CMPE 306 Fall-19

HW 5 Solution

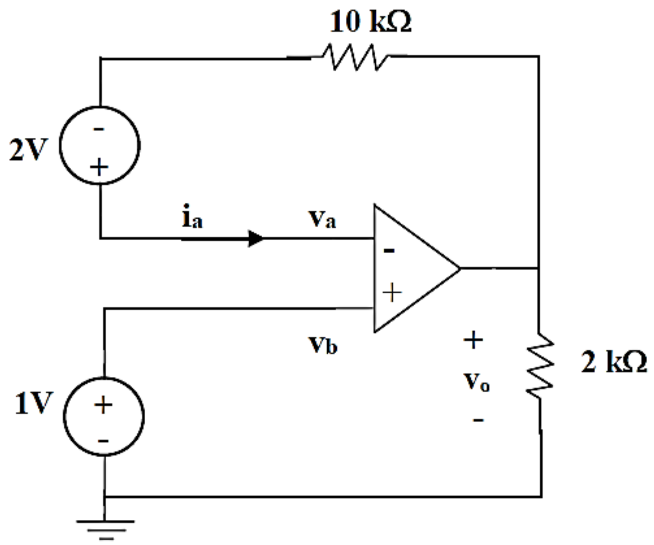
Solution 5.8

(a) If v_a and v_b are the voltages at the inverting and noninverting terminals of the op amp.

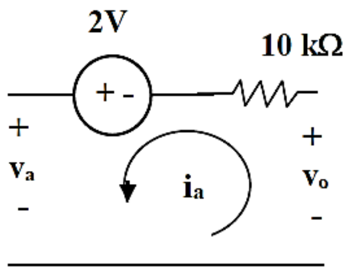
$v_a = v_b = 0$

$$1\text{mA} = \frac{0 - v_0}{2k} \longrightarrow v_0 = \mathbf{-2\ V}$$

(b)



(a)



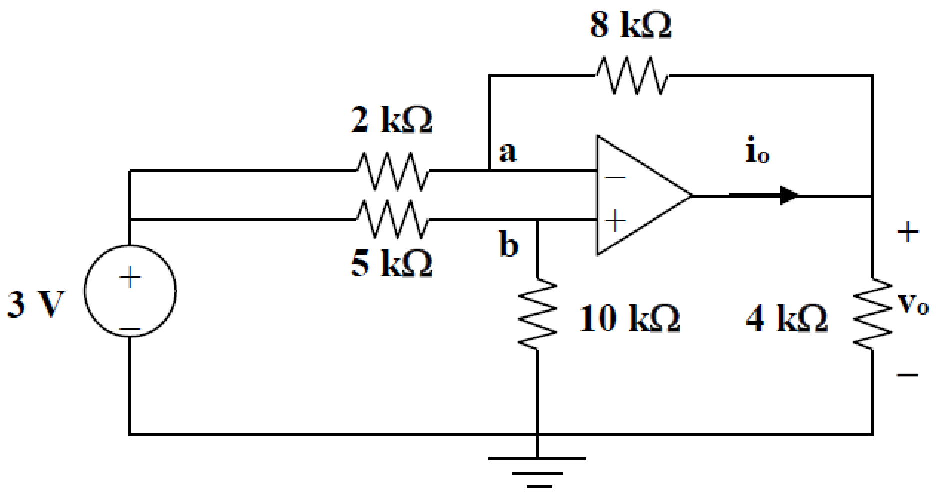
(b)

