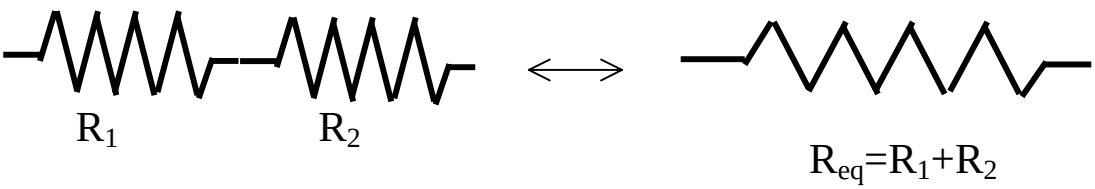
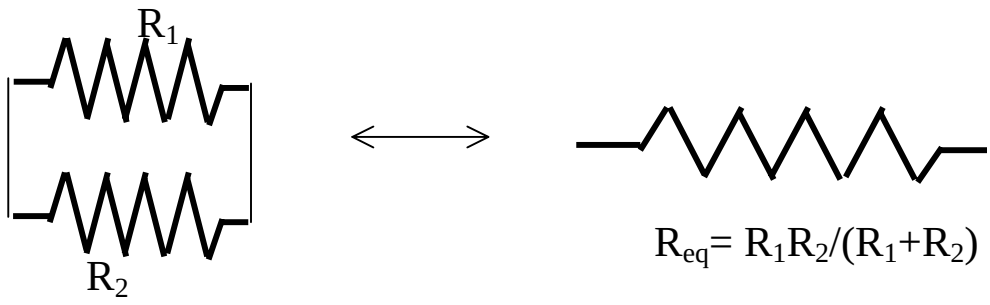
**Homework 7**

---

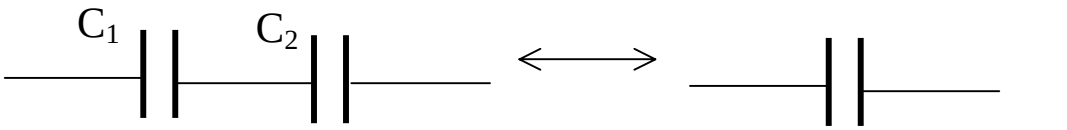
1. [4 points] Show that the following circuit segments shown on the left can be simplified to the ones shown on the left.



