Problems

2.1 For the circuit shown in Fig. P2.1, select node d as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

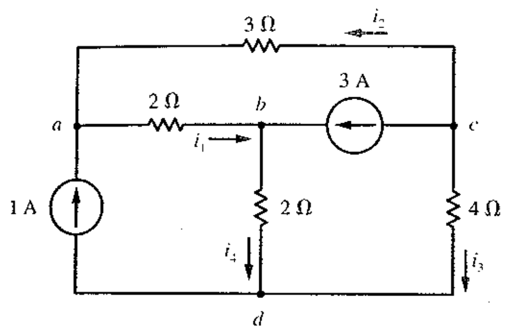

Fig. P2.1

2.2 For the circuit shown in Fig. P2.1, select node c as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

2.3 For the circuit shown in Fig. P2.1, select node b as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

2.4 For the circuit shown in Fig. P2.1, select node a as the reference node. (a) Use nodal analysis to find the node voltages. (b) Use the node voltages to determine i_1, i_2, i_3, and i_4.

2.5 Find the node voltages for the circuit shown in Fig. P2.5.

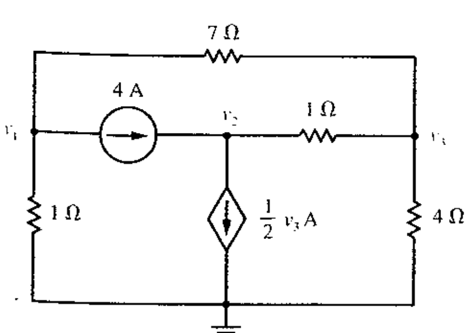

Fig. P2.5

2.6 Find the node voltages for the circuit shown in Fig. P2.6.

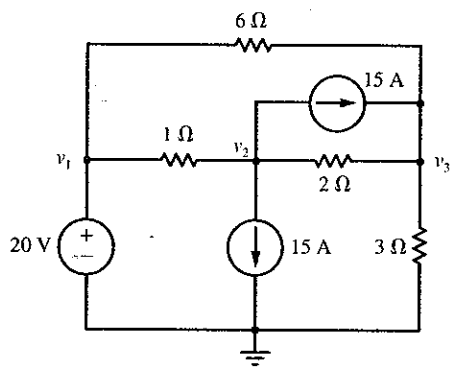

Fig. P2.6

2.7 Find the node voltages for the circuit shown in Fig. P2.7. (See p. 100.)

2.8 Find the node voltages for the circuit shown in Fig. P2.8.

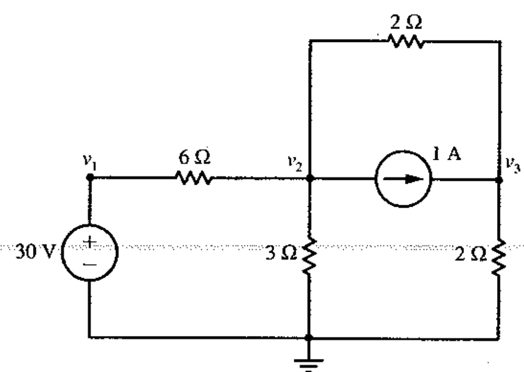

Fig. P2.8

2.9 Find the node voltages for the circuit shown in Fig. P2.9.

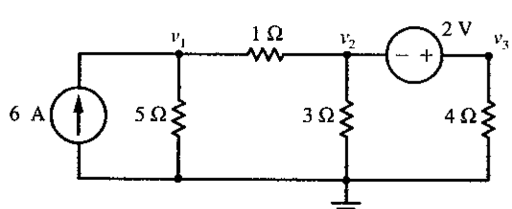

Fig. P2.9

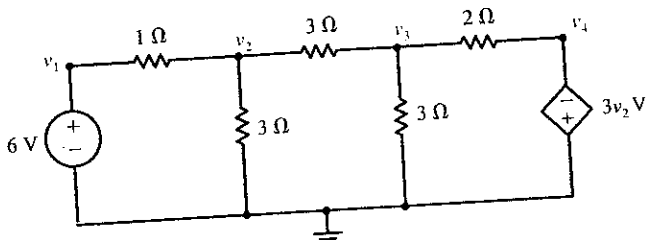

Fig. P2.7

2.10 Find the node voltages for the circuit shown in Fig. P2.10.

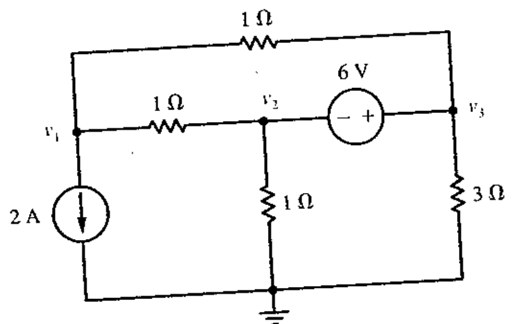

Fig. P2.10

2.11 Fig. P2.11 shows a single transistor amplifier circuit where the portion in the shaded box is the ***hybrid-*** or ***h-parameter model*** of a bipolar junction transistor (BJT). Note that h_i is a resistance and h_o is a conductance. Suppose that $h_i = 1$ kΩ, $h_r = 2.5 \times 10^{-4}$, $h_f = 50$, and $h_o = 25$ μ℧. (a) Use nodal analysis to find the voltage gain v_2/v_1 of this amplifier. (b) Determine the input resistance v_1/i_1 of this amplifier.

