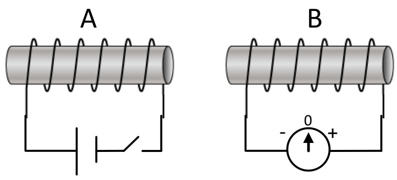
Electromagnetic Induction

Problems Worksheet

1. The diagram below shows the arrangement of two solenoids. Solenoid A is connected to an EMF source with a switch starting in the open position.



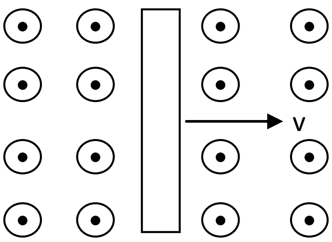
Describe and explain the observation made of the ammeter connected to solenoid B during each of the following events:

   a. The switch is moved from the open position to the closed position.

   b. The switch remains closed for an extended time.

   c. The switch is moved from the closed position to the open position.

2. A 2.50 m long copper pipe moves through a uniform 28.0 T magnetic field at a rate of 8.50 ms^{-1} as shown in the diagram below.



   a. Indicate on the diagram of the pipe the locations of the build up of positive and negative charges. Also draw the direction the current flows through the pipe to establish this separation of charge.

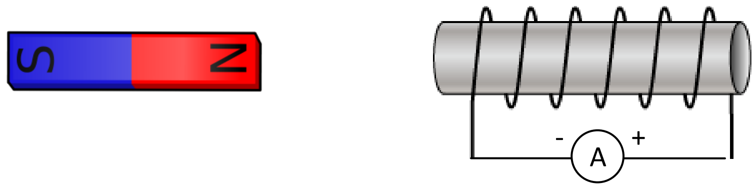
   b. Calculate the magnitude of the EMF induced across the pipe.

3. A 15.0 cm diameter circular loop of wire has a 5.00×10^{-2} T field passing through it, perpendicular to the area of the loop.

    a. Calculate the EMF induced in the loop if the field is doubled in a 1.00 ms time interval.

    b. Calculate the EMF induced in the loop if the field is reversed in a 1.00 ms time interval.

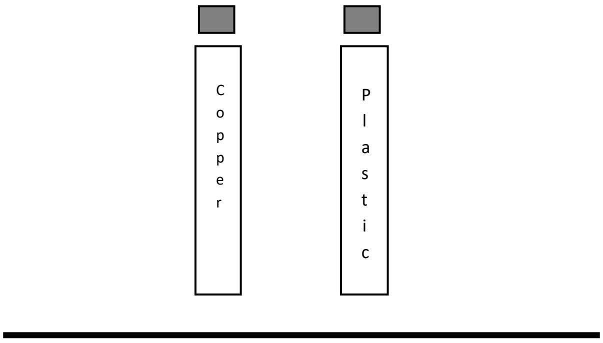
4. The bar magnet shown below is moving towards the solenoid.



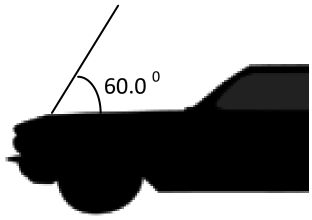
    a. Around the outside of the solenoid only, draw the magnetic field that is produced by the solenoid.

    b. Will the ammeter show a positive or negative current reading?

5. A copper pipe and plastic pipe each has a magnet falling through it with the same initial velocity and height above the ground. Explain which magnet will reach the ground first.



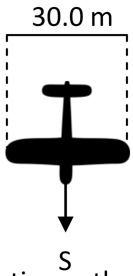
6. A 0.80 m long aerial on a car heading west at 65.0 kmh^{-1} is in a region where the Earth's magnetic field is 52.0 μT and parallel with the surface. The aerial makes a 60.0^{0} angle with the horizontal while the car is in motion.



   a. Calculate the EMF induced in the aerial.

   b. Will a positive charge accumulate at the top or bottom of the aerial?

