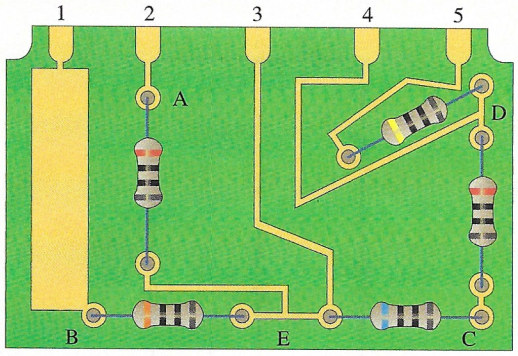

Figure P15

16. [I] THIS PROBLEM WILL HELP US DEAL WITH CIRCUIT DIAGRAMS AND RESISTANCE. With the switch S open in the circuit of Fig. P16, we put an ohmmeter between points-A and C. (a) Does the branch from A to B to C have any effect on the measurement? Explain. (b) What is the value of the resistance the ohmmeter will measure between points-A and C? (c) What will the ohmmeter read if we touch one of its probes to A and the other to ground? Explain. (d) What will the ohmmeter read if we touch one of its probes to D and the other to ground? (e) What will the ohmmeter read if we touch one of its probes to E and the other to ground?

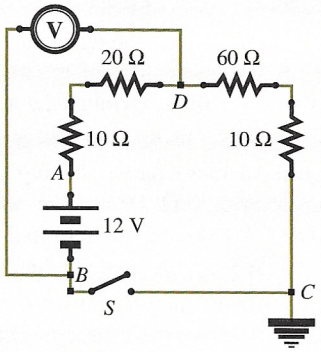

Figure P16

17. [I] What is the current in the circuit of Fig. P17 before and after the wire is clipped on at C and B? What happens to the 12-Ω bulb after the wire is attached? The battery has a negligible internal resistance.

18. [I] Two 30.0-Ω resistors are attached in series and then placed across the terminals of a 12.0 -V battery having a negligible internal resistance. How much current flows through the circuit?

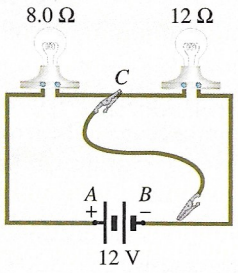

Figure P17

19. [I] Each lamp in Fig. P19 has a resistance of 20 Ω. How much current is drawn from the battery before and after the switch is closed? How does the power supplied to the circuit change when the switch is closed? The battery has a negligible internal resistance.

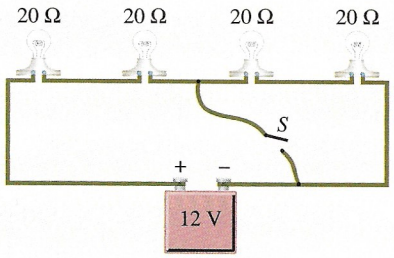

Figure P19

20. [I] Three 3.0-Ω resistors are connected in parallel and the combination is placed across a battery that has a terminal voltage of 9.0 V. How much current flows through the battery?

21. [I] Two 2.0-Ω resistors are in parallel. What is their equivalent resistance?

22. [I] Three resistors with values of 2.0 Ω, 3.0 Ω, and 6.0 Ω are connected in parallel. What is the equivalent resistance?

23. [I] A portable generator in a field hospital produces dc at 100 V. Five 100-W lamps are attached in parallel, and the string placed across the terminals of the generator. How much current must the source provide for the lamps to operate as designed?

24. [I] Three resistors with values of 1/2 Ω, 1/3 Ω, and 1/6 Ω are connected in parallel. What is the equivalent resistance?

25. [I] Show that if there are a number N of identical resistors in parallel, each with a value R, then $R_e = R/N$.

26. [I] THIS PROBLEM DEALS WITH AN ARRAY OF RESISTORS. Each resistor in Fig. P26 is color coded orange-black-black-silver. (a) What is the resistance of each resistor? (b) With the switch S open, we put an ohmmeter between points-D and C and measure the resistance. Does the branch from D to F to C have any effect on the measurement? Explain. (c) What can you say about points A, B, C, and E? (d) What is the value of the resistance the ohmmeter will measure between points-D and C? (e) What will the ohmmeter read if we touch one of its probes to D and the other to ground? Explain.

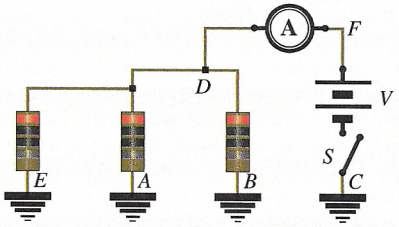

Figure P26

27. [I] Suppose each resistor in Fig.P26 was color coded orange-black-orange-silver. With the switch closed, how much voltage will be needed to produce a current in the ammeter of 120 μA? In what direction will it flow?

