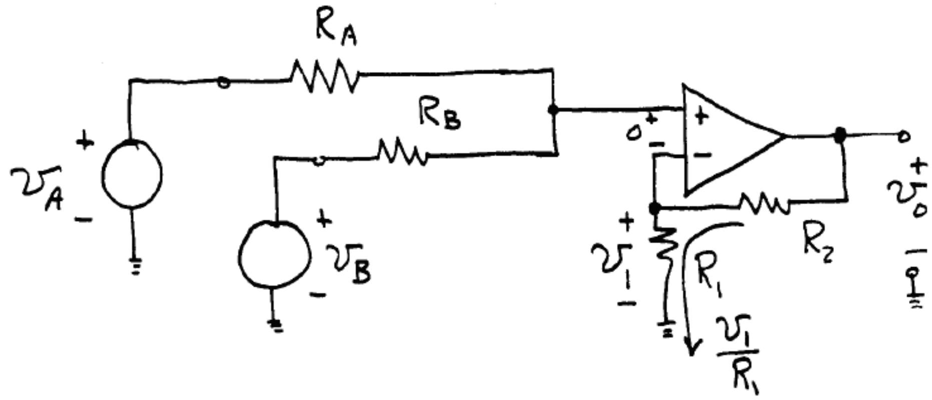
Practice problems

P14.19, P14.20, P14.22, P14.23, P14.32

P14.19* The circuit diagram is:



Writing a current equation at the noninverting input, we have

$$\frac{v_1 - v_A}{R_A} + \frac{v_1 - v_B}{R_B} = 0 \qquad (1)$$

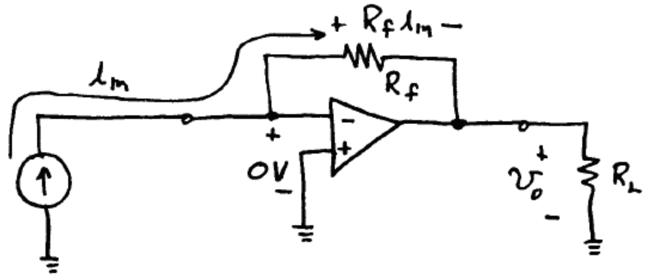
Using the voltage-division principle we can write:

$$v_1 = \frac{R_1}{R_1 + R_2} v_o \qquad (2)$$

Using Equation (2) to substitute for v_1 in Equation (1) and rearranging, we obtain:

$$v_o = \left(\frac{R_1 + R_2}{R_1}\right) \frac{v_A R_B + v_B R_A}{R_A + R_B}$$

P14.20*



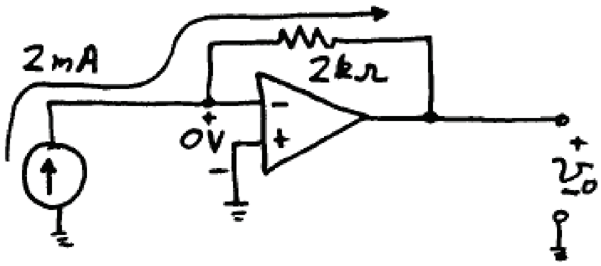
(a) $v_o = -R_f i_{in}$

(b) Since v_o is independent of R_L, the output behaves as a perfect voltage source, and the output impedance is zero.

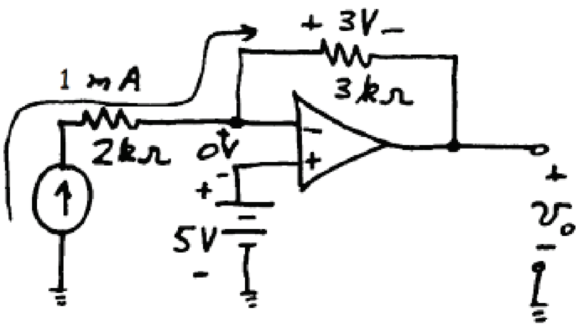
(c) The input voltage is zero because of the summing-point constraint, and the input impedance is zero.

(d) This is an ideal transresistance amplifier.

