ANALOG SIGNAL PROCESSING

ECE 210 & 211

Exercise 1

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Prof. Yang Xu (徐杨)

yangxu-isee@zju.edu.cn

Yue Dai, yuedai@zju.edu.cn
Jinfeng Huang, huangjinfeng@zju.edu.cn
Yance Chen, 12031045@zju.edu.cn
Yuan Ma, 22241064@zju.edu.cn
Youshui He, 22241003@zju.edu.cn
Zongwen Li, zongwen_li@zju.edu.cn
Muhammad Malik, mmalik@zju.edu.cn
Munir Ali, Munir_li@zju.edu.cn
Muhammad Abid, abid_anwar@zju.edu.cn

1kIx

ZJU-UIUC Institute

Zhejiang University / University of Illinois at Urbana-Champaign Institute

Question 1 a: Find I_o in the network in network given below? $I_o = -48\,mA$

$I =$

mA

44

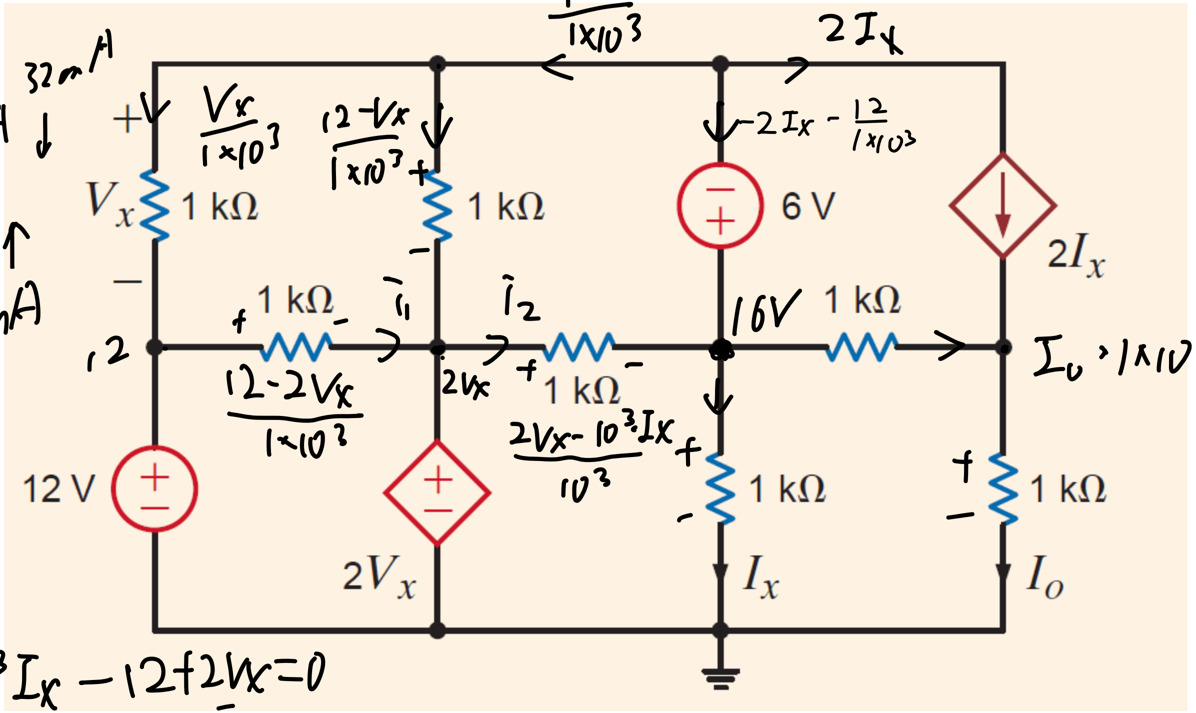
20 ← 11V ← 80mA ↓ 32mA

16mA

48mA

20

-4



$I_x = \frac{16}{10^3}\,A$

$-2 \cdot \frac{16}{10^3} - \frac{12}{1\times10^3}$

$\frac{-44}{10^3}$

$-32-12$

$2V_x \cdot 18 - V_x$

$18 + V_x$

$V_x + 6 + 2V_x - 10^3 I_x - 12 + 2V_x = 0$

$18 + V_x + 10^3 I_x = 0$

$$\frac{12 + V_x + 6}{1\times10^3} + \frac{18 + V_x - 10^3 I_o}{10^3} = \frac{V_x - 18}{10^3} - 2I_x - \frac{12}{10^3}$$

