same, but we increase the flow of current in just one of the wires. Do you think the magnitude of the forces acting on the wires will:
    A. increase
    B. decrease
    C. remain the same
    D. first get larger, then get smaller
    E. first get smaller, then get larger

3. Suppose we keep the distance between the wires constant, *and* we keep the amount of current flowing in the wires constant. But now, we make both wires *longer.* Do you think the magnitude of the *total* force acting on the wires will:
   A. increase
   B. decrease
   C. remain the same
   D. first get larger, then get smaller
   E. first get smaller, then get larger

4. Let's let I_1 stand for the magnitude of the current in the first wire; and I_2 stand for the current in the second wire. Let L be the length of the wires, and r represent the distance between the wires. Using these symbols, which of the following mathematical equations is consistent with the answers to questions #1-3:
   A. $F = I_1I_2\ r/L$
   B. $F = I_1I_2\ L/r$
   C. $F = r/L\ I_1I_2$
   D. $F = L/r\ I_1I_2$
   E. $F = rL\ I_1I_2$

5. Let's start out with the current flowing "upward" in both wires (i.e., the current is flowing in the same direction in both wires, from the bottom of the page toward the top of the page). We will keep the amount of current constant in both wires. As described in the introduction, each wire experiences a force pulling it toward the other wire. Now suppose we slowly rotate one of the wires about its center point so that eventually, the current is pointing *out* of the page; that is, so the current is now flowing directly toward you. (Later we will continue turning the wire, until it is "upside down.") Based on what was said in the introduction, what would you expect to happen to the force acting on the turning wire while we turn it so that the current flows outward toward your direction?

   A. The force will not change at all.
   B. There will still be a force pulling it towards the other wire, but it gets stronger.
   C. There will still be a force pulling it towards the other wire, but it gets weaker.

6. When the wire is turned so that the current flows directly at you, that is, at a 90º angle to its original direction, what would you guess would be true about the magnitude of the net force on the wire?
   A. It will be stronger than at the beginning.
   B. It will be weaker than at the beginning, but not zero.
   C. It will be zero.

7. (Answer this question based on the answer to #6.) When will the net force on the wire on the right be *zero*?
   A. It will never be zero.
   B. When the current flows upward.
   C. When the current flows downward.
   D. Only when the current flows out toward you.
   E. When the current flows out toward you, *or* when it flows directly "in" toward the page.

Suppose we cover up the wire on the left with a black cover, so that nobody can see it (but we keep the current flowing in it.) If someone should come along and make measurements on the wire on the right, they would find that a force is acting on it. As long as they don't *turn* the wire, they would find that the magnitude of the force depends on only three things: (1) the current I flowing in that wire, (2) the distance r of that wire from whatever is under the black cover, (3) the length L of the wire. There is something "unknown" being produced under the black cover that seems to be causing the force. Let us represent this "unknown" source by the symbol B.

8. What equation would be consistent with what is observed in this case?
   A. $F = B/IL$
   B. $F = I/BL$
   C. $F = BI/L$
   D. $F = BL/I$
   E. $F = L/BI$
   F. $F = BIL$

9. Now, suppose this observer starts to *turn* the wire, rotating it about its center point. They will find that the force also depends on the *angle* through which they turn it. Suppose an angle of 0º represents the position when the current is flowing inward away from you, and 90º represents the original position, when the current in the wire is flowing straight up. Then a 180º angle will represent the position when the current is flowing outward toward you, and 270º (or –90º) will represent the angle when the current is flowing straight down. Which of the following equations might be consistent with the observations?
   A. $F = BIL \sin\theta$
   B. $F = BIL \cos\theta$
   C. $F = BIL \tan\theta$
   D. $F = BIL\theta$