Desk Copy

ECE 300
Spring Semester, 2007
HW Set #5

Due: February 22, 2007: Version 2 Name wlg
wlg Print (last, first)

Use engineering paper. Work only on one side of the paper. Use this sheet as your cover sheet, placed on top of your work and stapled in the top left-hand corner. Number the problems at the top of the page, in the center of the sheet. **Do neat work. Underline your answers. Show how you got your equations.** **Be sure to show how you got your answers.** Each problem counts 10 points.

5.7 Ans: $V_0 = -10\text{mV}$, $V_d = 100\text{ nV}$

5.10 Ans $\frac{V_o}{V_s} = 2$

5.14 Ans: $V_o = -2.5\text{ V}$

5.15 Ans: (a) $\frac{V_o}{i_s} = -\left[R_1 + R_3 + \frac{R_1 R_3}{R_2}\right]$, (b) $\frac{V_o}{i_s} = -92\,k\Omega$

5.23 Ans: $\frac{V_o}{V_s} = \frac{-R_f}{R_i}$

5.30 Ans: $i_x = 10\ \mu\text{A}$, $P = 2\ \mu\text{W}$

5.32 Ans: $i_x = 600\text{ nA}$, $V_o = 12\text{ mV}$, $P = 2.4\text{ nW}$

5.58 Ans: $V_o = -2.738\text{ V}$ $i_o = 0.6848\text{ mA}$

5.58XX Simulate 5.58 with pspice and verify i_o. Use the μA741 op amp

H.W. #5 wlg
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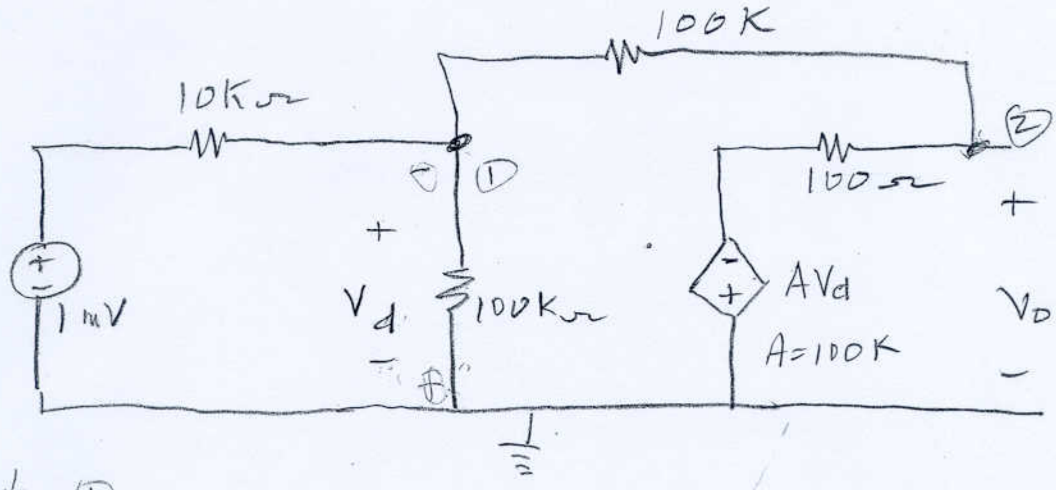
5.7 Redraw the circuit in the text using the op amp model.



At ①

$$\frac{V_d - 1\times10^{-3}}{10} + \frac{V_d}{100} + \frac{V_d - V_o}{100K} = 0$$

$$10V_d - 10\times10^{-3} + V_d + V_d - V_o = 0$$

$$\boxed{12V_d - V_o = 10\times10^{-3}} \quad (1)$$

At ②

$$\frac{V_o - V_d}{100K} + \frac{V_o + 100K\,V_d \;[AV_d]}{100} = 0$$

$$V_o - V_d + 1000V_o + 100\times10^{6}V_d = 0$$

$$\boxed{100\times10^{6}V_d + 1001V_o = 0} \quad (2)$$

solve (1) & (2)