SOLUTION: The resistance of each resistor is orange (3), black (0), orange (3) or 30 kΩ. Three of them in parallel is equivalent to 10 kΩ. $V = IR$ and so $V = (120 \times 10^{-6}\ \text{A})(10 \times 10^{3}\ \Omega) = 1.2$ V. Current flows from F to D, out of the plus terminal of the source.

28. [I] If in Fig. P28 the ideal ammeter reads 3.20 A, what will the ideal voltmeter read?

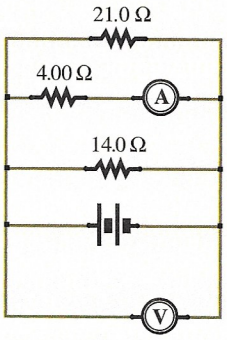

Figure P28

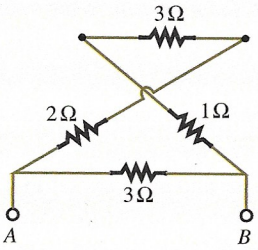

Figure P29

29. [I] What is the equivalent resistance of the circuit in Fig. P29 between terminals A and B? Note that the wires cross but do not make contact at the center.

30. [I] Determine the equivalent resistance of the circuit between points A and B in Fig. P30.

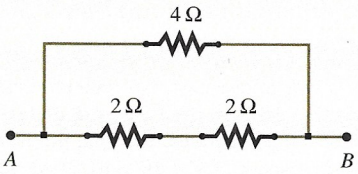

Figure P30

31. [I] Determine the equivalent resistance of the circuit between points *A* and *B* in Fig. P31.

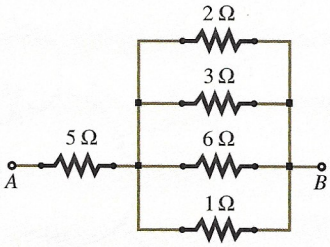

Figure P31

32. [I] Determine the equivalent resistance of the circuit between points *A* and *B* in Fig. P32.

33. [I] Determine the equivalent resistance of the circuit between points *A* and *C* in Fig. P32.

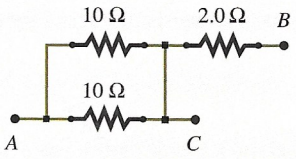

Figure P32

34. [I] Determine the equivalent resistance of the circuit between points *B* and *C* in Fig. P32.

35. [I] Determine the equivalent resistance of the circuit between points *A* and *B* in Fig. P35.

36. [I] Determine the equivalent resistance of the circuit between points *C* and *B* in Fig. P35.

37. [I] Figure P37 shows a portion of a circuit, the rest of which contains both sources and resistors. If the ammeter reads 9 A, what current passes through each resistor shown?

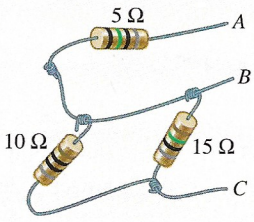

Figure P35

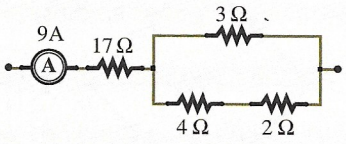

Figure P37

38. [I] Given that the ammeter in Fig. P38 reads 1.0 A, what is the emf of the ideal dc source as indicated by the voltmeter?

39. [I] How much current passes through each lamp in Fig. P39?

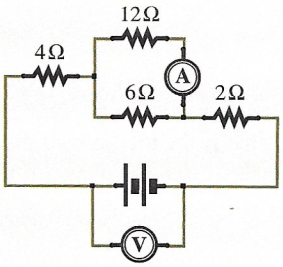

Figure P38

The battery has negligible internal resistance.

40. [I] A 10-Ω resistor is attached at one end to the + terminal of a 20-V dc source whose − terminal is grounded. The resistor's other end is attached to the + terminal of a 40-V dc source whose − terminal is grounded. What current traverses the resistor?

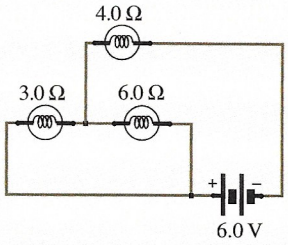

Figure P39

41. [I] A 20-V lamp designed to dissipate 80 W is placed in series with a resistor *R* and a 60-V dc source. What value should *R* be for the lamp to operate properly?

42. [I] What is the equivalent resistance between points *D* and *B* in the circuit shown in Fig. P42?

