

HOMEWORK PROBLEMS

Section 2.1: Definitions

2.1 An isolated free electron is traveling through an electric field from some initial point where its coulombic potential energy per unit charge (*voltage*) is 17 kJ/C and velocity = 93 Mm/s to some final point where its coulombic potential energy per unit charge is 6 kJ/C. Determine the change in velocity of the electron. Neglect gravitational forces.

2.2 The unit used for voltage is the volt, for current the ampere, and for resistance the ohm. Using the definitions of voltage, current, and resistance, express each quantity in fundamental MKS units.

2.3 The capacity of a car battery is usually specified in ampere-hours. A battery rated at, say, 100 A-h should be able to supply 100 A for 1 h, 50 A for 2 h, 25 A for 4 h, 1 A for 100 h, or any other combination yielding a product of 100 A-h.

- How many coulombs of charge should we be able to draw from a fully charged 100 A-h battery?
- How many electrons does your answer to part a require?

2.4 The charge cycle shown in Figure P2.4 is an example of a *two-rate charge*. The current is held constant at 50 mA for 5 h. Then it is switched to 20 mA for the next 5 h. Find

- The total charge transferred to the battery.
- The energy transferred to the battery.

Hint: Recall that energy w is the integral of power, or $P = dw/dt$.

2.5 Batteries (e.g., lead-acid batteries) store chemical energy and convert it to electric energy on demand. Batteries do not store electric charge or charge carriers. Charge carriers (electrons) enter one terminal of the battery, acquire electrical potential energy, and exit from the other terminal at a lower voltage. Remember the electron has a negative charge! It is convenient to think of positive carriers flowing in the opposite direction, that is, conventional current, and exiting at a higher voltage. All currents in this course, unless otherwise stated, are conventional current. (Benjamin Franklin caused this mess!) For a battery with a rated voltage = 12 V and a rated capacity = 350 A-h, determine

- The rated chemical energy stored in the battery.
- The total charge that can be supplied at the rated voltage.

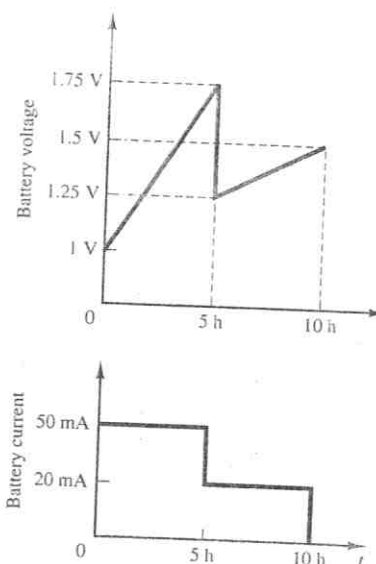


Figure P2.4

2.6 What determines the following?

- How much current is supplied (at a constant voltage) by an ideal voltage source.
- How much voltage is supplied (at a constant current) by an ideal current source.

2.7 An automotive battery is rated at 120 A-h. This means that under certain test conditions it can output 1 A at 12 V for 120 h (under other test conditions, the battery may have other ratings).

- How much total energy is stored in the battery?
- If the headlights are left on overnight (8 h), how much energy will still be stored in the battery in the morning? (Assume a 150-W total power rating for both headlights together.)

2.8 A car battery kept in storage in the basement needs recharging. If the voltage and the current provided by the charger during a charge cycle are shown in Figure P2.8,

- Find the total charge transferred to the battery.
- Find the total energy transferred to the battery.

2.9 Suppose the current flowing through a wire is given by the curve shown in Figure P2.9.

- Find the amount of charge, q , that flows through the wire between $t_1 = 0$ and $t_2 = 1$ s.
- Repeat part a for $t_2 = 2, 3, 4, 5, 6, 7, 8, 9$, and 10 s.
- Sketch $q(t)$ for $0 \leq t \leq 10$ s.