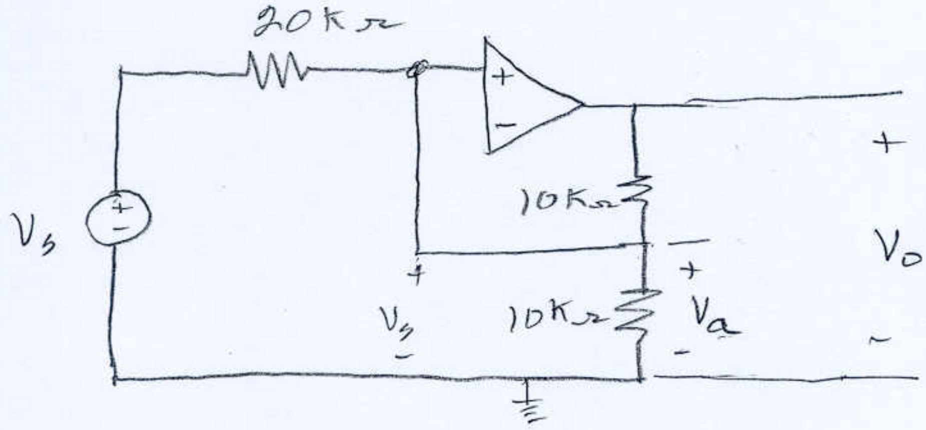
$V_d = 100nV$

$V_o = -.0099987\,V$

$V_o \doteq -10\,mV$

5.10

Find $\frac{V_o}{V_s}$ for the following op-amp circuit.



$$V_a = \frac{V_o \times 10K}{10K + 10K} = \frac{V_o}{2}$$

but $V_a = V_s$

∴

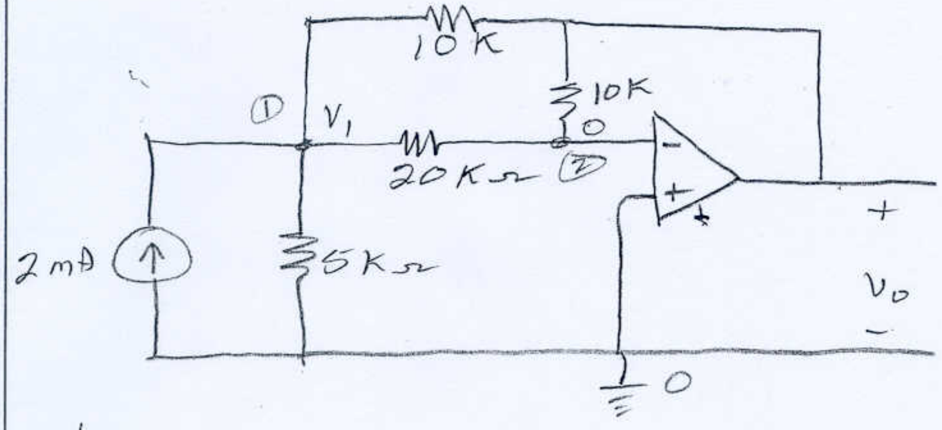
$$V_s = \frac{V_o}{2}$$

$$\boxed{\frac{V_o}{V_s} = 2}$$

.D1

5.14

Determine V_o for the following Op-Amp circuit.



At ①

$$\frac{V_1}{5K} + \frac{V_1 - V_o}{10K} + \frac{V_1 - 0}{20K} = 2\times10^{-3}$$

$$4V_1 + 2V_1 - 2V_o + V_1 = 40$$

$$\boxed{7V_1 - 2V_o = 40}$$

At ②

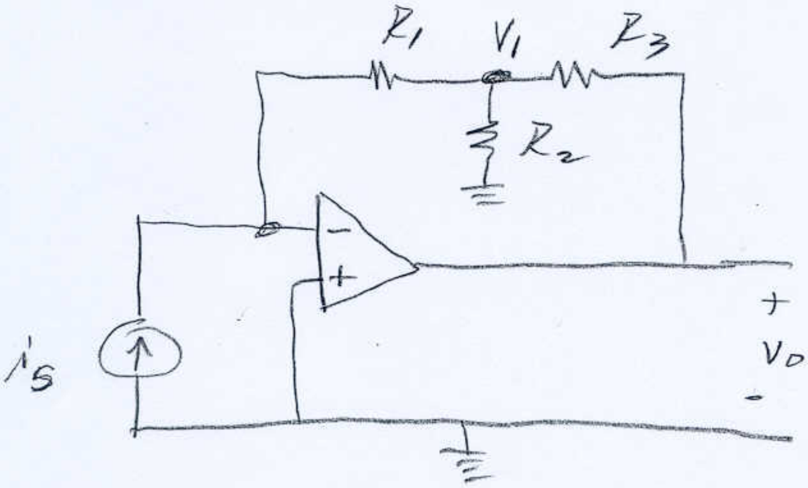
$$\frac{0 - V_1}{20K} + \frac{0 - V_o}{10K} = 0$$