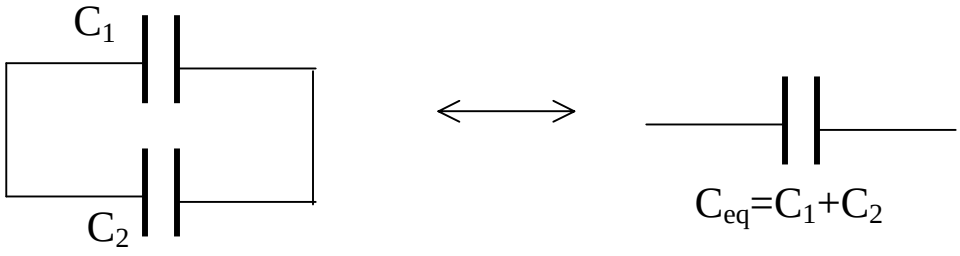

$R_{eq}=R_1+R_2$




$R_{eq}= R_1R_2/(R_1+R_2)$

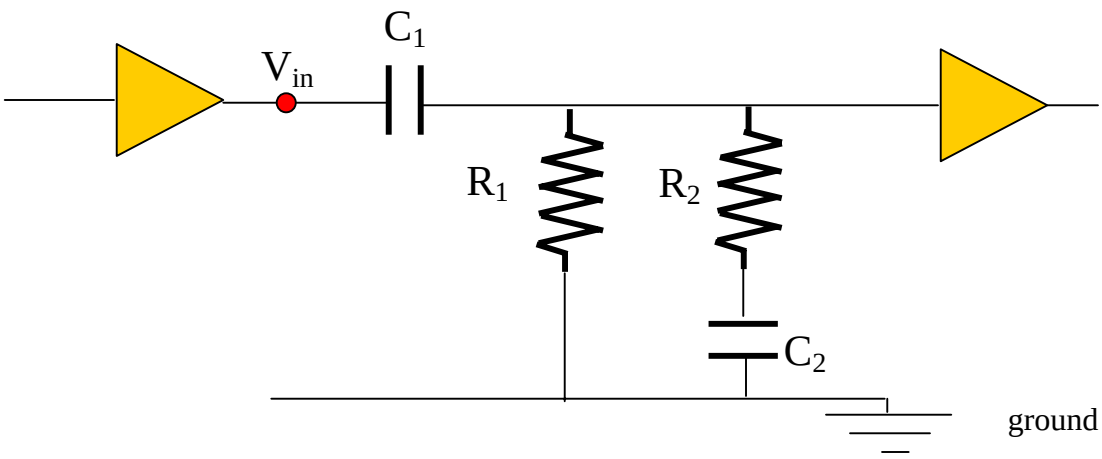



$C_{eq}= C_1C_2/(C_1+C_2)$




$C_{eq}=C_1+C_2$

2. Consider the circuit shown below.

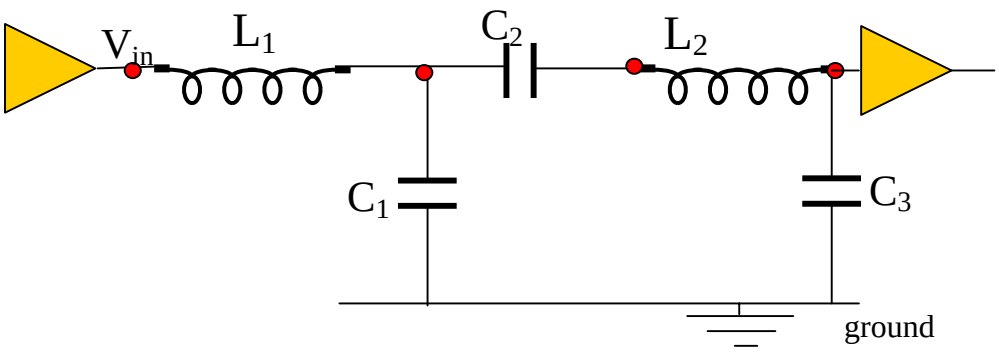



(2.i) [8 points] The capacitors in this circuit are initially uncharged when the switch is closed at time t=0. Systematically analyze this circuit to obtain the state equations for the voltages across the two capacitors in the form: $\underline{\dot{\mathbf{X}}} = \underline{\mathbf{A}}\,\underline{\mathbf{X}} + \underline{\mathbf{F}}$. Adapt a MATLAB code to solve this state equation.

(2.ii) [2 points] Given: $V_{in}(t)$ = 1.6kV constant, $C_1$=$C_2$=8.5μF, $R_1$=$R_2$=0.5MΩ plot the voltages across the two capacitors as a function of time. Qualitatively explain the behavior.

(2.iii) [4 points] Given $V_{in}(t)$ = 1.6kV*sin($\omega_f$t) where $\omega_f$ is the angular frequency of the input signal; $C_1$=$C_2$=6.5μF, $R_1$=$R_2$=0.73MΩ plot the voltages across the two capacitors as a function of time for values of $\omega_f$ equal to 0.5/s, 2/s, 4/s. Qualitatively describe the behavior.

3. Consider the circuit shown below. It consists of two LC-oscillators that are coupled together by a capacitor.




(3.i) What are the state variables for this circuit? [2 points]

(3.ii) Systematically obtain the first-order state equations in the form: $\dot{\underline{\mathbf{X}}} = \underline{\mathbf{A}}\underline{\mathbf{X}} + \underline{\mathbf{F}}$ [4 points]

(3.iii) Adapt a MATLAB code to analyze this circuit. Make sure that your code can plot the total energy in the left oscillator (L1-C1) and the right oscillator (L2-C3). Let the input voltage $V_{in}$ be a constant value applied for the first 4 seconds only and then zero thereafter. By using appropriate values for the capacitances and inductances, get this circuit to "slosh" similar to weakly-coupled mechanical oscillators. Show the sloshing behavior by means of time plots of energy in the left and right oscillators. [6 points]