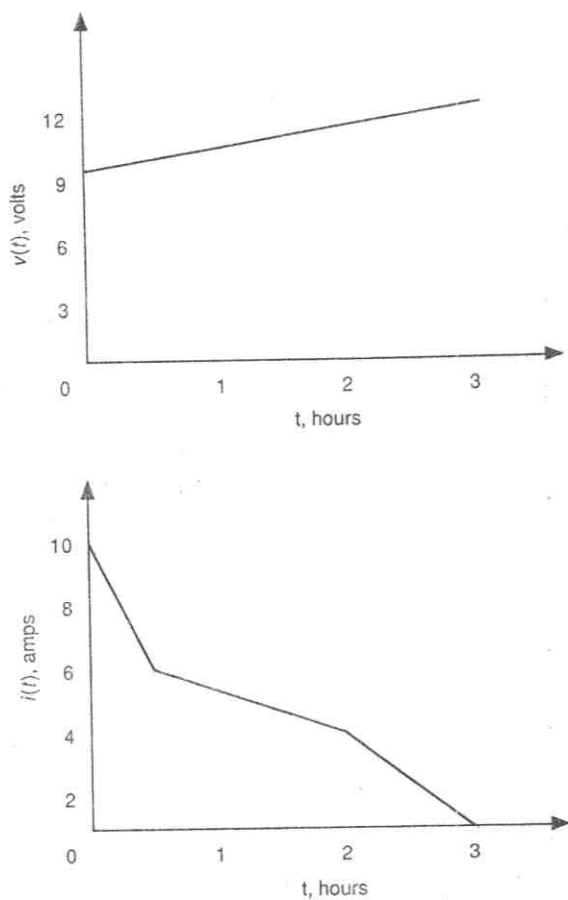


Figure P2.8

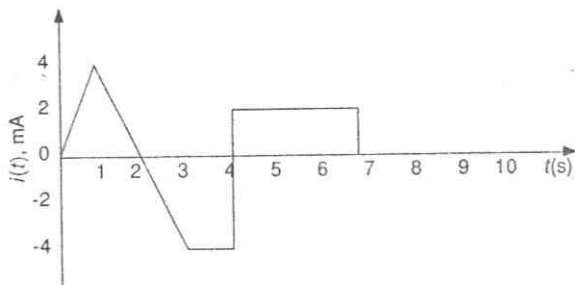


Figure P2.9

2.10 The charging scheme used in Figure P2.10 is an example of a constant-voltage charge with current limit. The charger voltage is such that the current into the battery does not exceed 100 mA, as shown in Figure P2.10. The charger's voltage increases to the

maximum of 9 V, as shown in Figure P2.10. The battery is charged for 6 h. Find:

- The total charge delivered to the battery.
- The energy transferred to the battery during the charging cycle.

Hint: Recall that the energy, w , is the integral of power, or $P = dw/dt$.

