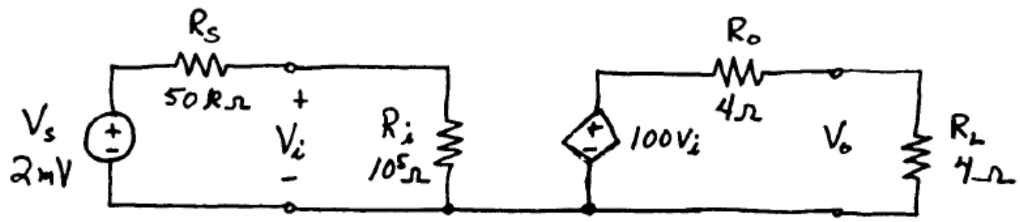
***P11.4.** A signal source with an open-circuit voltage of $V_s = 2$ mV rms and an internal resistance of 50 kΩ is connected to the input terminals of an amplifier having an open-circuit voltage gain of 100, an input resistance of 100 kΩ, and an output resistance of 4 Ω. A 4-Ω load is connected to the output terminals. Find the voltage gains $A_{vs} = V_o/V_s$ and $A_v = V_o/V_i$. Also, find the power gain and current gain.

P11.4* The equivalent circuit is:



$$A_v = \frac{V_o}{V_i} = A_{voc}\frac{R_L}{R_o + R_L} = 100\frac{4}{4+4} = 50$$

$$A_{vs} = \frac{V_o}{V_s} = A_{voc}\frac{R_i}{R_i + R_s}\frac{R_L}{R_o + R_L}$$

$$= 100\frac{100\times10^3}{100\times10^3 + 50\times10^3}\frac{4}{4+4}$$

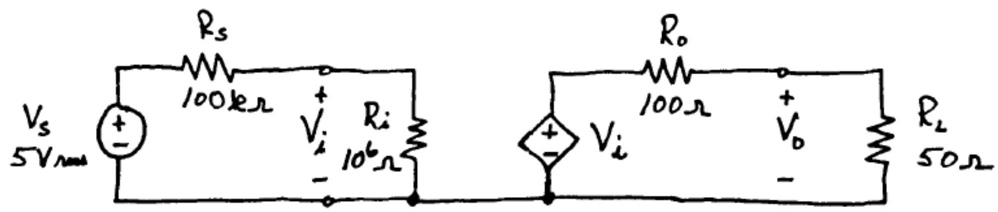
$$= 33.33$$

$$A_i = A_v\frac{R_i}{R_L} = 50\frac{10^5}{4} = 1.25\times10^6$$

$$G = A_v A_i = 62.5\times10^6$$

P11.8. A certain amplifier has an open-circuit voltage gain of unity, an input resistance of 1 MΩ, and an output resistance of 100 Ω. The signal source has an internal voltage of 5 V rms and an internal resistance of 100 kΩ. The load resistance is 50 Ω. If the signal source is connected to the amplifier input terminals and the load is connected to the output terminals, find the voltage across the load and the power delivered to the load. Next, consider connecting the load directly across the signal source without the amplifier, and again find the load voltage and power. Compare the results. What do you conclude about the usefulness of a unity-gain amplifier in delivering signal power to a load?

P11.8 The equivalent circuit using the amplifier is:



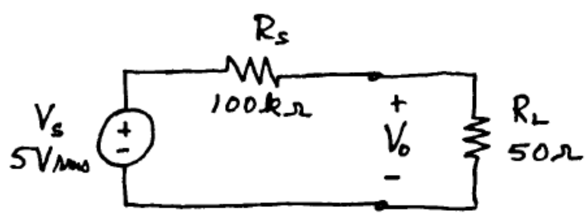
We have

$$A_{vs} = \frac{V_o}{V_s} = A_{voc}\frac{R_i}{R_i + R_s}\frac{R_L}{R_o + R_L} = 1\frac{10^6}{10^6 + 10^5}\frac{50}{100 + 50} = 0.303$$

$$V_o = A_{vs}V_s = 0.303 \times 5 = 1.52 \text{ V rms}$$

$$P_o = (V_o)^2 / R_L = 45.9 \text{ mW}$$

The equivalent for the load connected directly to the source without the amplifier is:



In this case, we have:

$$V_o = V_s\frac{R_L}{R_L + R_s} = 5\frac{50}{50 + 10^5} = 2.50 \text{ mV rms}$$

$$P_o = 125 \times 10^{-9} \text{ W}$$

Thus, the output voltage and output power is much higher when the amplifier is used, even though the open-circuit voltage gain of the amplifier is unity, because the amplifier alleviates source loading.

P14.9. Consider the circuit shown in Figure P14.9. Sketch $v_{in}(t)$ and $v_o(t)$ to scale versus time. The op amp is ideal.