$($ $10^3 I_x = -V_x - 18$

$5V_x - 6 + V_x + 18 = 0$

$6V_x = -12$

$V_x = -2V$

$I_a = \frac{V_x}{2}$ mA

$I_b = 4 - \frac{V_x}{2}$ mA

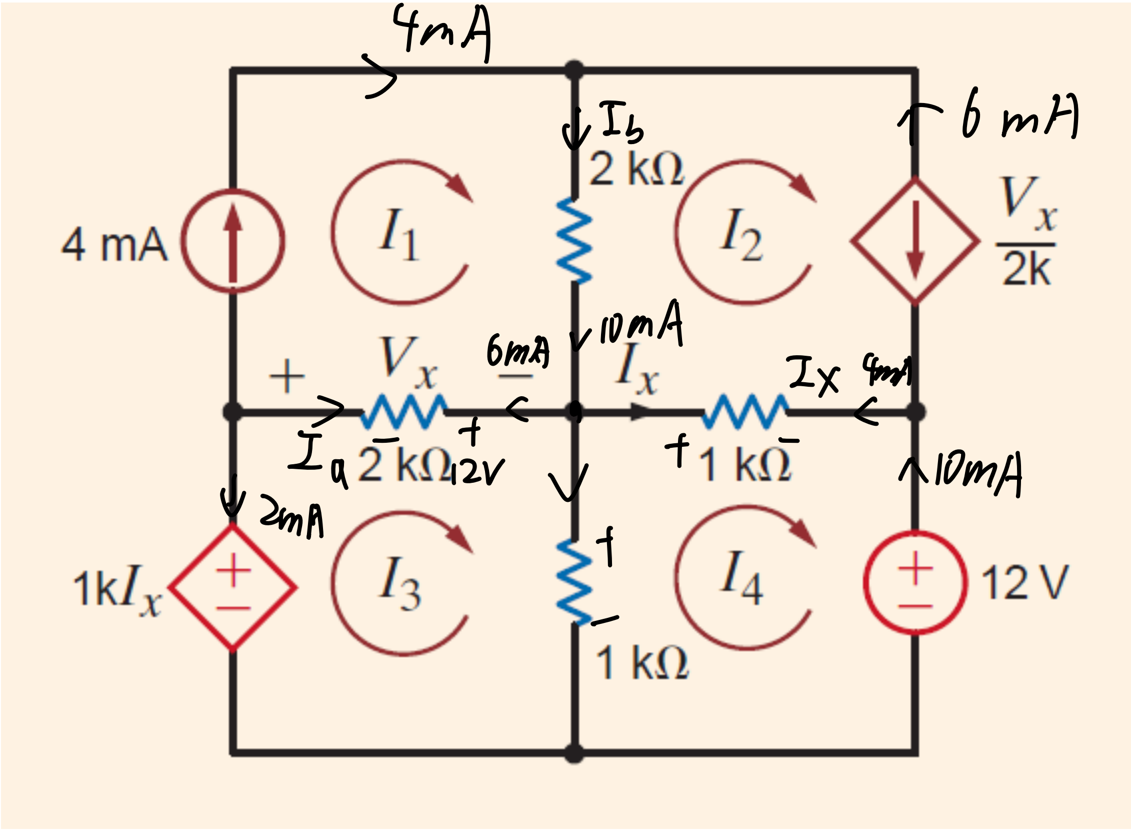
Question 1 b: Determine all loop currents?

