Review on Operational Amplifiers

Q1 [Modified from Rizzoni Problem 8.4]

With reference to the Figure P8.4 that shows an ideal op amp model,

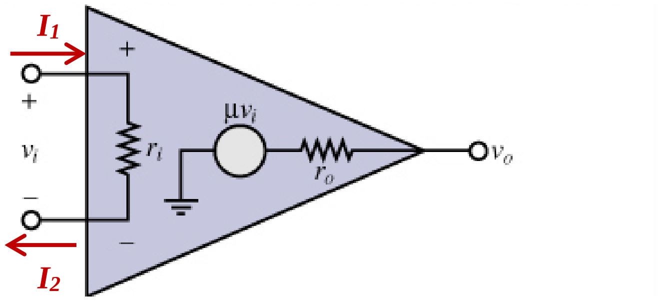

Figure P8.4

a) What approximations are made about the values of r_i, μ, and r_o?
b) Find the value of I_1 and I_2 if a voltage source was applied across the input terminals.
c) If the ideal op amp is connected in negative feedback, what would be the value of v_i?

Source Follower

Q2 [Modified from Alexander Problem 5.27]

For the circuit shown in Figure 5.65, assuming the op amp is ideal,

a) Determine I_1 and I_2;
b) Find v_1 and v_2;
c) Find v_o and I_4.
d) Determine I_3.

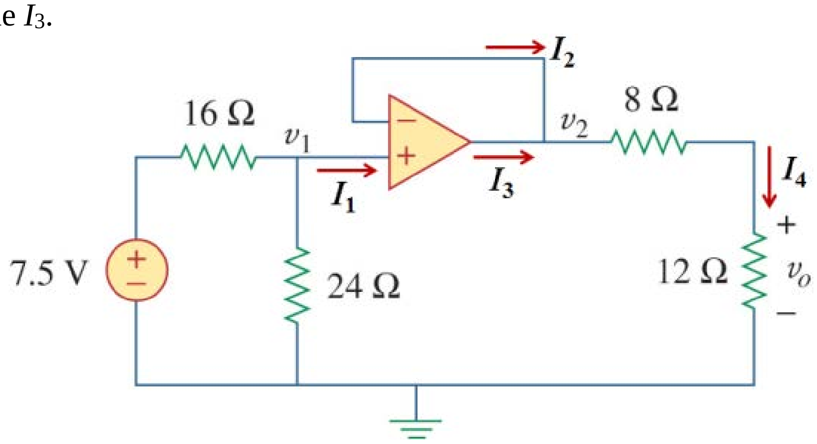

Figure 5.65

Inverting Amplifier

Q3 [Modified from Alexander Problem 5.12]

For the circuit shown in Figure 5.51, assuming the op amp is ideal, and given $v_s = 1$ V,

a) Find I_1 and I_2;
b) Find the voltage at the inverting and non-inverting inputs;
c) Find I_S and I_F;
d) Find v_o;

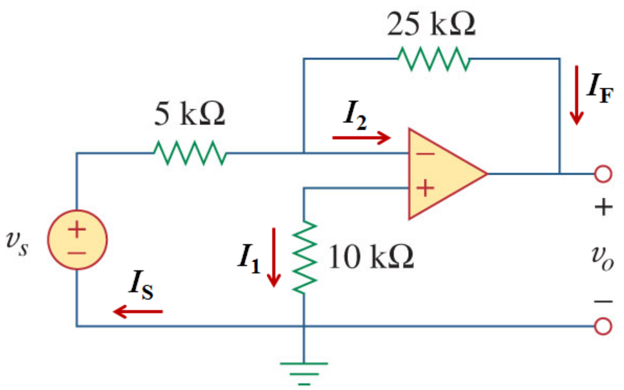

Figure 5.51

Q4 [Modified from Alexander Problem 5.19]
For the circuit shown in Figure 5.58, assuming the op amp is ideal,

a) Find V_1;
b) Find I_1, I_2, and I_3;
c) Find v_o and i_o.
d) Find the current supplied by the source and hence input resistance by the source.

