Time Schedule for remaining work

Friday Apr 9 Ch 6 Homework

Friday Apr 23 Ch 7 Homework

Thurs Apr 8 Thevenin Lab

Thurs Apr 15 OP-AMPS I Lab

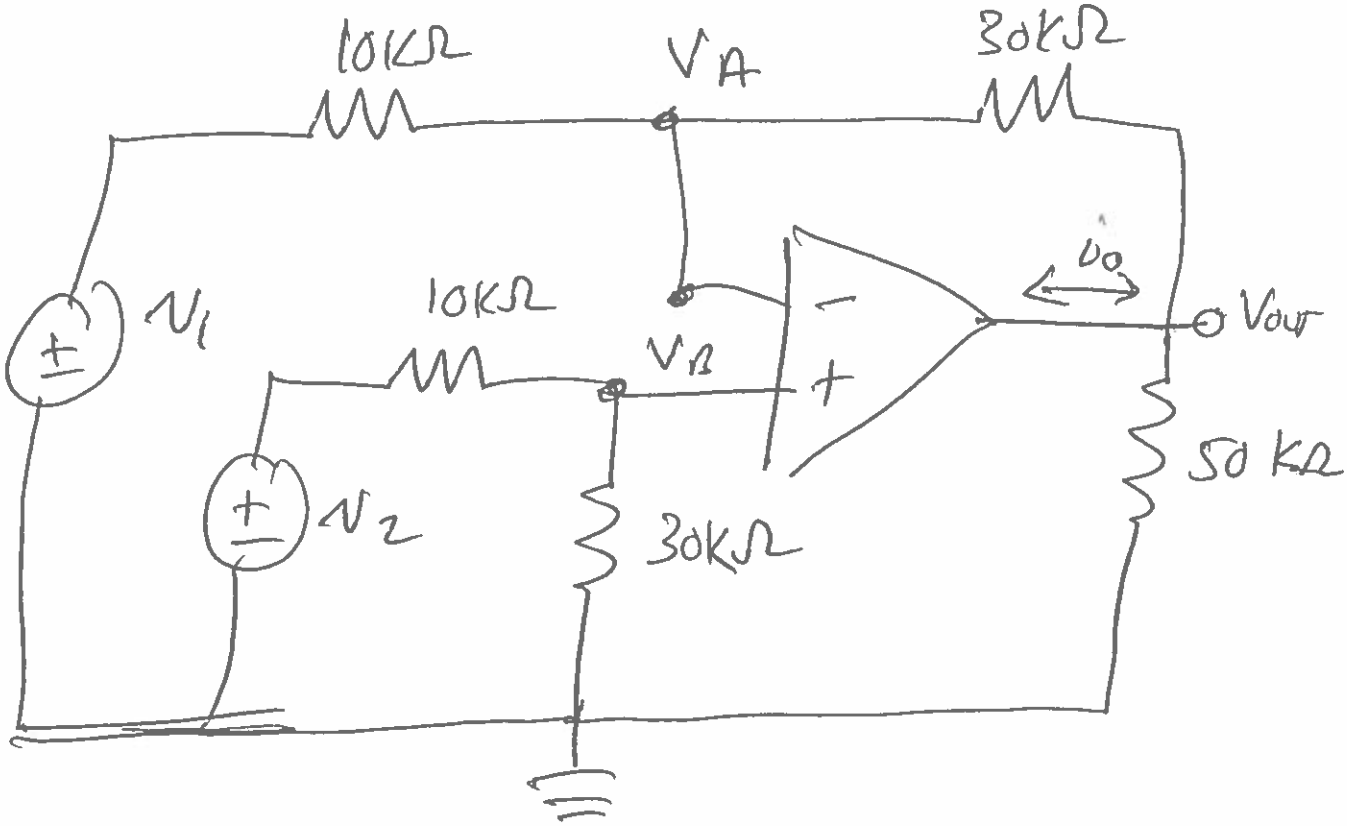
Thurs Apr 22 OP-AMPS II Lab

Tues Apr 20 Final Exam Handed out

~~Tues~~ Wed Apr 28 Final Exam Due

Apr 23 - All Homework/Labs must be turned in.

Node Analysis with OP-AMPS



OP-AMP is either a current source or sink to V_{out}. So you cannot write V_{out} as a primary node equation.