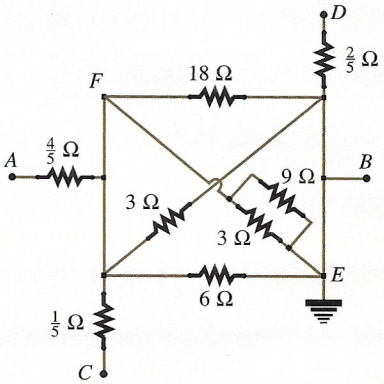

Figure P42

43. [II] THIS PROBLEM WORKS WITH A PRINTED CIRCUIT BOARD. Consider the circuit board in Fig. P43 where all the resistors are color coded red-black-black-silver. (a) What is the value of each resistor? We want to find out what an ohmmeter would read across terminals 5 and 6. (b) Redraw the circuit between these terminals simplifying what the ohmmeter would "see." (c) What path(s) would current take in going from 5 to 6? (d) What is the crucial role played by the wire from *J* to *K*? (e) What is the resistance between terminals-5 and 6?

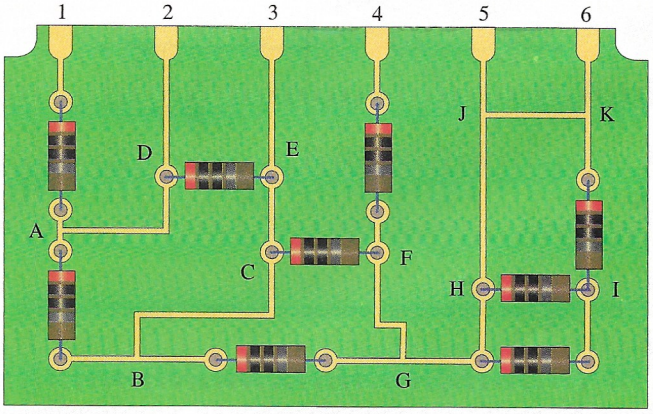

Figure P43

44. [II] THIS PROBLEM WORKS WITH A PRINTED CIRCUIT BOARD. Consider the circuit board in Fig. P43, but this time suppose all the resistors were color coded red-black-brown-silver. (a) What is the value of each resistor? We want to find out what an ohmmeter would read across terminals-1 and 2. (b) Redraw the circuit between these terminals simplifying what the ohmmeter would "see." (c) What path(s) would current take in going from 1 to 2? (d) What is the crucial role played by the wire from *D* to *A*? (e) What is the resistance between terminals-1 and 2?

45. [II] THIS PROBLEM WORKS WITH A PRINTED CIRCUIT BOARD. Consider the circuit board in Fig. P43, but this time suppose all the resistors were color coded orange-black-brown-silver. (a) What is the value of each resistor? We want to find out what an ohmmeter would read across terminals-2 and 3. (b) Redraw the circuit between these terminals simplifying what the ohmmeter would "see." (c) What is the crucial role played by the wire from E to B? (d) What is the resistance between terminals-2 and 3?

46. [II] THIS PROBLEM WORKS WITH A PRINTED CIRCUIT BOARD. Consider the circuit board in Fig. P43, but this time suppose all the resistors were color coded brown-black-yellow-silver. (a) What is the value of each resistor? We want to find out what an ohmmeter would read across terminals-3 and 4. (b) Redraw the circuit between these terminals simplifying what the ohmmeter would "see." (c) What is the crucial role played by the wire from E to B? (d) What is the resistance between terminals-3 and 4?

47. [II] Determine the equivalent resistance of the circuit between points A and B in Fig. P42.

48. [II] Two resistors R_1 and R_2 are in parallel with each other and with an ideal source ($r = 0$) having a terminal voltage V. Show that the branch currents are given by

$$I_1 = I\left(\frac{R_2}{R_1 + R_2}\right) \quad \text{and} \quad I_2 = I\left(\frac{R_1}{R_1 + R_2}\right)$$

where the larger current goes through the smaller resistor. (These are good relationships to remember.)

49. [II] Figure P49 shows a portion of a circuit, the rest of which contains both sources and resistors. If the ammeter reads 9 A, what current passes through each resistor in the diagram?

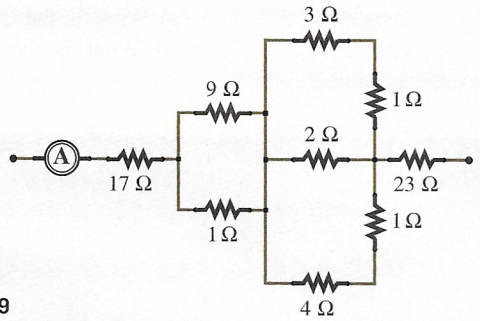

Figure P49

50. [II] Find the equivalent resistance between points C and E in Fig. P42.

51. [II] THIS PROBLEM DEALS WITH VOLTAGE AND CURRENT IN A DC CIRCUIT. Referring to Fig. P16 and Problem 16, we want to find the voltmeter reading when the switch in the circuit is closed, but we first have to find the current. (a) What is the equivalent resistance of the circuit? (b) What is the voltage across this equivalent resistance? (c) What is the direction of current around the circuit. (d) How much current flows? (e) What is the voltage drop across each resistor? (f) What is the sum of the voltage rises and drops between B and D? (g) What value will the voltmeter read? (h) Which voltmeter terminal has a higher potential?

