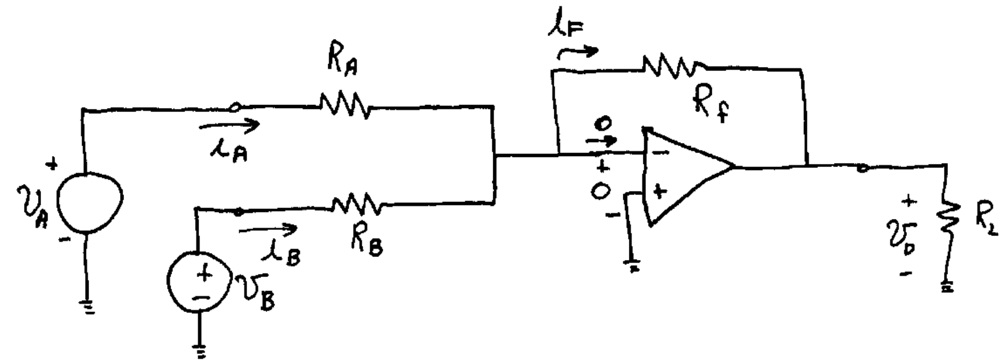
CHAPTER 14

Solutions for Exercises

E14.1



(a) $i_A = \frac{v_A}{R_A}$ $i_B = \frac{v_B}{R_B}$ $i_F = i_A + i_B = \frac{v_A}{R_A} + \frac{v_B}{R_B}$

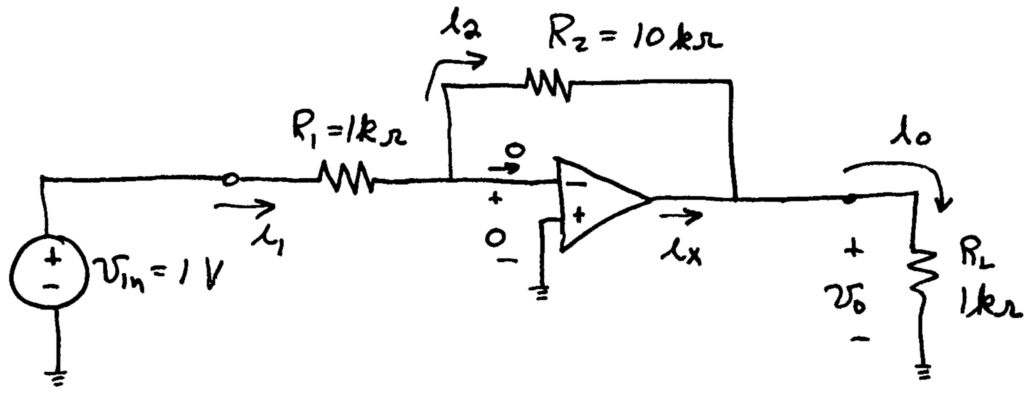
$v_o = -R_F i_F = -R_F\left(\frac{v_A}{R_A} + \frac{v_B}{R_B}\right)$

(b) For the v_A source, $R_{inA} = \frac{v_A}{i_A} = R_A$.

(c) Similarly $R_{inB} = R_B$.

(d) In part (a) we found that the output voltage is independent of the load resistance. Therefore, the output resistance is zero.

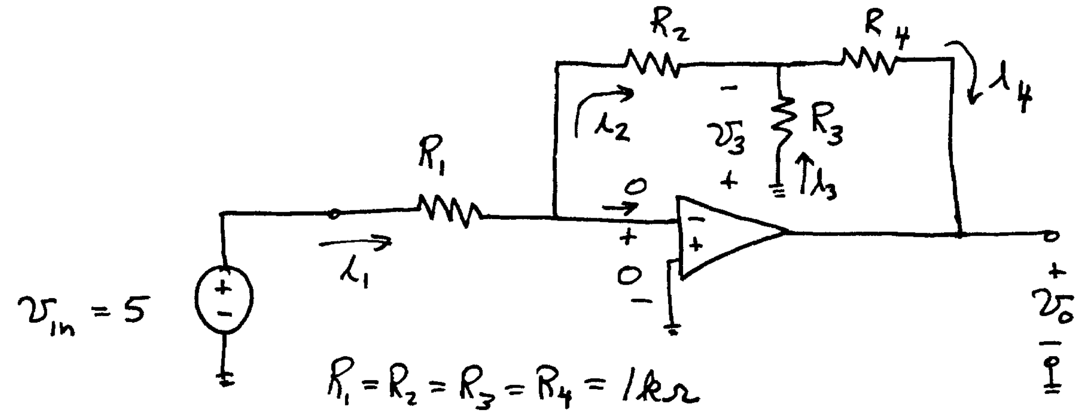
E14.2 (a)