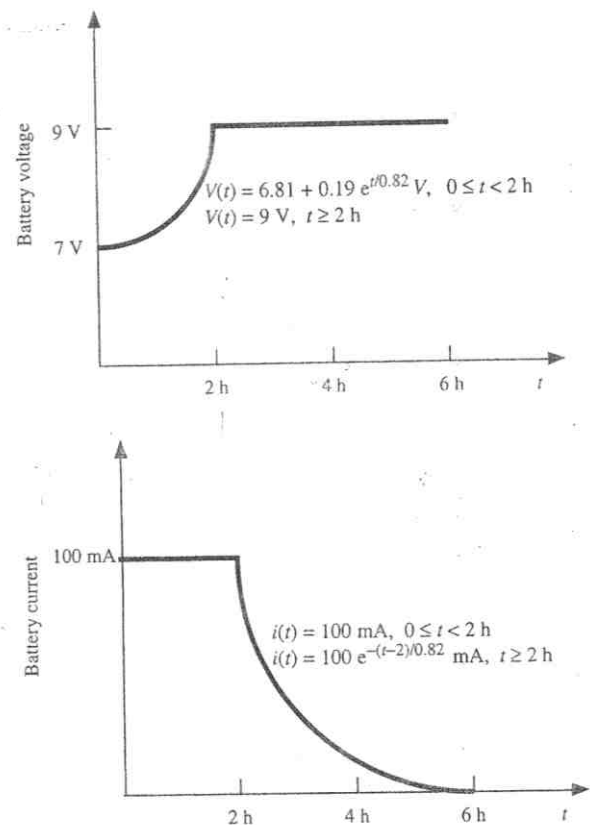


Figure P2.10

2.11 The charging scheme used in Figure P2.11 is an example of a constant-current charge cycle. The charger voltage is controlled such that the current into the battery is held constant at 40 mA, as shown in Figure P2.11. The battery is charged for 6 h. Find:

- The total charge delivered to the battery.
- The energy transferred to the battery during the charging cycle.

Hint: Recall that the energy, w , is the integral of power, or $P = dw/dt$.

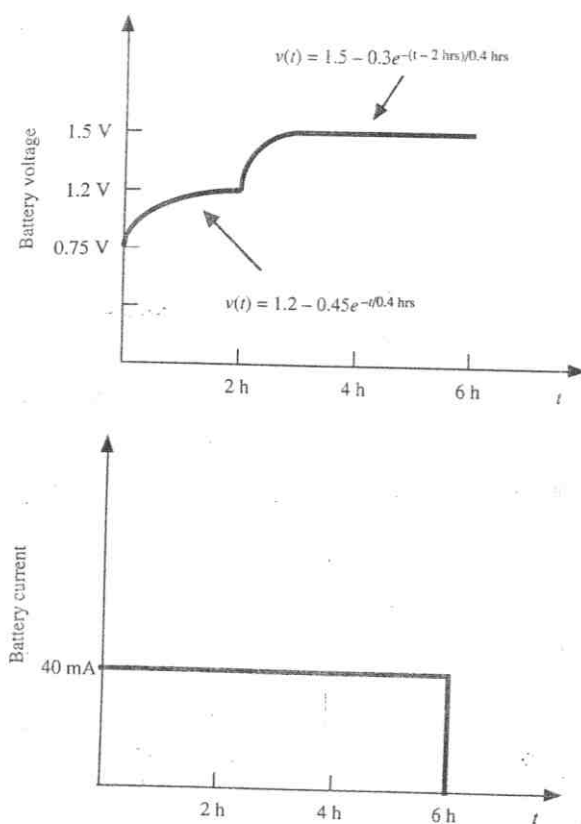


Figure P2.11

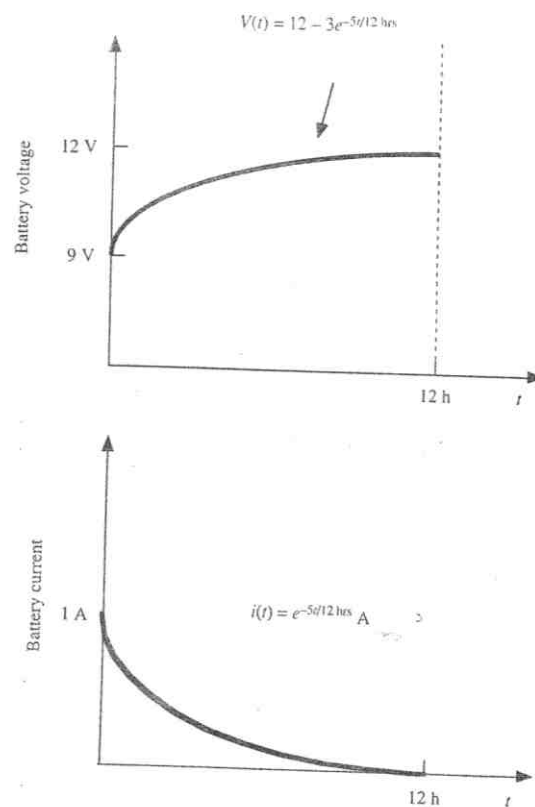


Figure P2.12

2.12 The charging scheme used in Figure P2.12 is called a *tapered-current charge cycle*. The current starts at the highest level and then decreases with time for the entire charge cycle, as shown. The battery is charged for 12 h. Find:

- The total charge delivered to the battery.
- The energy transferred to the battery during the charging cycle.

