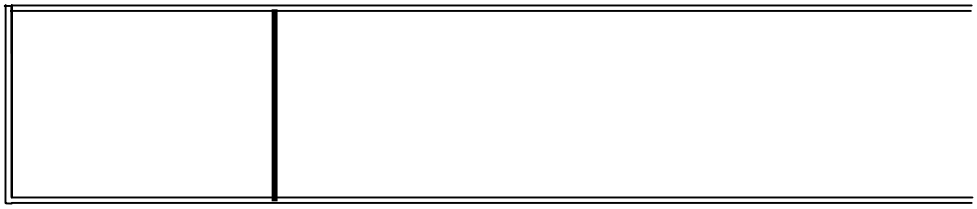
Motional EMF Worksheet



In the diagram above, a uniform magnetic field B is pointing out of the page. The metal bar (length *l*) can slide along the two parallel metal rails.

1. Suppose you push the bar at constant velocity *v* toward the right. Will there be any force acting on the positive charges in the metal bar? If not, explain why not. If so, what would be the magnitude and direction of the force on each charge *q*? (Draw an arrow to indicate direction.)

2. Suppose the positive charges in the bar are free to move. Would they move, and if so in which direction?

3. Suppose the positive charges moved from one end of the bar to the other. We want to find out what happens to the energy of the charges as they move through the bar. One way to do this is to consider any work that might be done on the charges as they move.

    A) First, state the definition of work.

    B) Would work be done on the charges as they move through the bar?

    C) If yes, would the work be positive or negative? Explain. (*Hint:* Consider the direction of the force, and the direction of the displacement.)

    D) How much work would be done on each charge as it moved from one end of the bar to the other?

4. In this situation (as you push the bar), is any work being done by nonconservative forces? If so, by what?

5. What is the relationship between the energy of an object, and the work done on it by nonconservative forces?

6. Remember we have already discussed the fact that, when charges are forced to move through conducting materials by an electric field, their average velocity doesn't change (due to "drag" from collisions with the atoms in the conductor). With that in mind, determine whether the potential energy of the charges changes as they move through the bar. Would the potential energy increase, decrease, or remain the same?

7. If the potential energy changes, by how much does it change for each charge q as the charge moves from one end of the bar to the other?

8. What is the relationship between potential energy, and electric potential?

9. Does the electric potential of the charges increase, decrease, or remain the same as they move through the bar? If it increases or decreases, by how much?

10. Based on your answer to #9, would you say that the effect of what happens in the bar is equivalent to the action of a battery, a resistor, or neither? Explain.

11. Suppose the total resistance in the bar + rails + crosspiece is R. What is the current that would flow in this 4-sided circuit?

12. At a moment when the distance from the bar to the crosspiece is L, how much magnetic flux is there through the rectangular loop formed by the four pieces?

13. After a time Δt (while the bar is being pushed to the right), what will be the flux through the loop?

14. What is the *change* in the flux through the loop, during this time period?

15. According to the relationship we have studied regarding magnetic induction (Faraday's law), should there be a current flowing around the loop? Explain why or why not.

16. If there is a current flowing in the loop, find an algebraic expression for the amount of this current:

    A) First, write down the relationship needed to find induced current in terms of magnetic field, etc.

    B) If you have not already done it, write this expression in terms of the magnetic flux (Φ_{mag}).

    C) Now use your previous answers to find the current.

17. Does your answer to #16 agree with your answer to #11?