$i_1 = \frac{v_{in}}{R_1} = 1\,\text{mA}$ $i_2 = i_1 = 1\,\text{mA}$ $v_o = -R_2 i_2 = -10\,\text{V}$

$$i_o = \frac{v_o}{R_L} = -10\ \text{mA} \qquad i_x = i_o - i_2 = -11\ \text{mA}$$

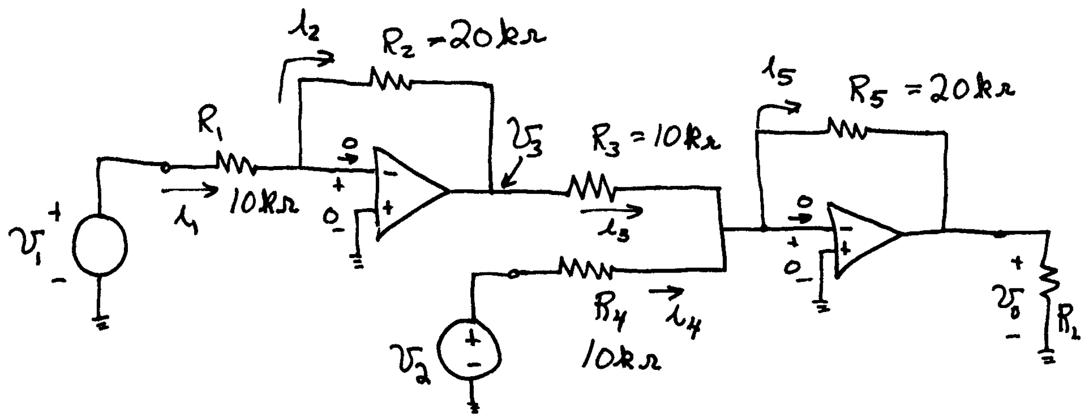
(b)



$$i_1 = \frac{v_{in}}{R_1} = 5\ \text{mA} \qquad i_2 = i_1 = 5\ \text{mA} \qquad v_3 = R_2 i_2 = 5\ \text{V}$$

$$i_3 = \frac{v_3}{R_3} = 5\ \text{mA} \qquad i_4 = i_2 + i_3 = 10\ \text{mA} \qquad v_o = -R_4 i_4 - R_2 i_2 = -15\ \text{V}$$

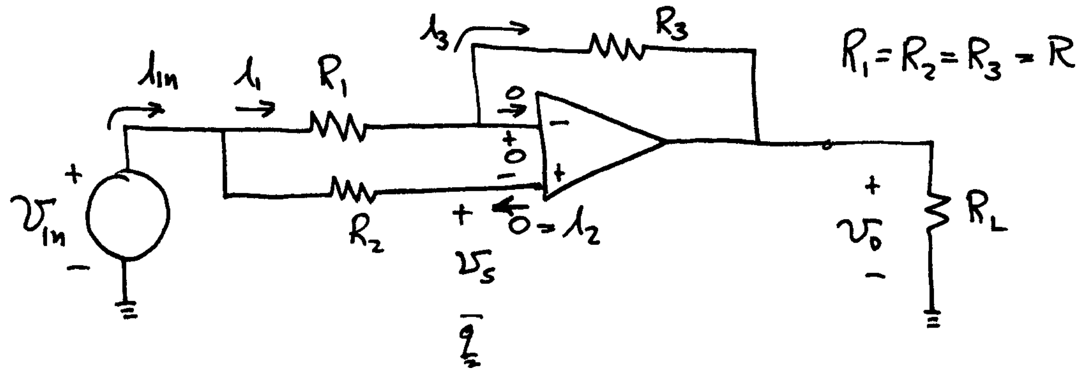
E14.3



Direct application of circuit laws gives $i_1 = \frac{v_1}{R_1}$, $i_2 = i_1$, and $v_3 = -R_2 i_2$. From the previous three equations, we obtain $v_3 = -\frac{R_2}{R_1} v_1 = -2v_1$. Then applying circuit laws gives $i_3 = \frac{v_3}{R_3}$, $i_4 = \frac{v_2}{R_4}$, $i_5 = i_3 + i_4$, and $v_o = -R_5 i_5$.

These equations yield $v_o = -\frac{R_5}{R_3}v_3 - \frac{R_5}{R_4}v_2$. Then substituting values and using the fact that $v_3 = -2v_1$, we find $v_o = 4v_1 - 2v_2$.