Hint: Recall that the energy, w , is the integral of power, or $P = dw/dt$.

Sections 2.2, 2.3: KCL, KVL

2.13 Use Kirchhoff's current law to determine the unknown currents in the circuit of Figure P2.13. Assume that $I_0 = -2$ A, $I_1 = -4$ A, $I_S = 8$ A, and $V_S = 12$ V.

2.14 Apply KCL to find the current i in the circuit of Figure P2.14.

2.15 Apply KCL to find the current I in the circuit of Figure P2.15.

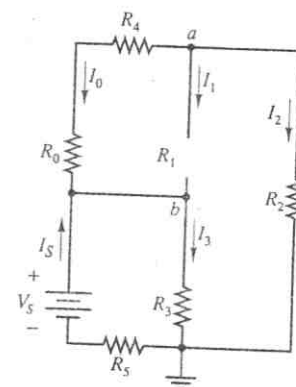


Figure P2.13

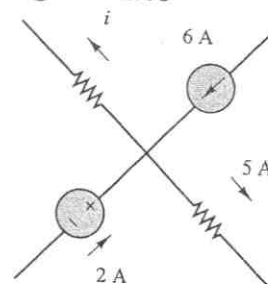


Figure P2.14

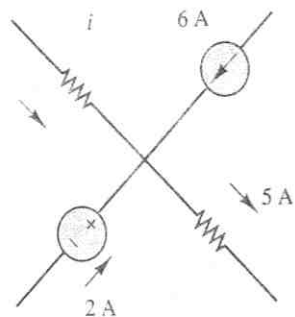


Figure P2.15

2.16 Apply KCL to find the voltages v_1 and v_2 in Figure P2.16.

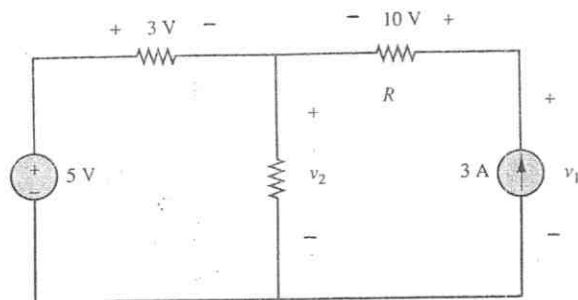


Figure P2.16

2.17 Use Ohm's Law and KCL to determine the current I_1 in the circuit of Figure P2.17.

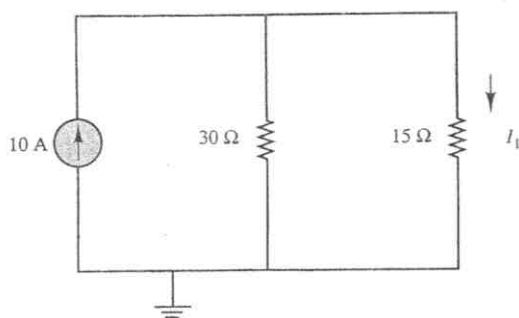
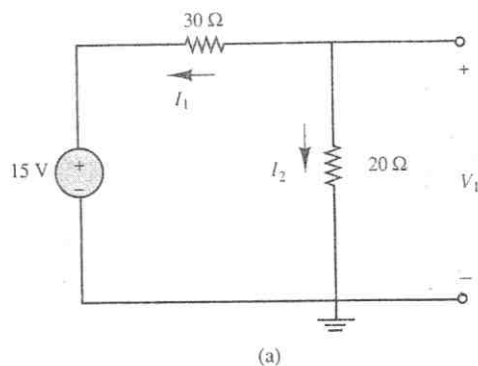