$$\boxed{-V_1 - 2V_o = 0}$$

$V_1 = 5V$ $\quad$ $V_o = -2.5V$

$$\boxed{V_o = -2.5\ V}$$

5.15 For the following op-amp configuration
(a) determine V_o / i_x
(b) evaluate the ratio for $R_1 = 20k\Omega$
$R_2 = 25 k\Omega$, $R_3 = 40 k\Omega$



$$-i_s + \frac{V_1}{R_2} + \frac{V_1 - V_o}{R_3} = 0$$

but $i_s = -\frac{V_1}{R_1}$ OR $V_1 = -i_s R_1$

so

$$-i_s - \frac{i_s R_1}{R_2} - \frac{i_s R_1 - V_o}{R_3} = 0$$

$$-i_s\left[1 + \frac{R_1}{R_2} + \frac{R_1}{R_3}\right] = \frac{V_o}{R_3}]$$

$$-i_s\left[R_3 + \frac{R_1 R_3}{R_2} + R_1\right] = V_o$$

5.15 cont

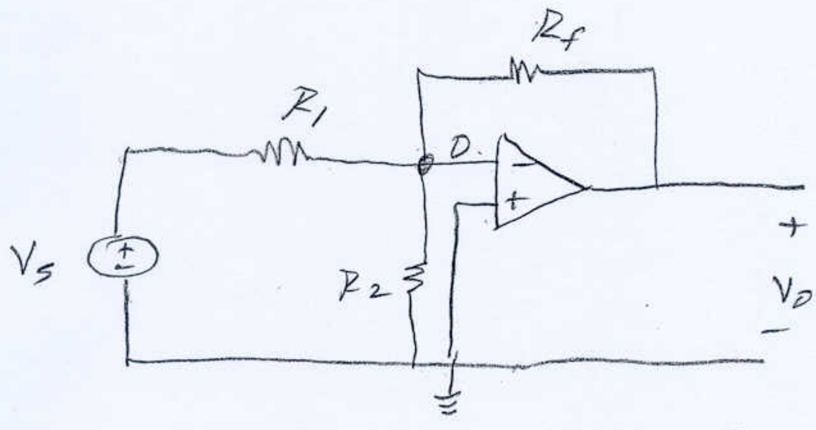
$$\frac{v_o}{i_s} = -\left[R_1 + R_3 + \frac{R_1 R_3}{R_2}\right]$$

$$= -\left[20K + 40K + \frac{(40K)(20K)}{25K}\right]$$

$$\boxed{\frac{v_o}{i_s} = -92K\,\Omega}$$

5.23

Find the voltage gain for $\frac{V_o}{V_s}$.



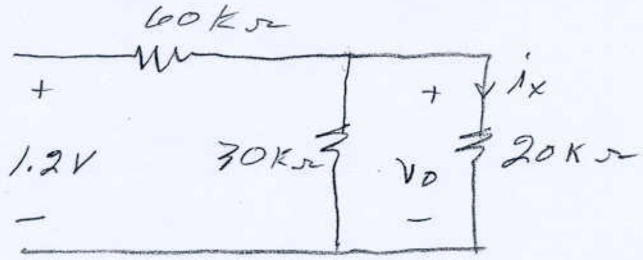
$$\frac{0 - V_s}{R_1} + \frac{0 - V_o}{R_f} + \frac{0}{R_2} = 0$$

$$-\frac{V_s}{R_1} - \frac{V_o}{R_f} = 0$$

$$\frac{V_o}{V_s} = -\frac{R_f}{R_1}$$

5.30

Circuit is arranged as a voltage follower. This means it is necessary to analyze the following