E14.4 (a)

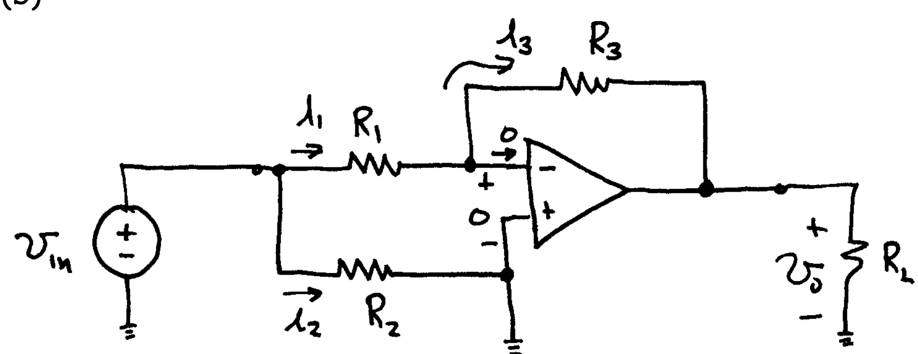


$v_s = v_{in} + R_2 i_2 = v_{in}$ (Because of the summing-point restraint, $i_2 = 0$.)

$i_1 = \frac{v_{in} - v_s}{R_1} = 0$ (Because $v_s = v_{in}$.) $\qquad i_{in} = i_1 - i_2 = 0$

$i_3 = i_1 = 0 \qquad v_o = R_3 i_3 + v_s = v_{in}$ Thus, $A_v = \frac{v_o}{v_{in}} = +1$ and $R_{in} = \frac{v_{in}}{i_{in}} = \infty$.

(b)

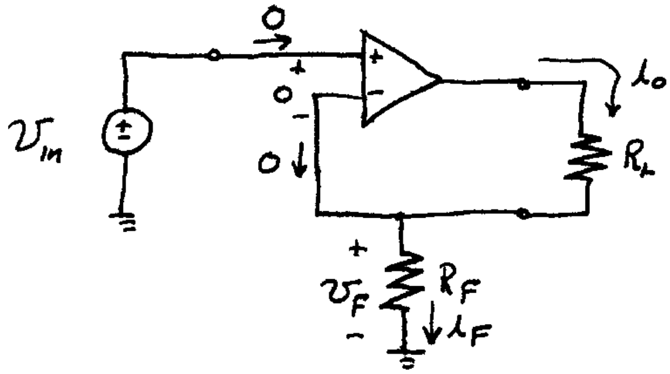


(Note: We assume that $R_1 = R_2 = R_3$.)

$i_1 = \frac{v_{in}}{R_1} = \frac{v_{in}}{R} \qquad i_2 = \frac{v_{in}}{R_2} = \frac{v_{in}}{R} \qquad i_{in} = i_1 + i_2 = \frac{2v_{in}}{R} \qquad R_{in} = \frac{R}{2}$

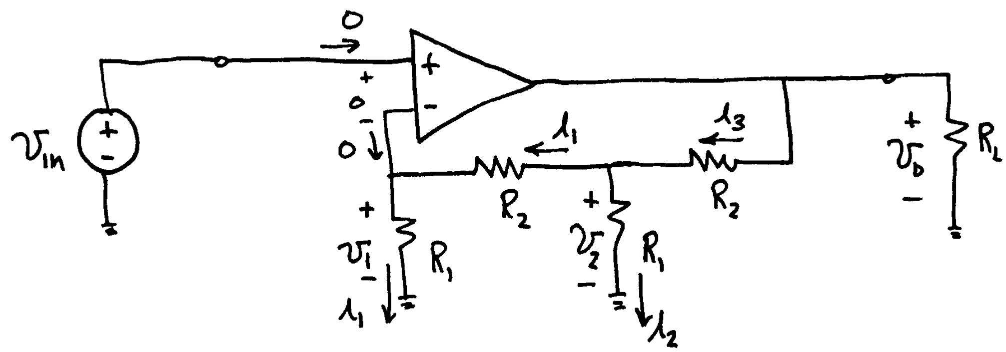
$i_3 = i_1 = \frac{v_{in}}{R_1} \qquad v_o = -R_3 i_3 = -\frac{R_3}{R_1}v_{in} = -v_{in} \qquad A_v = \frac{v_o}{v_{in}} = -1$

E14.5



From the circuit, we can write $v_F = v_{in}$, $i_F = \frac{v_F}{R_F}$, and $i_o = i_F$. From these equations, we find that $i_o = \frac{v_{in}}{R_F}$. Then because i_o is independent of R_L, we conclude that the output impedance of the amplifier is infinite. Also R_{in} is infinite because i_{in} is zero.

E14.6 (a)



$v_1 = v_{in}$ $\quad i_1 = \frac{v_1}{R_1}$ $\quad v_2 = R_2 i_1 + R_1 i_1$ $\quad i_2 = \frac{v_2}{R_1}$ $\quad i_3 = i_1 + i_2$ $\quad v_o = R_2 i_3 + v_2$

Using the above equations we eventually find that

$$A_v = \frac{v_o}{v_{in}} = 1 + 3\frac{R_2}{R_1} + \left(\frac{R_2}{R_1}\right)^2$$

(b) Substituting the values given, we find $A_v = 131$.

(c) Because $i_{in} = 0$, the input resistance is infinite.

(d) Because $v_o = A_v v_{in}$ is independent of R_L, the output resistance is zero.