

Physics 133 Homework 7
Faraday's Law
Due Friday, March 9

Problem 1.

A closed loop of wire has a resistance R . A magnetic field points out of the page. The magnetic flux through the loop is given by:

$$\Phi_m = 8t^2 + 6t \quad (1)$$

where Φ_m is in units of milliwebers and t is in seconds. See the figure on the figures page.

Find:

- a) The magnitude of the EMF induced in the loop.
- b) The direction of the current through the resistor R .

Problem 2.

Consider the two circular loops of wire, which have a common axis. The smaller loop has a radius r , and the larger loop a radius R . They are separated by a distance x , which is large compared to R . (See the figure on the figures page.)

A constant current of magnitude I flows in the larger loop as shown. If the smaller loop is moving away from the larger loop with a speed v , what is the magnitude of the EMF produced in the smaller loop? Assume that the smaller loop is far enough away so that the magnetic field is approximately a constant through the loop.

Problem 3.

Consider the circuit (shown on the figures page) in which there is a constant magnetic field pointing out of the page. The magnitude of the magnetic field increases linearly in time by the expression $B = ct$, where c is a constant.

Find an expression for the current I shown in the figure. Express your answer in terms of a , c and any other constants you deem necessary.

Problem 4.

Consider the circuit shown on the figures page. There is a magnetic field \vec{B} pointing out of the page. A bar of length L slides along the rails with a velocity v_0 :

- a) What is the EMF induced in the circuit?
- b) If the total resistance of the circuit is R , how much current flows in the circuit?
- c) What force is necessary to keep the bar moving with a velocity v_0 ?
- d) At $t = 0$ the velocity of the bar is v_0 , and no force is applied to the bar. What is the velocity of the bar for times $t > 0$?

Problem 5.

An infinite straight wire initially has a current i_0 . Next to the infinite wire is a rectangular wire, with one side a distance b and the other side a distance d from the infinite wire. The length of the rectangle is l . See the figure on the figures page.

At time $t = 0$, the current in the infinite wire is reduced to zero linearly:

$$I(t) = i_0(1 - at) \tag{2}$$

for times $0 < t < 1/a$. After the time $t = 1/a$, the current in the infinite wire remains zero. The resistance of the rectangular loop is R .

- a) Find an expression for the current in the rectangular loop as a function of time. Express your answer in terms of i_0 , b , d , l , a , and any other constants from the laws of electricity and magnetism.
- b) Find an expression for the total charge that flows in the rectangular wire. Note: your answer should be independent of a , the rate at which the current goes to zero in the long infinite wire.

Problem 6.

Find an expression for the self-inductance of a rectangular toroid. The toroid has a total of N turns, the rectangle has dimensions a by b , and the inner side is a distance R from the center of the toroid. See the figure on the figures page.