1. (20 points)

In the circuit shown, all elements are ideal. Note the battery polarity, and the “defined-positive” arrows for current. The capacitors is initially uncharged. At t=0 switch S7 is closed. t=0+ refers to an infinitesimal amount of time after t=0.

1-1. True or False:

- No current flows through the battery before the switch is closed
- The voltage across the battery is zero before the switch is closed
- Before the switch is closed, the left side of C3 has a higher potential (absolute voltage) than the right side

1-2. At t=0+, find the values of the voltage and the current in each element. Justify your answers.

1-3. In steady-state, find the values of the voltage and the current in each element. Justify your answers.
2. **(30 points)**

Consider the inductor-resistor-capacitor circuit to the right. The switch is initially open and the system is inert: all voltages and currents are zero, except the capacitor voltage $V_c=5\text{V}$. The switch is then closed at $t=0$.

2-1. Annotate the circuit, labeling currents and voltage polarities.

2-2. Write down the constitutive laws of each element, and a complete set of node equations (KCL) and loop equations (KVL).

2-3. Set up the state equation(s) for the system with the switch closed.

2-4. Find the analytical solution (both the general solution and particular solution) for the response of the system after closing the switch at $t=0$. You may find it helpful to refer to the analytical solution in the webtext for an RLC circuit. Sketch a plot of the current in the inductor from time 0 to steady state. Sketch a plot for the same timeframe for the current in $R_1$. Use $C=1\mu\text{F}$, $R_1=1\Omega$, $L_2=1\text{mH}$, and $R_3=1\Omega$. 


3. (25 points)

Cross-domain analogies: Remember that the effort variables of our domains are force, pressure and voltage; and that the flow variables are velocity, flow, and current. Also be careful in the switch between parallel and series components between domains: eg, resistors in series add, but dampers in parallel add. The switch occurs because while force=effort is a through variable in mechanical domain, voltage=effort is an across variable in the electrical domain.

Using these tips, carefully examine the systems below and write the analogous systems requested. Use the same numbers on the elements in the analogous systems to correspond to their counterpart in the system shown.

3-1. Draw the equivalent mechanical system for this circuit. Find the state equation for the mass and the inductor to show their equivalence.

3-2. Draw the equivalent electrical system for this system.
3-3. Draw the equivalent electrical system for this system.
4. (25 points)

The diagram to the right is a circuit consisting of ideal electric elements (resistors, capacitors, inductors, batteries). The batteries provide constant voltages. The capacitors were uncharged before the circuit was assembled.

4-1. Annotate the diagram, labeling currents and voltage polarities.

4-2. Write down the constitutive laws of each element, and a complete set of node equations (KCL) and loop equations (KVL).

4-3. How many distinct currents are there?

4-4. How many state variables are there?

4-5. Will the system reach a steady state? Will that steady state be oscillatory behavior or static? (Do not solve for state eqns; base your answer on the circuit components.)