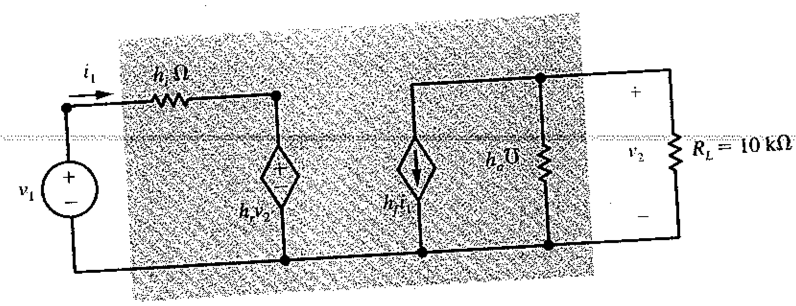

Fig. P2.11

2.12 Fig. P2.11 shows a single transistor amplifier circuit where the portion in the shaded box is the hybrid- or h-parameter model of a BJT. Note that h_i is a resistance and h_o is a conductance. Use nodal analysis to show that the voltage gain v_2/v_1 of this amplifier is

$$\frac{v_2}{v_1} = \frac{-h_f R_L}{h_i + (h_i h_o - h_f h_r)R_L}$$

2.13 Fig. P2.11 shows a single transistor amplifier circuit where the portion in the shaded box is the hybrid- or h-parameter model of a BJT. Note that h_i is a resistance and h_o is a conductance. Use the result given in Problem 2.12 to show that the input resistance v_1/v_1 of this amplifier is

$$\frac{v_1}{i_1} = h_i - \frac{h_f h_r}{h_o + 1/R_L}$$

2.14 The circuit shown in Fig. P2.14 is a single BJT amplifier with "feedback." The portion of the circuit in the shaded box is an approximate T-model of a transistor in the common-emitter configuration. (a) Use nodal analysis to find the voltage gain

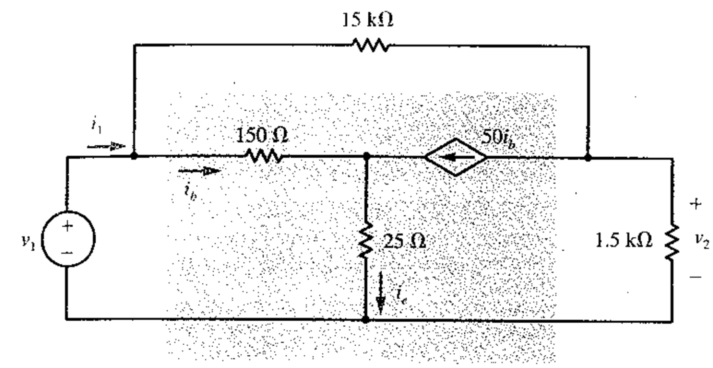

Fig. P2.14

v_2/v_1 of the amplifier. (b) Use the results of part (a) to determine the input resistance v_1/i_1 of the amplifier.

2.15 The circuit shown in Fig. P2.15 is a single BJT amplifier. The portion of the circuit in the shaded box is an approximate T-model of a transistor in the common-base configuration. (a) Use nodal analysis to find the voltage gain v_2/v_1 of the amplifier. (b) Use the results of part (a) to determine the input resistance v_1/i_e of the amplifier.

2.16 For the circuit given in Fig. P2.16, use nodal analysis to determine the conductance $G = i/v$ loading the source.

2.17 Suppose that a circuit contains the shaded box in Fig. P2.17*a*. Without affecting the remainder of the circuit, the box in Fig. P2.17*a* can be replaced by the box in Fig. P2.17*b*, provided that

$$G_{AB} = \frac{G_A G_B}{G_A + G_B + G_C} \quad G_{AC} = \frac{G_A G_C}{G_A + G_B + G_C}$$

$$G_{BC} = \frac{G_B G_C}{G_A + G_B + G_C}$$

Such a process is called a **Y-Δ (wye-delta) transformation.** The circuit in Fig. P2.17*c* is identical to the circuit given in Fig. P2.16. Use a Y-Δ transformation on the 1-℧, 2-℧, and 5-℧ conductances, and then combine elements in series and parallel to determine $G = i/v$. (See p. 102.)

