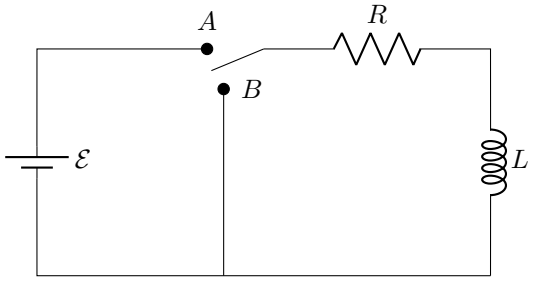
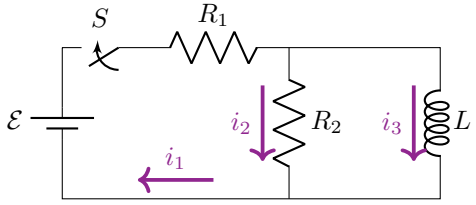
Chapter 30 - Inductance

Physics 207

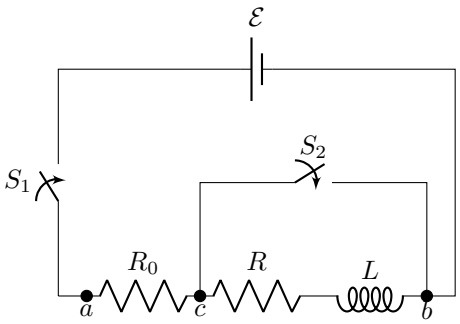
1a. In the circuit below, suppose the switch has been in position A for a very long time. If it is then switched to B, at $t = 0$, find the current as a function of time. Assume all the self-inductance is contained in the coil, L.
1b. Assume the switch has been in position B for a long time. At $t = 0$ the switch is moved to position A. At t_1 the switch is moved back to B. What is the current through the resistor at t_2 where $t_2 > t_1$?



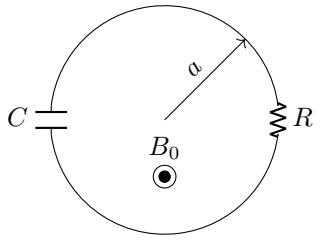
2. An inductor with inductance L and negligible resistance is connected to a battery, a switch S, and two resistors R_1 and R_2. The battery has an emf $\mathcal{E}$ and negligible internal resistance. S is closed at $t = 0$.
a) What are the currents i_1, i_2 and i_3 after S has been closed a long time?
b) What are the currents i_1, i_2 and i_3 after S has just been closed?
c) Apply Kirchoff's rules to the circuit and obtain a differential equation for $i_3(t)$. Integrate this equation to obtain an equation for i_3 as a function of time t that has elapsed since S was closed.



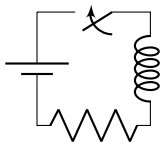
3. a) Switch S_1 is closed and switch S_2 is left open. Just after S_1 is closed, what are the current i_0 through R_0 and the potential differences v_{ac} and v_{bc}?
b) After S_1 has been closed a long time (S_2 is still open) so that the current has reached its final, steady value, what are i_0, v_{ac} and v_{cb}?
c) Find the expressions for i_0, v_{ac} and v_{cb}? as functions of time t since S_1 was closed.



4. A wire loop with radius a has a capacitor with capacitance C and a resistor with resistance R attached in series. The wire loop is placed in a uniform magnetic field, B_0, that is initially perpendicular to the loop. At $t = 0$, the wire loop begins to rotate with some frequency ω. The capacitor is initially uncharged. Find the differential equation that you would use to solve for the charge on the capacitor. You do not need to solve this equation!



5. In an RL-circuit contains a 30.0 Ω resistor, a 12.0 V battery and an unknown inductor that is in the shape of a solenoid. When the switch is closed, it takes 24.0 ms for the voltage across the inductor to drop to 42.5% of its initial value. An object that takes up the full volume of the solenoid is inserted into the inductor. When the experiment is redone, they find that it instead takes 30.0 ms.
a) What are the relative permeability and magnetic susceptibility of the material the object is made of?
b) Let B_f be the magnetic field in the solenoid when the object is inside and B_0 without. Is B_f larger or smaller in magnitude than B_0 and by what factor?
c) Let u_f be the magnetic energy density in the solenoid when the object is inside and u_0 without. Is u_f larger or smaller in magnitude than u_0 and by what factor?



6a. In the circuit below, both switches have been open for a long time so there is no current. If switch S_1 is closed at $t = 0$, what is the current through the 300 Ω resistor, the 30 mH and the 50 mH inductors right after the switch is closed and after the switch has been closed for a long time?
6b. Assume that S_2 has been closed for a long time and S_1 has been open for a long time and there is no current. Repeat part a with this new assumption.