Concepts, principles, relations that apply to the problem:

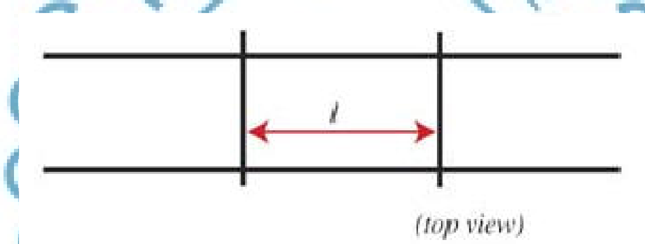
Why do they apply?

How do they apply?

Details of the calculation:

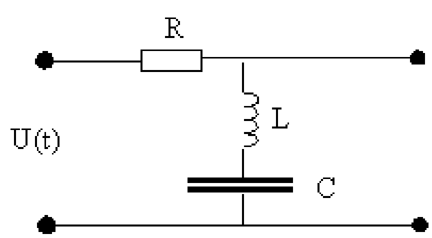
Problem 1:

Two identical conducting bars rest on two horizontal parallel conducting rails. The bars are perpendicular to the rails and parallel to each other as shown. The distance between the bars is l. At a certain moment, a uniform vertical upward magnetic field is turned on. The field quickly reaches its maximum magnitude and then remains constant.
Neglecting friction, find the new distance between the bars. Assume that the resistance of each bar is much greater than the resistance of the rails.



Problem 2:

On the input of the RLC filter shown below the periodic voltage oscillating as $U(t) = A \sin^4(\omega t)$ is applied. Calculate the output voltage after all transients have decayed if the elements R, L, C have been chosen such that $4\omega^2 LC = 1$ and $\omega RC = 2$.



Problem 3:

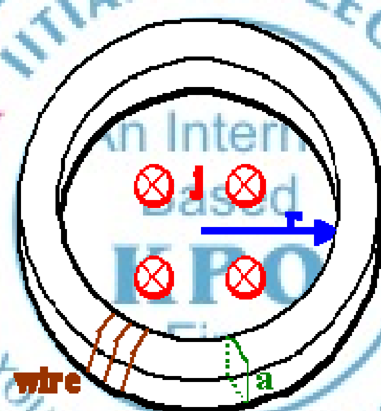
An electron accelerator employs a time varying magnetic flux through a plane circular loop of radius R = 0.85 m, and the electrons always move in this circular path with this radius. The magnetic induction in the loop plane

$$B(r) = B_0 - Kr^2, \quad r < R; \qquad B = 0, \; r > R,$$

is everywhere normal to the loop plane with r the distance from the loop center.
(a) Show that, at any instant, the average magnetic induction in the loop B_{av}, must be related to B_R by $B_{av} = 2B_R$. Evaluate K.
(b) B_0 increases linearly from 0 to 1.2 Tesla in 5.3 sec. Deduce the energy gain per turn for the electrons and the maximum electron energy achieved.

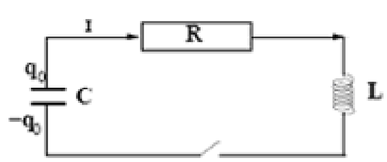
Problem 4:

A spatially uniform current density $\mathbf{j} = \mathbf{j}_0 \cos\omega t$ flows through the hole of a torus along the axis of the torus as shown. The inner radius of the torus is r, and the cross section is square with sides a (a << r). The torus is made of an insulating material with $\mu = \mu_0$. A wire of resistance R wraps around the torus with a total of N turns. Determine the current flowing in the wire.



Problem 5:

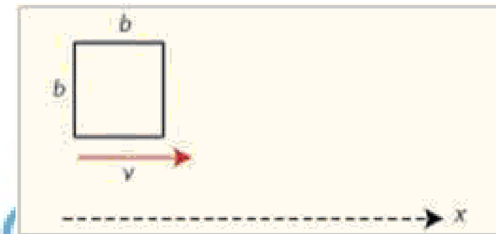
The capacitor shown in the circuit below initially holds a charge q_0. The switch is closed at t = 0. Find the charge on the capacitor as a function of time, if $R^2/4 < L/C$. What is the oscillation frequency of the circuit when $R \rightarrow 0$?



Problem 6:

A square loop made of wire with negligible resistance is placed on a horizontal frictionless table as shown (top view). The mass of the loop is m and the length of each side is b. A non-uniform vertical magnetic field exists in the region; its magnitude is given by the formula $B = B_0\,(1 + kx)$,

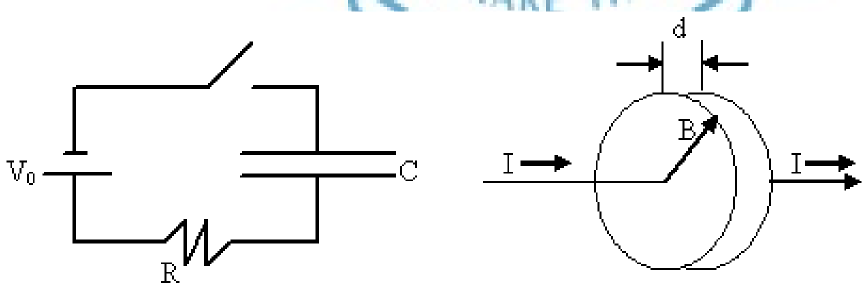
where B_0 and k are known constants.
The loop is given a quick push with an initial velocity v along the x-axis as shown. The loop stops after a time interval t. Find the self-inductance L of the loop.



Problem 7:

A switch is closed to charge a capacitor C from a battery of voltage V_o through a resistance R. (Fig. a). The capacitor is a circular parallel plate capacitor of area $A = \pi b^2$, plate spacing $d << b$ and dielectric constant ε. (Fig. b) (Neglect fringing fields and retardation effects.)

(a) Calculate the (time dependent) charge on the capacitor and the current through the resistor.
(b) What is the electric field inside the capacitor?
(c) What is the magnetic field inside the capacitor?



(a) (b)