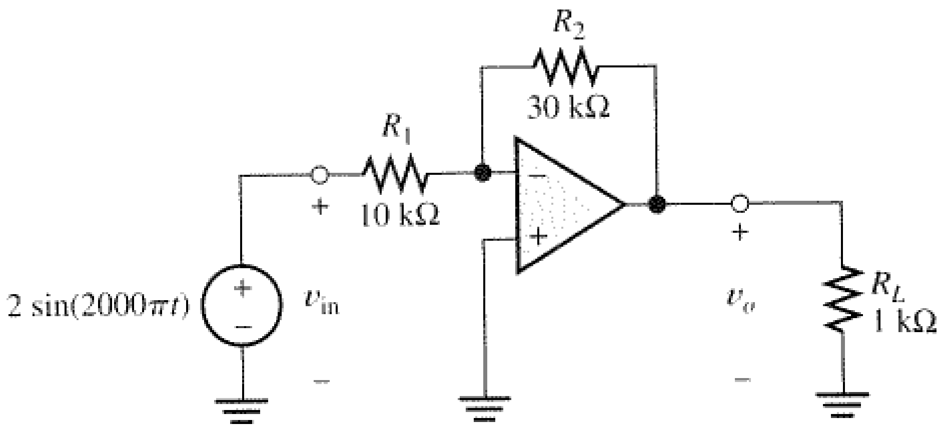
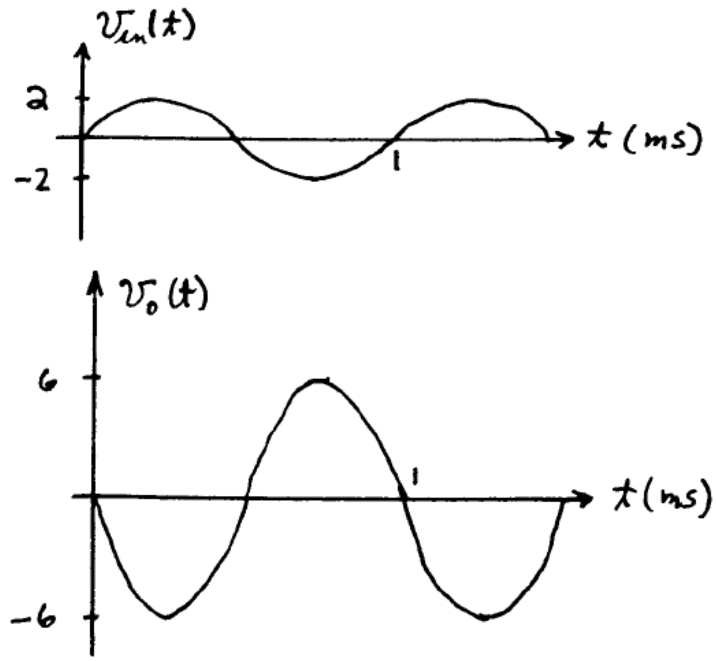


Figure P14.9

P14.9 This is an inverting amplifier having a voltage gain given by $A_v = -R_2/R_1 = -3$. Thus, we have $v_o(t) = -3 \times [2\cos(2000\pi t)]$

Sketches of $v_{in}(t)$ and $v_o(t)$ are



***P14.10.** Determine the closed-loop voltage gain of the circuit shown in Figure P14.10, assuming an ideal op amp.

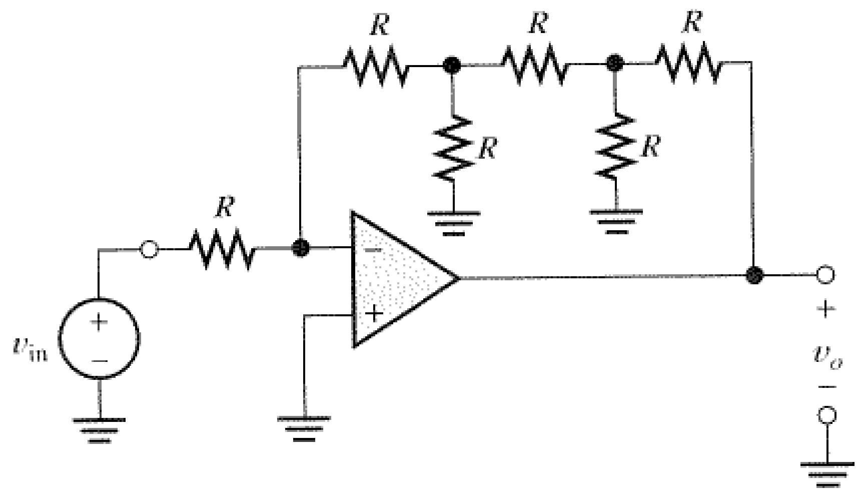
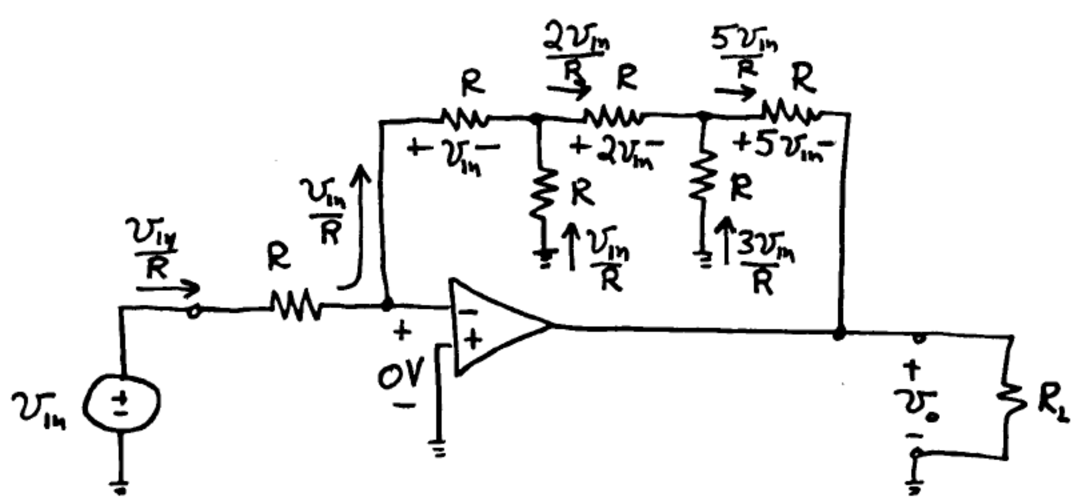


