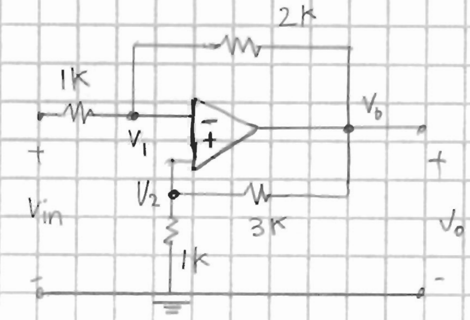
ECE 301
HW #6 Solutions

1 Given the following circuit; Find V_o



$V_{in} = 2V$

At node 1:

$$\frac{V_1 - V_{in}}{1k} + \frac{V_1 - V_o}{2k} = 0$$

$$3V_1 - V_o = V_{in} = 4 \quad \text{—— (1)}$$

At node 2:

$$\frac{V_2}{1k} + \frac{V_2 - V_o}{3k} = 0$$

$$4V_2 - V_o = 0 \quad \text{—— (2)}$$

$V_1 = V_2 = V_x$

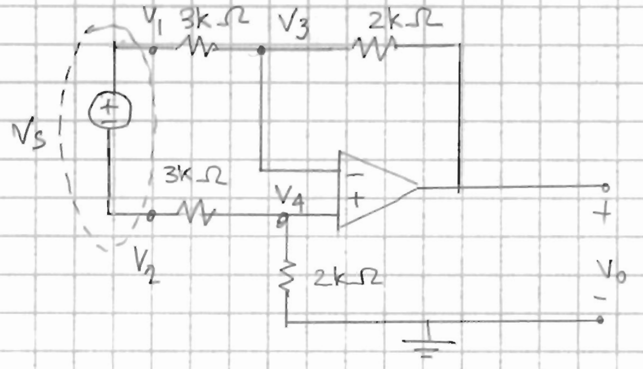
gives (1) $3V_x - V_o = 4$

(2) $4V_x - V_o = 0$

$\therefore \quad V_x = -4V \quad \Rightarrow \quad V_o = 4V_x$

$= -16V$

#5 Given the following op-AMP ckt, find V_o



At the supernode ::

but $V_3 = V_4$

$$\frac{V_1 - V_3}{3k} + \frac{V_2 - V_4}{3k} = 0$$

$$\Rightarrow V_1 + V_2 - 2V_3 = 0 \quad \text{---} (1)$$

At V_3 :

$$\frac{V_3 - V_1}{3k} + \frac{V_3 - V_o}{2k} = 0$$

$$-2V_1 + 5V_3 - 3V_o = 0 \quad \text{---} (2)$$

At V_4 :

$$\frac{V_4 - V_2}{3k} + \frac{V_4 - V_o}{2k} = 0 \qquad V_4 = V_3$$

$$\frac{V_3 - V_2}{3k} + \frac{V_3}{2k} = 0$$

$$-2V_2 + 5V_3 = 0 \quad \text{---} (3)$$

Constraint eqn :

$$V_1 - V_2 = V_s \quad \text{---} (4)$$

Let $V_s = 1V$, solving eqns (1), (2), (3) & (4) using matrix

$$\begin{bmatrix} 1 & 1 & -2 & 0 \\ -2 & 0 & 5 & -3 \\ 0 & -2 & 5 & 0 \\ 1 & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_o \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ V_s \end{bmatrix}$$

We have

$$V_o = -\frac{2}{3} V_s$$

#3 cont'd

At node V_1, the voltage $V_1 = V_{in} \frac{R_2}{R_1+R_2}$

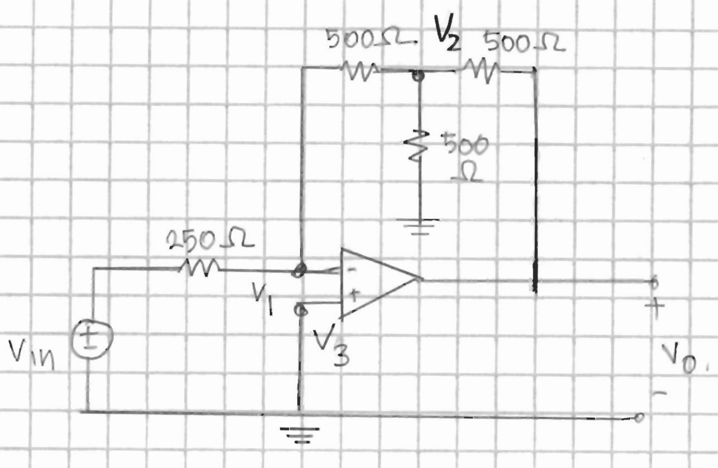
At node V_2, the voltage $V_2 = V_o \frac{R_1}{R_1+R_2}$

