EXERCISES

4.1 Nodal Analysis

1. (*a*) Find v_2 if $0.1v_1 - 0.3v_2 - 0.4v_3 = 0$, $-0.5v_1 + 0.1v_2 = 4$, and $-0.2v_1 - 0.3v_2 + 0.4v_3 = 6$. (*b*) Evalute the determinant:

$$\begin{vmatrix} 2 & 3 & 4 & 1 \\ 3 & 4 & 1 & 2 \\ 4 & 1 & 2 & 3 \\ 1 & -2 & 3 & 0 \end{vmatrix}$$

2. (*a*) Find v_A, v_B, and v_C if $v_A + v_B + v_C = 27$, $2v_B + 16 = v_A - 3v_C$, and $4v_C + 2v_A + 6 = 0$. (*b*) Evaluate the determinant:

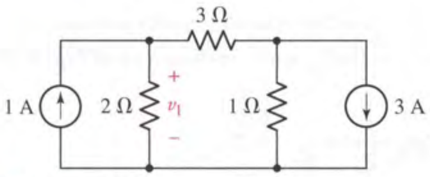
$$\begin{vmatrix} 0 & 1 & 2 & 3 \\ 1 & 2 & 3 & 4 \\ 2 & 3 & 4 & 1 \\ 3 & 4 & 1 & 2 \end{vmatrix}$$

3. (*a*) Solve the following system of equations:

$$4 = v_1/100 + (v_1 - v_2)/20 + (v_1 - v_x)/50$$
$$10 - 4 - (-2) = (v_x - v_1)/50 + (v_x - v_2)/40$$
$$-2 = v_2/25 + (v_2 - v_x)/40 + (v_2 - v_1)/20$$

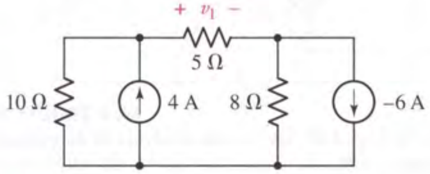
(*b*) Verify your solution using MATLAB.

4. Determine the value of the voltage labeled v_1 in Fig. 4.34.



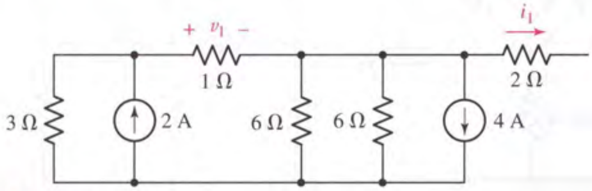
■ **FIGURE 4.34**

5. Determine the value of the voltage labeled v_1 in Fig. 4.35.



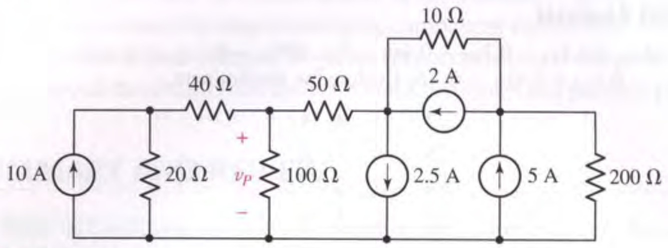
■ **FIGURE 4.35**

6. For the circuit of Fig. 4.36, determine the value of the voltage labeled v_1 and the current labeled i_1.

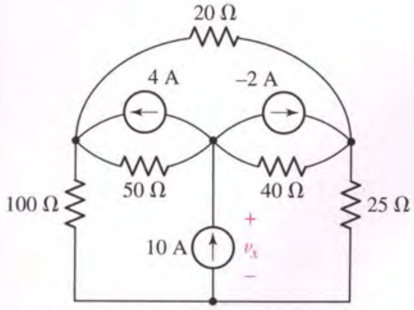


■ **FIGURE 4.36**

7. Use nodal analysis to find v_P in the circuit shown in Fig. 4.37.



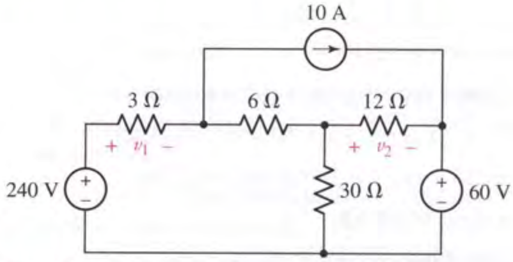
■ **FIGURE 4.37**



■ **FIGURE 4.38**

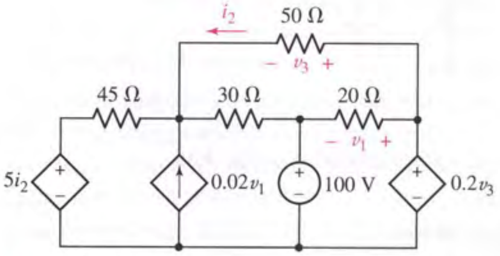
8. Use nodal analysis to find v_x in the circuit of Fig. 4.38.

