EECS 16B   Designing Information Devices and Systems II
Fall 2021   Discussion Worksheet   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 $V_{\text{in}}, R_1, R_2, R_3$.
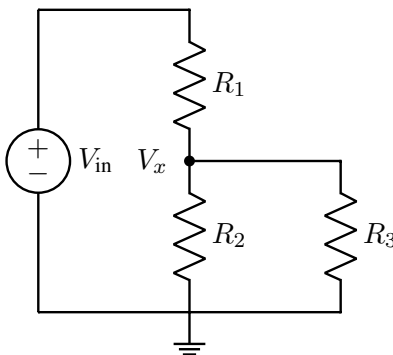

Figure 1: Example Circuit

(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** (The following problem has been adapted from EECS16A Fall 20 Disc 9A.)

Recall charge has units of Coulombs (C), and capacitance is measured in Farads (F) $= \frac{Coulomb}{Volt}$.

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

Given the circuit below, find an expression for $v_{out}(t)$ in terms of I_s, C, V_0, and t, where V_0 is the initial voltage across the capacitor at $t = 0$.
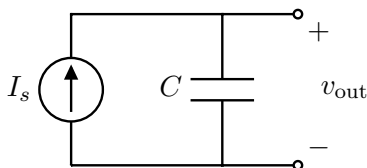
Then plot the function $v_{out}(t)$ over time on the graph below for the following conditions detailed below. Use the values $I_s = 1\text{mA}$ and $C = 2\,\mu F$.

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

(b) Capacitor has been charged with $V_0 = +1.5\text{V}$ at $t = 0$.

(c) **Practice:** Swap this capacitor for one with half the capacitance $C = 1\,\mu F$, 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 $f'(x) = \frac{df}{dx}$.
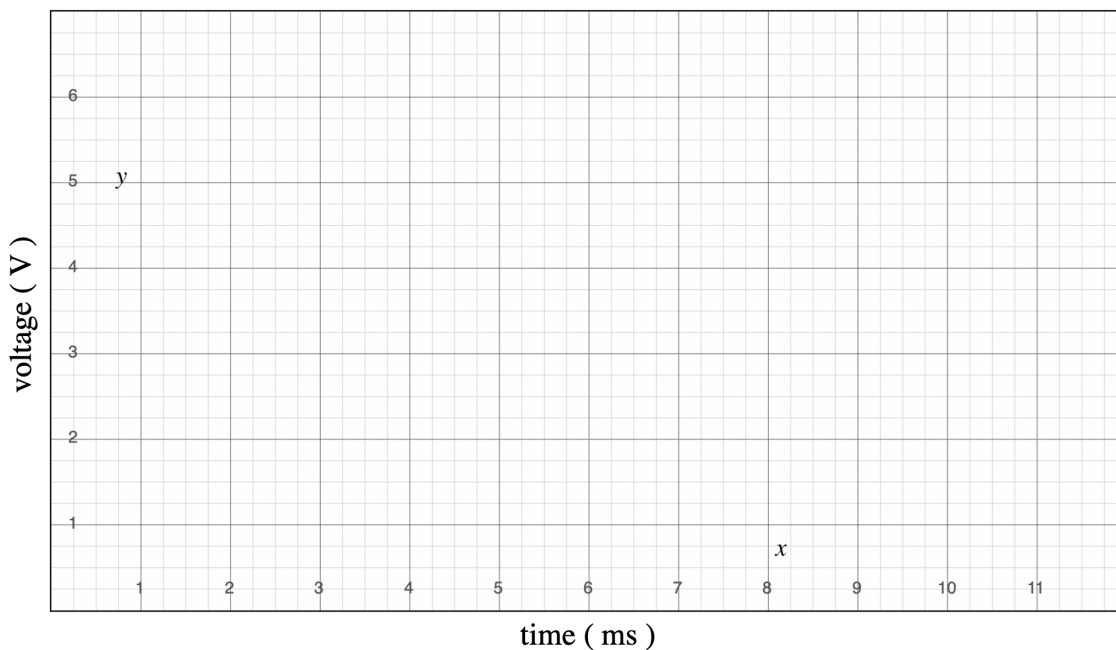
4. (Take-Home) Op-Amp Summer

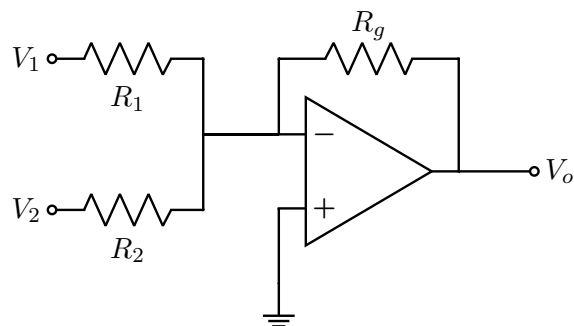Consider the following circuit (assume the op-amp is ideal):

Figure 2: 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_g are known.