but $V_1 = V_2$

therefore $V_{in} \frac{R_2}{R_1+R_2} = V_o \frac{R_1}{R_1+R_2}$

$$\therefore \frac{V_o}{V_1} = \frac{R_2}{R_1}$$

#4 Given an op-amp configuration: Find $V_o = f(V_{in})$



At V_2: $\frac{V_2}{500} + \frac{V_2 - V_1}{500} + \frac{V_2 - V_o}{500} = 0$ but $V_1 = V_3 = 0$

$$\frac{3V_2}{500} - \frac{V_o}{500} = 0$$

$$3V_2 - V_o = 0.$$

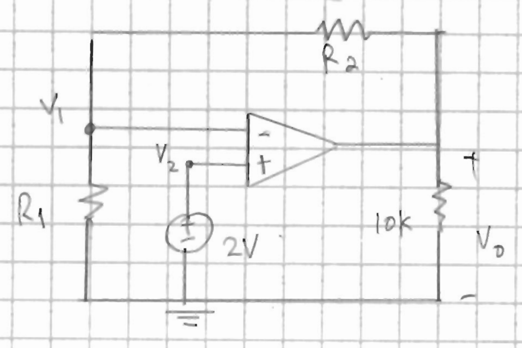
$$V_o = 3V_2 \quad \text{——— ①}$$

At V_1: $\frac{V_1 - V_{in}}{250} + \frac{V_1 - V_2}{500} = 0$

$$-2V_{in} = V_2 \quad \text{——— ②}$$

Substitute ② into ①, we have $V_o = -6V_{in}$

#2 Given an op-AMP configuration, find Vo



At node V_1 :

$$\frac{V_1}{R_1} + \frac{V_1 - V_o}{R_2} = 0 \quad , \quad \text{but} \quad V_1 = V_2 = 2V$$

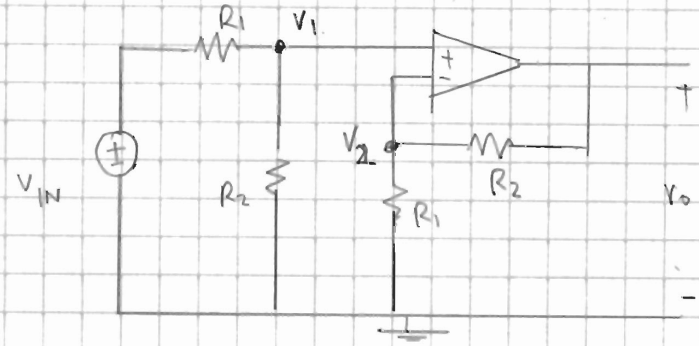
therefore,

$$\frac{2}{R_1} + \frac{2 - V_o}{R_2} = 0$$

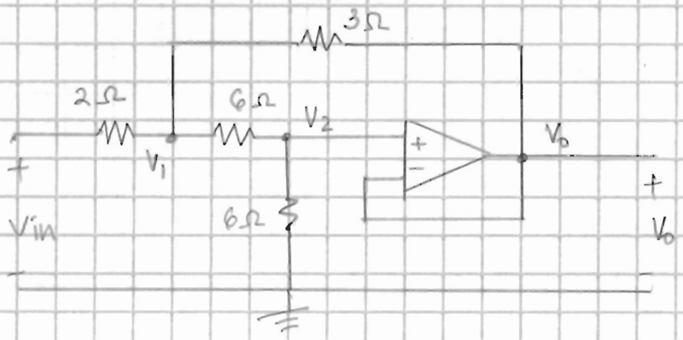
$$\frac{2}{R_1} = \frac{V_o - 2}{R_2}$$

$$V_o = \frac{2 R_2}{R_1} + 2 = 2\left(1 + \frac{R_2}{R_1}\right)$$

#3 Given an opamp ckt, find Vo/Vin



#6 Given the following op-AMP ckt ; find $V_o = f(V_{in})$



At V_1 :

$$\frac{V_1 - V_{in}}{2} + \frac{V_1 - V_2}{6} + \frac{V_1 - V_o}{3} = 0 \qquad \text{but } V_2 = V_o$$

$$\frac{V_1 - V_{in}}{2} + \frac{V_1 - V_o}{6} + \frac{V_1 - V_o}{3} = 0$$

$$6V_1 - 3V_{in} = 3V_o$$

$$2V_1 - V_{in} = V_o \qquad \text{——— (1)}$$

At V_2 :

$$\frac{V_2}{6} + \frac{V_2 - V_1}{6} = 0$$

$$\frac{V_o}{6} + \frac{V_o - V_1}{6} = 0$$

$$2V_o = V_1 \qquad \text{——— (2)}$$

Substitute (2) into (1) :

$$4V_o - V_{in} = V_o$$

$$3V_o = V_{in}$$

$$\therefore \quad V_o = \left(\tfrac{1}{3}\right) V_{in}$$