$I_1 = 4$ mA

$I_2 = -6$ mA

$I_3 = -2$ mA

$I_4 = -10$ mA



$12 + 10^3 I_x$ mA

$10^3 I_x - V_x - 10^3 I_x - 12 = 0$

$V_x = -12V$

$I_a = 6mA$

$12V + 10^3 I_x = (\frac{4}{10^3} - I_x)10^3$

$= 4 - 10^3 I_x$

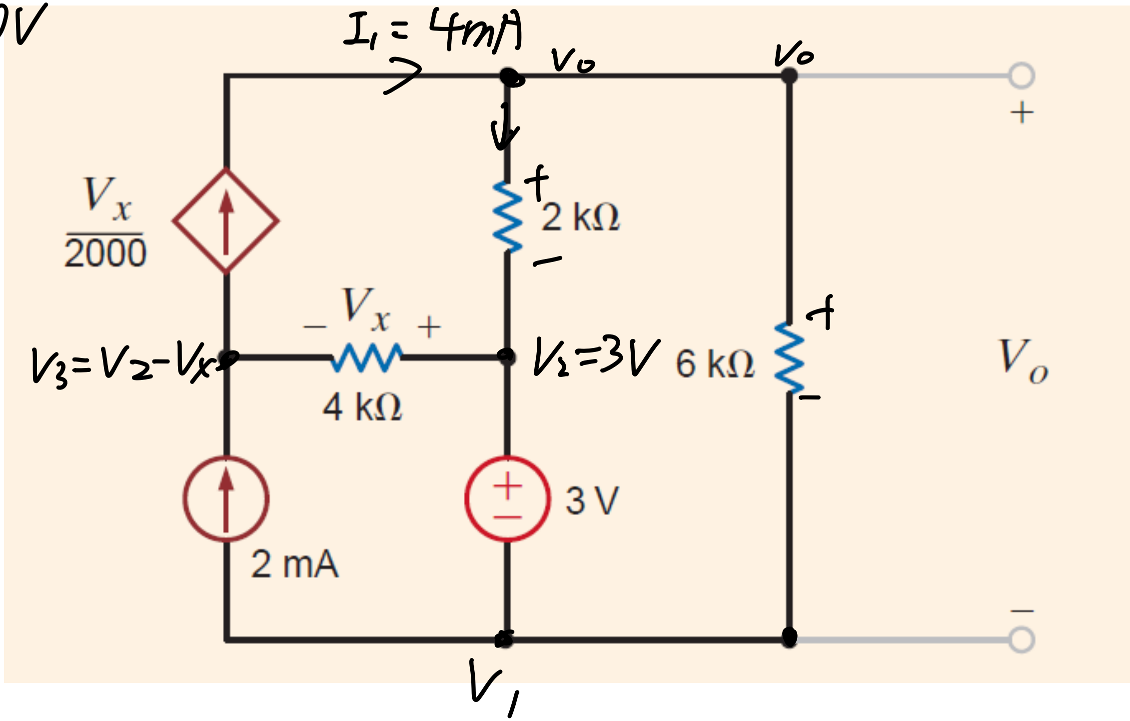
$2 \cdot 10^3 I_x = -8 - 4$

$I_x = -4mA$

Question 2 : Determine V_o in the circuit using Thevenin theorem?

$V_o = \frac{33}{4}\ V$

Assume $V_1 = 0V$



KCL for node 3

$\frac{Vx}{2} = 2 + \frac{Vx}{4}$

$\Rightarrow Vx = 8V$

$I_1 = 4mA$

KCL for node 0

$4 = \frac{V_0 - 3}{2} + \frac{V_0 - 0}{6}$

$\Rightarrow V_0 = \frac{33}{4}\ V$

Question 3 :

