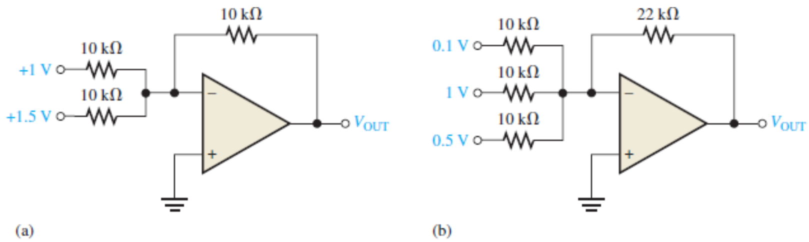
Sheet P.1

Wednesday, November 16, 2022 1:19 PM

Determine the output voltage for each circuit shown.



a) $V_o = 1V * -\frac{10}{10} + 1.5V * -\frac{10}{10} = -2.5V$

b) $V_o = -\left(\frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3\right)$

$= -3.52V$

Sheet P.2

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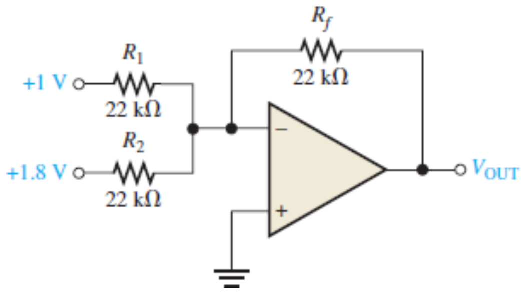
For the circuit shown, determine V_{out}. Also, find the value of R_f necessary to produce an output that is five times the sum of the inputs in the shown circuit.



$V_{out} = -2.8 \text{ V}$

$$V_{out} = -\frac{R_f}{R}(V_1 + V_2)$$

$$\frac{R_f}{R} = 5 \qquad \because R = R_1 = R_2 = 22\,k\Omega$$

$$\therefore R_f = 110\ k\Omega$$

Sheet P.3

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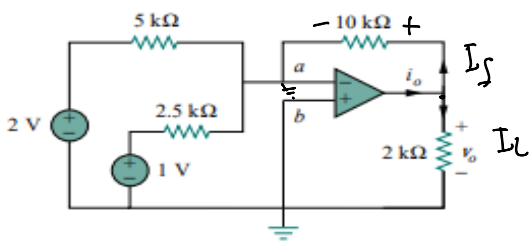
Calculate Vo and io for the following Op-amp circuit.



$$V_{out} = 2 * -\frac{10K}{5K} + 1 * \frac{10K}{2.5K} = -8\ V$$

using KCL at output node

$$I_o = I_f + I_L$$

$$I_f = \frac{V_o}{10K} \qquad I_L = \frac{V_o}{2K}$$

$$I_o = -4.8\ mA$$

Sheet P.4

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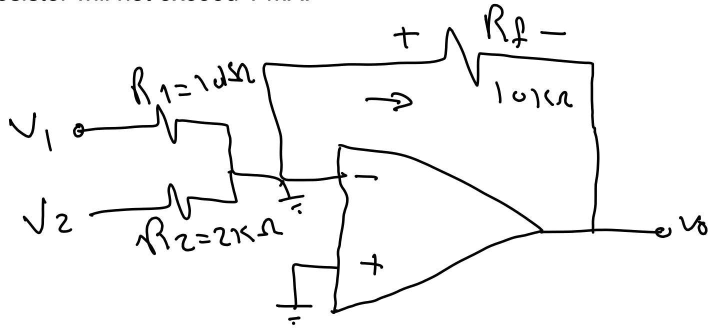
Design an inverting op-amp circuit to form the weighted sum Vo of two inputs V1 and V2. It is required that Vo= -(V1 +5V2). Choose values for R1, R2, and RF so That for a maximum output voltage of 10V the current in the feedback resistor will not exceed 1 mA.