30k∥20k = 12kΩ

$$V_o = \frac{1.2 \times 12K}{60K + 12K}$$

$$V_o = 0.2V$$

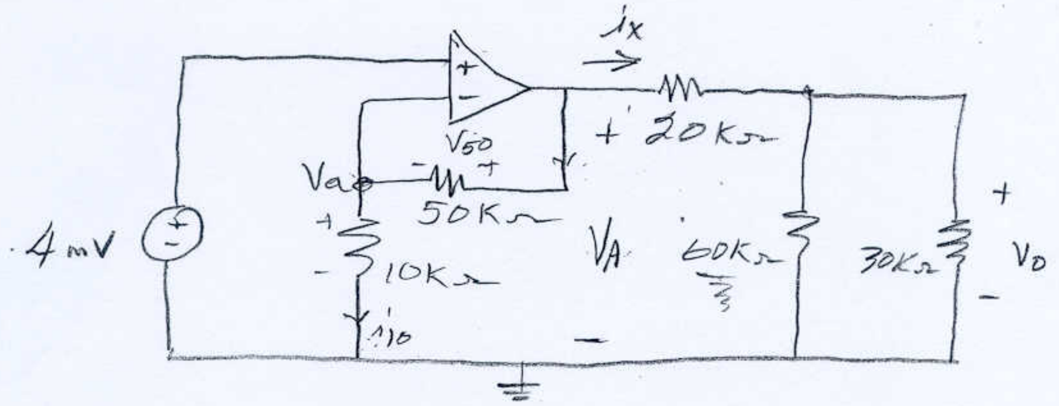
$$i_x = \frac{V_o}{20K} = \frac{.2}{20} \times 10^{-3}$$

$$i_x = 10 \times 10^{-6} A = 10 \mu A$$

$$P_{20k} = \frac{V_o^2}{20k} = \frac{(.2)^2}{20k} = 2 \times 10^{-6} W$$

$$P_{20k} = 2 \mu W$$

5.32 Calculate i_x and V_o in the circuit below. Also find the power dissipate in the 60-kΩ resistor.



$V_a = 4\,mV$

$i_{10} = \frac{4 \times 10^{-3}}{10 \times 10^{3}} = .4 \times 10^{-6}\,A$

$V_A = (.4 \times 10^{-6})(50 \times 10^{3}) + 4 \times 10^{-3}$

$V_A = 20 \times 10^{-3} + 4 \times 10^{-3}$

$V_A = 24\,mV$

2×10^{-6}

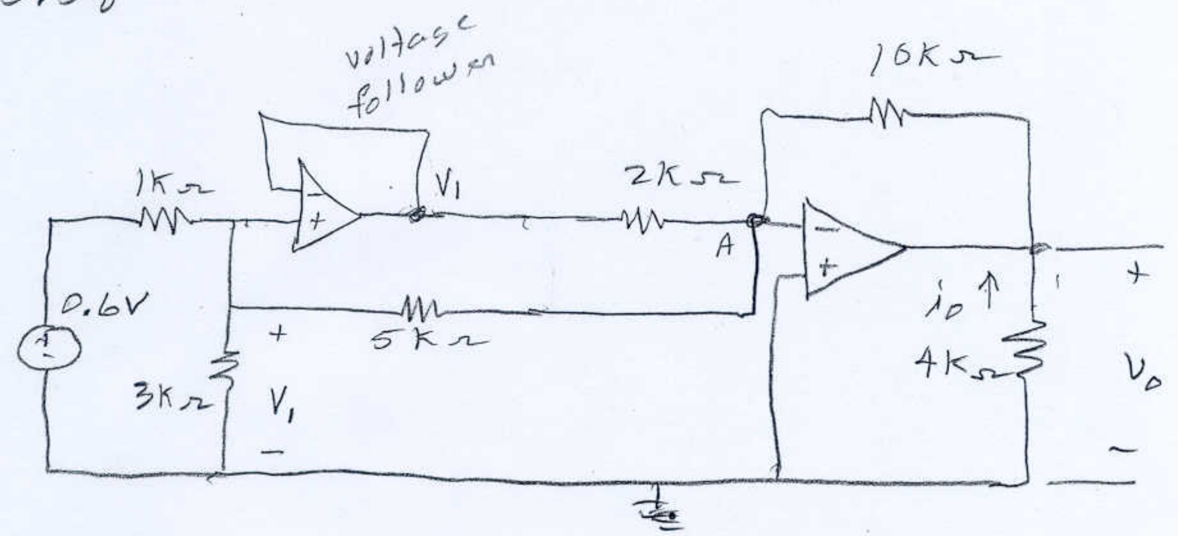
$30K \parallel 60K = 20k$

$V_o = \frac{V_A \times 20K}{20K + 20K} = 12\,mV$

$i_x = \frac{V_A}{40K} = 600\,nV$

$P_{60K} = \frac{V_o^2}{60K} = \frac{(.012)^2}{60K} = 2.4\,nW$

5.58



Point A is at ground. Therefore

$$V_1 = \frac{0.6 \times 3K \| 5K}{1K + 3K \| 5K} = \frac{0.6 \times 1.875K}{2.875K}$$