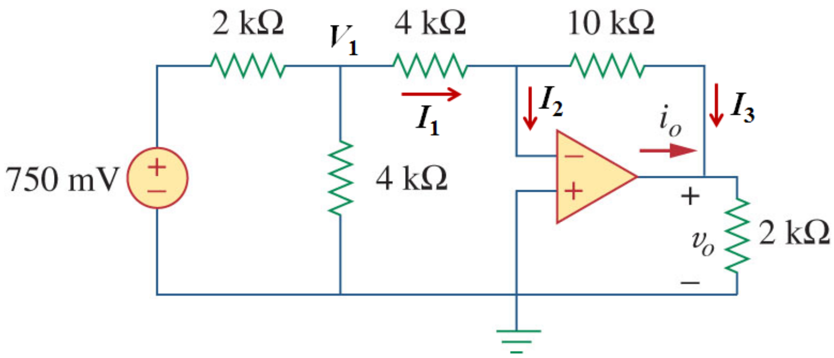

Figure 5.58

Q5 [Modified from Alexander Problem 5.21]
For the circuit shown in Figure 5.60, assuming the op amp is ideal,

a) Find the voltage at the inverting input;
b) Find I_1, I_2 and I_3;
c) Find v_o.

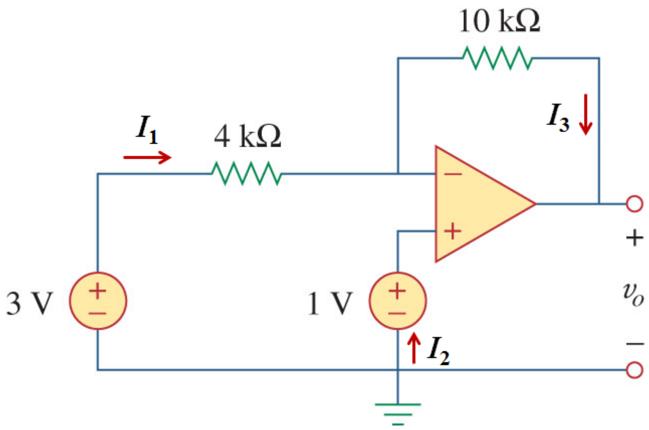

Figure 5.60

Non-inverting Amplifiers

Q6 [Modified from Alexander Problem 5.10]
For the circuit in Figure 5.49, assuming the op amp is ideal and letting v_s = 1 V,

a) Find I_1 and I_2;
b) Determine the voltage at the inverting input;
c) Find v_o and hence determine v_o/v_i;
d) Find I_3;
e) If a 5 kΩ load is added across v_o, find the resulting I_3;
f) Determine in the input resistance seen by the source v_s.

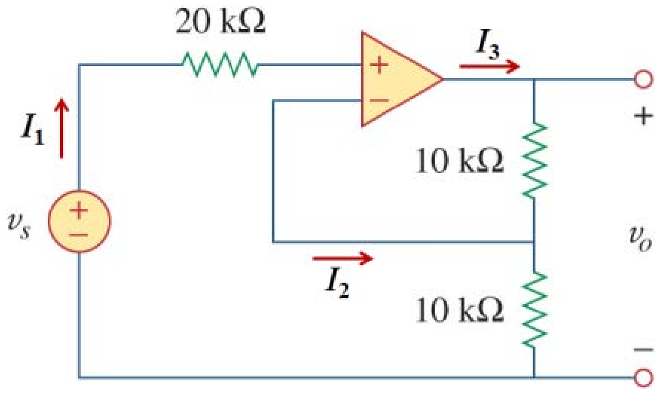

Figure 5.49

Q7 [Modified from Alexander Problem 5.13]
For the circuit in Figure 5.52, assuming the op amp is ideal,

a) Find the voltages at the inverting and non-inverting inputs of the op amp;
b) Find I_1, I_2, and I_3;
c) Find v_o and i_o;