2.18 Suppose that a circuit contains the shaded box in Fig. P2.17*b*. Without affecting the remainder of the circuit, the box in Fig. P2.17*b* can be replaced by the box in Fig. 2.17*a*, provided that

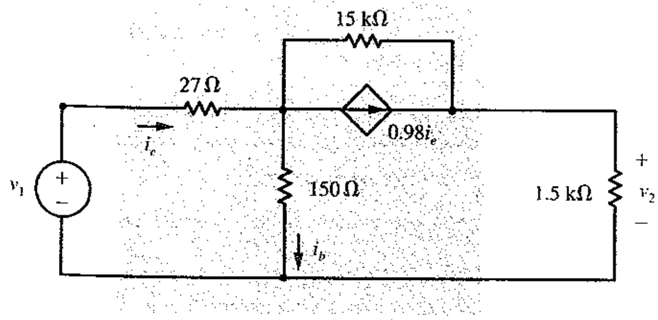

Fig. P2.15

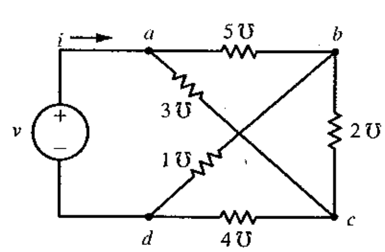

Fig. P2.16

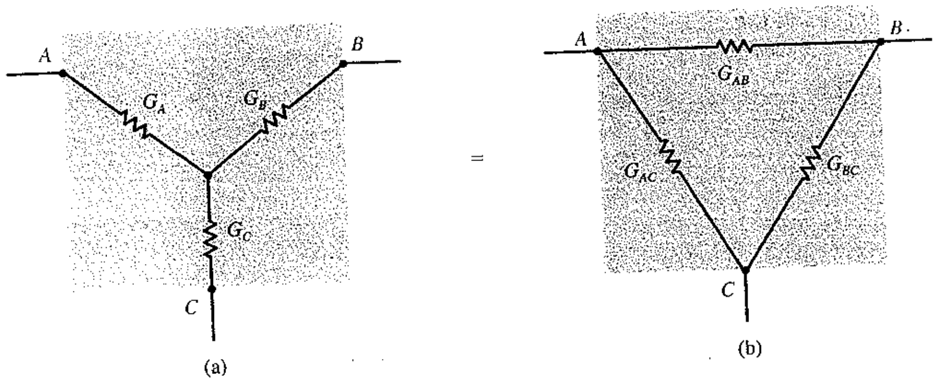

Fig. P2.17 *a,b*

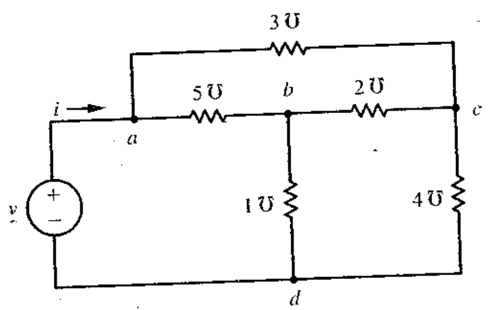

Fig. P2.17 *c*

$$R_A = \frac{R_{AB}R_{AC}}{R_{AB} + R_{AC} + R_{BC}} \quad R_B = \frac{R_{AB}R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

$$R_C = \frac{R_{AC}R_{BC}}{R_{AB} + R_{AC} + R_{BC}}$$

where $R = 1/G$. Such a process is called a **Δ-Y (delta-wye) transformation.**

The circuit shown in Fig. P2.18 is identical to the circuit given in Fig. P2.16. Use a Δ-Y transformation on the 2-℧, 3-℧, and 5-℧ conductances, and then combine elements in series and parallel to determine $G = i/v$.

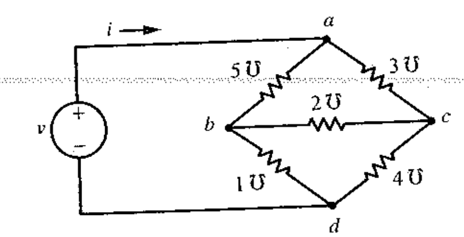

Fig. P2.18

2.19 Find the mesh currents for the circuit shown in Fig. P2.19.

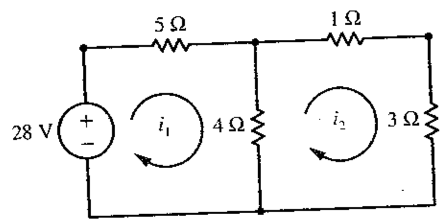

Fig. P2.19

2.20 Assume clockwise mesh currents for the circuit shown in Fig. 2.9 on p. 64. Use mesh analysis to find these mesh currents.