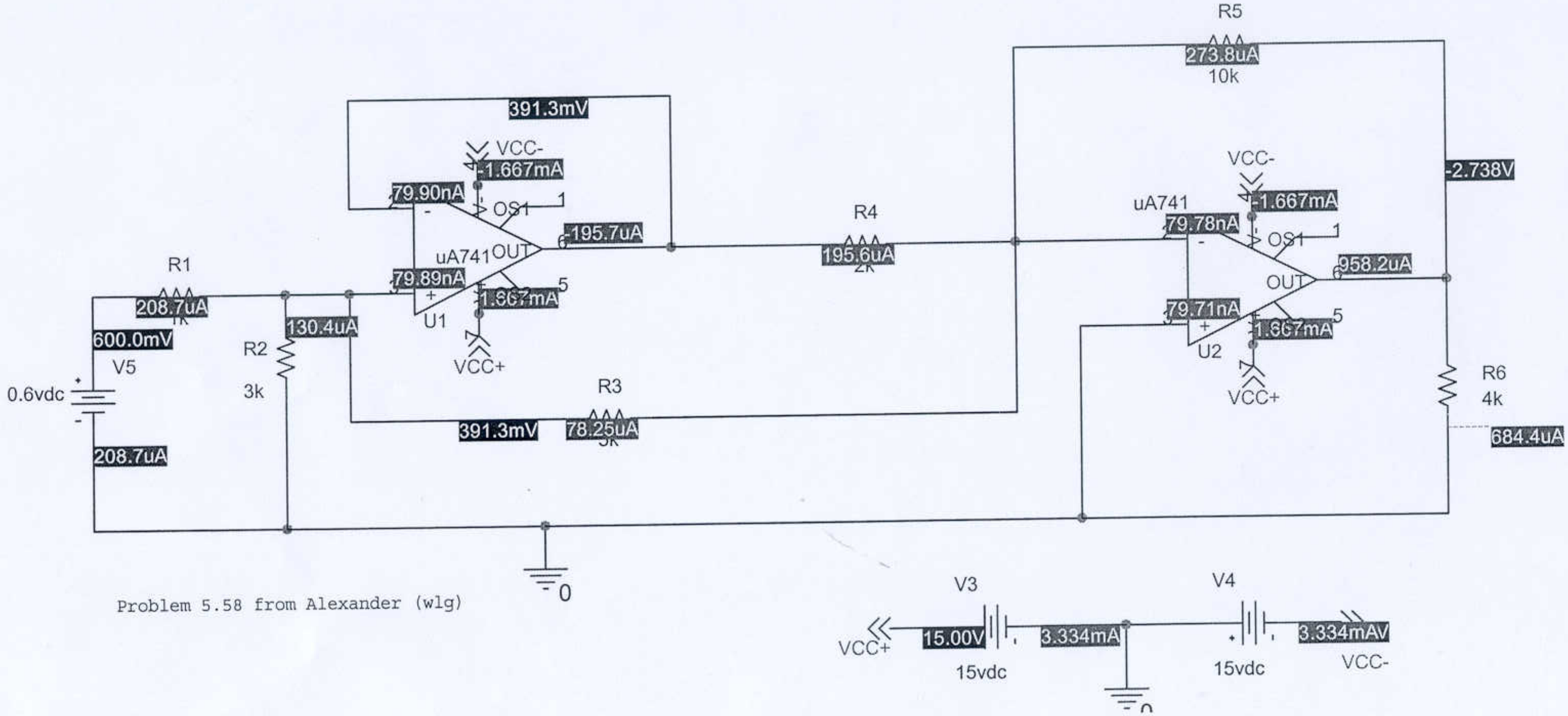
$$V_1 = 0.3913\ V$$

$$V_o = -\left(\frac{10K}{2K} + \frac{10K}{5K}\right) V_1$$

$$V_o = -2.739\ V$$

$$i_o = \frac{-V_o}{4K} = \frac{2.739}{4K}$$

$$i_o = 684.8\ \mu A$$



Problem 5.58 from Alexander (wlg)