

Q1

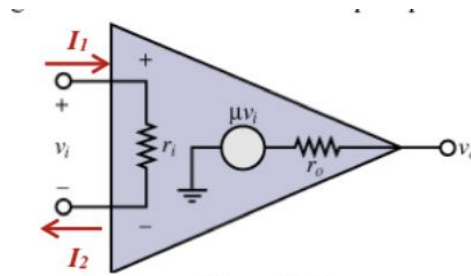
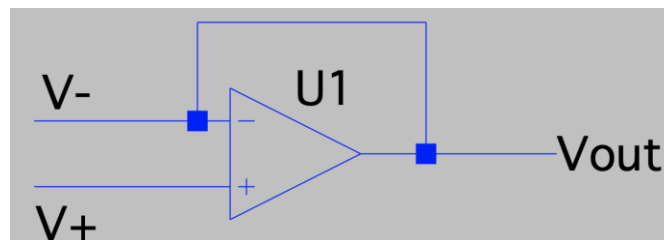


Figure P8.4

Ideal op-amp model:

1. $V_{out} = A(V^+ - V^-)$; $A \rightarrow \infty$: Infinity open loop gain; zero output resistance
2. Input current: 0, which implies Infinity input resistance
3. $A = \frac{V_{out}}{(V^+ - V^-)}$, $A \rightarrow \infty$; $V^+ - V^- = 0$, then $V^+ = V^-$
 - a) For r_i : $I_1 = I_2 = 0 = V_i / r_i$; μ = open loop gain; r_o = output resistance
 - b) If a voltage source was applied across the input terminal: $I_1 = I_2 = V_i / r_i$
 - c) If the ideal op-amp is connected in negative feedback (source follower):

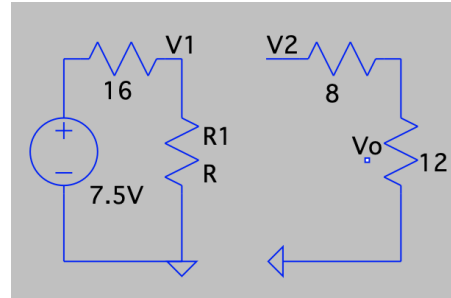
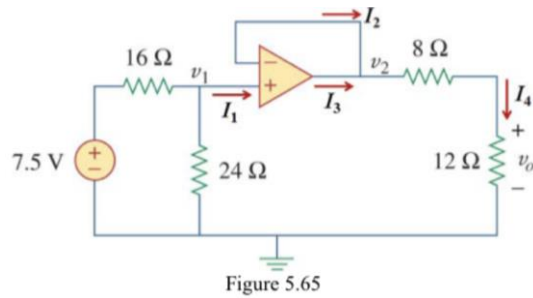


$$V_{out} = V^-; V^+ = V^-; V_i = V^+ - V^-$$

Q2

Ideal op-amp model:

- a) Input current = 0
- b) For negative feedback circuit: $V^- = V_{out}$; For ideal op-amp: $V^+ = V^-$
- c) $V_1 = V^+$, $V_2 = V^-$, $V^+ = V^-$ which means $V_1 = V_2$; $I_1 = 0$, can be seen as open circuit

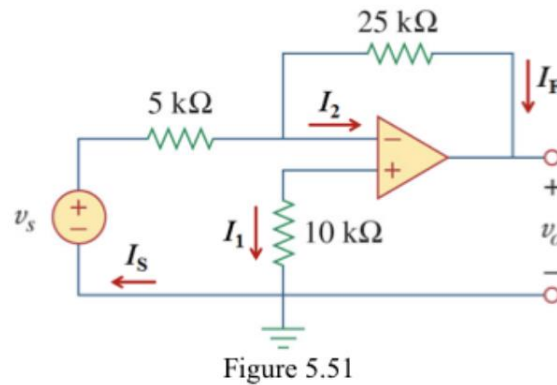


$$V_o = V_2 \times \frac{12}{12 + 8}$$

$$V_1 = V_{source} \times \frac{24}{16 + 24}$$

d) Node analysis: $I_4 = I_3 + I_2$, $I_2 = I_1$; $I_4 = \frac{V_2}{8+12}$

Q3



Ideal op-amp model:

a) $I_1 = I_2 =$ input current

b) inverting inputs: V^- , non-inverting inputs: V^+ and $V^+ = V^-$

V^+ is connected to the ground and there is no current flow, so $V^+ = 0V$

c) Use node analysis: $I_s = I_2 + I_F$, $I_2 =$ input current $= 0$; $I_s = \frac{(V_s - V^-)}{5000}$

