PHYS306 Homework#1 (Due on 30Jan2022)

Q#1:

(a) Two metal objects are embedded in weakly conducting material of conductivity σ as shown in Figure 1. Show that the resistance between them is related to the capacitance of the arrangement by $R = \frac{\epsilon_0}{\sigma C}$

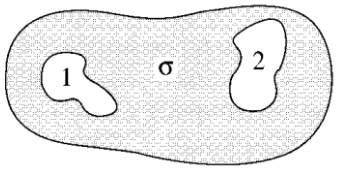

Figure 1:

(b) If a battery is connected between the objects 1 and 2 and charged them up to a potential difference of V_o and then disconnected the charge will gradually leak off. Show that the potential difference between the metal objects decreases exponentially. Also find the time constant of the setup.

Q#2: A metal bar of mass m can slide frictionlessly on two parallel conducting rails a distance *l* apart. A resistor R is connected between the rails and a uniform magnetic field pointing into the page fills the entire region.

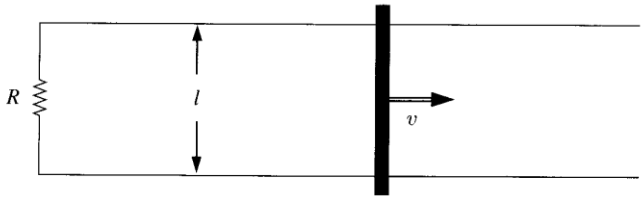

Figure 2:

(a) If the bar moves to the right, what is the current in the resistor? Which direction current will it move?

(b) What is the magnetic force on the bar?

(c) If the bar starts out with a speed v_o at $t = 0$ then what is its speed at a later time t?

(d) The initial kinetic energy was $\frac{1}{2}mv_o^2$, check that the energy delivered to the resistor is exactly $\frac{1}{2}mv_o^2$.

Q#3: A square loop of wire of side *a* lies on a table, a distance s from a very long straight wire, which carries a current I, as shown in Figure 4.

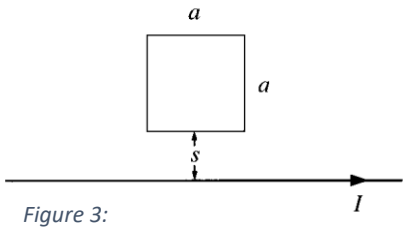

Figure 3:

(a) Find the flux of B through the loop.

(b) If a loop is pulled directly away from the wire, what EMF is generated in the loop. In what direction does the current flow?

(c) What if the loop is pulled parallel to the wire instead of away from the wire, what EMF will be generated and what will be the current in the wire.

Q#4:

A long solenoid of radius a, is driven by an alternating current, so that the field inside is sinusoidal $\vec{B}(t) = B_o \cos(\omega t)\,\hat{z}$. A circular loop of wire of radius *a/2* and resistance R, is placed inside the solenoid, and coaxial with it. Find the current induced in the loop as a function of time.

Q#5:

A square loop of wire, with sides of length a, lies in the first quadrant of the xy-plane, with one corner at the origin. In this region there is a nonuniform time-dependent magnetic field $\vec{B}(y,t) = ky^3t^2\hat{z}$ (where k is a constant). Find the EMF induced in the loop.

Q#6:

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 magnitude and direction of the electric field at a distance s from the axis (both inside and outside the solenoid), in the quasistatic approximation.

Q#7: A square loop of wire, of side a, lies midway between two long wire, 3a apart and in the same plane. (Actually long wires are sides of a larger rectangular loop, but the short ends are so far away that they can be neglected). A clockwise current I in the square loop is gradually increasing $dI/dt = k$ (a constant). Find the EMF induced in the big loop. Which way will the induced current flow.

Q#8: A capacitor C is charged upto a potential V and connected to an inductor L as shown in figure 6. At time t=0 the switch is closed. Find the current in the circuit as a function of time. What will be the current if a resistance R is included in the circuit in series with C and L?

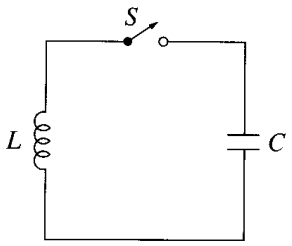

Figure 4:

Q#9:

A long cable carries current in one direction uniformly distributed over its circular cross-section. The current returns along the surface (there is a very thin insulating sheath separating the currents). Find the self-inductance per unit length.