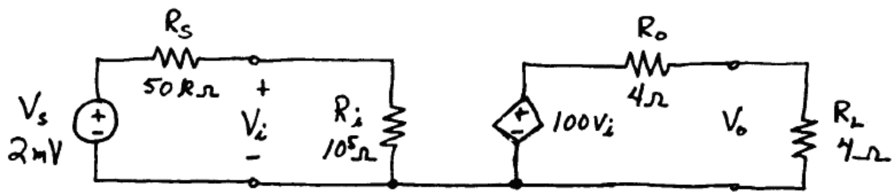
Practice problems

–P11.4, P11.8

–P14.9, P14.10, P14.11, P14.16

P11.4* The equivalent circuit is:



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

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

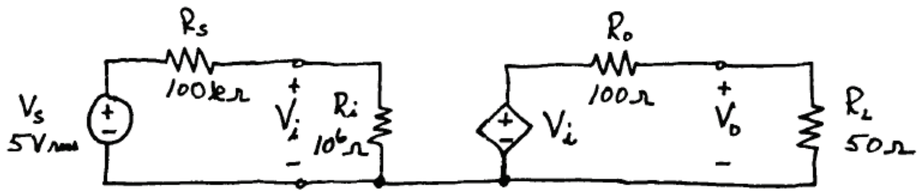
$$= 100\frac{100 \times 10^3}{100 \times 10^3 + 50 \times 10^3}\frac{4}{4+4}$$

$$= 33.33$$

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

$$G = A_v A_i = 62.5 \times 10^6$$

P11.8 The equivalent circuit using the amplifier is:



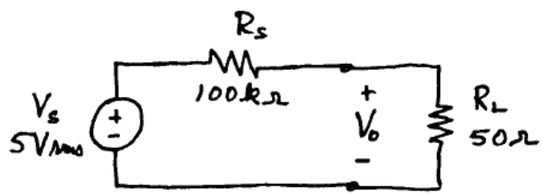
We have

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

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

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

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



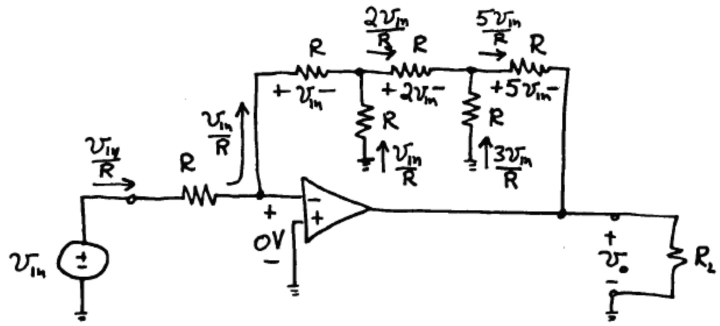
In this case, we have:

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

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

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.

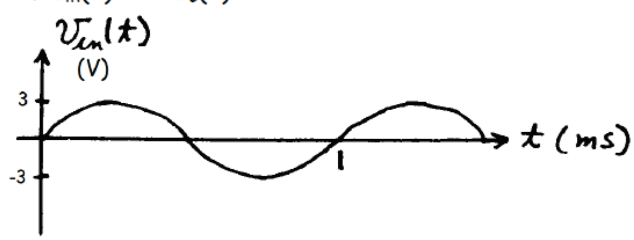
P14.9* The circuit has negative feedback so we can employ the summing-point constraint. Successive application of Ohm's and Kirchhoff's laws starting from the left-hand side of the circuit produces the results shown:

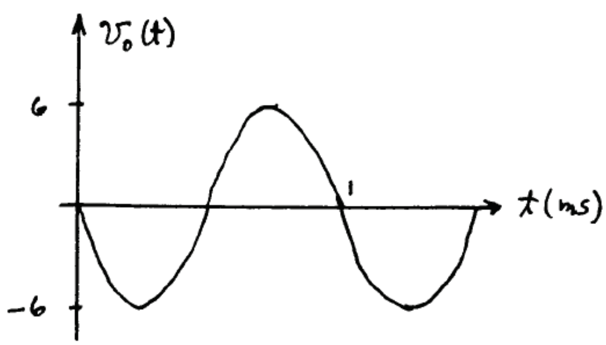


From these results we can use KVL to determine that $v_o = -8v_{in}$ from which we have $A_v = -8$.

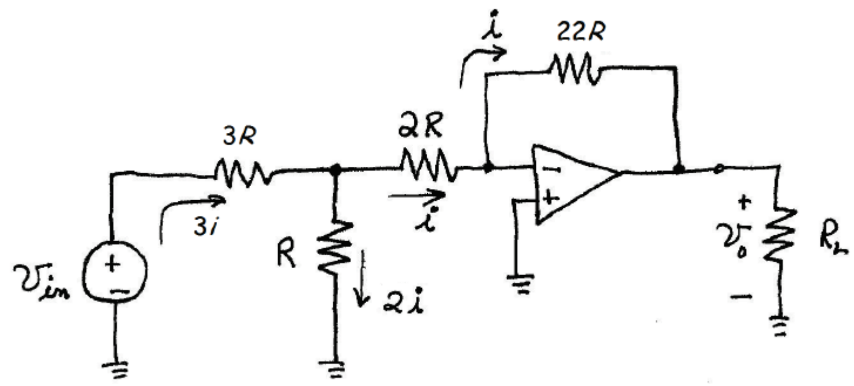
P14.10 This is an inverting amplifier having a voltage gain given by $A_v = -R_2/R_1 = -2$. Thus, we have $v_o(t) = -2 \times [3\cos(2000\pi t)]$

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





P14.11 Because of the summing-point constraint, the voltages across the resistors of values R and $2R$ are equal. Thus, the current in the resistor of value R is twice that of the current in the $2R$ resistor as indicated:



Applying KCL, we find the other currents as shown. Then, applying KVL, we have $v_{in} = 3R(3i) + 2Ri$ and $v_o = -22Ri$. Solving, we find $A_v = \frac{v_o}{v_{in}} = -2$.

P14.16 This circuit has positive feedback and the output can be either +5 V or −5 V. Writing a current equation at the inverting input terminal of the op amp, we have

$$\frac{v_x - 2}{1000} + \frac{v_x - v_o}{1000} = 0$$

Solving we find

$$v_x = 1 + 0.5v_o$$

For $v_o = 5$ V, we have $v_x = 3.5$ V. On the other hand for $v_o = -5$ V, we

have $v_x = -1.5$ V. Notice that for v_x positive the output remains stuck at its positive extreme and for v_x negative the output remains stuck at its negative extreme.