d) $I_F = \frac{(V^- - V_o)}{25000}$

Q4

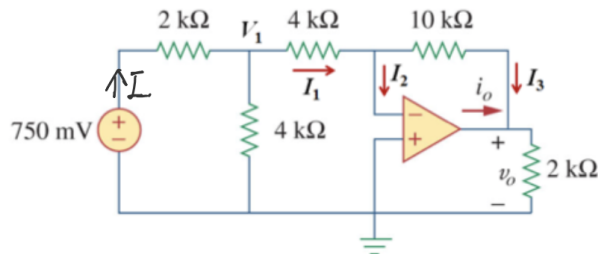


Figure 5.58

Ideal op-amp model:

a) $V^- = V^+ = 0V$; $I_1 = \frac{V_1 - V^-}{4000} = \frac{1}{2} \times \frac{750mV - V^-}{2000}$ (Current flowing through 2kΩ)

b) $I_1 = \frac{V_1 - V^-}{4000}$, I_2 : input current = 0A; From Node analysis: $I_1 = I_2 + I_3$

c) $V_o = (i_o + I_3) \times 2000$; $I_3 = \frac{-(V_o - V^-)}{10000}$

d) $I = \frac{750mV - V^-}{2000}$; input resistance = $\frac{750mV}{I}$

Q5

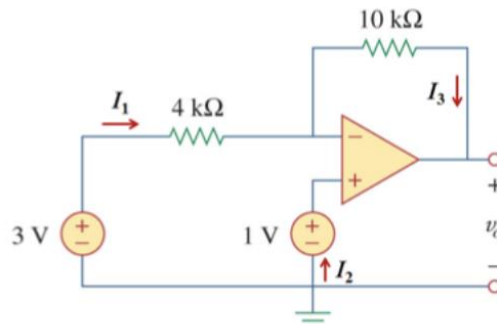


Figure 5.60

Ideal op-amp model:

a) For inverting input: $V^- = V^+$; input current $I_2 = 0$, $V^+ = 0 + 1V$

b) $I_1 = \frac{3 - V^-}{4000}$, $I_2 = 0A$

c) $I_3 = \frac{V^- - V_o}{10000}$, $I_1 = I_2 + I_3 \Rightarrow \frac{3 - V^-}{4000} = \frac{V^- - V_o}{10000}$

Q6

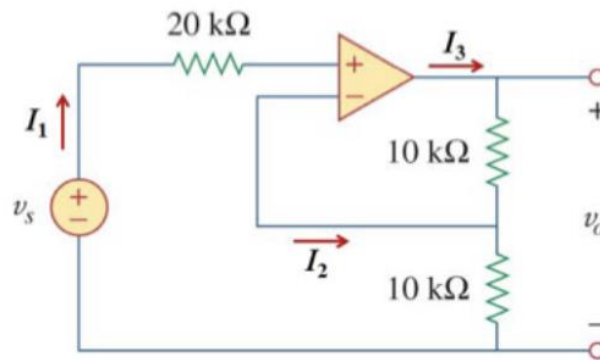
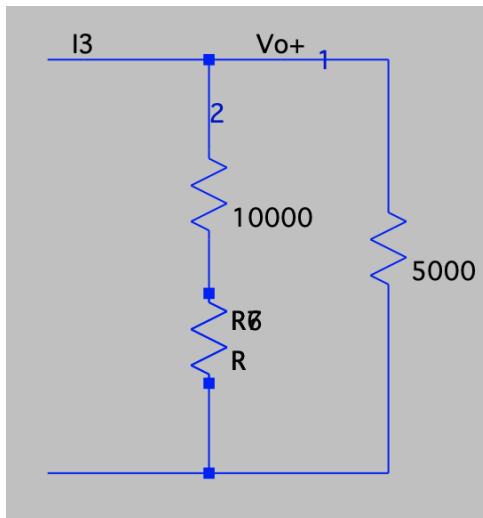


Figure 5.49

Ideal op-amp model:

a) I_1, I_2 are the input currents; $I_1 = I_2 = 0$ b) $I_1 = 0\text{ A} = \frac{V_s - V_+}{20000} \Rightarrow V_s = V_+$; $V_+ = V_- \Rightarrow$ inverting input voltagec) $V_- = \frac{10000}{10000+10000} \times V_o$; $V_+ = V_-$ $V_s = V_+ \Rightarrow V_s = V_- = \frac{10000}{10000+10000} \times V_o$ d) $I_3 = \frac{V_o}{10000+10000}$ e) $I_3 = \frac{V_o}{10000+10000} + \frac{V_o}{5000}$ f) input resistance $= \frac{V_s}{I_1}$, $I_1 = 0$