9. For the circuit of Fig. 4.39 (*a*) use nodal analysis to determine v_1 and v_2. (*b*) Compute the power absorbed by the 6 Ω resistor.



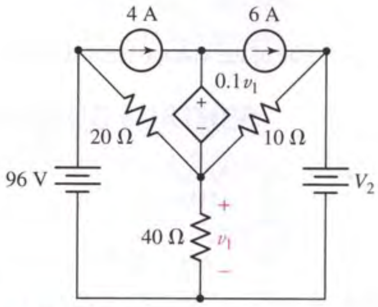
■ **FIGURE 4.39**

10. Employ nodal analysis techniques to find v_1 and i_2 in the circuit of Fig. 4.40.



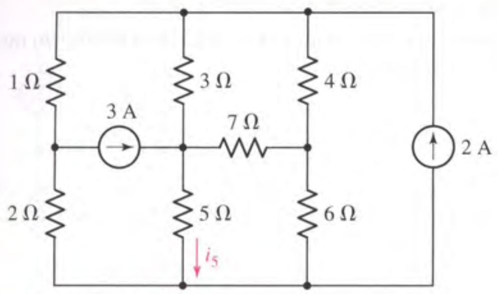
■ **FIGURE 4.40**

11. Referring to the circuit depicted in Fig. 4.41, use nodal analysis to determine the value of V_2 that will result in $v_1 = 0$.



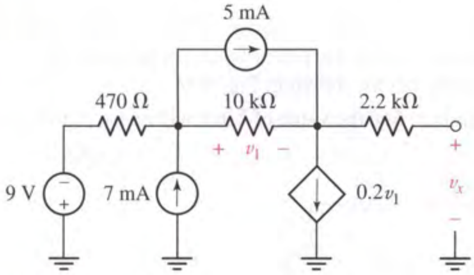
■ **FIGURE 4.41**

12. For the circuit of Fig. 4.42, use nodal analysis to determine the current i_5.



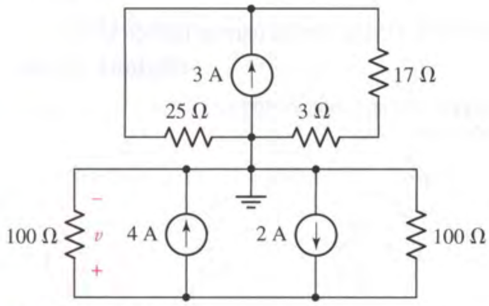
■ **FIGURE 4.42**

13. Employ nodal analysis to obtain a value for v_x as indicated in Fig. 4.43.



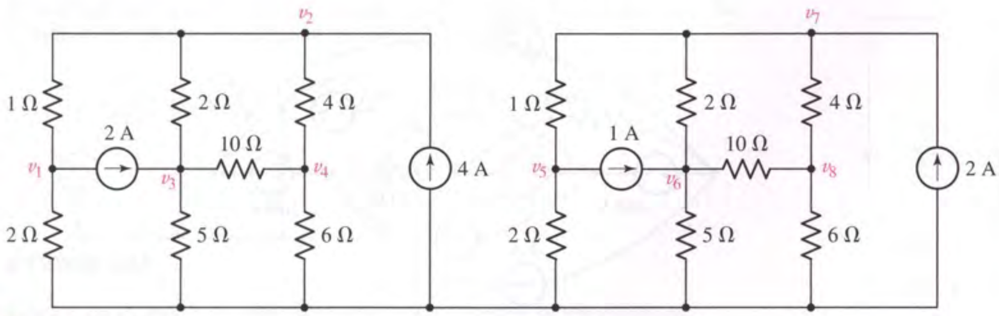
■ **FIGURE 4.43**

14. Determine the voltage labeled v in the circuit of Fig. 4.44 using nodal analysis techniques.



■ **FIGURE 4.44**

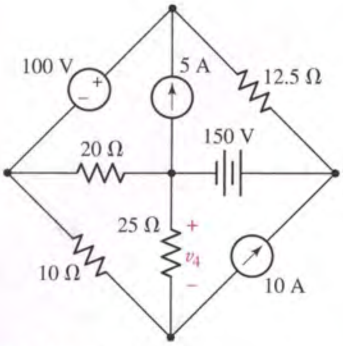
15. Determine the nodal voltages indicated in the circuit of Fig. 4.45.