The two op-amp circuits shown produce an output given by the equation

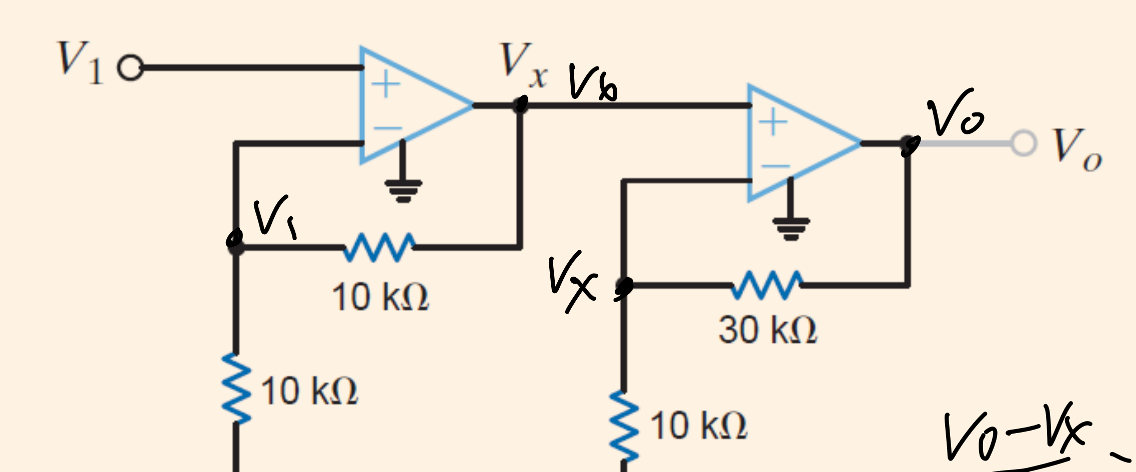
$$V_o = 8V_1 - 4V_2$$

where

$$1\text{ V} \le V_1 \le 2\text{ V} \quad \text{and} \quad 2\text{ V} \le V_2 \le 3\text{ V}$$

We wish to determine (a) the range of V_o and (b) if both of the circuits will produce the full range of V_o given that the dc supplies are ± 10 V.