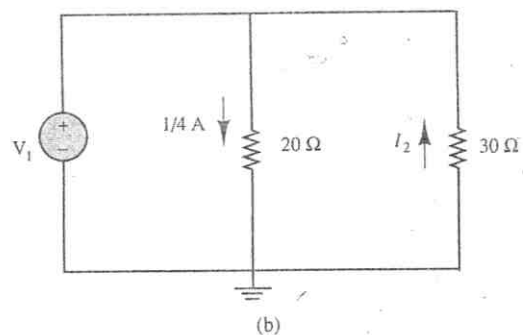
Figure P2.17

Section 2.4: Sign Convention

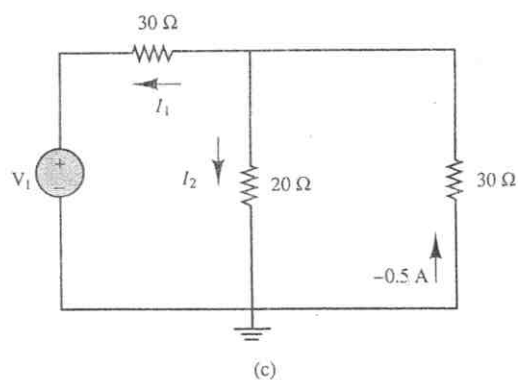
2.18 In the circuits of Figure P2.18, the directions of current and polarities of voltage have already been defined. Find the actual values of the indicated currents and voltages.



(a)



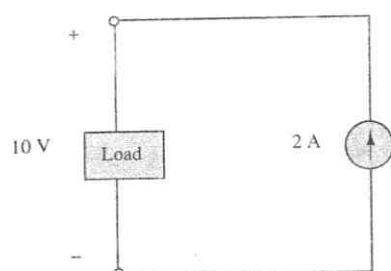
(b)



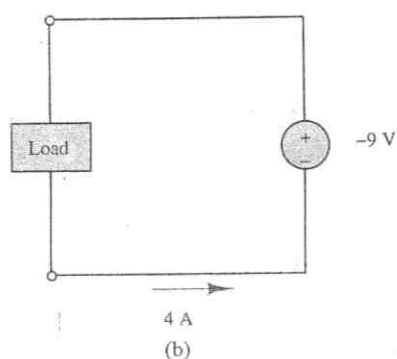
(c)

Figure P2.18

2.19 Find the power delivered by each source in the circuits of Figure P2.19.



(a)



(b)

Figure P2.19

2.20 Determine which elements in the circuit of Figure P2.20 are supplying power and which are dissipating power. Also determine the amount of power dissipated and supplied.

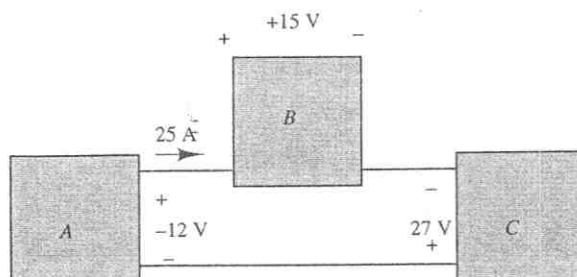


Figure P2.20

2.21 In the circuit of Figure P2.21, determine the power absorbed by the resistor R and the power delivered by the current source.

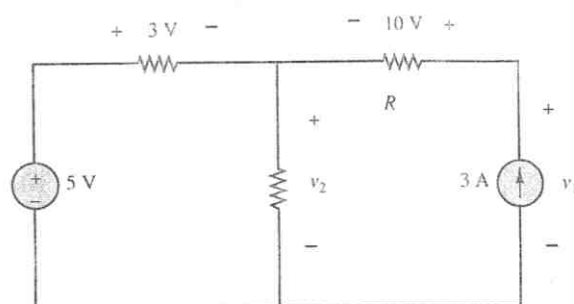


Figure P2.21

2.22 For the circuit shown in Figure P2.22:

- Determine which components are absorbing power and which are delivering power.
- Is conservation of power satisfied? Explain your answer.