■ **FIGURE 4.45**

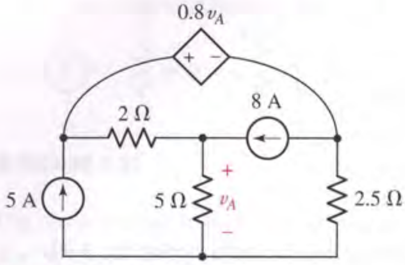
4.2 The Supernode

16. Use nodal analysis to find v_4 in the circuit shown in Fig. 4.46.



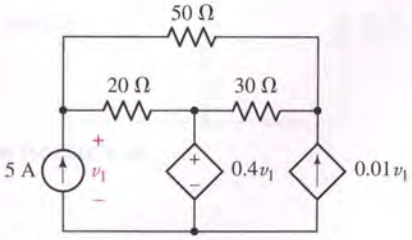
■ **FIGURE 4.46**

17. With the help of nodal analysis on the circuit of Fig. 4.47, find (*a*) v_A; (*b*) the power dissipated in the 2.5 Ω resistor.



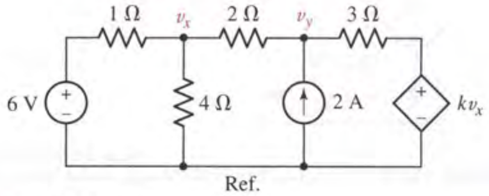
■ **FIGURE 4.47**

18. Use nodal analysis to determine v_1 and the power being supplied by the dependent current source in the circuit shown in Fig. 4.48.



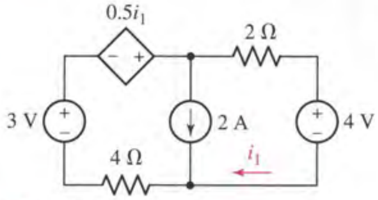
■ **FIGURE 4.48**

19. In Fig. 4.49, use nodal analysis to find the value of k that will cause v_y to be zero.



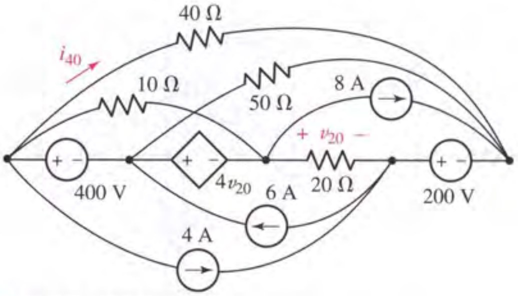
■ **FIGURE 4.49**

20. Consider the circuit of Fig. 4.50. Determine the current labeled i_1.



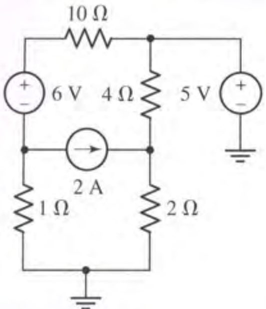
■ **FIGURE 4.50**

21. Make use of the supernode concept to assist in the determination of the voltage labeled v_{20} in Fig. 4.51. Crossed wires not marked by a solid dot are not in physical contact.