$V_o \in [-4V, 8V]$



$\frac{V_2 - V_1}{10} = \frac{V_1 - V_x}{10}$

$\frac{V_o - V_x}{30} = \frac{V_x}{10}$

$V_o = 4V_x$

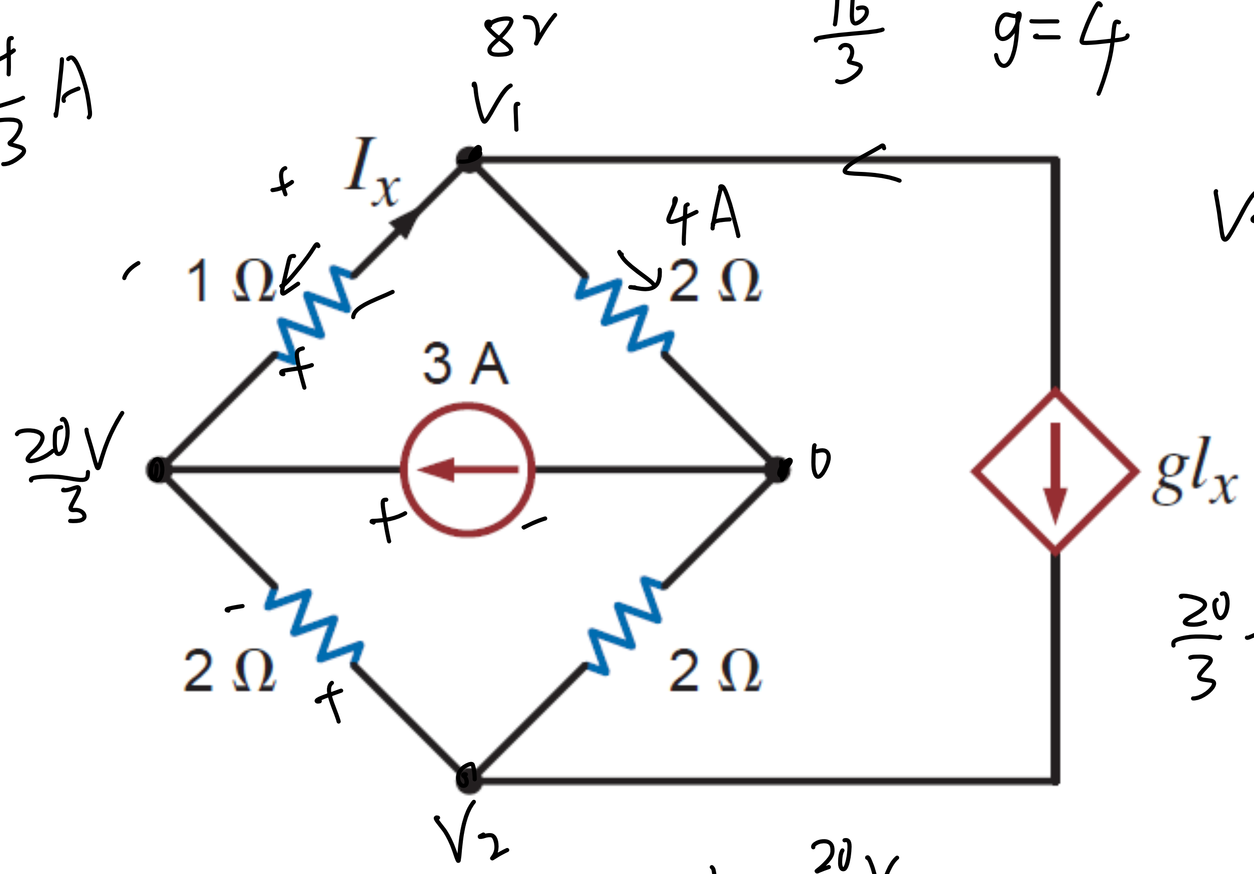
$= 8V_1 - 4V_2$

$V_x = 2V_1 - V_2$

Question 5 : Find the value of *g* in the network shown below such that the power supplied by 3-A source is 20W?

$\frac{16}{3}$ $g = 4$

$\frac{4}{3}$ A



$V = \frac{20}{3}$ ✓

$$\frac{20}{3} - V_1 + \frac{-V_1}{2} = \frac{V_2 - \frac{20}{3}}{2} + \frac{V_2}{2}$$

$$= g\left(\frac{20}{3} - V_1 + \frac{-V_1}{2}\right)$$

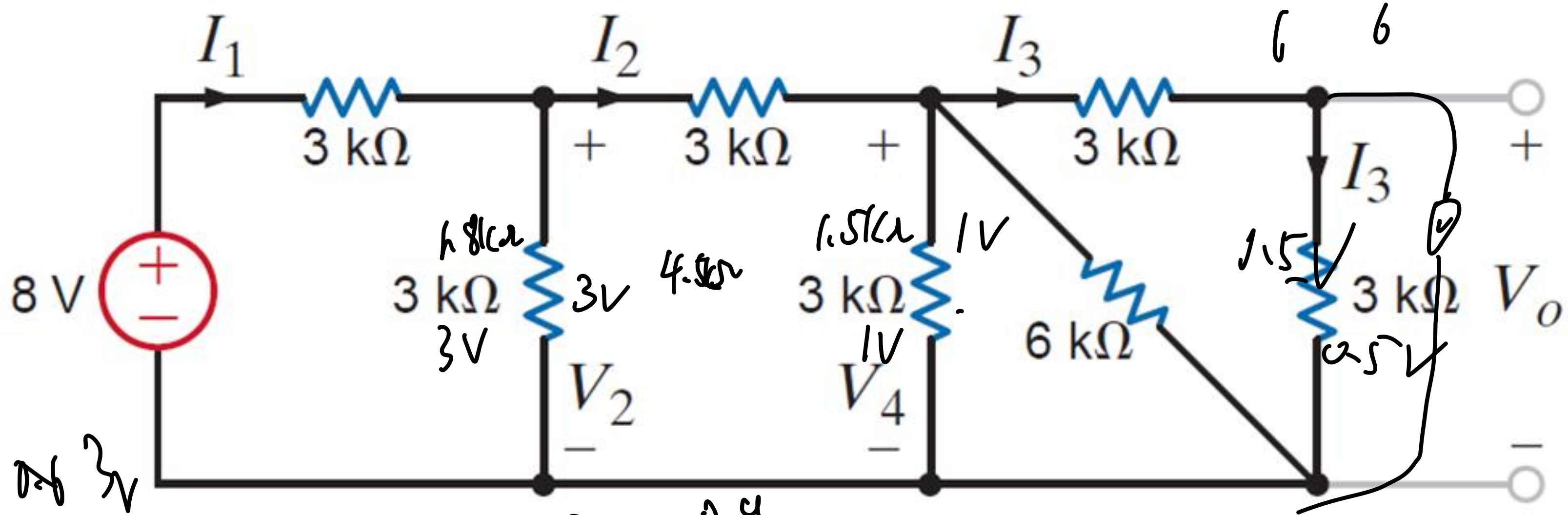
$$\frac{V_2 - \frac{20}{3}V}{2} + 3 = \frac{20}{3} - V_1 \qquad \frac{20}{3} - \frac{3}{2}V_1 = 14 - 2V_1 - \frac{10}{3}$$