Later we use $V_A = V_B$

V_A node equation

$$0 = V_A\left(\frac{1}{10K\Omega} + \frac{1}{30K\Omega}\right) - V_{out}\left(\frac{1}{30K\Omega}\right) - V_1\left(\frac{1}{10K\Omega}\right)$$

V_B node

$$0 = V_B\left(\frac{1}{10K\Omega} + \frac{1}{30K\Omega}\right) - V_2\left(\frac{1}{10K\Omega}\right)$$

$$V_A = V_B$$

$$V_B\left(\frac{4}{30K\Omega}\right) = V_2\left(\frac{1}{10K\Omega}\right)$$

$$V_B = \frac{3}{4}V_2$$

$$V_A\left(\frac{4}{30K\Omega}\right) = V_{OUT}\left(\frac{1}{30K\Omega}\right) + V_1\left(\frac{1}{10K\Omega}\right)$$

$$V_A = \frac{1}{4}V_{OUT} + \frac{3}{4}V_1$$

$$V_A = V_B \qquad \frac{3}{4}V_2 = \frac{1}{4}V_{OUT} + \frac{3}{4}V_1$$

$$V_{OUT} = 3(V_2 - V_1)$$

$$V_{OUT} = 3(V_2 - V_1)$$

$$i_o = ?$$

$$i_o = i_{50} + i_{30}$$

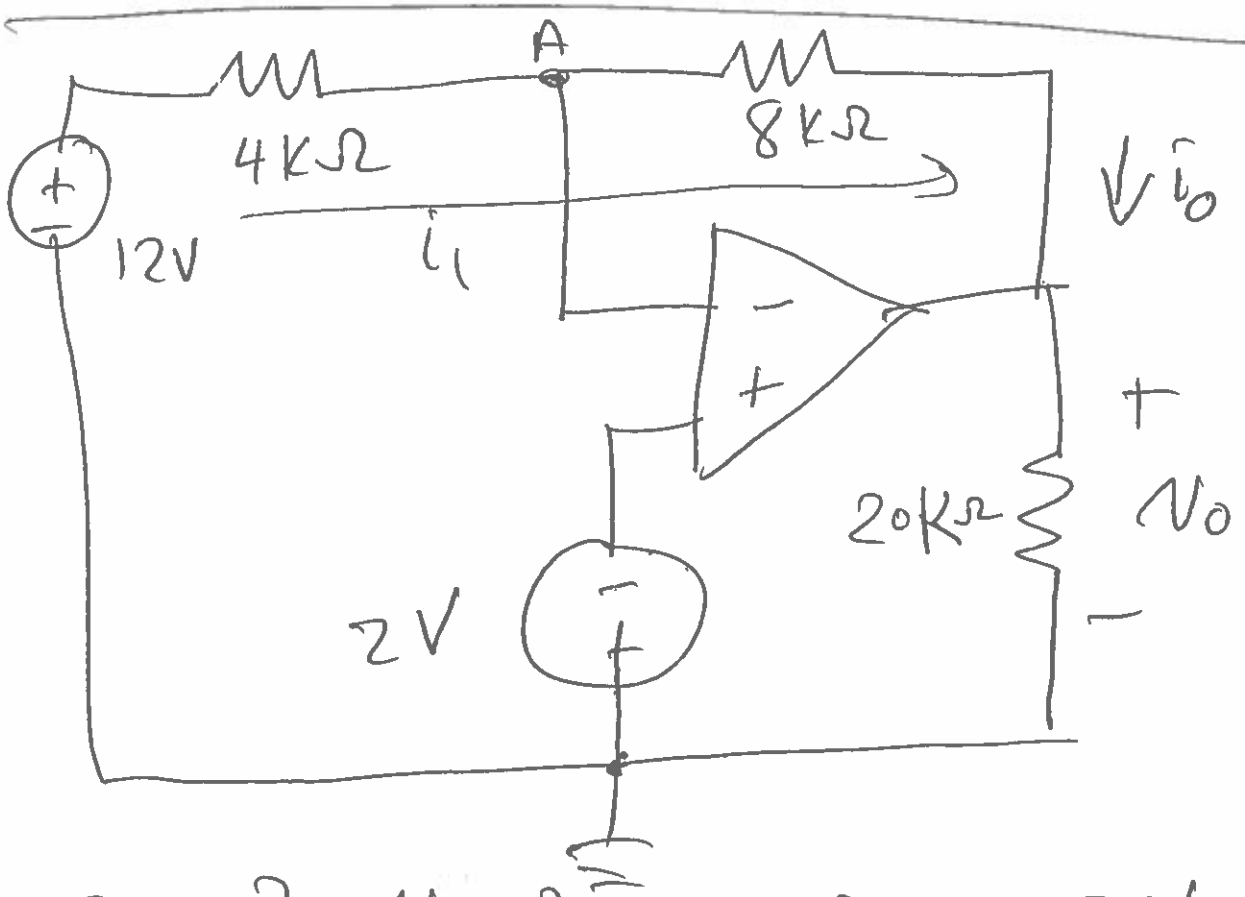
$$i_{50} = \frac{V_{OUT}}{50k\Omega} = \frac{3(V_2 - V_1)}{50k\Omega}$$

