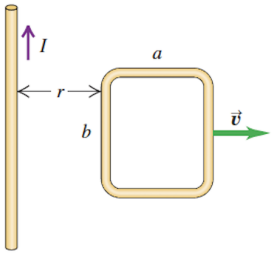
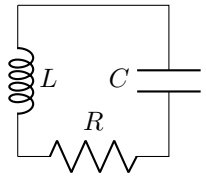
Problem 1. A Wire and a Loop (15 pts)



In the figure at right, the loop is being pulled to the right at a constant speed v. A constant current I flows in the long wire, in the direction shown. Calculate the magnitude of the net emf $\mathcal{E}$ induced in the loop by using Faraday's Law of induction (6 points). Find the direction of the current induced in the loop (3 points). Check that your answer for the emf is physically reasonable when: (i) the loop is stationary, (ii) the loop is very thin so $a \to 0$, and (iii) the loop gets very far from the wire (6 points).

Problem 2. Damped Circuit (10 Points)

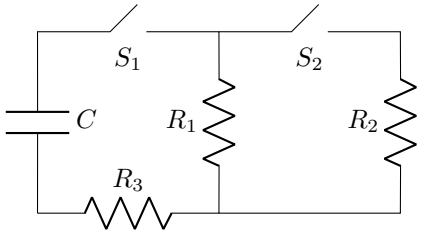
Consider the RLC circuit:



Write a differential equation that models the circuit **(4 points)**. Find the general solution to the differential equation, using for instance the method of characteristic equations **(4 points)**. Apply the boundary conditions $Q(0) = Q_0$ and $\dot{Q}(0) = 0$ to find the solution to the differential equation for these boundary conditions **(2 points)**. Note: $I = \dot{Q}$.

Problem 3. Discharging Capacitor (5 Points)

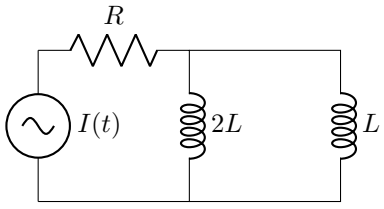
Consider the RC circuit:



Suppose that at time t_1 switch S_1 is closed, that at time $t_2 > t_1$ switch S_2 is closed, and that the initial charge on the capacitor C is Q_0. Sketch the voltage through R_3 as a function of time and label the dependence (constant/exponential/reciprocal) and any applicable time constants.

Problem 4. Circuit with Impedance (20 Points)

Consider the driven circuit:



Supposing that $I(t) = I_0 \cos(\omega t)$, what is the impedance of the circuit as measured across the current source **(5 points)**? What is the current through the resistor with resistance R **(5 points)**? What is the current through the inductor with inductance L as a function of time **(5 points)**? What is the phase difference between the voltage in the resistor and the inductor with inductance L **(5 points)**?