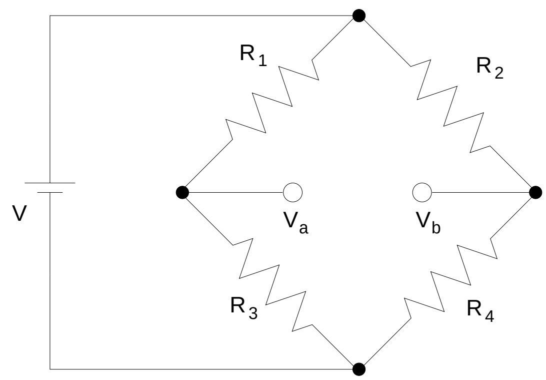
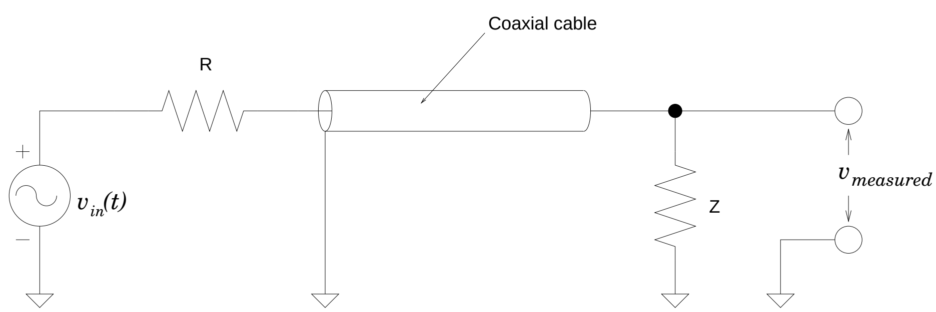
Physics 536 - Assignment #2

1. Consider the following circuit:



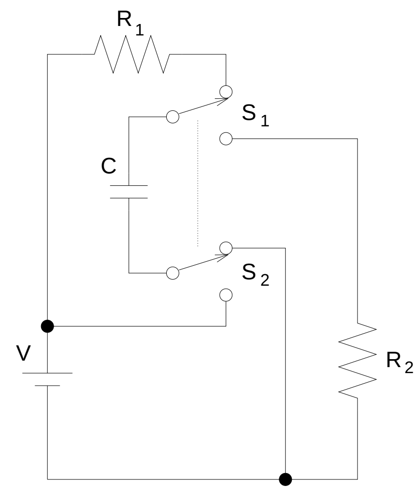
(a) Calculate the values of V_{Th} and R_{Th} needed for Thevenin's equivalent circuit for the voltage $\Delta V = V_a - V_b$.
(b) Calculate the values of I_{N} and R_{N} needed for Norton's equivalent circuit for the voltage ΔV.

2. A simple, low-inductance oscilloscope probe can be constructed by attaching a $R = 1\ \text{k}\Omega$ resistor to the end of a short piece of coaxial cable as shown:



(a) With the input to the oscilloscope terminated with a $Z = 50$ Omega resistance to ground, calculate the measured voltage, v_{measured} in terms of v_{in}, R and Z, assuming v_{in} is a constant, ideal voltage source.
(b) Draw the equivalent circuit if a 3 ft length of cable was treated as a single capacitor with $C = 0.05$ pF and calculate the time needed for the measured voltage to reach 90% of its maximum value in response to an instantaneous step function for v_{in}.
(c) The high-impedance oscilloscope probes have a similar equivalent circuit but with $Z = 10\ \text{M}\Omega$ and $C = 10$ pF. Calculate the time needed for the measured voltage to reach 90% of its maximum value when probing a non-ideal step-function voltage source with an impedance of $R = 50\ \Omega$.

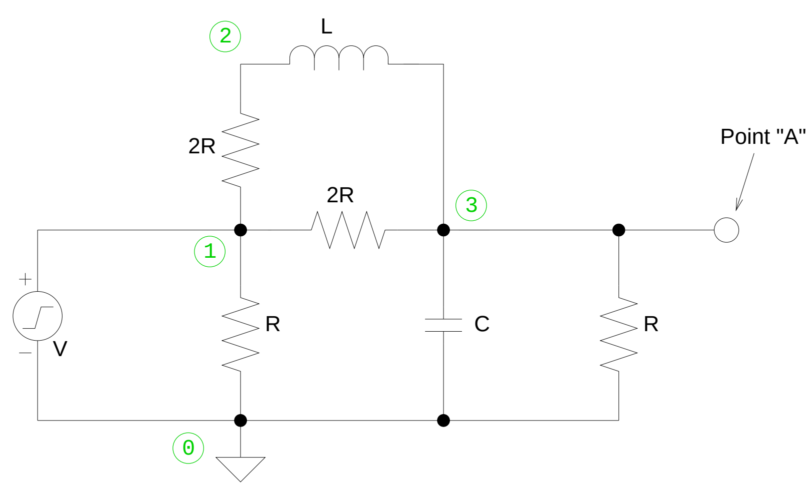
3. Consider the following circuit containing two switches, S_1 and S_2, which change the way the capacitor, C, is connected in the circuit:



(a) Draw the equivalent circuit when the switches are in the position indicated in the diagram and calculate the potential difference that develops across the capacitor in the limit when $t \gg 1/R_1C$.
(b) At some later time, the both S_1 and S_2 switched simultaneously. Draw the equivalent circuit and calculate the potential difference across R_2 the instant after this event.

In this type of curcuit is commonly found in DC-DC converters. In such a circuit configuration, C is called a *flying capacitor*.

4. Consider the following circuit:



(a) If the voltage source makes a transition from 0 to V at $t = 0$, calculate the voltage at point "A" in the limit as $t \to \infty$.

(b) Using the following component values:

$$\begin{aligned} C &= 50 \text{ nF} \\ L &= 1 \text{ mH} \\ R &= 100\ \Omega \\ V &= \begin{cases} 0 \text{ V} & \text{when } t < 0 \\ 5 \text{ V} & \text{when } t > 0 \end{cases} \end{aligned}$$

write the SPICE netlist for this circuit. The time-dependent voltage source can be described using

```
Vxxxx N+ N- PULSE(V1 V2)
```

where `V1` is the initial voltage for $t < 0$ and `V2` is the voltage for $t > 0$.

(c) Use SPICE to calculate the DC operating point of this circuit. In this case, the voltage source should be described using a constant 5 V DC voltage source. Compare the calculated voltage at point "A" with the value determined in part (a). Attach the SPICE simulation output to your assignment.

(d) Use SPICE to calculate the time-dependent voltage at point "A" by performing the numerical integration of the circuit with the *transient* analysis: Include the line

```
.TRAN 0.1US 50US
```

to simulate the circuit for times $0 < t < 50\ \mu$s in 0.1 μs time steps, and include the line

```
.PRINT TRAN V(3)
```

to print and graph the voltage at node 3 (*ie.* point "A") as a function of time. Check that the behavior of the circuit as $t \to \infty$ is as expected. Print out and hand in the resulting graph.