$$i_{30} = \frac{V_{OUT} - V_A}{30k\Omega} \qquad V_A = \frac{1}{4}(V_{OUT} + 3V_1)$$

$$i_{30} = \frac{3(V_2 - V_1) - \frac{1}{4}\left(3(V_2 - V_1) + 3V_1\right)}{30k\Omega}$$

$$= \frac{3V_2 - 3V_1 - \frac{3}{4}V_2}{30k\Omega} = \frac{\frac{5}{4}V_2 - 3V_1}{30k\Omega}$$

$$i_o = \frac{3}{50k\Omega}(V_2 - V_1) + \frac{\left(\frac{5}{4}V_2 - 3V_1\right)}{30k\Omega}$$



$i_o = ?$ $V_o = ?$ $V_A = -2V$

$$i_1 = \frac{12V - (-2V)}{4k\Omega} = \frac{14V}{4k\Omega} = \frac{14}{4}\ mA$$

$$i_1 = \frac{-2V - V_o}{8k\Omega} = \frac{14}{4}\ mA$$

$$28\,\text{mA} = -2\text{V} - V_o$$

$$V_o = -30\text{V}$$

$$i_o = i_1 = 3.5\,\text{mA}$$

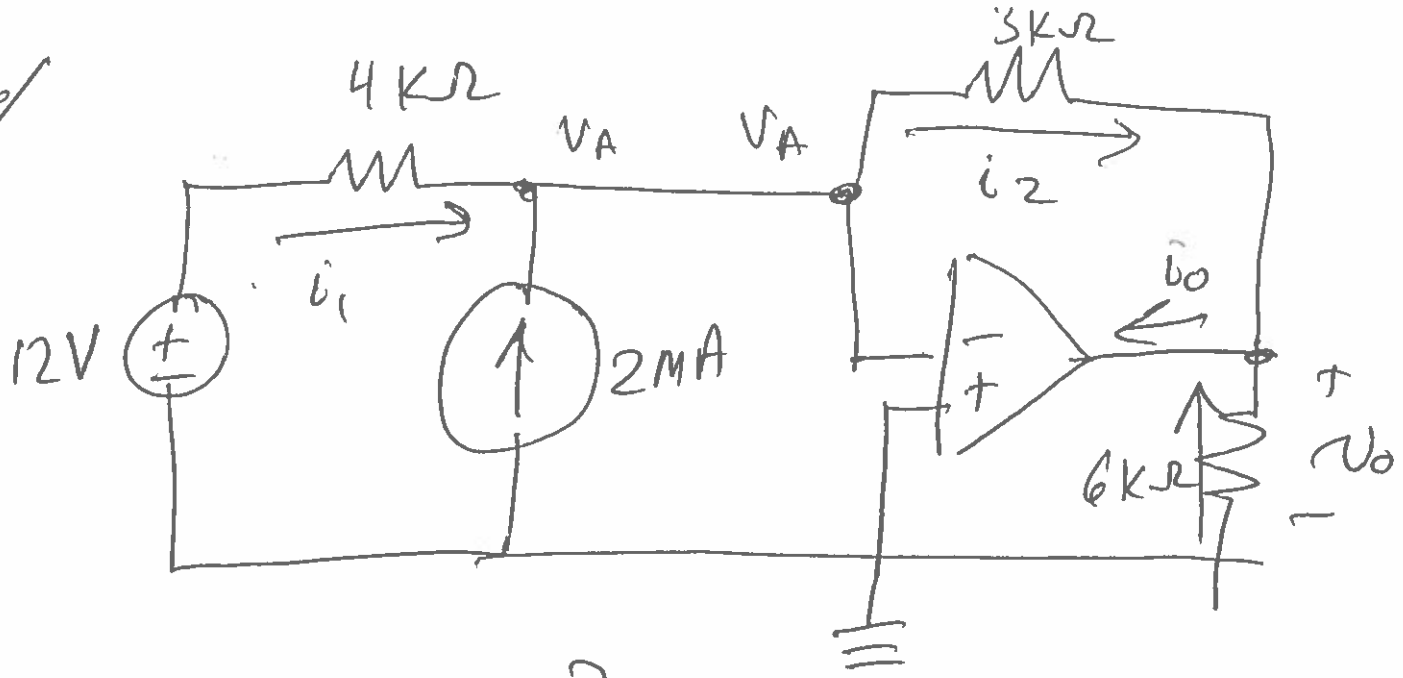
i in or out of op-amp

$$i_{ground} = \frac{-30\text{V}}{20\,\text{k}\Omega} = -1.5\,\text{mA}$$

i in or out of op-amp

$i = 5.0\,\text{mA}$ in.!