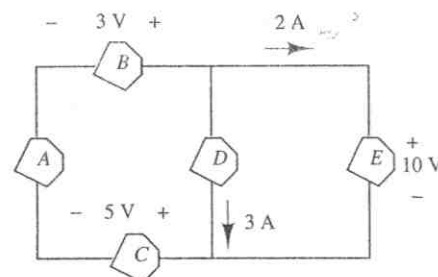


Figure P2.22

2.23 For the circuit shown in Figure P2.23, determine the power absorbed by the $5\ \Omega$ resistor.

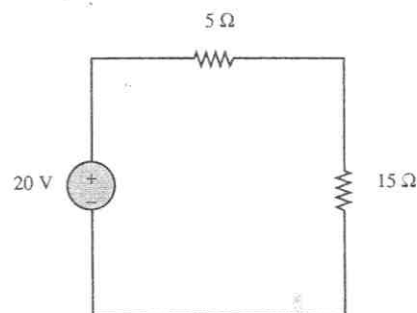


Figure P2.23

2.24 For the circuit shown in Figure P2.24, determine which components are supplying power and which are dissipating power. Also determine the amount of power dissipated and supplied.

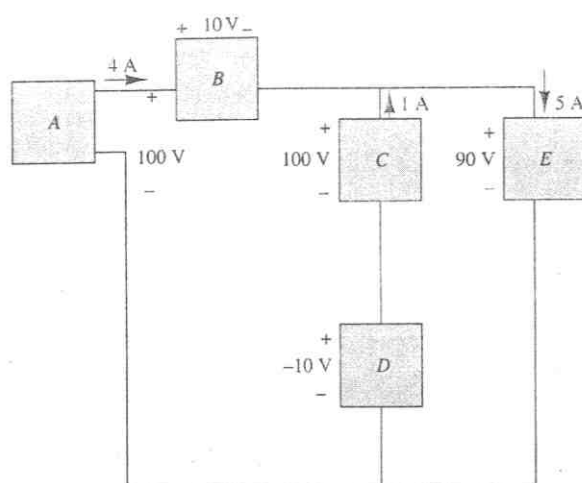


Figure P2.24

- 2.25** For the circuit shown in Figure P2.25, determine which components are supplying power and which are dissipating power. Also determine the amount of power dissipated and supplied.

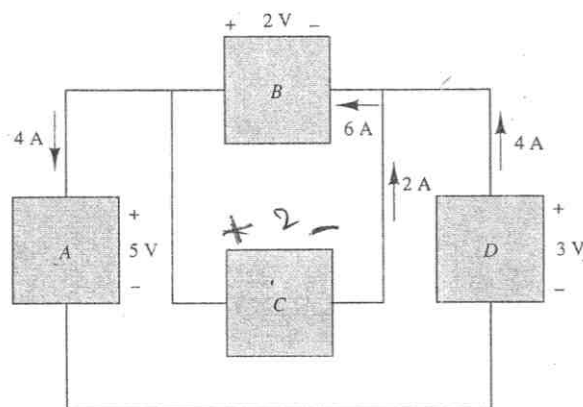


Figure P2.25

- 2.26** If an electric heater requires 23 A at 110 V, determine
- The power it dissipates as heat or other losses.
 - The energy dissipated by the heater in a 24-h period.
 - The cost of the energy if the power company charges at the rate 6 cents/kWh.

- 2.27** In the circuit shown in Figure P2.27, determine the terminal voltage of the source, the power supplied to the circuit (or load), and the efficiency of the circuit. Assume that the only loss is due to the internal resistance of the source. Efficiency is defined as the ratio of load power to source power.

$$V_S = 12 \text{ V} \quad R_S = 5 \text{ k}\Omega \quad R_L = 7 \text{ k}\Omega$$

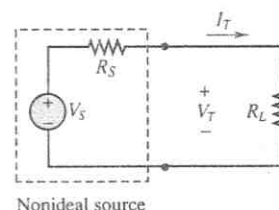


Figure P2.27

- 2.28** A 24-volt automotive battery is connected to two headlights, such that the two loads are in parallel; each of the headlights is intended to be a 75-W load, however, a 100-W headlight is mistakenly installed. What is the resistance of each headlight, and what is the total resistance seen by the battery?