2.21 Assume clockwise mesh currents for the circuit shown in Fig. P2.7. Use mesh analysis to find these mesh currents.

2.22 Assume clockwise mesh currents for the circuit shown in Fig. P2.9. Use mesh analysis to find these mesh currents.

2.23 Assume clockwise mesh currents for the circuit shown in Fig. P2.10. Use mesh analysis to find these mesh currents.

2.24 Use mesh analysis to find the conductance $G = i/v$ for the circuit given in Fig. P2.18.

2.25 Assume clockwise mesh currents for the circuit shown in Fig. P2.8. Use mesh analysis to find these mesh currents.

2.26 Assume clockwise mesh currents for the circuit shown in Fig. P2.26 (below). Use mesh analysis to find these mesh currents.

2.27 For the circuit shown in Fig. P2.27, find v_o when the ideal amplifier (a) is an op amp, and (b) has finite gain A.

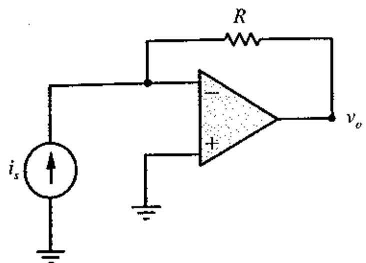

Fig. P2.27

2.28 For the op-amp circuit shown in Fig. P2.28, find (a) v_o, and (b) i_o.

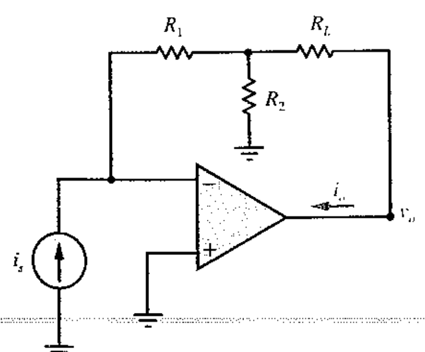

Fig. P2.28

2.29 For the op-amp circuit shown in Fig. P2.29, find (a) v_o, and (b) i_o.

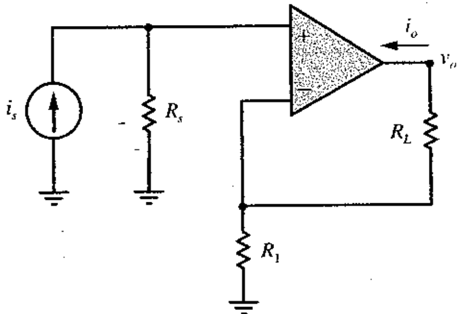

Fig. P2.29

2.30 The op-amp circuit shown in Fig. P2.30 is known as a **negative-impedance converter.** For this circuit, find (a) v_o, and (b) the resistance v_s/i_s.

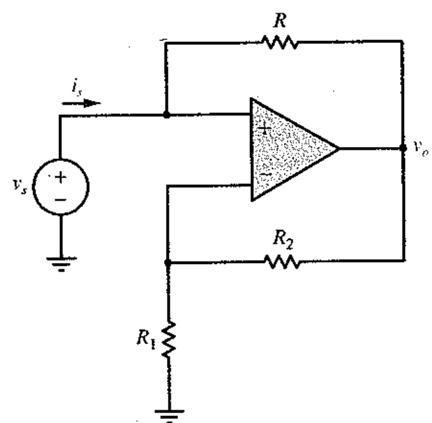

Fig. P2.30

2.31 For the op-amp circuit shown in Fig. P2.31, find (a) v_o, and (b) the resistance v_s/i_s. (See p. 104.)

2.32 For the op-amp circuit shown in Fig. P2.31, interchange the 1-Ω and 2-Ω resistors, and find (a) v_o, and (b) the resistance v_s/i_s. (See p. 104.)