52. [II] Consider the circuit board in Fig. P15 where the large printed area is ground. (a) If 75 V is put across terminals-1 and 5 (with 5 being +), what would a voltmeter read across terminals-1 and 4? (b) What is then the voltage between terminals-1 and 3? (c) What, if any, is the voltage between terminals-1 and 2?

SOLUTION: The equivalent resistance between terminals-1 and 5 is 40 Ω + 20 Ω + 60 Ω + 30 Ω = 150 Ω. $V = IR$ and so a current of I = (75 V)/(150 Ω) = 0.50 A flows. (a) That produces a voltage drop across the 40-Ω resistor of $V = IR$ = (0.50 A)(40 Ω) = 20 V and so the voltage at D is 75 V − 20 V = 55 V above ground. (b) The voltage at A equals the voltage at E, which is 75 V − 20 V − 10 V − 30 V= 15 V above ground. (c) There's no current in the branch from 2 to E so there's no voltage drop between 2 and E. The drop across the 30-Ω resistor is 15 V and so E is 15 V above ground.

53. [II] What is the equivalent resistance between points A and B of the circuit shown in Fig. P53? How much power would be dissipated by this circuit if a constant 20-V dc source with a 0.10-Ω internal resistance were placed across A and B?

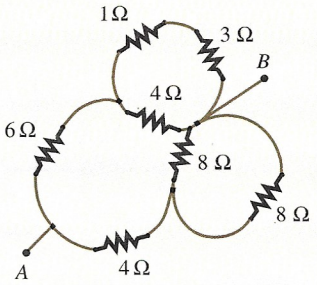

Figure P53

54. [II] How much current passes through each of the 5.0-Ω resistors in Fig. P54? How much power is delivered by the dc source?

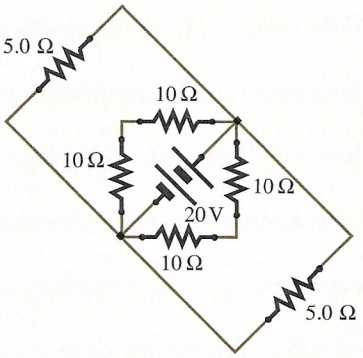

Figure P54

55. [II] Given the circuit in Fig. P55, calculate the current in each resistor. What power is delivered by the battery? What is the potential difference between A and C?

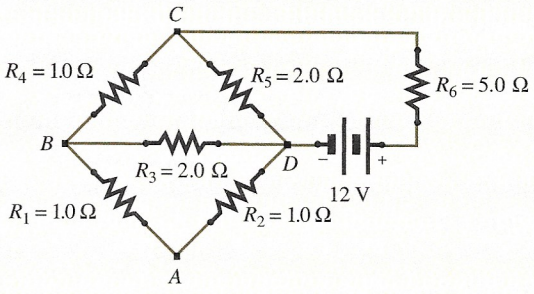

Figure P55

56. [II] The battery in Fig. P56 has an emf of 9.0 V and an internal resistance of 0.50 Ω. (a) What current does it supply? (b) What is the total power dissipated by the entire circuit? (c) What is the terminal voltage of the battery?

57. [II] How much power is dissipated by the automobile circuit in Fig. P57 when switches A, B, C, and D are all closed?

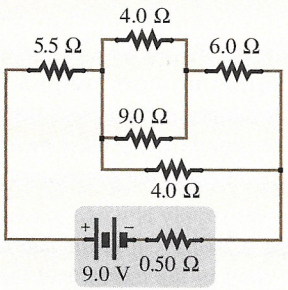

Figure P56

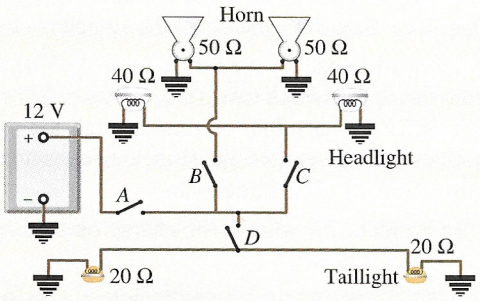

Figure P57

58. [II] Find the current supplied by the source in Fig. P58. The resistors are mounted around a cylindrical form.

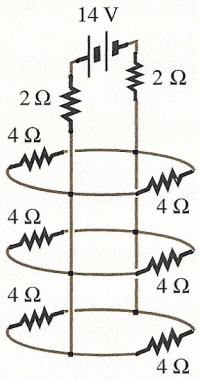

Figure P58

59. [II] What is the current provided by the battery in Fig. P59, given that its internal resistance is 0.50 Ω? What is its terminal voltage?