7. Aeronautic engineers have to be aware of the potential for an EMF to be created across the various parts of planes. A plane with a 30.0 m wingspan is moving 185 ms^{-1} horizontally through a region of air where the Earth's magnetic field is 4.80×10^{-5} T and inclined at 18^{0} above the horizontal. The diagram below is taken from a view point above the plane.



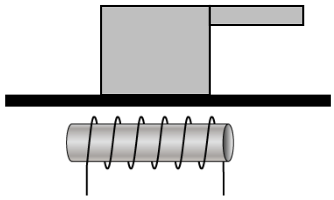
   a. Calculate the EMF across the wing tips as the plane flies south.

   b. Would the pilot detect a build up of negative charge on the wing to his left or to his right?

   c. Explain how the EMF across the wingtips would change if the plane was instead heading towards the west.

8. Induction stove tops consist of a solenoid with AC current underneath a ceramic stove top. When an iron saucepan is placed on the stove it heats up while the ceramic stays relatively cool.

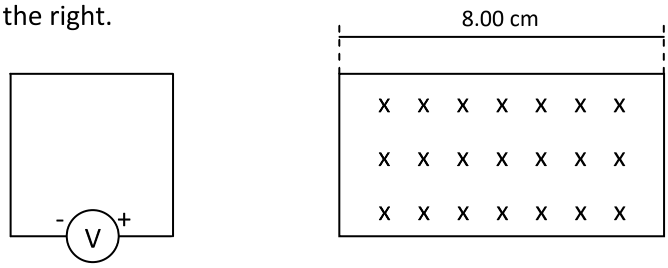
    a. Explain this observation.



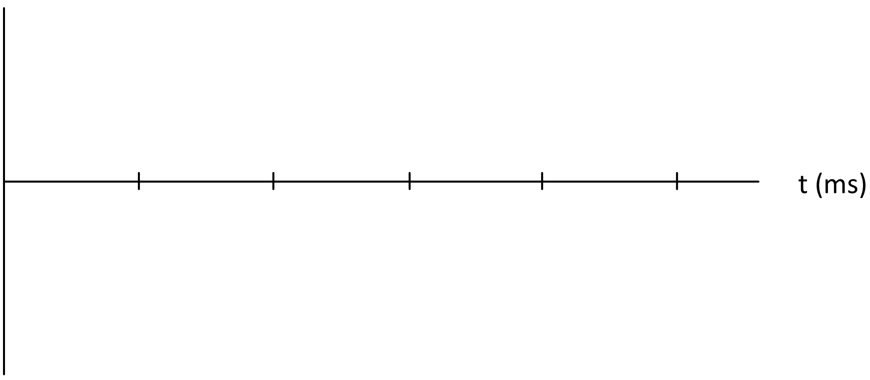
    b. Explain any changes to the observations if copper was used in the construction of the saucepan rather than iron.

    c. Why would the saucepan not get hot if the solenoid was powered by a very powerful battery?

9. The right edge of the 4.00 cm square coil connected to a voltmeter is 4.00 cm from the magnetic field and is moving at 40.0 ms^{-1} towards the right.



    a. Sketch the voltage as measured by the voltmeter over the next 5.00 ms.



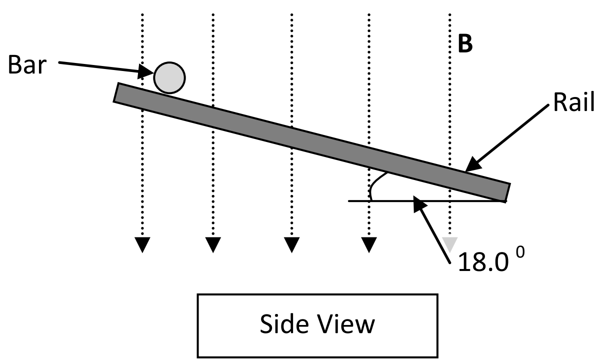
b. Explain how you determined the voltage profile for between t=1.00 and t=2.00 ms.