$V_2 - \frac{20}{3}V + 6 = \frac{40}{3} \cdot 2V_1$ $\quad 10 - 14 = -\frac{1}{2}V_1$

$V_2 = 14 - 2V_1$ $\quad V_1 = 8$

Question 6 : Find V_o in the network using linearity and assume that $V_o = 1V$?

$\frac{3 \cdot \cancel{4.5}\ 3}{\cancel{7.5}\ 5} = 1.8k\Omega$



$\frac{\cancel{1.8}}{\cancel{4.8}} \cdot 8$ $\quad \frac{3 \cdot \cancel{4.5}\ 3}{\cancel{7.5}\ 5}$ $\quad \frac{\cancel{3 \cdot 4.5}}{\cancel{7.5}} = 1.8k\Omega$

$\frac{1.8}{1.8+3} \cdot 8 = \frac{1.8}{4.8} \cdot 8 = 3V$

Question 7: Show that circuit can produce the output

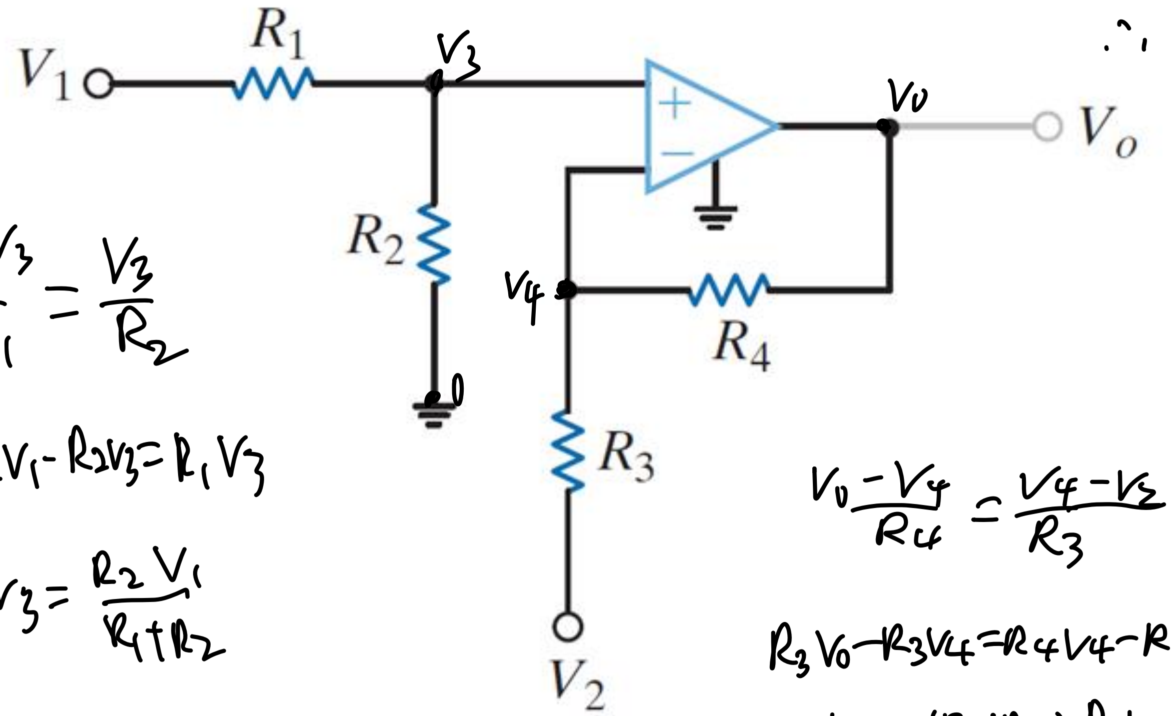
$$V_o = K_1V_1 - K_2V_2$$

$$\textbf{only for } 0 \leq K_1 \leq K_2 + 1$$

$\therefore\ K_1 = \left(\frac{R_2}{R_1+R_2}\right)\cdot\left(1+\frac{R_4}{R_3}\right)$

