Discussion 0B

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

2. KVL/KCL Review

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

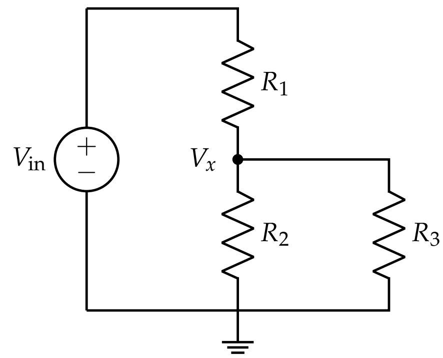


Figure 1: Example Circuit

(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. Determine V_x by leveraging resistor equivalence and recognition of a design block.

(c) As a check, as $R_3 \to \infty$, 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?

3. Current Sources And Capacitors

(Adapted from EECS16A Fall 20 Disc 9A.)

(*HINT: Recall charge has units of Coulombs.* (C)*, and capacitance is measured in Farads.* (F)*. Also,* $1\,\mathrm{F} = \frac{1\,\mathrm{C}}{1\,\mathrm{V}}$*. It may also help to note metric prefix examples:* $3\,\mu\mathrm{F} = 3 \times 10^{-6}\mathrm{F}$.)

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 $t = 0$.

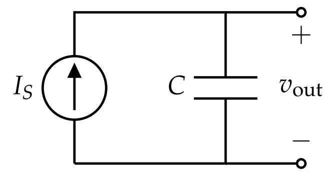


Figure 2: A current source attached to a capacitor.

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

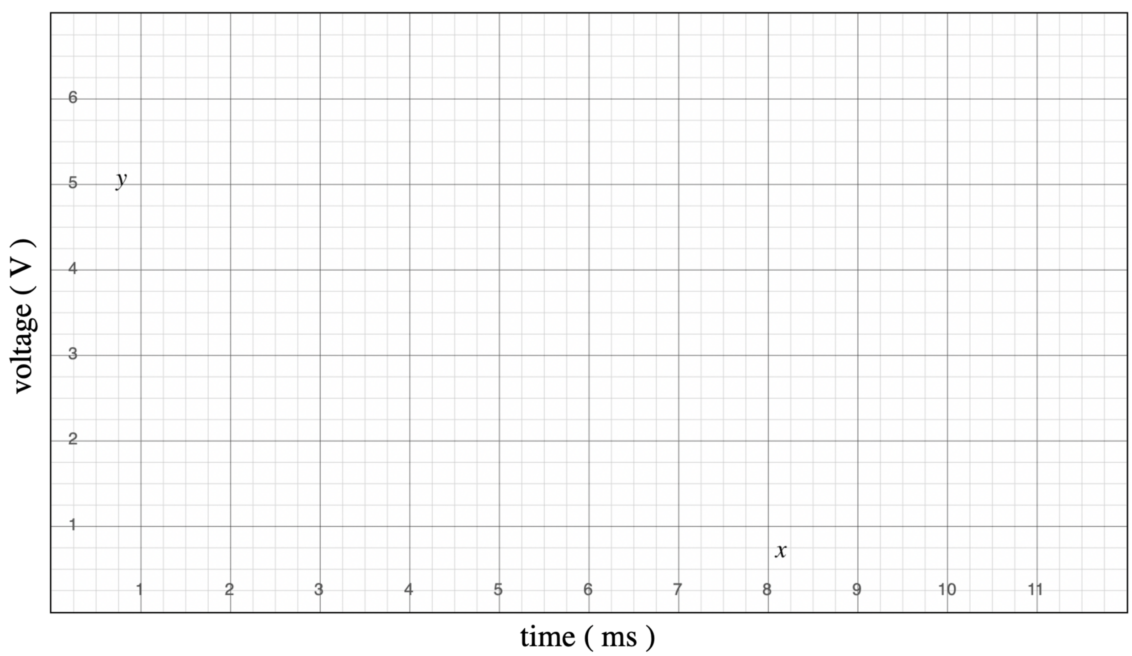
Use the values $I_S = 1\,\mathrm{mA}$ and $C = 2\,\mu\mathrm{F}$.

(1) Capacitor is initially uncharged $V_0 = 0$ at $t = 0$.

(2) Capacitor has been charged with $V_0 = 1.5\,\mathrm{V}$ at $t = 0$.

(3) **(PRACTICE)** Swap this capacitor for one with half the capacitance $C = 1\,\mu\mathrm{F}$, which is initially uncharged $V_0 = 0$ at $t = 0$.

(*HINT: Recall the calculus identity* $\int_a^b f'(x)\,\mathrm{d}x = f(b) - f(a)$*, where* $f'(x) = \frac{\mathrm{d}f}{\mathrm{d}t}$.)



4. (OPTIONAL) Op-Amp Summer

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

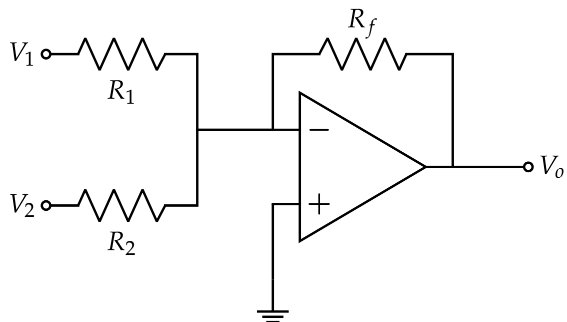


Figure 3: Op-amp Summer

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