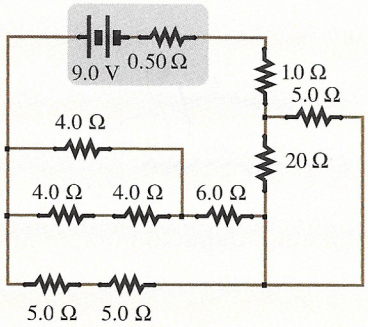

Figure P59

60. [II] THIS PROBLEM IS CONCERNED WITH A CIRCUIT CONSTRUCTED ON A PROTOBOARD. The circuit shown in Fig. P60 is mounted on a protoboard (go back and reread the caption for the photo on p. 643). There are four resistors color coded brown-red-black-silver, and one on the far left color coded brown-gray-black-silver . Power will be supplied through the red and green clips, and a voltmeter reading will be made using the black and yellow clips. We want to determine the source voltage when the voltmeter reads 6.0 V. (a) What can you say about the way the resistors are wired? (b) With no source attached, how much resistance will an ohmmeter measure across the red and green clips? (c) How much current flows through the 12-Ω resistor when the voltmeter across it reads 6.0 V? (d) What is the voltage across the equivalent resistance? (e) What is the voltage across the power supply? (f) What is the voltage across either of the two vertical resistors at the right?

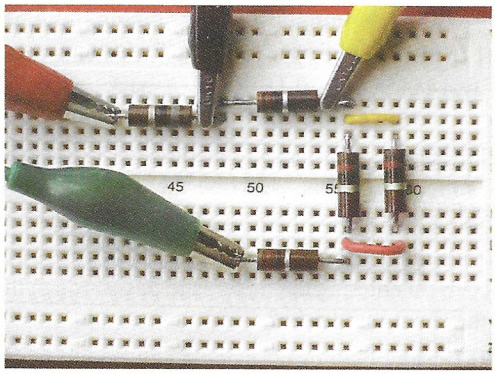

Figure P60

61. [III] THIS PROBLEM DEALS WITH RESISTORS ON A PRINTED CIRCUIT BOARD. All the resistors in the circuit shown in Fig. P61 are color coded brown-red-red-silver. We want to put in a current via one set of terminals and read out a voltage across another set of terminals. What is the resistance between terminals (a) 1 and 2? (b) 1 and 5? (c) 3 and 4? (d) 1 and 4? (e) 6 and 7? (f) 5 and 7? (g) If 26 V is put across terminals-1 and 2 how much current will flow from 1 to 2? (h) What voltage will then appear across 1 and 7? (i) across 1 and 5?

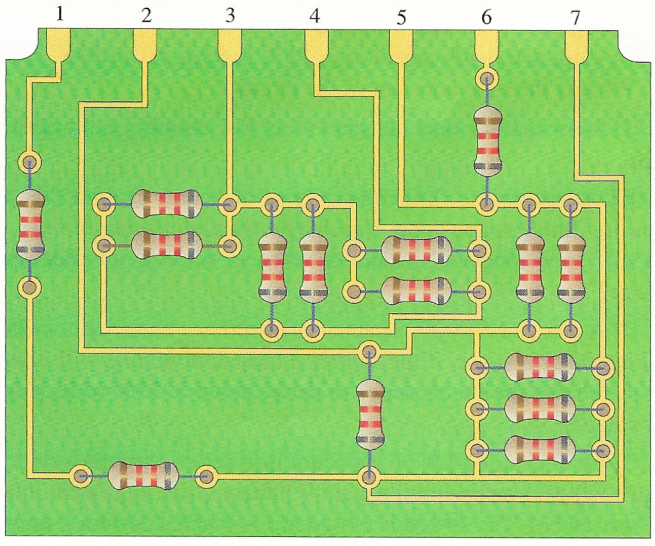

Figure P61

62. [III] Imagine a wire cube with identical resistors R in each arm (Fig. P62). What is the equivalent resistance between points A and B?

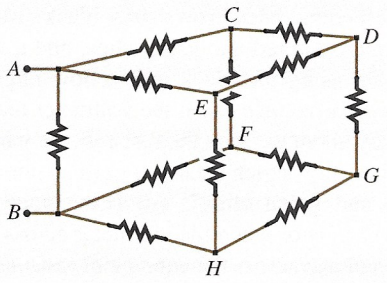

Figure P62

SECTION 18.3: AMMETERS AND VOLTMETERS

63. [I] In an ammeter the coil has a resistance of 100 Ω and the shunt resistance is 0.20 Ω. If 2.0 A pass through the shunt, how much current enters the coil?

64. [I] If the total resistance of a voltmeter is 6.0 kΩ and it contains a 50-Ω coil movement, describe the other circuit element in the meter.