$K_2 = \frac{R_4}{R_3}$

$\therefore\ 0 \leq K_1 \leq K_2+1$



$\frac{V_1-V_3}{R_1} = \frac{V_3}{R_2}$

$R_2V_1 - R_2V_3 = R_1V_3$

$V_3 = \frac{R_2V_1}{R_1+R_2}$

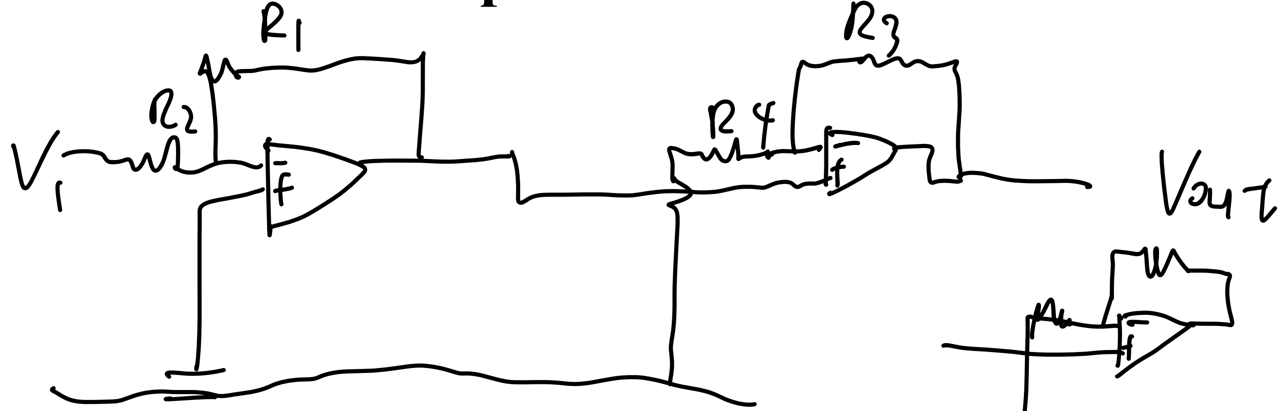
$\frac{V_o-V_4}{R_4} = \frac{V_4-V_2}{R_3}$

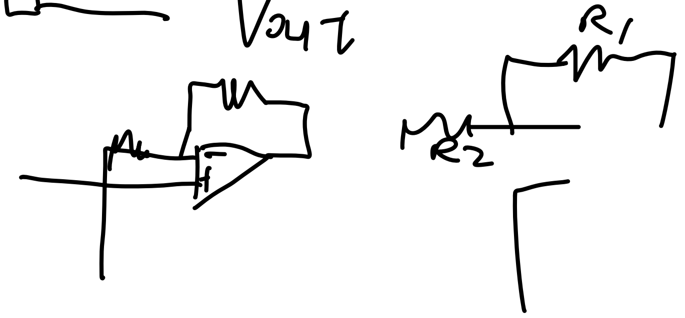
$R_3V_o - R_3V_4 = R_4V_4 - R_4V_2$

$V_o = (R_3+R_4)\cdot \frac{R_2V_1}{\ldots} - \frac{R_4V_2}{\ldots}$

$R_3(R_1+R_2) \quad R_3$

Question 8: Design a two stage op-amp network that has a gain of -50,000 while no current into its input terminal. Use no resistors ~~smaller than 1 kΩ~~





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

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

$$V_{out} = \left(1+\frac{R_3}{R_4}\right)\cdot\left(-\frac{R_1}{R_2}\right)V_1$$

$$\left(1+\frac{R_3}{R_4}\right)\cdot\left(\frac{R_1}{R_2}\right) = 50000$$

$R_1 = 25000\,k\Omega$

$\therefore\ R_3 = R_4 = R_2 = 1\,k\Omega$

$1\,k\Omega$