Since $v_a = v_b = 1V$ and $i_a = 0$, no current flows through the 10 kΩ resistor. From Fig. (b),

$$-v_a + 2 + v_0 = 0 \longrightarrow v_0 = v_a - 2 = 1 - 2 = \mathbf{-1V}$$

5.11

Solution



$$v_b = \frac{10}{10+5}(3) = 2V$$

At node a,

$$\frac{3-v_a}{2} = \frac{v_a - v_o}{8} \longrightarrow 12 = 5v_a - v_o$$

But $v_a = v_b = 2V$,

$$12 = 10 - v_o \longrightarrow v_o = \mathbf{-2V}$$

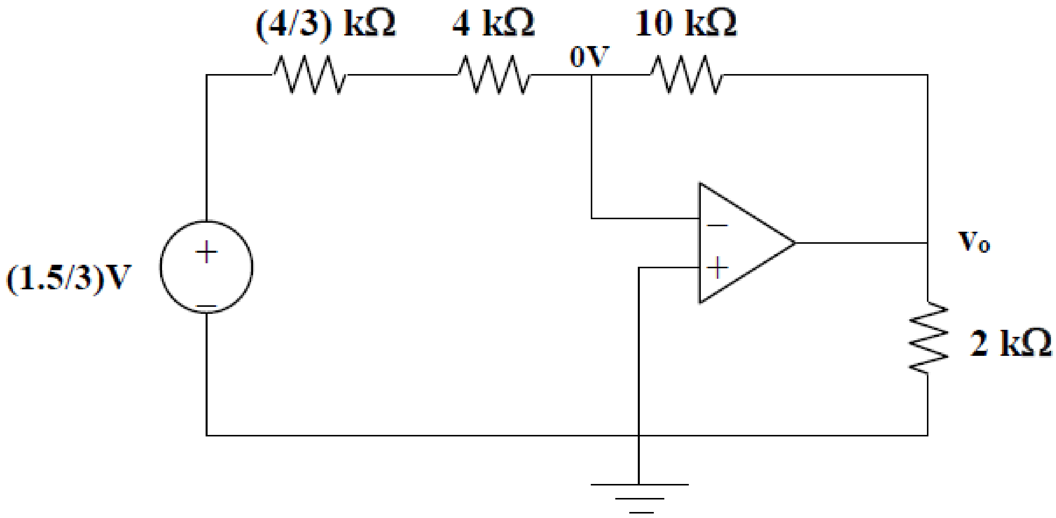
$$-i_o = \frac{v_a - v_o}{8} + \frac{0 - v_o}{4} = \frac{2+2}{8} + \frac{2}{4} = 1mA$$

$$i_o = \mathbf{-1mA}$$

Solution 5.19

We convert the current source and back to a voltage source.

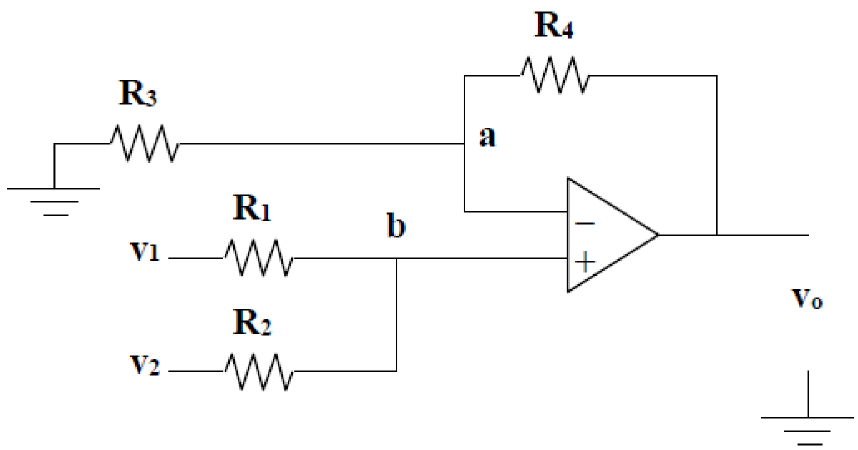
$$2 \| 4 = \frac{4}{3}$$



$$v_o = -\frac{10k}{\left(4+\frac{4}{3}\right)k}\left(\frac{1.5}{3}\right) = -937.5 \text{ mV.}$$

$$i_o = \frac{v_o}{2k} + \frac{v_o - 0}{10k} = \mathbf{-562.5\ \mu A}.$$

Solution 5.44



At node b, $\frac{v_b - v_1}{R_1} + \frac{v_b - v_2}{R_2} = 0 \longrightarrow v_b = \frac{\frac{v_1}{R_1} + \frac{v_2}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}}$ (1)