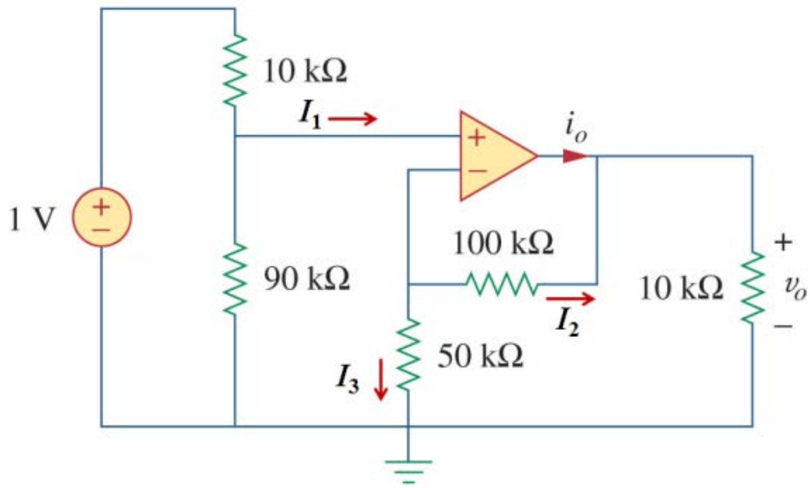

Figure 5.52

Summing Amplifiers

Q8 [Modified from Alexander Problem 5.37]

For the circuit shown in Figure 5.74, assuming the op amp is ideal,

a) Determine the voltage at the inverting input;
b) Find currents I_1, I_2 and I_3;
c) Find current I_4;
d) Hence find v_o.

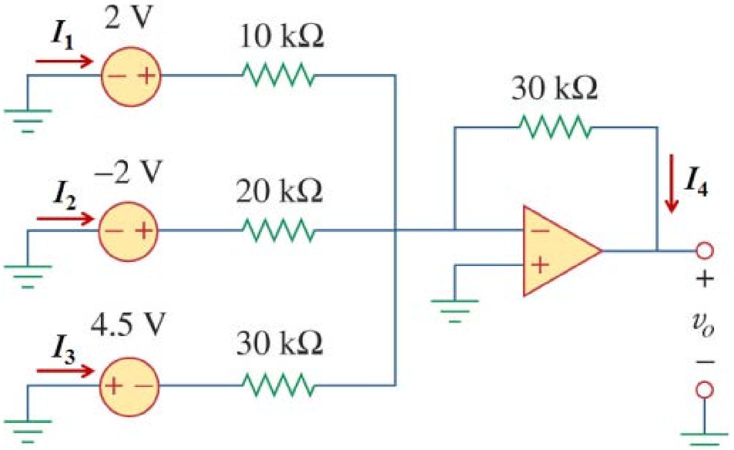

Figure 5.74

Q9 [Modified from Alexander Problem 5.40]

For the circuit shown in Figure 5.77, assuming the op amp is ideal and v_1 = 1 V and v_2 = 2 V,

a) Find currents I_1 and I_2;
b) Find currents I_3 and I_4;
c) Hence find V_o and I_o.
d) If a 10 kΩ resistor was connected between the inverting input and ground, find the resulting value of V_o.