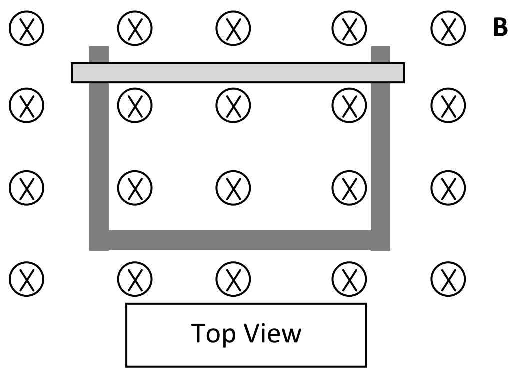
c. Explain how you determined the voltage profile for between t=2.00 and t=3.00 ms.

d. If the magnetic field had a density of 18.0 mT, determine the maximum voltage reading of the voltmeter within the 5.00 ms time frame.

The following questions require knowledge presented in the Gravity and Motion section.

10. A 30.0 cm long, 0.500 kg metal bar is rolling down a frictionless, metal rail inside a vacuum chamber . There is a 3.00 T magnetic field within the chamber. The arrangement of the bar, metal rail and magnetic field are shown in the diagrams below.



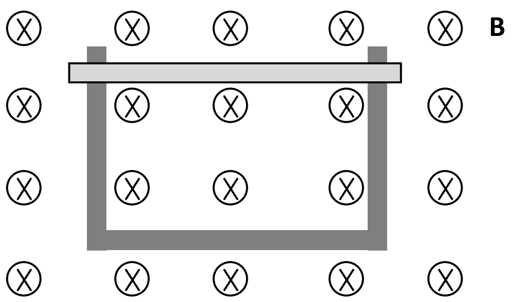


a. Explain why the bar will not accelerate indefinitely, despite being on a frictionless track inside a vacuum. Note: assume the tracks are infinitely long.

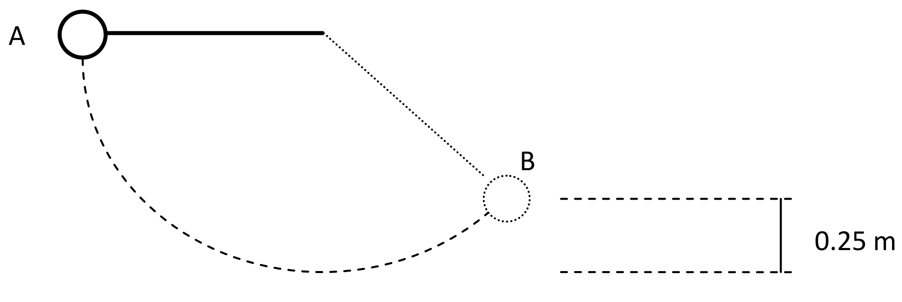
b. Calculate the magnitude of the component of the bar's weight force acting parallel with the rails.

c. Calculate the current passing through the bar once the bar has reached its maximum velocity.

d. Identify all sections of the rail that would be experiencing a force because of the presence of the magnetic field while the bar is rolling. Draw an arrow to indicate the direction of these forces on the diagram below..



11. A 210 g copper pendulum bob is attached to the end of a 1.50 m long cotton string and is held so the string is parallel with the ground (point A). A magnetic field is in the same region, directed vertically upward. The pendulum bob is released and its path is shown by the dashed line. There is negligible air resistance or friction during the motion. The bob reaches point B before swinging back.



a. Explain why position B, the point where the pendulum bob swings back, is not as high as point A.

b. Calculate the work done by the magnetic field on the pendulum bob.

c. Indicate on the diagram where the largest force applied to the bob by the magnetic field would occur. State two reasons why this location would have the greatest application of force.