65. [I] An ammeter movement consists of a 50.0-Ω coil. If 0.10% of the current entering the meter is to pass through the coil, how big must the shunt resistor be?

66. [II] Design a voltmeter using a galvanometer with a coil resistance of 100 Ω and a full-scale current of 1.00 mA that will measure 100 V full scale.

67. [II] Design a shunt such that a galvanometer with a coil resistance of 100 Ω and a full-scale current of 1.00 mA can be used as an ammeter to measure up to 1.00 A.

68. [II] The coil of a galvanometer has a resistance of 20 Ω, and it deflects full scale when a current of 0.50 mA passes through it. By shunting the coil with a 2.0-mΩ resistor, it becomes an ammeter. What full-scale current will it now read?

SECTION 18.4: *R-C* CIRCUITS

69. [I] Three circuit elements are connected in series to form a closed loop; a 100-μF capacitor, a 12-V battery, and a 50-Ω resistor. What is the time constant of the circuit?

70. [I] Show that the time constant of an *R-C* circuit has the correct units.

71. [I] An electronic flash fires a blast of energy from a 800-μF capacitor into a xenon lamp. It recharges through a series resistor of 5.0 kΩ. How long will it take to recharge 63% of its maximum charge?

72. [I] A charged 600-μF capacitor is in series with an open switch and a 4.0-kΩ resistor. If the switch is closed, how long will it take for the charge on the capacitor to decay down to 37% of its original value?

73. [I] An uncharged 1.0-μF capacitor is in series, through a switch, with a 2.0-MΩ resistor and a 12.0-V battery (with negligible internal resistance). The switch is closed at $t = 0$ and a current I_i immediately appears. Determine I_i. How long will it take for the current in the circuit to drop to $0.37I_i$? [*Hint: What is the value of the current after one time constant?*]

74. [I] A resistor is placed in series with an uncharged 2.0-μF capacitor, and a 12.0-V battery is put across the two. If the current that immediately flows around the circuit is measured to be 12 μA, determine the resistance. What is the time constant of the circuit?

75. [I] A 10.0-V dc power supply is wired across the series combination of an uncharged 0.20-μF capacitor and a 1.0-MΩ resistor. What are the initial current in the circuit and the current after one time constant has passed?

76. [I] A 3.0-μF capacitor is put across a 12-V ideal battery. After an hour, it is disconnected and put in series, through a switch, with a 200-Ω resistor. (a) What is the initial charge on the capacitor? (b) What is the initial current when the switch is closed?

77. [II] A 6.0-μF capacitor is charged up to 12 V and subsequently connected through a switch to a 100-Ω resistor. At $t = 0$, the switch is closed. What is the initial current through the circuit? Draw a rough plot of current versus time. How long does it take for the current to drop to 37% of its initial value?

78. [II] In Problem 77, what is the charge on the capacitor 6.0 ms after the switch is closed?

79. [II] A 12-V battery with negligible internal resistance is placed across a series combination of a 1.0-MΩ resistor and a 12.0-μF capacitor for 10 hours. The battery is then removed and the circuit closed at $t = 0$. What is the current through the resistor at $t = 24$ s?

80. [II] Three circuit elements are connected in series to form a closed loop: an uncharged 20.0-μF capacitor, a 100-V dc power supply, and a 10.0-MΩ resistor. What is the maximum charge that will be stored in the capacitor? What is the initial charge on the capacitor and current through the resistor? Determine the current in the circuit and the charge on the capacitor after an interval of one time constant.

81. [II] An uncharged 10.0-μF capacitor, a 80.0-V dc power supply, and a 20.0-MΩ resistor are connected in series to form a closed loop. Determine the current in the circuit 400 s after the circuit is closed.

82. [III] An uncharged 10.0-μF capacitor, a 120.0-V dc power supply, and a 40.0-MΩ resistor are connected in series to form a closed loop. Using Fig. 18.20*a* write an equation for the charge on the capacitor as a function of time. Determine that charge 4.00 s after the circuit is closed.

SECTION 18.5: KIRCHHOFF'S RULES

83. [I] Use Kirchhoff's Loop Rule to solve for the currents in branches *A–D–C* and *A–B–C* of the circuit in Fig. P83. Then use the Node Rule to find the current in branch *A–C*.

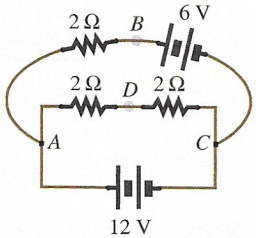

Figure P83

84. [I] Find the current through each element of the circuit in Fig. P72.

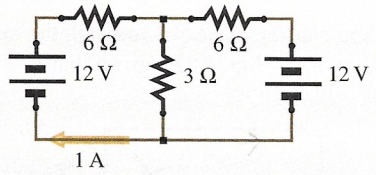

Figure P84

85. [I] Apply Kirchhoff's Rules to the circuit of Fig. P73, and solve for the three branch currents. Next, simplify the network, determine all the currents, and check your answers.