$$V_o = -(V_1 + 5V_2)$$

$$= -\left(\frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2\right)$$

$$\frac{R_f}{R_1} = 1 \longrightarrow R_f = R_1 \longrightarrow 1$$

$$\frac{R_f}{R_2} = 5 \longrightarrow R_f = 5R_2 \longrightarrow 2$$

$$R_f = \left|\frac{0 - V_o}{I_f}\right| = \left|\frac{0 - 10}{1mA}\right| = 10\ k\Omega$$

from eq 1

$R_1 = 10\ k\Omega$

from eq 2

$R_2 = 2\ k\Omega$

Sheet P.5

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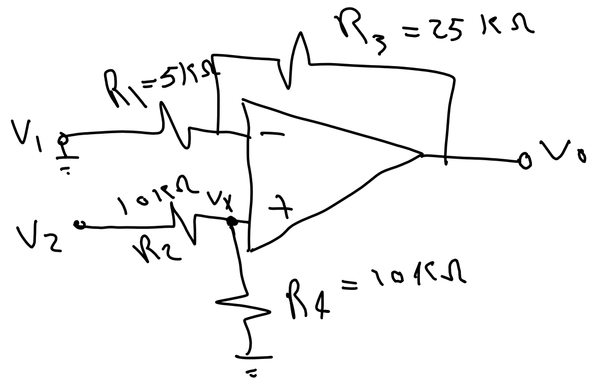
Design Op-amp circuit with inputs V_1 and V_2 such that $V_o=-5V_1+3V_2$ using:
a. Only one Op-amp. b. More than one Op-amp.

a)



$$V_o = V_{o1} + V_{o2}$$
$$= -\frac{R_3}{R_1} V_1 + V_x \left(1 + \frac{R_3}{R_1}\right)$$

using voltage divider

$$V_x = V_2 \frac{R_4}{R_2 + R_4}$$

$$V_o = \underbrace{-\frac{R_3}{R_1}}_{-5} V_1 + \underbrace{\frac{R_4}{R_2+R_4} * \left(1 + \frac{R_3}{R_1}\right)}_{3} V_2$$
$$= -5 V_1 + 3 V_2$$

$$\frac{R_3}{R_1} = 5 \rightarrow (1)$$

$$\frac{R_4}{R_2+R_4} (1+5) = 3$$

$$\frac{R_4}{R_2+R_4} = \frac{1}{2} \rightarrow 2R_4 = R_2 + R_4$$

$$\therefore \quad R_4 = R_2 \rightarrow (2)$$

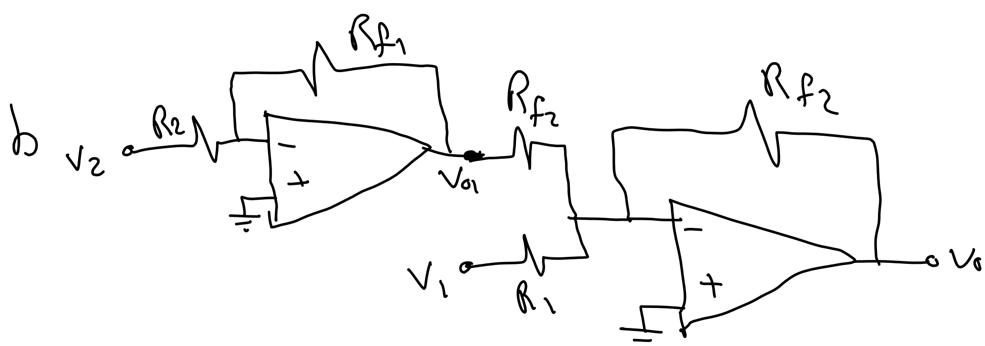
Let $R_1 = 5\,k\Omega$

$\therefore \quad R_3 = 25\,k\Omega$

Let $R_2 = 10\,k\Omega$

$\therefore \quad R_4 = 10\,k\Omega$

b



$$V_{o1} = -\frac{R_{f1}}{R_2} V_2$$

$$V_o = -\frac{R_{f2}}{R} V_{o1} + \frac{-R_{f2}}{R_1} V_1$$

$$= +\frac{\cancel{R_{f2}}}{\cancel{R_{f2}}} \cdot + \frac{R_{f1}}{R_2} V_2 - \frac{R_{f2}}{R_1} V_1$$