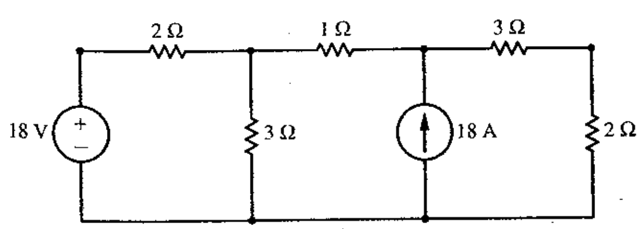

Fig. P2.26

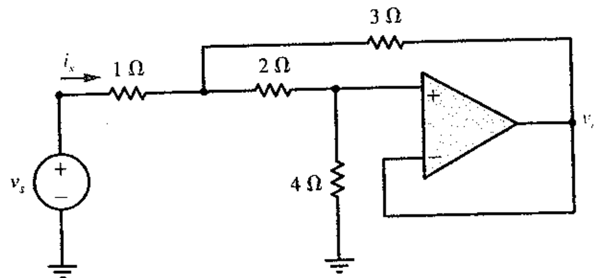

Fig. P2.31

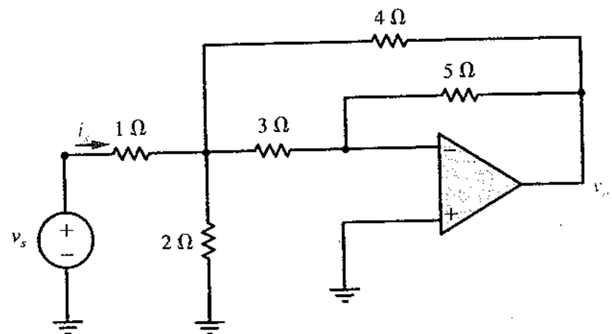

Fig. P2.33

2.33 For the op-amp circuit shown in Fig. P2.33, find (a) v_o, and (b) the resistance v_s/i_s.

2.34 For the op-amp circuit shown in Fig. P2.34, find (a) v_o, and (b) the resistance v_s/i_s. (See p. 105.)

2.35 For the op-amp circuit shown in Fig. P2.35, find v_o.

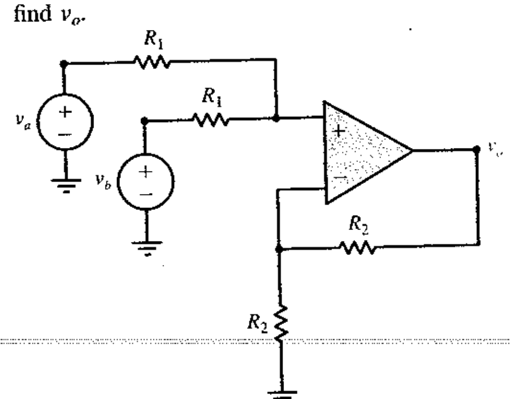

Fig. P2.35

2.36 For the op-amp circuit shown in Fig. P2.36, find v_o. (See p. 105.)

2.37 Consider the circuit shown in Fig. P2.37. (a) Find the Thévenin equivalent of the circuit to the left of terminals a and b. (b) Use the Thévenin-equivalent circuit to find the power absorbed by $R_L = 2\ \Omega$. (c) Determine the value of R_L, which absorbs the maximum amount of power, and find this power.

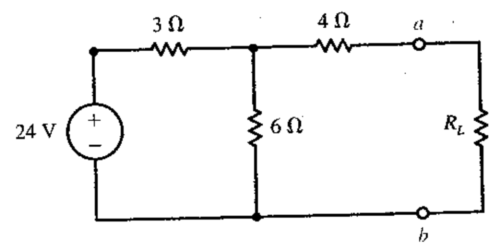

Fig. P2.37

2.38 For the circuit shown in Fig. P2.37, connect a 12-Ω resistor between terminal a and the positive terminal of the voltage source. (a) Find the Thévenin equivalent of the resulting circuit to the left of ter-

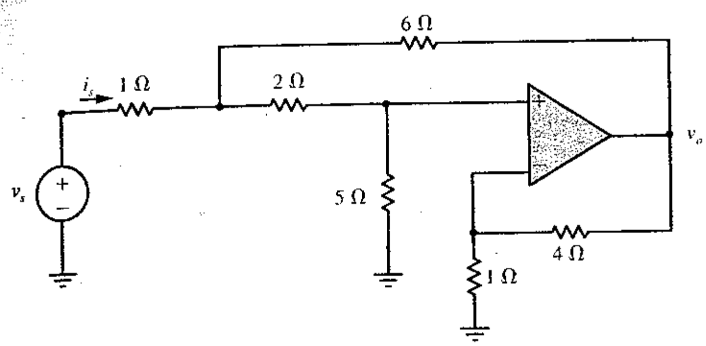

Fig. P2.34

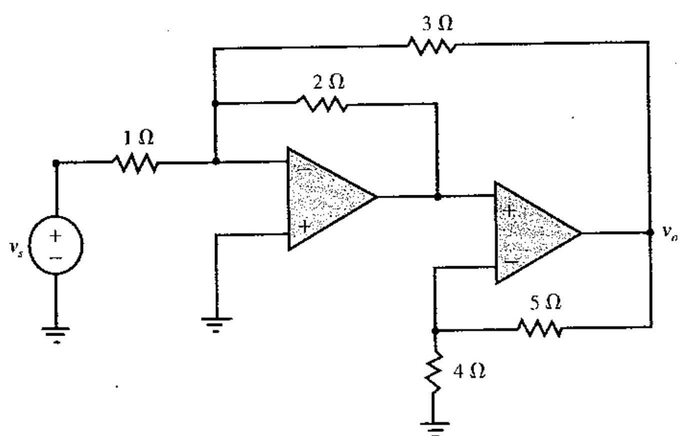

Fig. P2.36

minals a and b. (b) Use the Thévenin-equivalent circuit to find the power absorbed by $R_L = 2\ \Omega$. (c) Determine the value of R_L which absorbs the maximum amount of power, and find this power.

