PHYSICS 231 – SAMPLE FINAL EXAM

Problem 1

(a) A rubber balloon has a single point charge in its interior. Does the electric flux through the balloon depend on whether or not it is fully inflated? Explain.

(b) The two plates of a capacitor are given charges $+Q$ and $-Q$. Keeping the capacitor connected to the battery, insert a dielectric of constant $K > 1$. How do the charge and energy change (increase, decrease, or stay the same)?

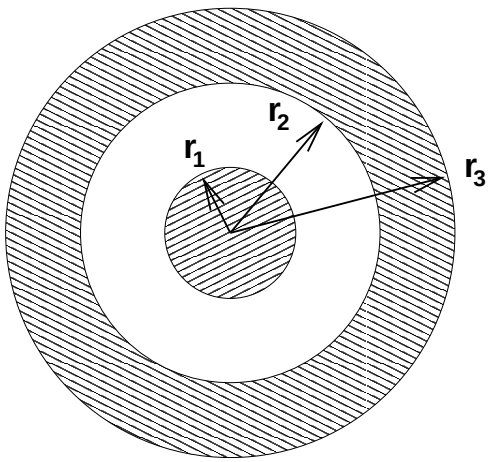
(c) Can the potential difference between the terminals of a battery ever be opposite in direction to the emf? If it can, give an example. If it cannot, explain why not.

(d) Two 120 V light bulbs, one 25 W and one 200 W, were connected in series across a 240 V line. It seemed like a good idea at the time, but one bulb burned out almost instantaneously. Which one burned out and why?

(e) Two closely wound circular coils have the same number of turns ($N_1 = N_2$), but one has twice the diameter of the other ($d_1 = 2d_2$). What is the ratio of their self-inductances, L_1/L_2?

(f) The current in an ac power line changes direction 120 times per second and its average value is zero. Explain how it is possible for power to be transmitted in such a system.

Problem 2



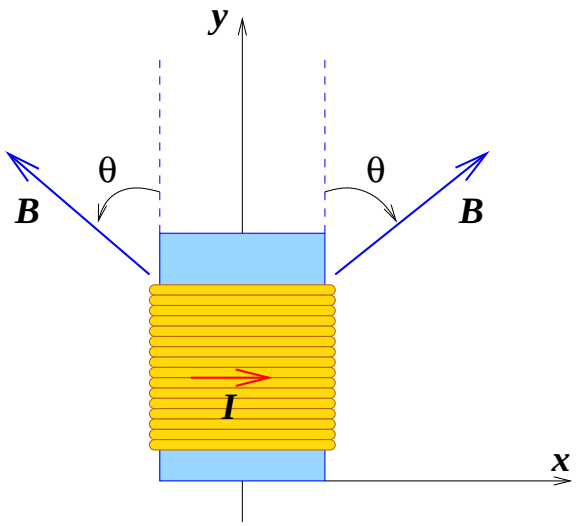
A conducting sphere of radius $r_1 = 3$ cm and negative charge $q_1 = -5$ nC is placed at the center of a conducting spherical shell of inner radius $r_2 = 16$ cm and outer radius $r_3 = 20$ cm, as shown. The shell carries positive charge $q_2 = +4$ nC.

(a) What is the electric field at $r = 6$ cm, 18 cm and 90 cm from the center?

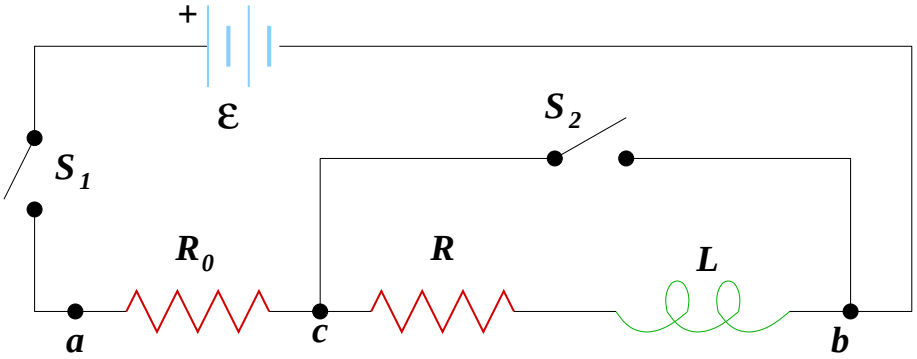
(b) How much charge is on the outer surface of the shell (at $r = r_3$)?

Problem 3

A voice coil in a loudspeaker has 50 turns of wire and a diameter of 2 cm. The current in the coil is 1.5 A. The magnetic field at each point of the coil has constant magnitude 0.3 T and is directed at an angle $\theta = 50^o$ outward from the normal to the plane of the coil.
Calculate the magnitude and direction of the net magnetic force on the coil.



Problem 4



In the circuit shown,
$R_0 = 60\ \Omega$,
$R = 200\ \Omega$,
$L = 5$ H, and
$\mathcal{E} = 40$ V.

(a) Switch S_1 is closed and S_2 is left open. What is the current through R_0, *(i)* right after, *(ii)* at 0.05 s after and *(iii)* a very long time after S_1 is closed?

(b) After the current has reached its final steady-state value with S_1 closed and S_2 open, switch S_2 is closed, thus short-circuiting the inductor. Switch S_1 remains closed. What are the currents through R_0, R and S_2, *(i)* right after, *(ii)* at $t = 0.1$ s after and *(iii)* a very long time after S_2 is closed?

Problem 5

A resistor of $R = 50\ \Omega$ is connected in series with an inductor of $L = 0.1$ H. The voltage across the resistor has amplitude 120 V and frequency 60 Hz.

(a) Derive an expression for the current as a function of time and sketch it.

(b) Calculate the inductive reactance of the inductor.

(c) Derive an expression for the voltage across the inductor as a function of time and sketch it.