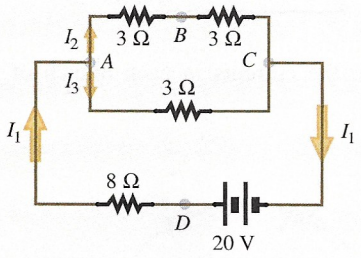

Figure P85

86. [I] Solve for the unknown source voltage and the power delivered by the 12-V battery in Fig. P86.

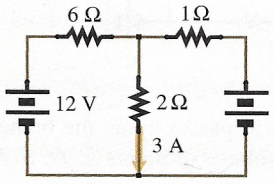

Figure P86

87. [I] The transistor circuit of Fig. P87 is to be checked for proper operation. According to specifications, the collector voltage (point *C*) should be at a constant +6 V with respect to ground. If that's the case, what should be the voltage measured at point *D*? [*Hint: Read Discussion Question 4 to learn that a capacitor is an open circuit to dc.*]

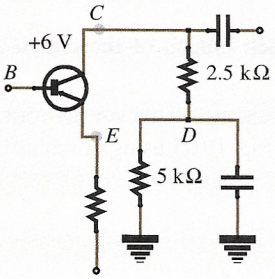

Figure P87

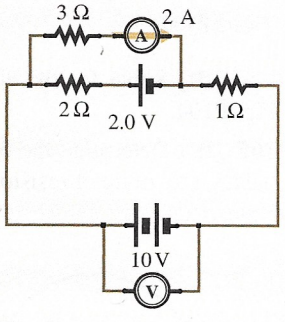

Figure P88

88. [I] If the ammeter and voltmeter in Fig. P88 read 2.0 A and 10 V, respectively, what current passes through the 1.0-Ω resistor?

89. [I] The ammeter in Fig. P89 reads 2.0 A; what will the voltmeter read?

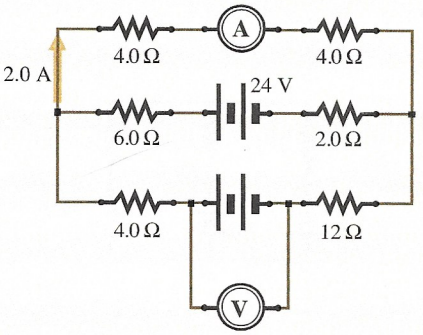

Figure P89

90. [I] Referring to the bridge circuit of Fig. P90, if I = 6 A, I_2 = 4 A, and I_3 = 0, find I_1, I_4, and I_5.

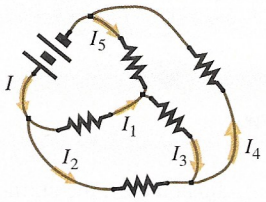

Figure P90

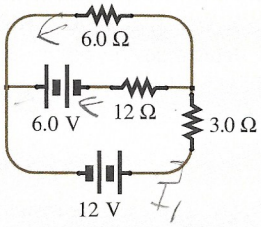

Figure P91

91. [I] Determine the current in each branch of the circuit of Fig. P91.

92. [I] Find the current in each resistor of the circuit in Fig. P92 using Kirchhoff's Rules. Then simplify the circuit and compare your results.

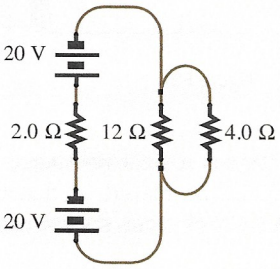

Figure P92

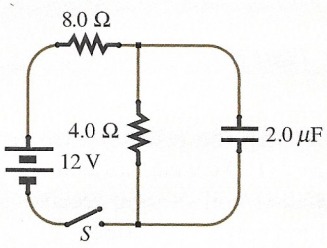

Figure P93

93. [I] The switch in the circuit of Fig. P93 is closed, and a steady state is established. What is the charge on the capacitor?

94. [I] Figure P94 shows a 200-V dc generator (the pictorial symbol used is another fairly common one) supplying 100 A to a load via a two-lead cable having a resistance of 0.20 Ω per length of conductor. What is the voltage across the load?

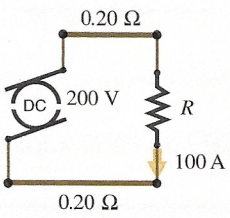

Figure P94

95. [II] Find the values of R_1 and $\mathscr{E}_1$ in Fig. P95.

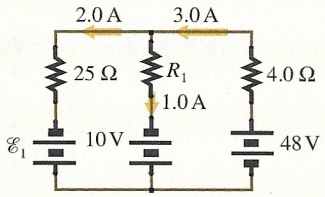

Figure P95

96. [II] The variable resistor in Fig. P96 is adjusted to 20 Ω, whereupon the ammeter (which has a negligible internal resistance) reads zero. Use Kirchhoff's Rules to determine the power provided by the sources. What is the voltage at points *B*, *C*, and *D*?