2.39 Consider the circuit shown in Fig. P2.39. (a) Find the Thévenin equivalent of the circuit to the left of terminals a and b. (b) Use the Thévenin-equivalent circuit to find i and the power absorbed by R_L when $R_L = 6\ \Omega$. (c) Determine the value of R_L, which absorbs the maximum amount of power, and find this power. (See p. 106.)

2.40 Consider the circuit shown in Fig. P2.40. (a) Find the Thévenin equivalent of the circuit to the left of terminals a and b. (b) Use the Thévenin-equivalent circuit to find v and the power absorbed by R_L when $R_L = 3\ \Omega$. (c) Determine the value of R_L, which absorbs the maximum amount of power, and find this power. (See p. 106.)

2.41 For the circuit given in Fig. P2.41, determine the value of R_L, which absorbs the maximum amount of power, and find this power when $v_1 = 20$ V.

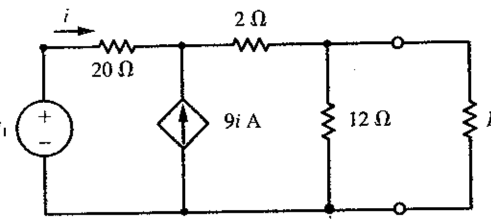

Fig. P2.41

2.42 Find the Norton equivalent of the circuit to the left of terminals a and b for the circuit shown in Fig. P2.42. Use this result to find i.

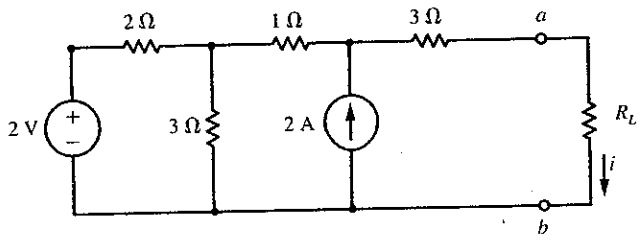

Fig. P2.39

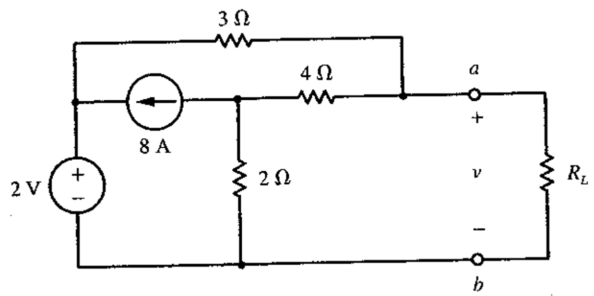

Fig. P2.40

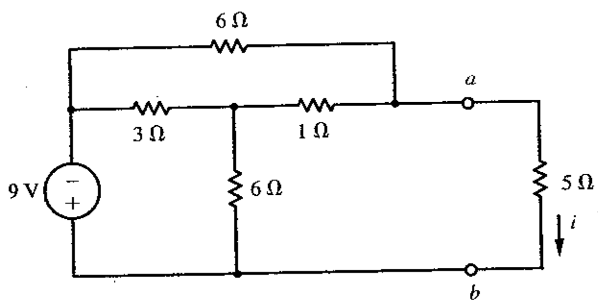

Fig. P2.42

2.43 Find the Norton equivalent of the circuit shown in Fig. P2.43.

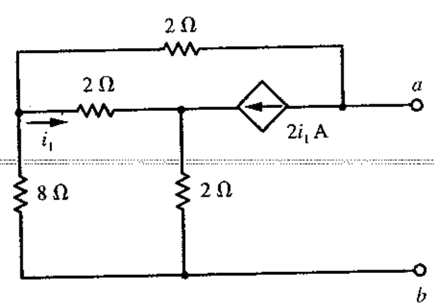

Fig. P2.43

2.44 Find the Thévenin equivalent of the circuit shown in Fig. P2.44.

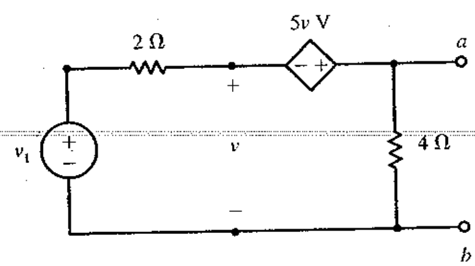

Fig. P2.44

2.45 Find the Thévenin equivalent of the op-amp circuit shown in Fig. P2.45. (*Hint:* To find R_o, apply a current source i_o and calculate the resulting voltage v_o.)

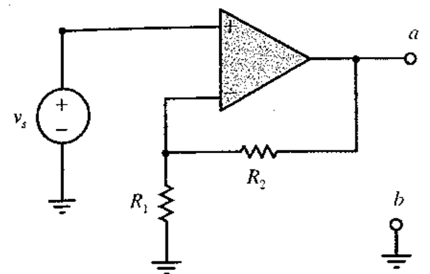

Fig. P2.45

2.46 Find the Thévenin equivalent of the op-amp circuit shown in Fig. P2.46. (*Hint:* To find R_o, apply a current source i_o and calculate the resulting voltage v_o.)

