

1. KVL/KCL Review

Use Kirchhoff's Laws on the circuit below to find V_x in terms of V_{in} , R_1 , R_2 , R_3 .

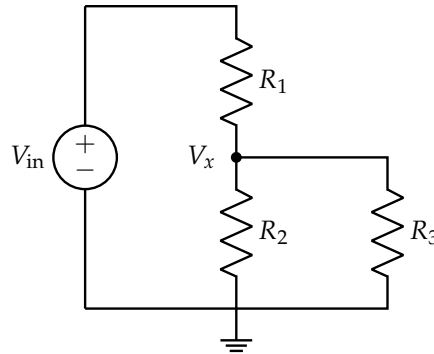


Figure 1: Example Circuit

- (a) Recall Node Voltage Analysis (NVA). Determine V_x by labeling the circuit and writing equations to solve a system of equations in node voltages.

- (b) In EECS16A, you learned you can simplify analysis by replacing series or parallel resistors with equivalents and memorizing common circuit design blocks. Replace two of the resistors in the circuit with an equivalent resistor and then redraw the circuit. Then, use recognition of a design block to find an expression for V_x .

- (c) As a check, as $R_3 \rightarrow \infty$, what is V_x for what you found in (a) and (b)? The V_x 's of each part should approach the same value. What is the name we used for this type of circuit?

2. Current Sources And Capacitors

(Adapted from EECS16A Fall 20 Disc 9A.)

(HINT: Use the I-V relationship for a capacitor (which may involve derivatives). If you do not remember it, you can find it by using the capacitor equation $Q = CV$ and $I = \frac{dQ}{dt}$.)

(HINT: It may also help to note metric prefix examples: $3 \mu\text{F} = 3 \times 10^{-6}\text{F}$.)

Given the circuit in fig. 2, find an expression for $v_{\text{out}}(t)$ in terms of I_S , C , V_0 , and t , where V_0 is the initial capacitor voltage at $t = 0$.

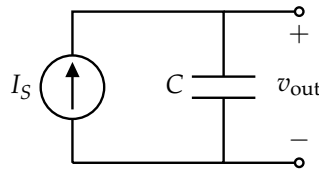


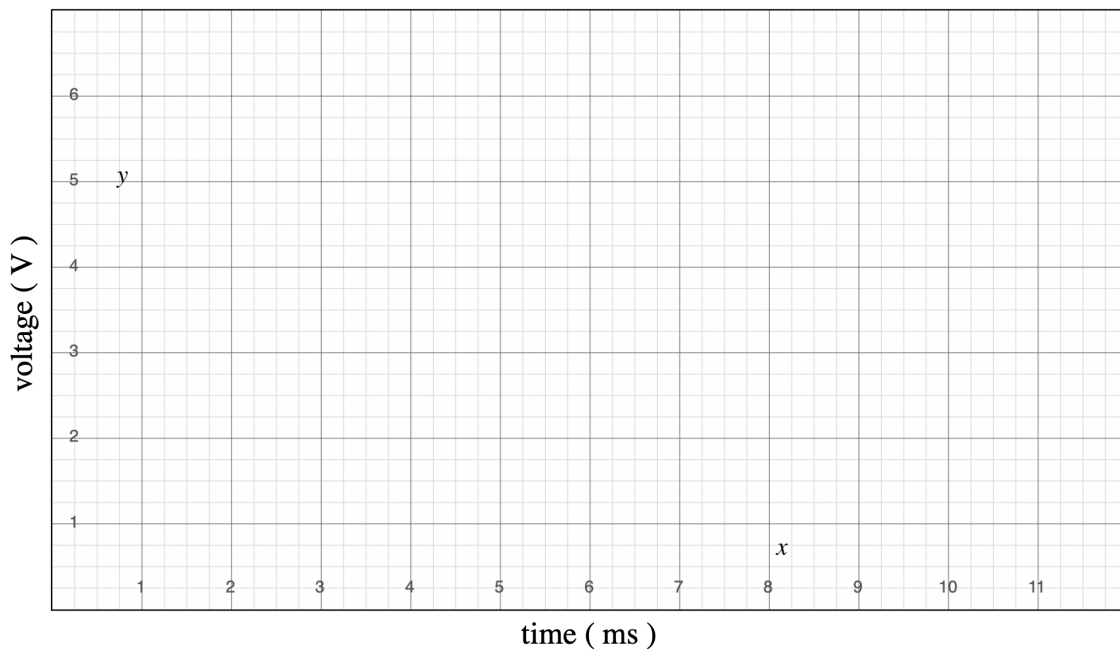
Figure 2: A current source attached to a capacitor.

Then plot the function $v_{\text{out}}(t)$ over time on the graph below for each set of conditions, detailed below.

Use the values $I_S = 1 \text{ mA}$ and $C = 2 \mu\text{F}$.

- (1) Capacitor is initially uncharged $V_0 = 0$ at $t = 0$.
- (2) Capacitor has been charged with $V_0 = 1.5 \text{ V}$ at $t = 0$.
- (3) (PRACTICE) Swap this capacitor for one with half the capacitance $C = 1 \mu\text{F}$, which is initially uncharged $V_0 = 0$ at $t = 0$.

(HINT: Recall the calculus identity $\int_a^b f'(x) dx = f(b) - f(a)$, where $f'(x) = \frac{df}{dt}$.)



3. Linear Algebra Review

For the following matrices, find the following properties:

- i. **What is the column space of the matrix?**
- ii. **What is the null space of the matrix?**
- iii. **What are the eigenvalues and corresponding eigenspaces for the matrix?**

(a) $\begin{bmatrix} 2 & 4 \\ 0 & 3 \end{bmatrix}$

(b) $\begin{bmatrix} 1 & -2 \\ 2 & -4 \end{bmatrix}$.

4. (OPTIONAL) Op-Amp Summer

Consider the following circuit (assume the op-amp is ideal):

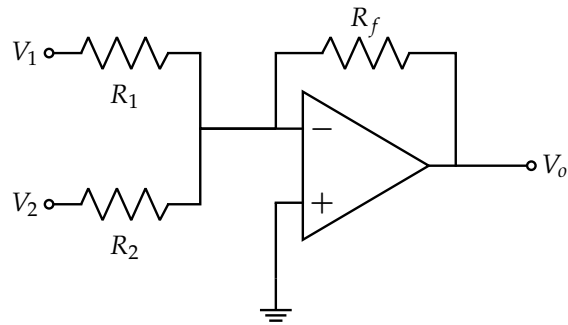


Figure 3: Op-amp Summer

What is the output V_0 in terms of V_1 and V_2 ? You may assume that R_1 , R_2 , and R_f are known.

(For extra practice, solve this problem twice: once using Node Voltage Analysis (NVA) with both V_1 and V_2 and another time using superposition of V_1 and V_2 .)