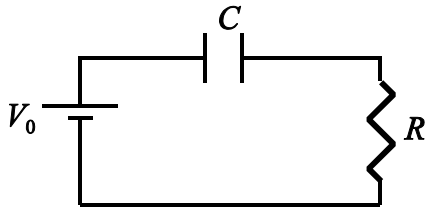
Phys 321 – E & M II – Test 1 – Sept. 24, 2003

1. (25 pts) Consider *charging up* 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 equation and solve for the charge $Q(t)$ and the current $I(t)$.

b) The power supplied to the capacitor is given by $P(t) = I(t)V_C(t) = I(t)Q(t)/C$. Integrate the power supplied to the capacitor to determine the total energy stored in the capacitor.

Recall: $\int_0^\infty x^n e^{-ax} dx = \frac{n!}{a^{n+1}}$

2. (25 pts) A long solenoid with radius *a* and *n* turns per unit length carries a time-dependent current in the $\hat{\phi}$ direction given by $I(t) = I_0(1 - e^{-t/\tau})$, where I_0 and τ are constants. Find the electric field (magnitude and direction) at a distance *s* from the axis (both inside and outside the solenoid), in the quasi-static approximation.

3. (25 pts) A long coaxial cable carries current *I* (the current flows down the surface of the inner cylinder, radius *a*, and back along the outer cylinder, radius $b > a$).

a) Find the magnetic energy stored in a section of length *l*.

b) Find the self-inductance *L* of the coaxial cable in a section of length *l*.

4. (25 pts) A long solenoid with radius *a* and n_1 turns per unit length is surrounded coaxially by a short solenoid with radius $b > a$ of length l_2 with n_2 turns per unit length.

a) Find the self-inductance per unit length of the long solenoid.

b) Find the mutual inductance of the long and short solenoids.

c) If the current in the long solenoid varies as $I(t) = I_0 \sin(\omega t)$, determine the emf (or voltage) induced in the long solenoid and the emf (or voltage) induced in the short solenoid.

d) What is the ratio of the two emf's (or voltages).