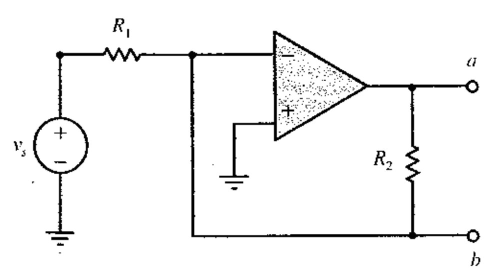

Fig. P2.46

2.47 Show that the Norton equivalent of the circuit shown in Fig. P2.47 is an ideal current source. (*Hint:* To find R_o, apply a voltage source v_o and calculate the resulting current i_o.)

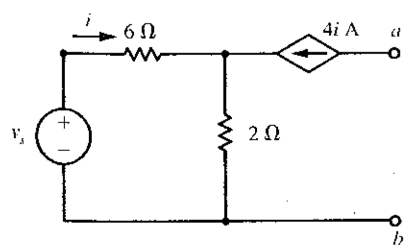

Fig. P2.47

2.48 For the circuit shown in Fig. P2.48, find (a) the Norton-equivalent circuit, and (b) the Thévenin-equivalent circuit.

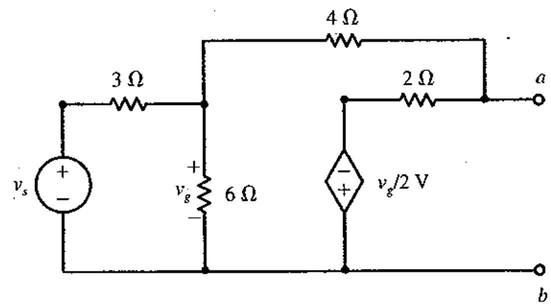

Fig. P2.48

2.49 Figure P2.49 demonstrates the concept of a **source transformation.** Specifically, the voltage source v_s connected in series with a resistance R_s is equivalent to a current source v_s/R_s connected in parallel with R_s. Without using Thévenin's or Norton's theorem, confirm the equivalence of Fig. P2.49*a* and *b* by writing expressions relating i and v.

2.50 Figure P2.50 also demonstrates the concept of a **source transformation.** Specifically, the current source i_g connected in parallel with R_g is equivalent to a voltage source $R_g i_g$ connected in series with a resistance R_g. Without using Thévenin's or Norton's theorem, confirm the equivalence of Fig. P2.50*a* and *b* by writing expressions relating i and v.

2.51 Use source transformations as described in Problems 2.49 and 2.50 to reduce the circuit given in Fig. P2.8 to a circuit having one mesh. Calculate v_3 from this reduced circuit.

2.52 Use source transformations as described in Problems 2.49 and 2.50 to reduce the circuit given in Fig. P2.9 to a circuit having one mesh. Calculate v_3 from this reduced circuit.

2.53 Use source transformations as described in Problems 2.49 and 2.50 and combine independent sources to reduce the circuit given in Fig. P2.39 to a circuit having one mesh. Calculate i from this reduced circuit when $R_L = 6\ \Omega$.

