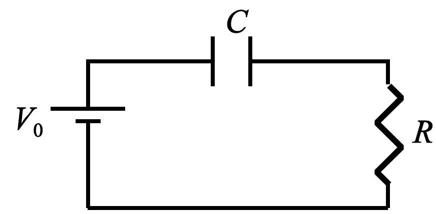
Phys 321 – E&M II – Test 1 – Sept. 23, 2005

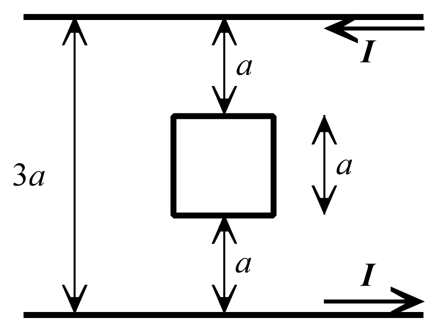
1.(25 pts) Consider charging a capacitor C, by connecting it and a resistor R to a battery of fixed voltage V_0, at time $t = 0$.



a) Set up the circuit equations and solve them to obtain expressions for $Q(t)$ and $I(t)$.

b) Determine the final energy stored in the capacitor by integrating the power supplied to the capacitor, *i.e.*, $\int \frac{Q}{C} I \, dt$.

2.(25 pts) A long solenoid with radius a and n turns per unit length carries a time-dependent current $I(t)$ in the $\hat{\phi}$ direction. Find the electric field (magnitude and direction) at a distance s from the z axis (both inside and outside the solenoid), in the quasi-static approximation.



3.(25 pts) A transmission line can be thought of as two very long wires carrying current in opposite directions so that the wires form a 'loop'. Assume a current I flows down one wire and returns along the other wire. The transmission wires are a distance of $3a$ apart.

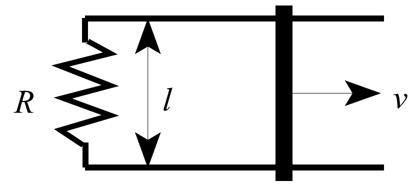
a) A square loop of side a and N turns is placed symmetrically between the two long parallel wires and in the same plane. Determine the magnetic flux through the square loop.

b) Determine the mutual inductance between the long parallel wires and the square loop.

c) If the current in the transmission line 'loop' is given by $I(t) = kt$, where k is a constant, what current is induced in the square loop if it has a resistance R.

d) What direction is the current induced in the square loop, clockwise (CW) or counter-clockwise (CCW)?

4.(25 pts) A metal bar of mass m slides frictionlessly on two parallel conducting rails a distance l apart. A resistor R is connected across the rails, and a uniform magnetic field $\vec{B}$, pointing out of the page, fills the entire region.



a) If the bar moves to the right at speed v, what is the current in the resistor? In what direction does it flow?

b) What is the magnetic force on the bar?

c) If the bar starts out with speed v_0 at time $t = 0$, and is left to slide, what is its speed at a later time t?

d) The initial kinetic energy of the bar was, of course, $\frac{1}{2} m v_0^2$. Where does this energy go? Prove that energy is conserved in this process by showing that the energy gained elsewhere is exactly $\frac{1}{2} m v_0^2$.