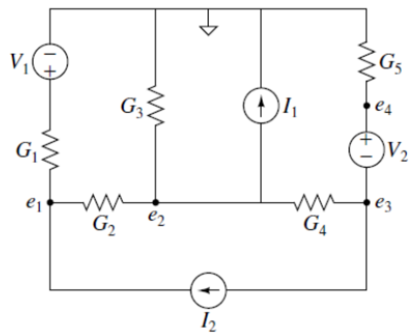
Problem 1

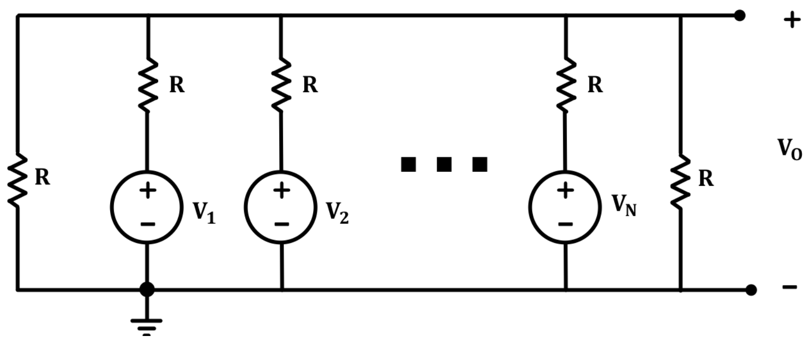
Use the node-to-reference voltages indicated on the circuit below to write a set of independent node equations (KCL statements) sufficient to solve for the unknown voltages. **<u>Do not solve them</u>**.

Note: the resistor parameter G represents the conductance, G = 1/R



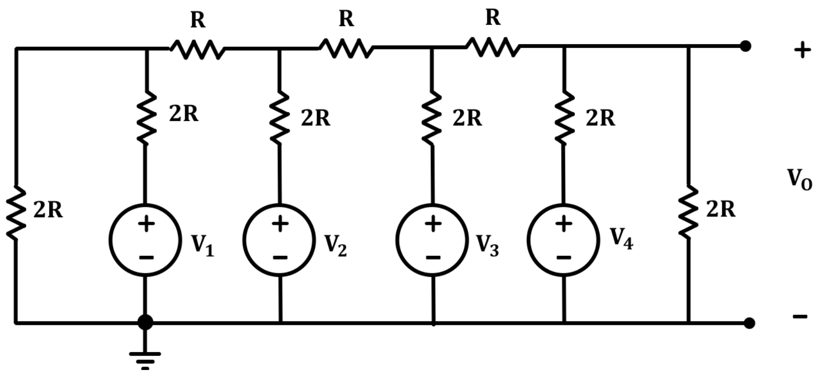
Problem 2: DAC

Your friend does not like the DAC we built in lab and proposes the alternative design shown below. The DAC output is V_O. Further, assume that the independent voltage sources for all bits can take on only the values of 0 V or V_B.



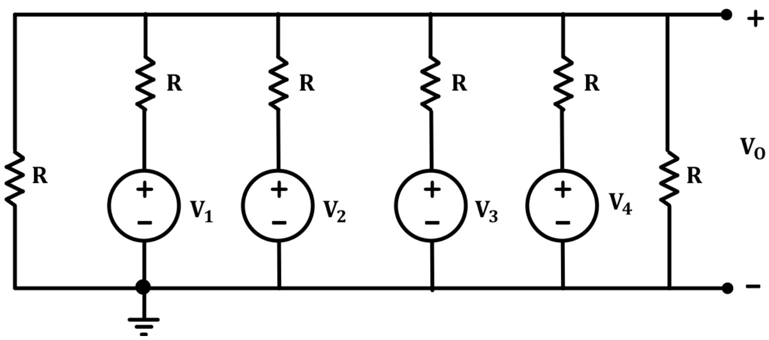
(2A) How many unique voltages can be generated by the newly-proposed DAC? Explain with supporting equations if you prefer. Please answer in terms of N, R and V_B.

(2B) Is the answer from Part (A) greater or less than the number of unique voltages one could generate using a R-2R DAC with an equivalent number of bits, as built in lab and shown below with four bits? Please briefly explain. The DAC output is again V_O, and the independent voltages sources for all bits can again take on only the values of 0 V or V_B.



(2C) What is the smallest non-zero voltage, and the largest voltage, that the newly-proposed DAC can produce? Please answer in terms of N, R and V_{B}.

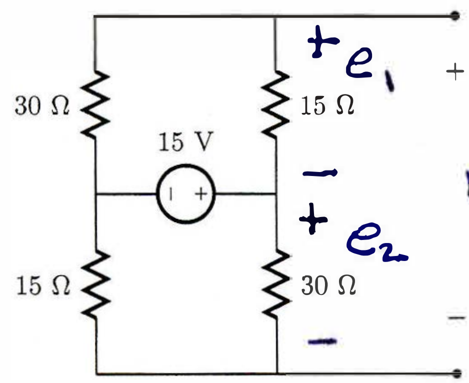
(2D) A four-bit version of the newly-proposed DAC is shown below. At its output port, derive a Thevenin equivalent for it as a function of R and the voltage source values V_1 through V_4.