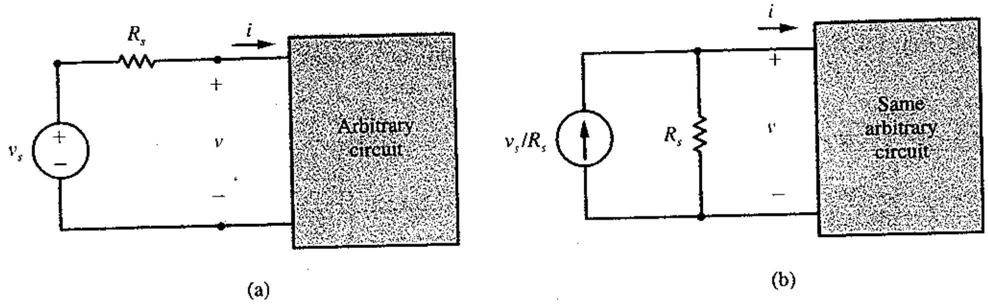

Fig. P2.49 *a,b*

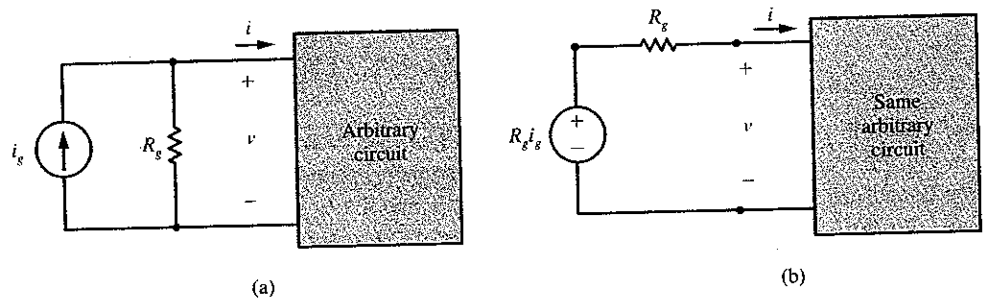

Fig. P2.50 *a,b*

2.54 Confirm that the source transformations described in Problems 2.49 and 2.50 can be applied to dependent sources, as well as independent sources, by reducing the circuit given in Fig. P2.7 to a circuit with one independent and one dependent current source, and then determining v_2.

2.55 Consider the circuit shown in Fig. 2.6 on p. 56. (a) Find the portion of i_3 that is due to the 6-A current source. (b) Find the portion of i_3 that is due to the 12-A current source. (c) Find i_3.

2.56 Consider the circuit shown in Fig. 2.10 on p. 66. (a) Find the portion of v_3 that is due to the 5-V voltage source. (b) Find the portion of v_3 that is due to the 10-V voltage source. (c) Find v_3.

2.57 Consider the circuit shown in Fig. P2.39, where $R_L = 6\ \Omega$. (a) Find the portion of i that is due to the 2-V voltage source. (b) Find the portion of i that is due to the 2-A current source. (c) Find i.

2.58 Consider the circuit shown in Fig. P2.40, where $R_L = 3\ \Omega$. (a) Find the portion of v that is due to the 2-V voltage source. (b) Find the portion of v that is due to the 8-A current source. (c) Find v.

2.59 Consider the circuit shown in Fig. P2.59. (a) Find the portion of i and the portion of v that are due to the 6-V voltage source. (b) Find the portion of i and the portion of v that are due to the 2-A current source. (c) Find i and v.

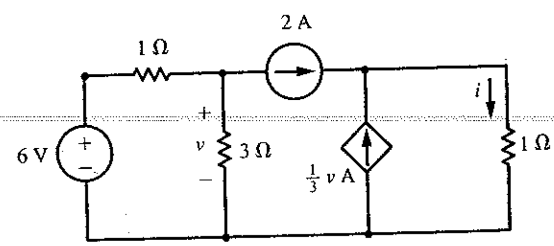

Fig. P2.59

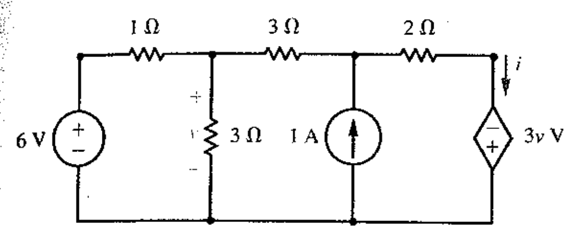

Fig. P2.60

2.60 Consider the circuit shown in Fig. P2.60. (a) Find the portion of i and the portion of v that are due to the 6-V voltage source. (b) Find the portion of i and the portion of v that are due to the 1-A current source. (c) Find i and v.

2.61 Consider the circuit shown in Fig. P2.61. (a) Find the portion of i and the portion of v that are due to the 2-A current source. (b) Find the portion of i and the portion of v that are due to the 6-V voltage source. (c) Find the portion of i and the portion of v that are due to the 4-V voltage source. (d) Find i and v.

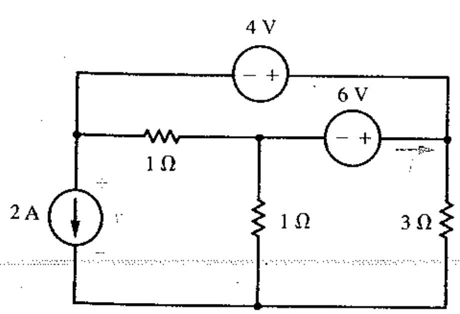

Fig. P2.61

2.62 Consider the circuit shown in Fig. P2.62. (a) Find the portion of i and the portion of v that are due to the 12-V voltage source. (b) Find the portion of i and the portion of v that are due to the 6-V voltage source. (c) Find the portion of i and the portion of v that are due to the 6-A current source. (d) Find i and v.

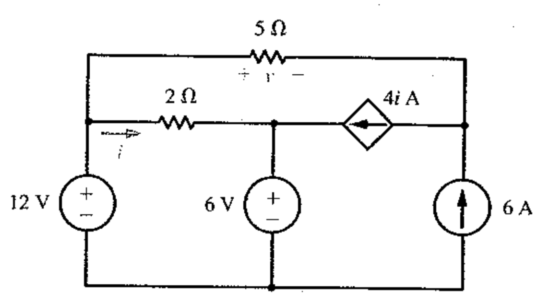

Fig. P2.62