P14.22 (a) $v_o = -(2\ \text{k}\Omega) \times 2\ \text{mA} = -4\ \text{V}$

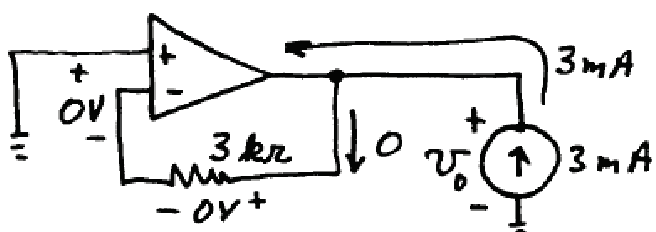


(b) $v_o = -3 + 0 + 5 = 2\ \text{V}$

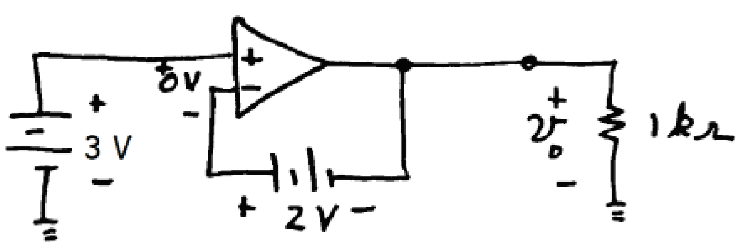


(c) A current of 1 mA flows downward through the 4-kΩ and from right to left through the 3-kΩ resistor. Thus, $v_o = 3 + 4 = 7\ \text{V}$.

(d) $v_o = 0$



(e) $v_o = 3 - 2 = 1\ \text{V}$



P14.23 Analysis of the circuit using the summing-point constraint yields

$$v_o = -\frac{R_2}{10^4} v_{in} + 2\left(1 + \frac{R_2}{10^4}\right)$$

Substituting the expression given for v_{in} yields

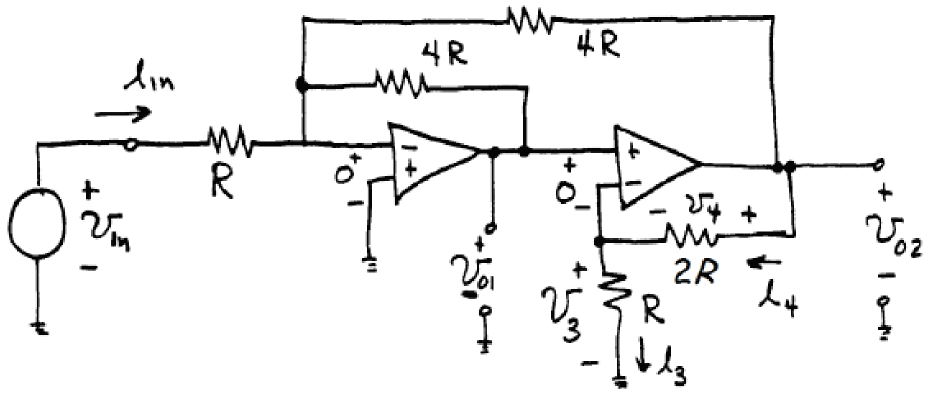
$$v_o = -3\frac{R_2}{10^4} - 3\frac{R_2}{10^4}\cos(2000\pi t) + 2\left(1 + \frac{R_2}{10^4}\right)$$

Then setting the dc component to zero, we have

$$0 = -3\frac{R_2}{10^4} + 2\left(1 + \frac{R_2}{10^4}\right)$$

which yields R_2 = 20 kΩ and then we have $v_o = -6\cos(2000\pi t)$

P14.32



From the circuit we can write:

$$v_{o1} = v_3$$

$$i_4 = i_3 = \frac{v_{o1}}{R}$$

Thus we have

$$v_4 = 2Ri_3 = 2v_3 = 2v_{o1}$$

$$v_{o2} = v_3 + v_4 = 3v_{o1} \qquad (1)$$

$$i_{in} + \frac{v_{o1}}{4R} + \frac{v_{o2}}{4R} = 0$$

$$i_{in} = \frac{v_{in}}{R}$$

$$\frac{v_{in}}{R} + \frac{v_{o1}}{4R} + \frac{v_{o2}}{4R} = 0 \qquad (2)$$

Using Equation (1) to substitute into Equation 2 and rearranging, we have

$$A_1 = \frac{v_{o1}}{v_{in}} = -1$$

$$A_2 = \frac{v_{o2}}{v_{in}} = \frac{3v_{o1}}{v_{in}} = 3A_1 = -3$$