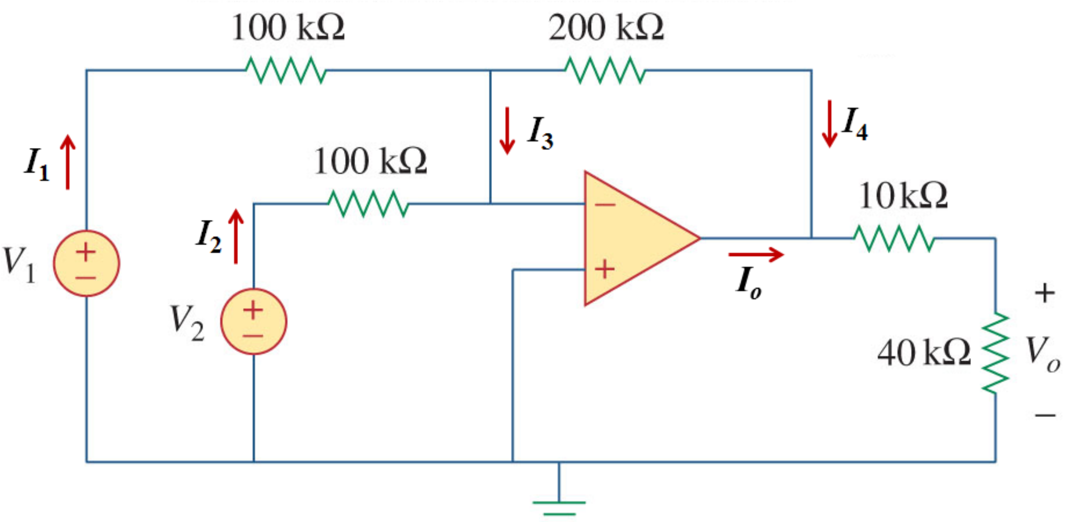

Figure 5.77

Numerical solutions

Q1 [Modified from Rizzoni Problem 8.4]

a) Input resistance, $r_i \to \infty$, Open loop gain, $\mu \to \infty$, Output resistance, $r_o = 0$
b) $I_1 = 0$ A, $I_2 = 0$ A
c) In negative feedback, $v_i = 0$

Q2 [Modified from Alexander Problem 5.27]

a) $I_1 = 0$ A, $I_2 = 0$ A
b) $v_1 = 4.5$ V, $v_2 = 4.5$ V
c) $v_o = 2.7$ V, $I_4 = 0.225$ A
d) $I_3 = 0.225$ A

Q3 [Modified from Alexander Problem 5.12]

a) $I_1 = 0$ A, $I_2 = 0$ A
b) $v^+ = 0$ V, $v^- = 0$ V
c) $I_S = 0.2$ mA, $I_F = 0.2$ mA
d) $v_o = -5$ V

Q4 [Modified from Alexander Problem 5.19]

a) $V_1 = 375$ mV
b) $I_1 = 93.75$ µA, $I_2 = 0$, $I_3 = 93.75$ µA
c) $v_o = -0.9375$ V, $i_o = -0.5625$ mA
d) Source current = 0.1875 mA, Input resistance = 4 kΩ

Q5 [Modified from Alexander Problem 5.21]

a) $v^- = 1$ V
b) $I_1 = 0.5$ mA, $I_2 = 0$ A, $I_3 = 0.5$ mA
c) $V_o = -4$ V

Q6 [Modified from Alexander Problem 5.10]

a) $I_1 = 0$ A, $I_2 = 0$ A
b) $v^- = 1$ V
c) $v_o = 2$ V, $v_o/v_i = 2$
d) $I_3 = 0.1$ mA
e) With load added, $I_3 = 0.5$ mA
f) Input resistance seen by source is infinite

Q7 [Modified from Alexander Problem 5.13]

a) $v^+ = 0.9$ V, $v^- = 0.9$ V
b) $I_1 = 0$ A, $I_2 = -18$ µA, $I_3 = 18$ µA
c) $v_o = 2.7$ V, $i_o = 288$ µA

Q8 [Modified from Alexander Problem 5.37]

a) $v^- = 0$ V
b) $I_1 = 0.2$ mA, $I_2 = -0.1$ mA, $I_3 = -0.15$ mA
c) $I_3 = -0.05$ mA
d) $v_o = 1.5$ V

Q9 [Modified from Alexander Problem 5.40]

a) $I_1 = 10$ μA, $I_2 = 20$ μA
b) $I_3 = -20$ μA, $I_4 = 30$ μA
c) $V_o = -4.8$ V, $I_o = -0.15$ mA