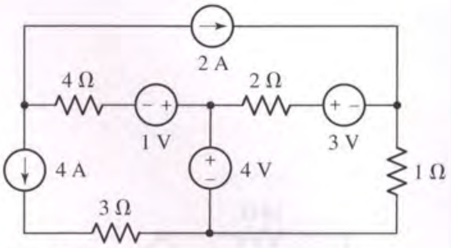
■ **FIGURE 4.51**

22. For the circuit of Fig. 4.52, determine all four nodal voltages.



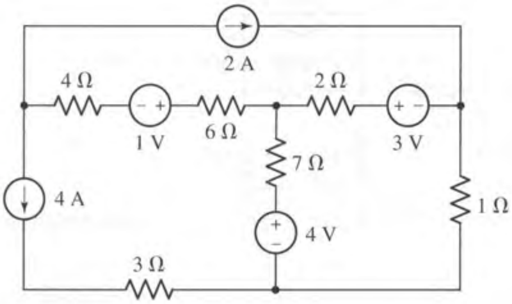
■ **FIGURE 4.52**

23. Determine the power supplied by the 2 A source in the circuit of Fig. 4.53.



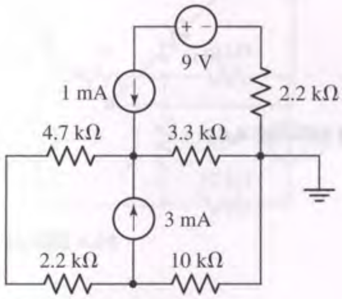
■ **FIGURE 4.53**

24. Determine the power supplied by the 2 A source in the circuit of Fig. 4.54.



■ **FIGURE 4.54**

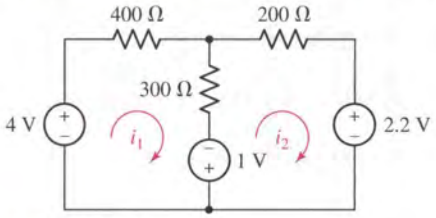
25. Determine the nodal voltages characterizing the circuit of Fig. 4.55.



■ **FIGURE 4.55**

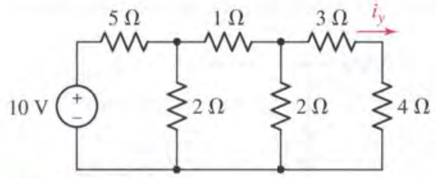
4.3 Mesh Analysis

26. Determine the mesh currents i_1 and i_2 as shown in the circuit of Fig. 4.56.



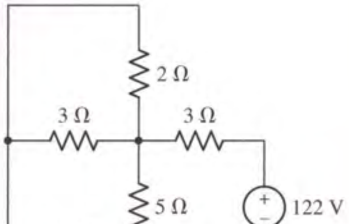
■ **FIGURE 4.56**

27. Regarding the circuit of Fig. 4.57, employ mesh analysis to determine (*a*) the current i_y; (*b*) the power supplied by the 10 V source.



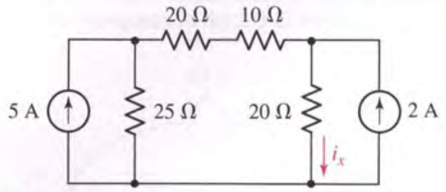
■ **FIGURE 4.57**

28. Employ mesh analysis to determine the current flowing in the circuit of Fig. 4.58 through (*a*) the 2 Ω resistor; (*b*) the 5 Ω resistor.



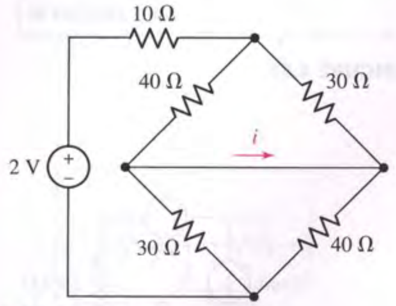
■ **FIGURE 4.58**

29. For the circuit of Fig. 4.59, use mesh analysis to determine (*a*) the current labeled i_x; (*b*) the power absorbed by the 25 Ω resistor.

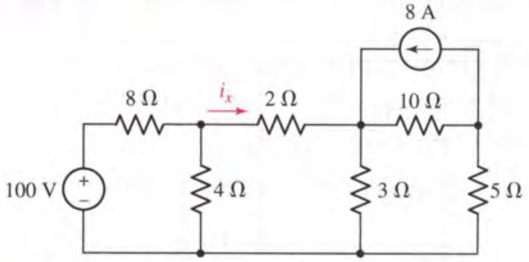


■ **FIGURE 4.59**

30. Use mesh analysis to determine the current labeled i in the circuit of Fig. 4.60.
31. Use mesh analysis to find i_x in the circuit shown in Fig. 4.61.

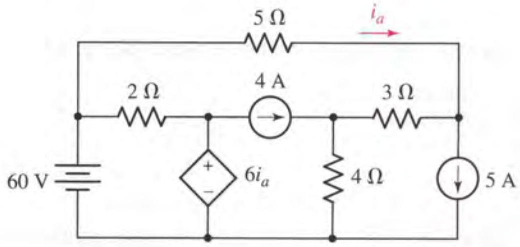


■ **FIGURE 4.60**



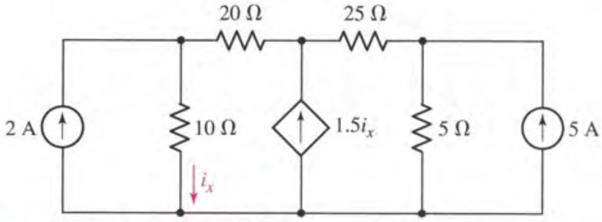
■ **FIGURE 4.61**

32. Calculate the power being dissipated in the 2 Ω resistor for the circuit of Fig. 4.62.



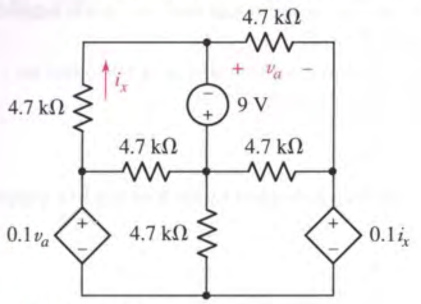
■ **FIGURE 4.62**

33. Use mesh analysis on the circuit shown in Fig. 4.48 to find the power being supplied by the dependent voltage source.
34. Use mesh analysis to find i_x in the circuit shown in Fig. 4.63.