$$= +3V_2 - 5V_1$$

$$\frac{R_{f2}}{R_1} = 5 \longrightarrow (1)$$

$$\frac{R_{f1}}{R_2} = 3 \longrightarrow (2)$$

Let $R_1 = 3\,K\Omega$

$\therefore R_{f2} = 15\,K\Omega$

Let $R_2 = 3\,K\Omega$

$\therefore R_{f1} = 9\,K\Omega$

Sheet P.6

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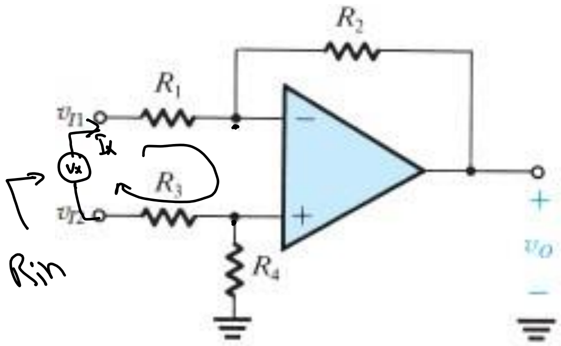
Consider the difference-amplifier shown, for the case $R_1 = R_3 = 2$ kΩ and $R_2 = R_4 = 200$ kΩ.

a. Find the value of the differential gain A_d.

b. Find values for the resistances in the circuit so that the circuit behaves as a difference amplifier with an input resistance of 20 kΩ and a gain of 10.



a)

$$V_o = (V_{i2} - V_{i1}) \underbrace{\frac{R_2}{R_1}}$$

$$A_d = \frac{R_2}{R_1} = \frac{200}{2} = 100$$

b) KVL

$$V_x = I_x R_1 + I_x R_3$$

$$= I_x (R_1 + R_3)$$

$$\frac{V_x}{I_x} = R_{in} = R_1 + R_3$$

Let $R_1 = R_3$ and $R_2 = R_4$

$R_{in} = 20\text{K}\Omega \longrightarrow R_1 = R_3 = 10\text{K}\Omega$

$\frac{R_2}{R_1} = 10 \rightarrow R_2 = 100\text{K}\Omega = R_4$

Sheet P.7

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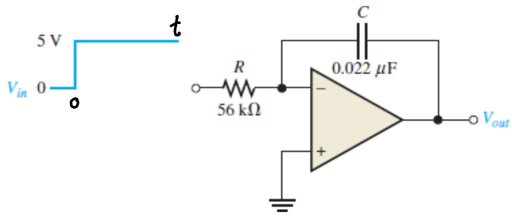
Determine the rate of change of the output voltage in response to the step input to the integrator shown in figure.



$$V_o = -\frac{1}{RC}\int V_i\,dt$$

$$= -\frac{1}{RC}\int_0^t 5\,dt$$

$$V_o = -4058\,t$$

Sheet P.8

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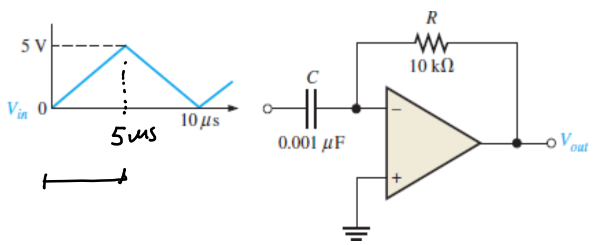
A triangular waveform is applied as an input to the circuit shown. Determine what the output should be and sketch its waveform in relation to the input.



$$V_{out} = -RC\,\frac{dV_{in}}{dt}$$

for $0 < t < 5\,\mu s$

$$V_o = -RC\,\frac{5-0}{5\,\mu s - 0} = -10\,V$$

for $5\,\mu s < t < 10\,\mu s$

$$V_o = -RC\,\frac{0-5}{10\,\mu s - 5\,\mu s} = 10\,V$$