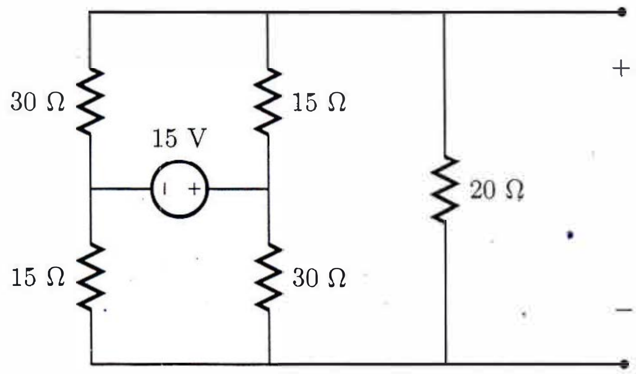
Problem 3: Linear Resistor/Source Circuits

The problem studies circuits involving independent sources, linear resistors and linear dependent sources. Note that the circuit in Part (A) is used again in Parts (B) and (C), though it is extended in the process.

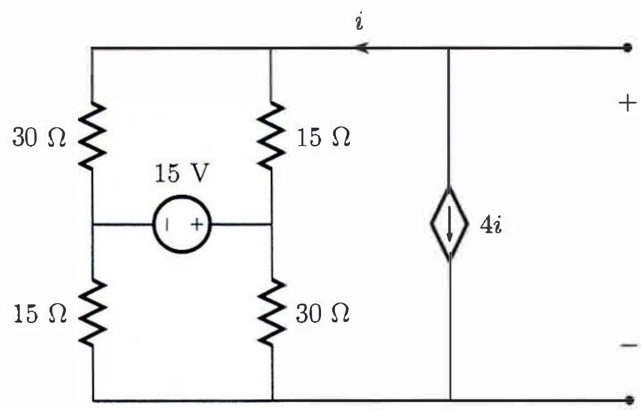
(3A) Determine and draw the Thevenin equivalent for the circuit shown below as viewed from the indicated terminals. *Numerical results with appropriate units are expected.*



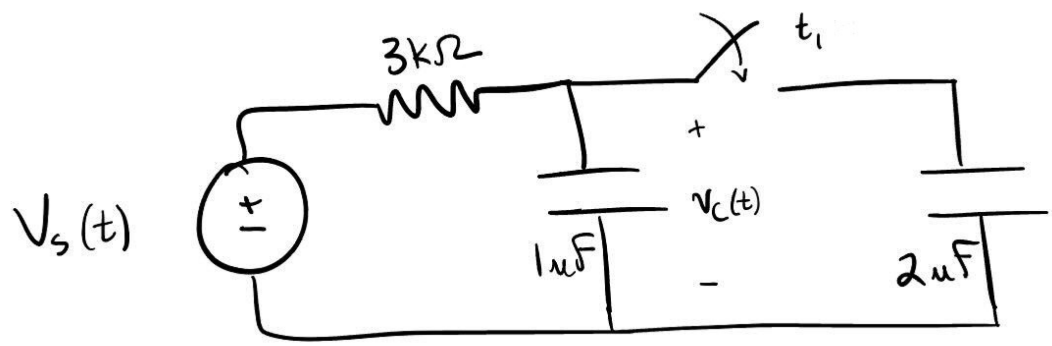
(3B) A 20-Ω resistor is now connected to the circuit from Part (A) as shown below. What is the Thevenin equivalent of the modified circuit as viewed from the indicated terminals? *Numerical results with appropriate are expected.*



(3C) The circuit from Part (A) is again modified, this time by the addition of a dependent source as shown below. What is the Thevenin equivalent of the modified circuit as viewed from the indicated terminals? *Numerical results with appropriate units are expected.*



Problem 4: Double Trouble



(4A) For all time $t < t_0$, assume that $V_S = 0$ and the switch is open. At $t_0 = 0s$, the source steps up to $V_S = 7V$. Determine the value of the voltage across the 1uF capacitor after 6 milliseconds, $v_c(6ms)$.

(4B) Exactly at this time $t_1 = 6ms$, two things happen: the voltage source is turned off to $V_S = 0V$, and the switch is closed. Considering this case with a closed switch, draw an equivalent circuit that only has one capacitor, and state its capacitance value (*hint: think about what it means for capacitors to be in parallel)*.

(4C) If we assume that the 2uF capacitor had already been charged to an initial voltage that is equal to the value that you solved for in Part A, $v_c(t_1)$, what is the value of v_c at a later time $t_2 = 15ms = t1 + 9ms$?