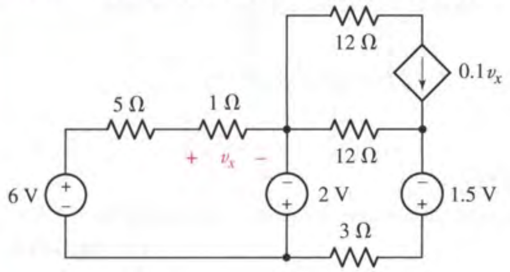
■ **FIGURE 4.63**

35. Determine the clockwise mesh currents for the circuit of Fig. 4.64.



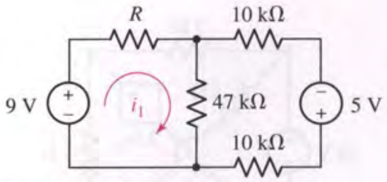
■ **FIGURE 4.64**

36. Determine each mesh current in the circuit of Fig. 4.65.



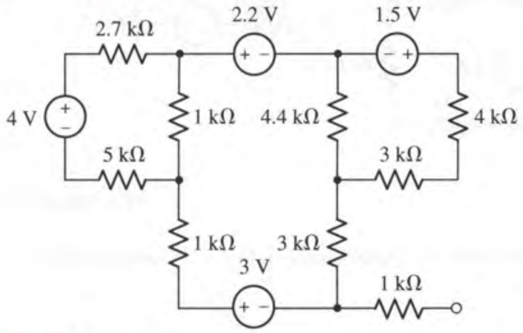
■ **FIGURE 4.65**

37. (*a*) Referring to the circuit of Fig. 4.66, determine the value of R if it is known that the mesh current $i_1 = 1.5$ mA. (*b*) Is the value of R necessarily unique? Explain.



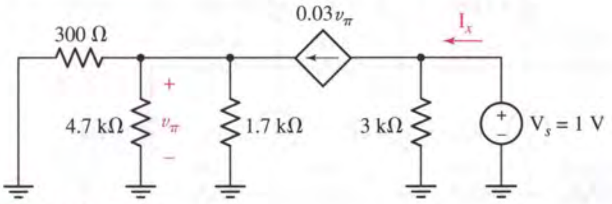
■ **FIGURE 4.66**

38. For the circuit of Fig. 4.67, employ the mesh analysis technique to find the power absorbed by each resistor.

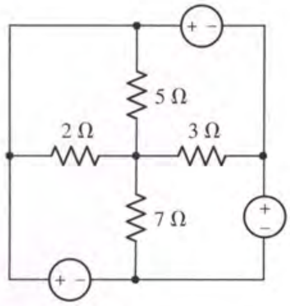


■ **FIGURE 4.67**

39. The circuit shown in Fig. 4.68 is the equivalent circuit of a common-base bipolar junction transistor amplifier. The input source has been shorted, and a



■ **FIGURE 4.68**



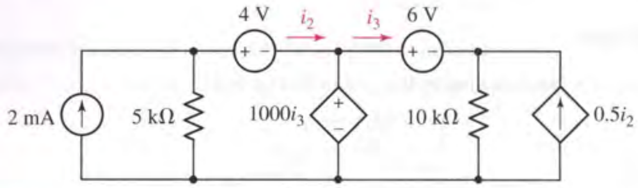
■ FIGURE 4.69

1 V source has been substituted for the output device. (*a*) Use mesh analysis to find I_x. (*b*) Verify your solution to part (*a*) using nodal analysis. (*c*) What is the physical significance of the quantity V_s/I_x?

40. Choose nonzero values for the three voltage sources of Fig. 4.69 so that no current flows through any resistor in the circuit.

4.4 The Supermesh

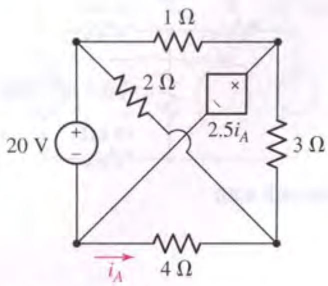
41. Use mesh analysis to help find the power generated by each of the five sources in Fig. 4.70.



