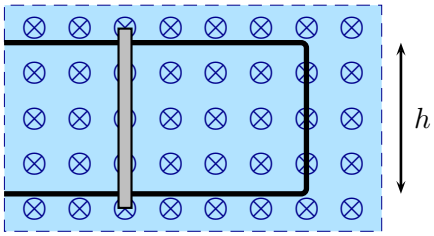
Phys 311
Fall 2019

Electromagnetic Theory: Homework 23

Due: 22 November 2019

1 Sliding bar

A perfect conducting bar with mass m rests on a partial loop of wire as illustrated. The entire arrangement is in a uniform magnetic field as illustrated. The bar is given a brief initial kick to the right with speed v_0. The loop has resistance R.



a) Determine an expression for the current in the loop. In what direction does the current flow?

b) Does the bar move with constant speed after it has been pushed? If not will its speed increase or decrease as time passes? Explain your answers.

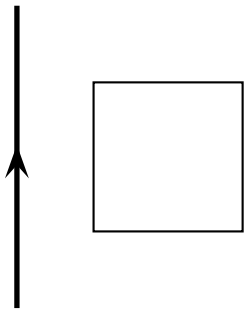
c) Determine an expression for the speed of the bar as a function of time. Use this to determine an expression for the total distance traveled by the bar. Both expressions should only involve the problem variables plus constants.

d) Use the previous results to determine an expression for the current that flows through the loop as a function of time.

e) Determine the total energy dissipated by the current. Does this show that energy is conserved in this situation?

2 Current around a loop being dragged near to a wire

An infinitely long wire lies along the z axis and carries a constant current I. A square loop with sides a is initially a distance d from the wire in the illustrated configuration. The resistance of the loop is R.



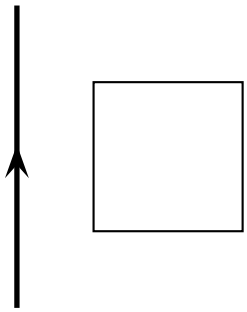
a) The loop is dragged at speed v directly away from the wire ($\rightarrow$ in the diagram). Determine an expression for the current in the loop.

b) The loop is dragged at speed v directly away from the wire ($\rightarrow$ in the diagram). Determine an expression for the magnetic force exerted by the straight wire on the loop.

c) The loop is dragged at speed v directly parallel to the wire ($\uparrow$ in the diagram). Determine an expression for the current in the loop.

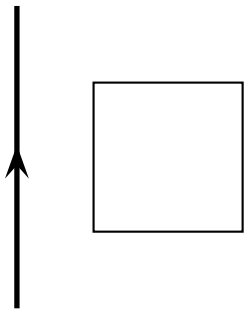
3 Loop kicked toward a current

An infinitely long wire lies along the z axis and carries a constant current I. A square loop with sides a is initially a distance d from the wire in the illustrated configuration. The loop is given a brief kick so that it instantly moves toward ($\leftarrow$ in the diagram) the straight wire. Describe whether the loop will ever reach the wire or not. Explain your answer.



4 Current around a loop near to a wire with an oscillating current

An infinitely long wire lies along the z axis and carries a current $I = I_0 \cos \omega t$. A square loop with sides a is placed a distance d from the wire in the illustrated configuration. The resistance of the loop is R.



a) Determine an expression for the current in the loop.

b) Suppose that the loop is rotated into a new orientation. Its center is in the same place as before, but a corner is nearest to the wire. Will the current in the loop be different to the illustrated orientation? Explain your answer qualitatively.

5 Generator

A rectangular loop with sides a and b is mounted on a vertical axis passing through the middle of the loop. The loop is initially in the the xz plane at $t = 0$. It then rotates counterclockwise about the $+z$ axis with constant angular velocity ω. Determine the EMF induced in the loop in the following cases:

a) There is a uniform magnetic field $\mathbf{B} = B\hat{\mathbf{x}}$ present.

b) There is a uniform magnetic field $\mathbf{B} = B\hat{\boldsymbol{z}}$ present.

c) There is a uniform magnetic field $\mathbf{B} = B_x\hat{\mathbf{x}} + B_y\hat{\mathbf{y}}$ present.

d) Do the results depend on whether the longer edge of the loop is vertical or horizontal?