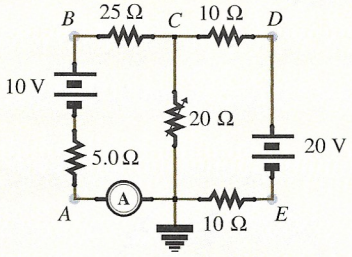

Figure P96

97. [II] The variable resistor in Fig. P97 is adjusted until the ammeters read (#1) 120 mA and (#2) 80 mA, with the directions of the currents as shown. Find the value of *R*.

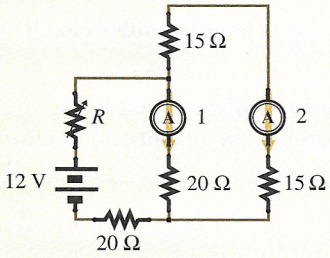

Figure P97

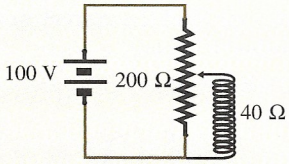

Figure P98

98. [II] The potentiometer in Fig. P98 has a total resistance of 200 Ω. At what position must the slider be placed so that the 40.0-Ω coil of wire receives 1.00 A? Check your results using Kirchhoff's Loop Rule.

99. [II] With only switch S_1 closed in Fig. P99, (a) what is the steady-state reading of the voltmeter? (b) what is the charge on the 3.0-μF capacitor?

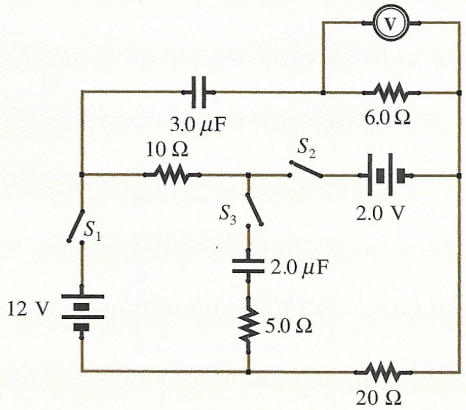

Figure P99

100. [II] With Problem 99 in mind, how much power does the 12-V battery supply in the steady state a few minutes after all the switches are closed? What's the charge on the 2.0-μF capacitor?

101. [II] Find the values of *R*, *V*, and all the unknown branch currents in the network of Fig. P101, given that $I_3 = 1.0$ A.

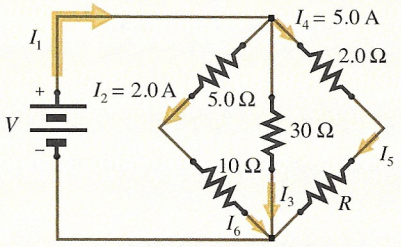

Figure P101

102. [II] Solve for the currents in each branch of the circuit in Fig. P102.

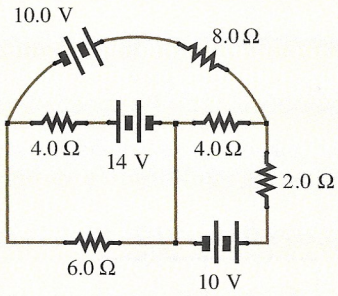

Figure P102

103. [II] Given that 5.0 A passes along the branch from *C* to *B* in Fig. P103, what is the voltage of points *A*, *D*, *E*, *F*, and *G*?

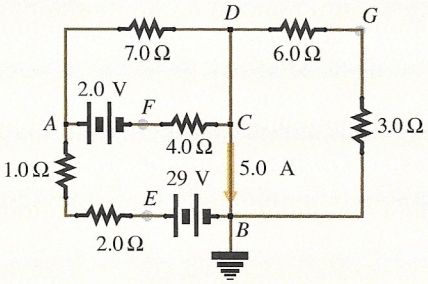

Figure P103

104. [III] Solve for the currents in each branch of the circuit in Fig. P104.

105. [III] Determine the equivalent resistance between the terminals of the group of resistors shown in Fig. P105 using Kirchhoff's Rules.

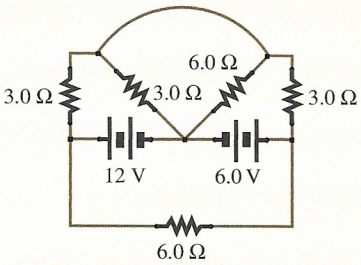

Figure P104

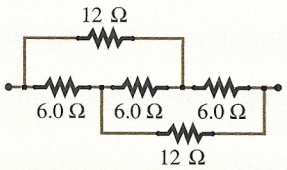

Figure P105