Physics 133 Homework 7
Faraday's Law
Due Friday, November 30

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:

$$\Phi_m = 8t^2 + 6t \tag{1}$$

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 Voltage 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 $v = dx/dt$, what is the magnitude of the Voltage induced 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 wires are connected so as to have a rectangle of sides a by $3a$ next to a square of sides a. The resistance of the wires per unit length is r. The magnitude of the magnetic field increases linearly everywhere out of the page 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, r 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 Voltage 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 $i_0 0$. 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.

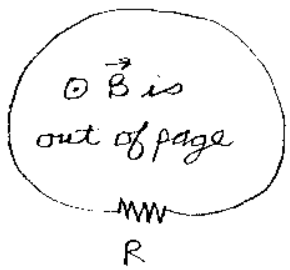
a) Find an expression for the current in the rectangular loop as a function of time. Express your answer in terms of i_0, b, d, l, a, and any other constants from the laws of electricity and magnetism.

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.

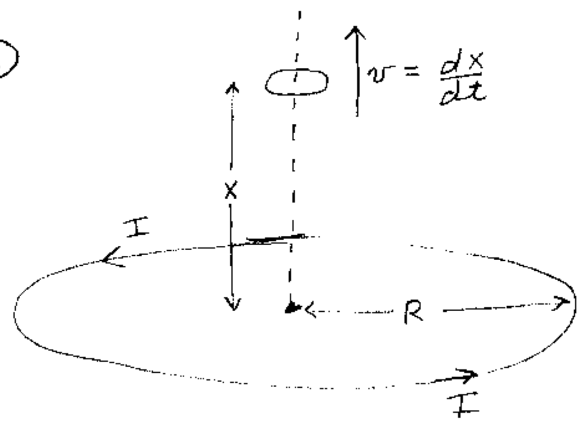
Problem 6.
Find an expression for the self-inductance of a rectangular toroid. The toroid has a total of N turns, the rectangle has dimensions a by b, and the inner side is a distance R from the center of the toroid. See the figure on the figures page.

Figures for HWK 7 Phy 133

(1)



(2)



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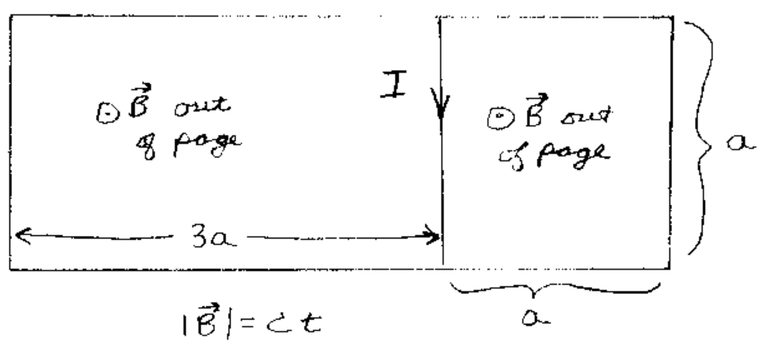

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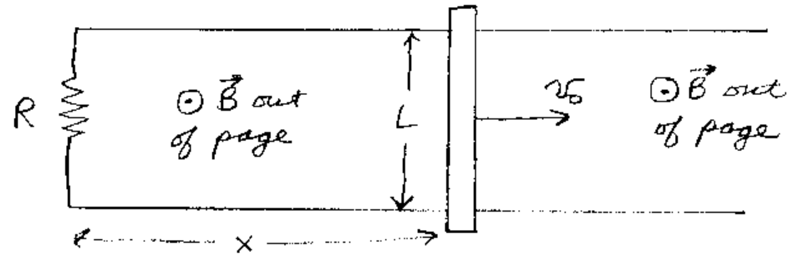
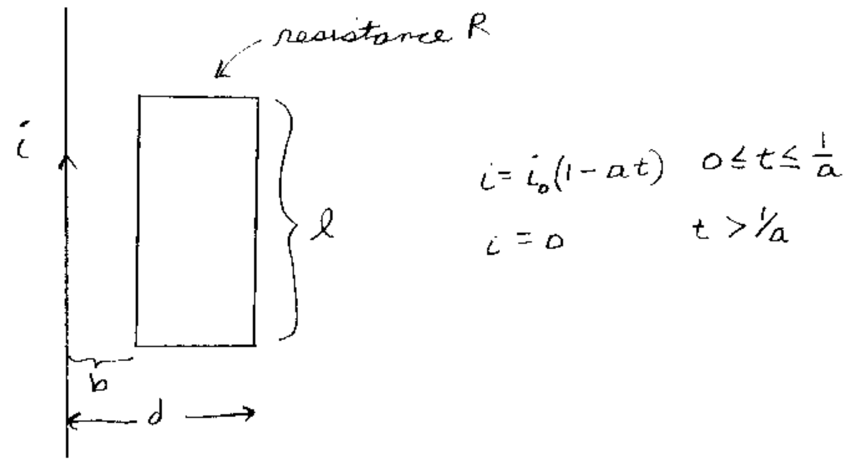
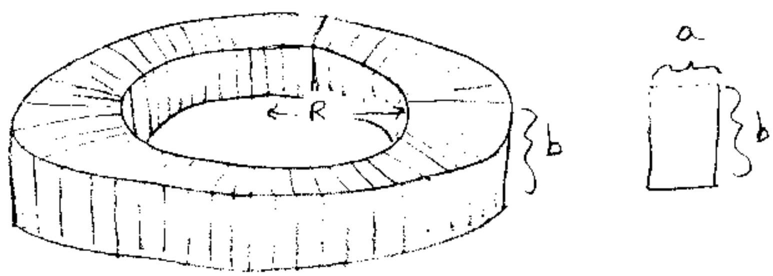

R
⊙ B out of page
L
v₀
⊙ B out of page
x

(5)


resistance R
i
l
b
d
i = i₀(1 − at)   0 ≤ t ≤ 1/a
i = 0   t > 1/a

(6)


R
b
a
b