Ex/



i_o, v_o = ?

$V_A = 0$

$$i_1 = \frac{12V}{4K\Omega} = 3mA$$

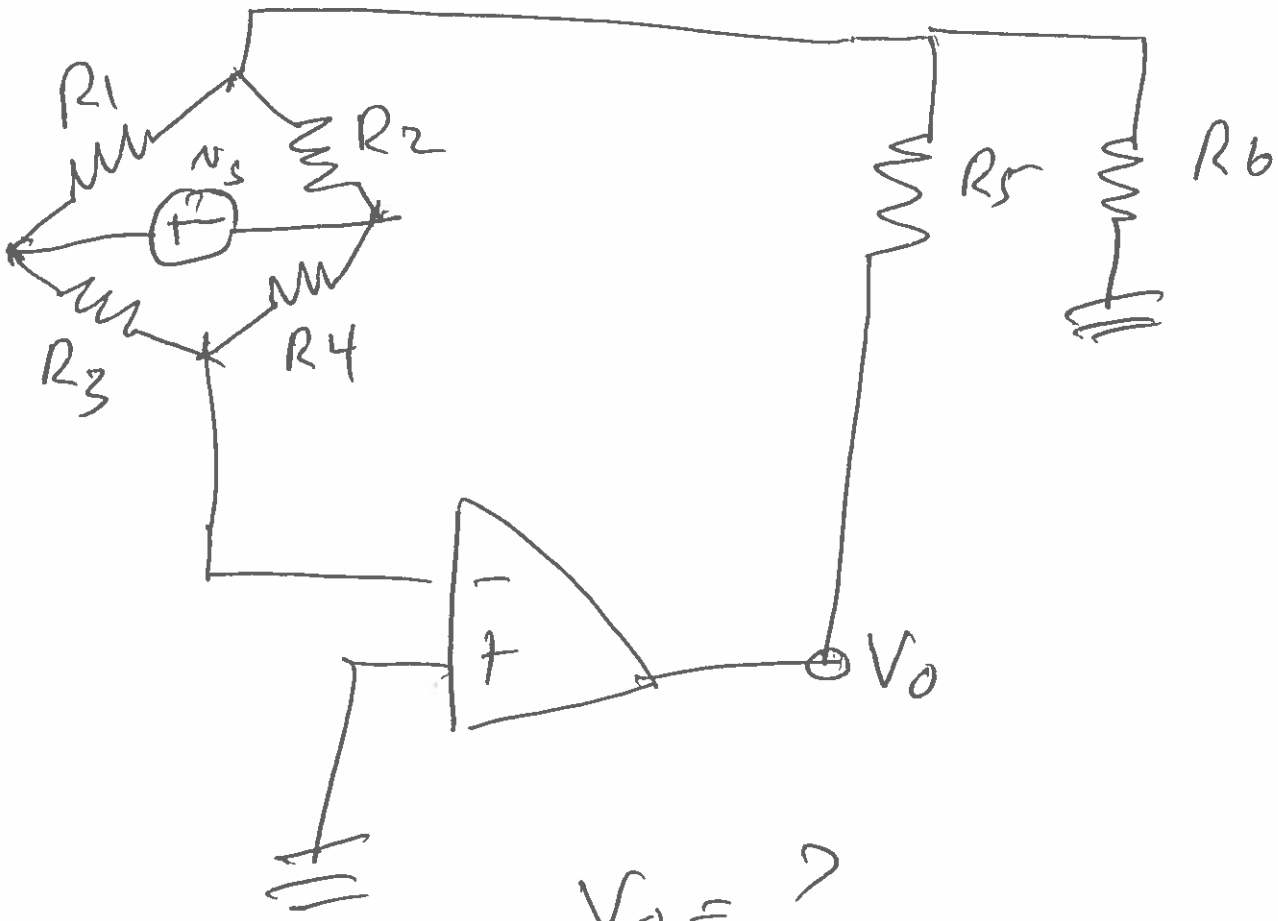
$$i_2 = i_1 + 2mA$$

$$= 3mA + 2mA = 5mA$$

$$v_o = -(5mA)(3K\Omega) = -15V$$

$$i_{6K\Omega} = \frac{15V}{6K\Omega} = 2.5mA$$

$$i_o = 5mA + 2.5mA = 7.5mA$$



$V_o = ?$