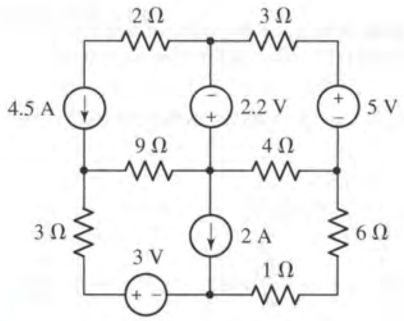
■ FIGURE 4.70

42. Find i_A in the circuit of Fig. 4.71.

43. Use the supermesh concept to determine the power supplied by the 2.2 V source of Fig. 4.72.

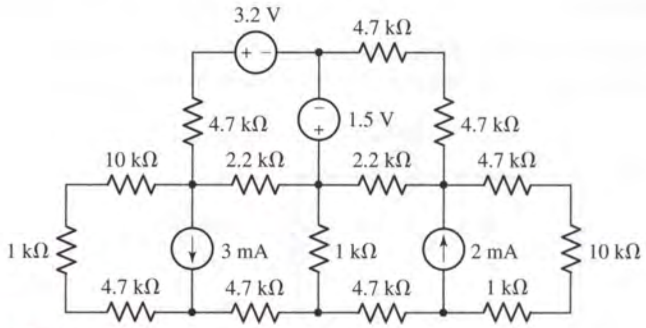


■ FIGURE 4.71



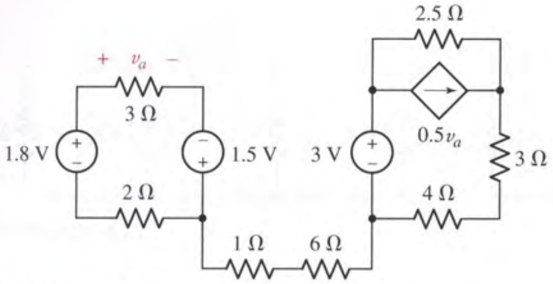
■ FIGURE 4.72

44. Determine the voltage across the 2 mA source in Fig. 4.73, assuming its bottom node is ground.



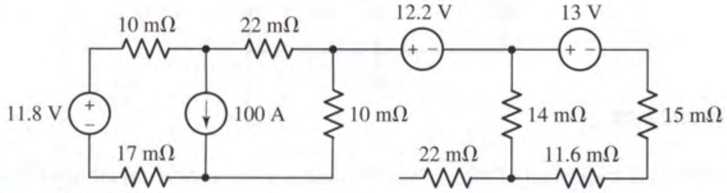
■ FIGURE 4.73

45. Employ mesh analysis to obtain the voltage across the 2.5 Ω resistor of Fig. 4.74.



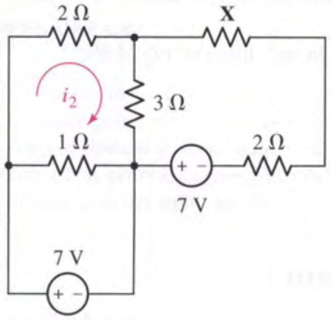
■ **FIGURE 4.74**

46. Calculate the mesh currents for the circuit of Fig. 4.75.



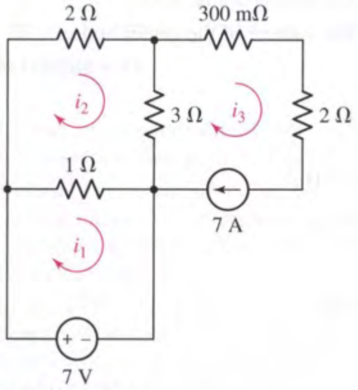
■ **FIGURE 4.75**

47. For the circuit of Fig. 4.76, determine the value of resistor **X** if $i_2 = 2.273$ A.



■ **FIGURE 4.76**

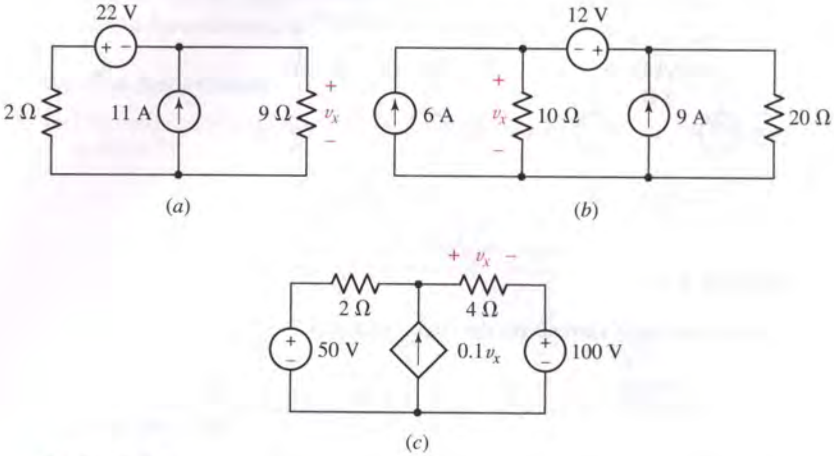
48. Consider the circuit of Fig. 4.77. Compute the three mesh currents indicated.