Q7

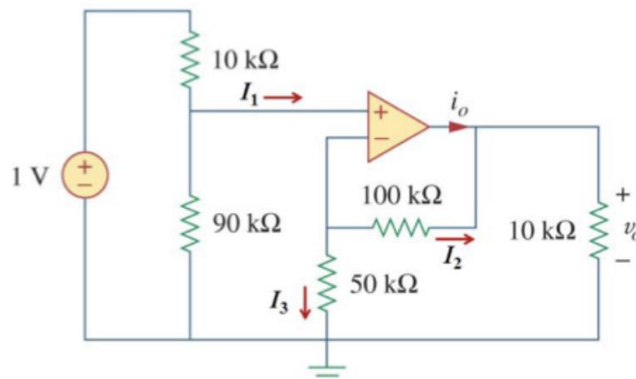


Figure 5.52

Ideal op-amp model:

a) $I_1 = 0A$, $V_+ = 1V \times \frac{90000}{90000+10000}$, $V_+ = V_-$

b) $I_1 = 0A$, $I_3 = \frac{V_- - 0V}{50000}$; Since current flowing into the inverting input = 0A, $I_3 = -I_2$

c) $I_2 = \frac{V_- - V_o}{100000}$ to find V_o ; $i_o + I_2 = \frac{V_o}{10000}$ to find i_o

Q8

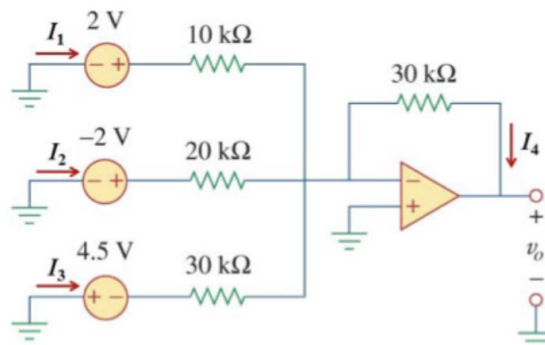


Figure 5.74

Ideal op-amp model:

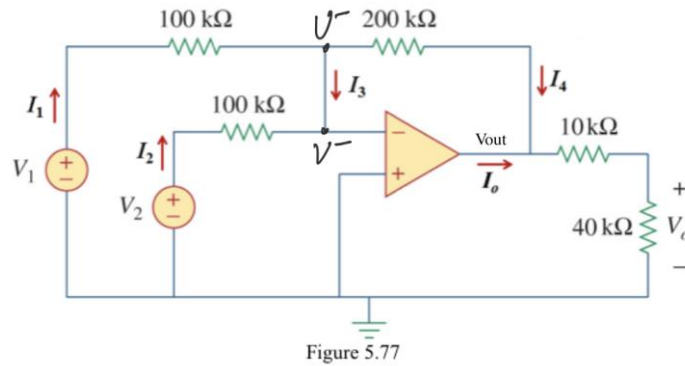
a) $V_- = V_+$ (because V_+ is connected to ground)

b) $I_1 = \frac{(0V+2V)-V_-}{10000}$, $I_2 = \frac{(0V-2V)-V_-}{20000}$, $I_3 = \frac{(0V-4.5V)-V_-}{30000}$

c) Since current flowing into inverting input $I_- = 0A$, $I_1 + I_2 + I_3 = I_- + I_4$

$$d) I_4 = \frac{V_- - V_o}{30000}$$

Q9



Ideal op-amp model:

a) V_+ is connected to ground, so $V_- = V_+ = 0V$;

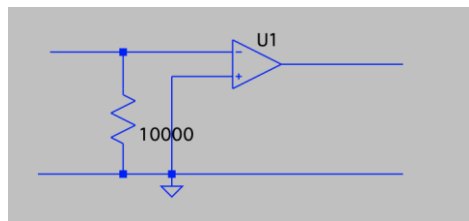
$$I_2 = \frac{(0V + V_2) - V_-}{100000}; I_1 = \frac{(0V + V_1) - V_-}{100000}$$

b) $I_2 + I_3 = I_- \Rightarrow 0A$ because input current has no current (zero amp); $I_1 = I_3 + I_4$

$$c) I_4 + I_o = \frac{V_o}{40000}; I_4 + I_o = \frac{V_{out} - V_o}{10000};$$

$$V_{out} = V_- - (I_4 \times 200k); V_{out} = \frac{5}{4} V_o = V_- - (I_4 \times 200k)$$

d)

No current will flow through the 10kohm resistor $\Rightarrow$ Nothing changed