At node a, $\frac{0 - v_a}{R_3} = \frac{v_a - v_o}{R_4} \longrightarrow v_a = \frac{v_o}{1 + R_4/R_3}$ (2)

But $v_a = v_b$. We set (1) and (2) equal.

$$\frac{v_o}{1 + R_4/R_3} = \frac{R_2 v_1 + R_1 v_2}{R_1 + R_2}$$

or

$$v_o = \frac{(R_3 + R_4)}{R_3(R_1 + R_2)}(R_2 v_1 + R_1 v_2)$$

Solution 5.62

Let v_1 = output of the first op amp
v_2 = output of the second op amp

The first stage is a summer

$$v_1 = -\frac{R_2}{R_1}v_i - \frac{R_2}{R_f}v_o \qquad (1)$$

The second stage is a follower. By voltage division

$$v_o = v_2 = \frac{R_4}{R_3 + R_4}v_1 \longrightarrow v_1 = \frac{R_3 + R_4}{R_4}v_o \qquad (2)$$

From (1) and (2),

$$\left(1 + \frac{R_3}{R_4}\right)v_o = -\frac{R_2}{R_1}v_i - \frac{R_2}{R_f}v_o$$

$$\left(1 + \frac{R_3}{R_4} + \frac{R_2}{R_f}\right)v_o = -\frac{R_2}{R_1}v_i$$

$$\frac{v_o}{v_i} = -\frac{R_2}{R_1}\cdot\frac{1}{1 + \frac{R_3}{R_4} + \frac{R_2}{R_f}} = \frac{-\boldsymbol{R_2R_4R_f}}{\boldsymbol{R_1(R_2R_4 + R_3R_f + R_4R_f)}}$$

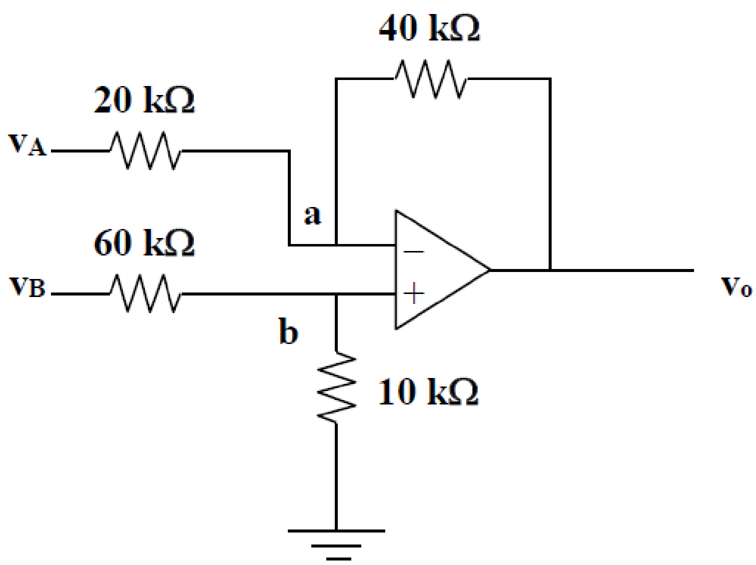
Solution 5.70

The output of amplifier A is

$$v_A = -\frac{30}{10}(1) - \frac{30}{10}(2) = -9$$

The output of amplifier B is

$$v_B = -\frac{20}{10}(3) - \frac{20}{10}(4) = -14$$



$$v_b = \frac{10}{60+10}(-14) = -2V$$

At node a, $\frac{v_A - v_a}{20} = \frac{v_a - v_o}{40}$

But $v_a = v_b = -2V$, $2(-9+2) = -2 - v_o$

Therefore, $v_o = \mathbf{12V}$