■ **FIGURE 4.77**

4.5 Nodal vs. Mesh Analysis: A Comparison

49. Determine the voltage labeled v_x in each of the circuits of Fig. 4.78.

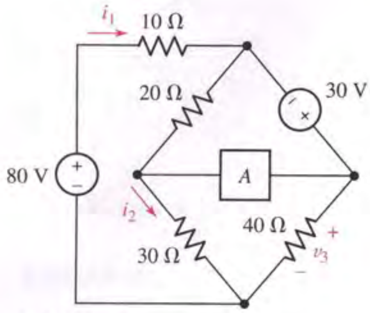


■ **FIGURE 4.78**

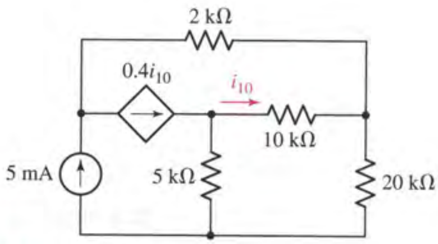
50. Find v_3 in the circuit of Fig. 4.79 if element A is (*a*) a short circuit; (*b*) a 9 V independent voltage source, with positive reference on the left; (*c*) a dependent current source, arrow head on the left, labeled $5i_1$.

51. Determine the currents i_1 and i_2 in the circuit of Fig. 4.79 if element A is a 12 Ω resistor. Explain the logic behind your choice of either nodal or mesh analysis.