Figure P14.10

P14.10* The circuit has negative feedback so we can employ the summing-point constraint. Then successive application of Ohm's and Kirchhoff's laws starting from the left-hand side of the circuit produces the results shown:



From these results we can use KVL to determine that $v_o = -8v_{in}$ from which we have $A_v = -8$.

P14.11. Determine the closed-loop voltage gain of the circuit shown in Figure P14.11, assuming an ideal op amp.

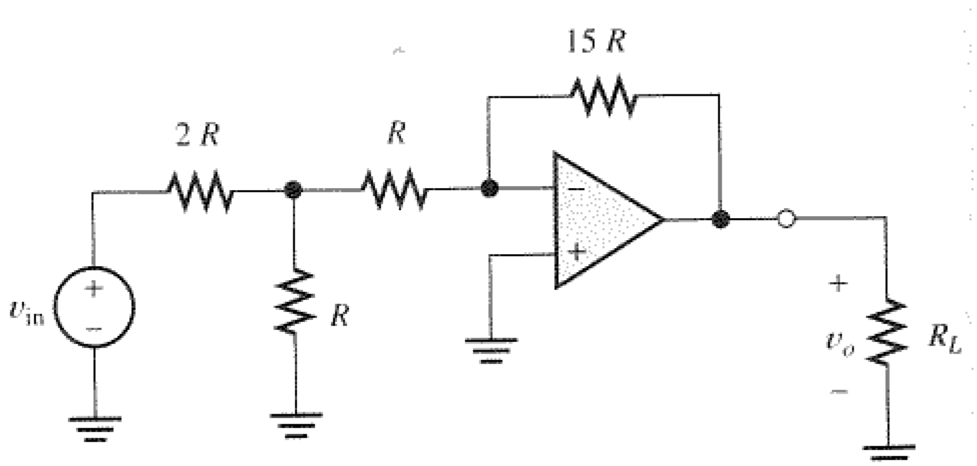
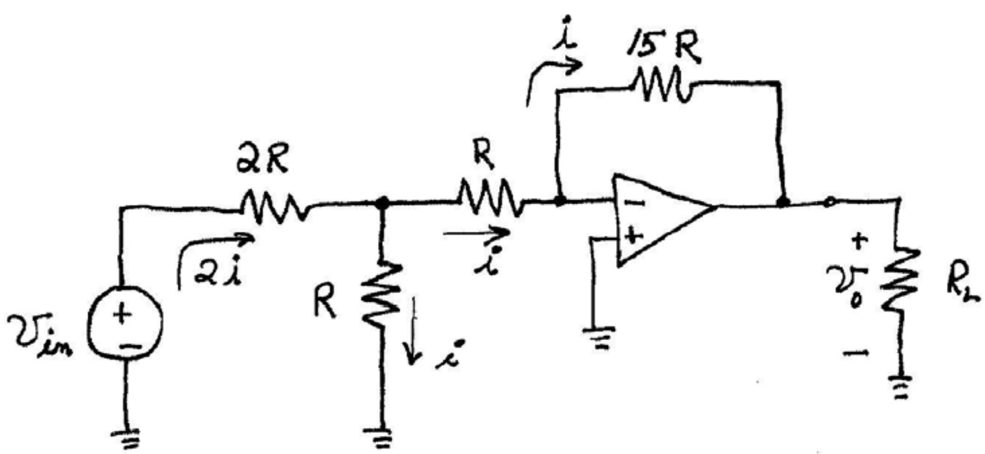


Figure P14.11

P14.11 Because of the summing-point constraint, the voltages across the two resistors of value R are equal. Thus, the currents in the resistors of value R are equal as indicated:



Then applying KVL, we have $v_{in} = 2R(2i) + Ri$ and $v_o = -15Ri$. Solving, we find $A_v = \frac{v_o}{v_{in}} = -3$.