52. Obtain a value for the current labeled i_{10} in the circuit of Fig. 4.80.



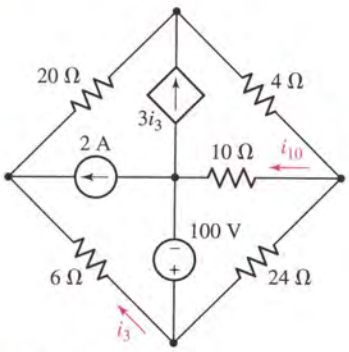
■ **FIGURE 4.79**



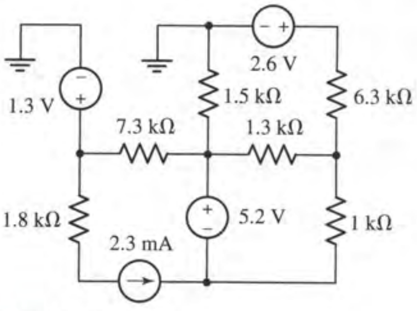
■ **FIGURE 4.80**

53. Determine the two currents labeled in the circuit of Fig. 4.81.

54. For the circuit of Fig. 4.82, determine the voltage of the center node.

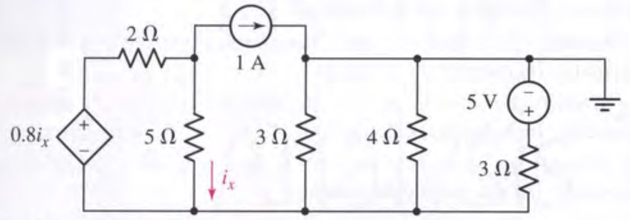


■ **FIGURE 4.81**



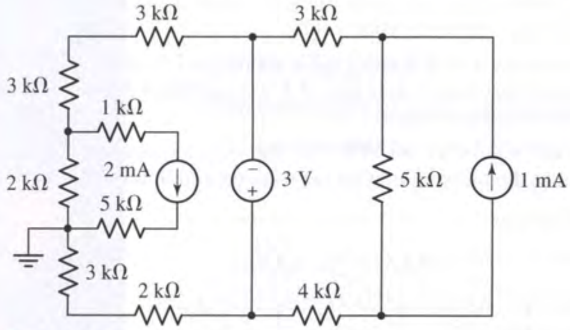
■ **FIGURE 4.82**

55. Determine the current through each branch of the circuit in Fig. 4.83.



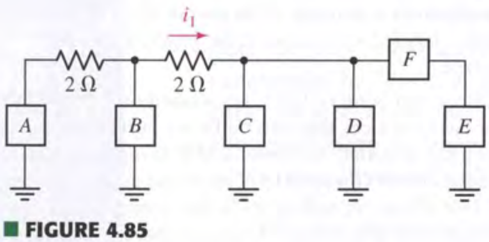
■ **FIGURE 4.83**

56. Determine the voltage across the 2 mA current source of Fig. 4.84.



■ **FIGURE 4.84**

57. For the circuit of Fig. 4.85, let A be a 5 V voltage source with positive reference at the top, let B represent a 3 A current source with the arrow pointing toward ground, let C be a 3 Ω resistor, let D be a 2 A current source with arrow pointing toward ground, let F be a 1 V voltage source with negative reference on the right, and let E be a 4 Ω resistor. Compute i_1.

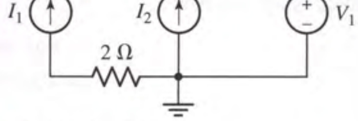


■ **FIGURE 4.85**

58. Choose any nonzero values for I_1, I_2, and V_1 so that 6 W is dissipated by the 6 Ω resistor in the circuit of Fig. 4.86.

59. Referring to the circuit of Fig. 4.84, replace the 2 mA current source with a 2 V voltage source, "+" reference terminal at the bottom, and the 3 V source with a 7 mA current source, arrow pointing down. Determine the mesh currents for the new circuit.

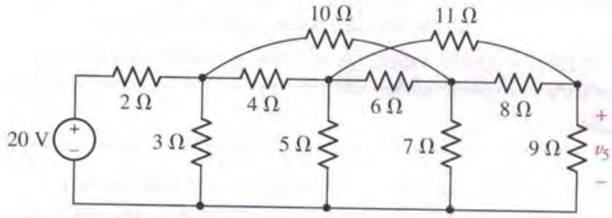
60. In the circuit of Fig. 4.85, A is a dependent current source with arrow pointing down and labeled $5i_1$. Let B and E be 2 Ω resistors, let C be a 2 A current source with arrow pointing toward ground, let F be a 2 V voltage source with negative reference on the right, and let D be a 3 A current source with the arrow at the top. Determine the nodal voltages and all mesh currents.



■ **FIGURE 4.86**

4.6 Computer-Aided Circuit Analysis

61. Use PSpice to verify the solution of Exer. 52. Submit a printout of a properly labeled schematic. Include hand calculations.
62. Use PSpice to verify the solution of Exer. 54. Submit a printout of a properly labeled schematic. Include hand calculations.
63. Use PSpice to verify the solution of Exer. 56. Submit a printout of a properly labeled schematic. Include hand calculations.
64. Use PSpice to verify the solution of Exer. 58. Submit a printout of a properly labeled schematic. Include hand calculations.
65. Use PSpice to verify the solution of Exer. 60. Submit a printout of a properly labeled schematic. Include hand calculations.
66. Construct a circuit consisting of a 5 V source in series with a 100 Ω resistor, connected to a network containing at least one 3 A source, three different resistors, and a voltage-controlled current source that depends on the voltage across the 100 Ω resistor. (*a*) Determine all node voltages and all branch currents. (*b*) Use PSpice to verify your results.
67. Construct a circuit using a 10 V battery, a 3 A source, and as many 1 Ω resistors as necessary to obtain a potential of 5 V across the 3 A source. Verify your hand calculations using PSpice.
68. Write an appropriate input deck for SPICE to find v_5 in the circuit of Fig. 4.87. Submit a printout of the output file, with the solution highlighted.



■ **FIGURE 4.87**

69. Design a circuit using only 9 V batteries and resistors that will provide nodal voltages of 4 V, 3 V, and 2 V. Write an appropriate input deck for SPICE to simulate your solution, and submit a printout of the output file with the desired voltages highlighted. Draw a labeled schematic on the printout for reference, with node numbers identified.
70. A very long string of multicolored outdoor lights is installed on a house. After applying power, the homeowner notices that two bulbs are burned out. (*a*) Are the lights connected in series or parallel? (*b*) Write a SPICE input deck to simulate the lights, assuming 20 AWG wire, 115 V ac power supply, and an individual bulb rating of 1 W. There are 400 lights in the string; simulate an electrically equivalent circuit with fewer than 25 components for simplicity. Submit a printout of the output file, with the power supplied by the wall socket highlighted. (*c*) After replacing the burned-out bulbs, the homeowner notices that the lights closest to the outlet are approximately 10 percent brighter than the lights at the far end of the string. Provide a possible explanation, keeping in mind that nothing in the string is zero ohms.