- 2.29** What is the equivalent resistance seen by the battery of Problem 2.28 if two 15-W taillights are added (in parallel) to the two 75-W (each) headlights?

- 2.30** For the circuit shown in Figure P2.30, determine the power absorbed by the variable resistor R , ranging from 0 to 20Ω . Plot the power absorption as a function of R .

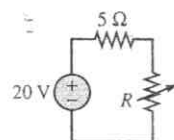


Figure P2.30

- 2.31** Refer to Figure P2.31.

- Find the total power supplied by the ideal source.
- Find the power dissipated and lost within the nonideal source.

- c. What is the power supplied by the source to the circuit as modeled by the load resistance?
- d. Plot the terminal voltage and power supplied to the circuit as a function of current.

Repeat $I_T = 0, 5, 10, 20, 30$ A.

$$V_S = 12 \text{ V} \quad R_S = 0.3 \Omega$$

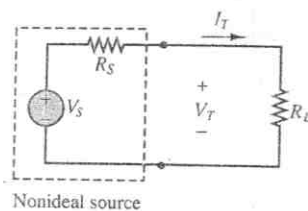


Figure P2.31

- 2.32** In the circuit of Figure P2.32, if $v_1 = v/4$ and the power delivered by the source is 40 mW, find R , v , v_1 , and i . Given: $R_1 = 8 \text{ k}\Omega$, $R_2 = 10 \text{ k}\Omega$, $R_3 = 12 \text{ k}\Omega$.

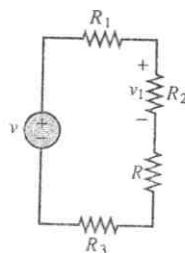


Figure P2.32

- 2.33** A GE SoftWhite Longlife lightbulb is rated as follows:

$$P_R = \text{rated power} = 60 \text{ W}$$

$$P_{\text{OR}} = \text{rated optical power} = 820 \text{ lumens (lm) (average)}$$

$$1 \text{ lumen} = \frac{1}{680} \text{ W}$$

$$\text{Operating life} = 1,500 \text{ h (average)}$$

$$V_R = \text{rated operating voltage} = 115 \text{ V}$$

The resistance of the filament of the bulb, measured with a standard multimeter, is 16.7Ω . When the bulb is connected into a circuit and is operating at the rated values given above, determine

- a. The resistance of the filament.
- b. The efficiency of the bulb.

- 2.34** An incandescent lightbulb rated at 100 W will dissipate 100 W as heat and light when connected across a 110-V ideal voltage source. If three of these

bulbs are connected in series across the same source, determine the power each bulb will dissipate.

- 2.35** An incandescent lightbulb rated at 60 W will dissipate 60 W as heat and light when connected across a 100-V ideal voltage source. A 100-W bulb will dissipate 100 W when connected across the same source. If the bulbs are connected in series across the same source, determine the power that either one of the two bulbs will dissipate.

- 2.36** For the circuit shown in Figure P2.36, find

- a. The equivalent resistance seen by the source.
- b. The current i .
- c. The power delivered by the source.
- d. The voltages v_1 and v_2 .
- e. The minimum power rating required for R_1 .

Given: $v = 24 \text{ V}$, $R_0 = 8 \Omega$, $R_1 = 10 \Omega$, $R_2 = 2 \Omega$.

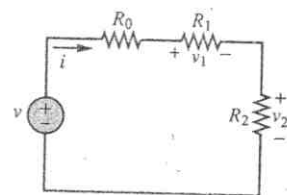


Figure P2.36

- 2.37** For the circuit shown in Figure P2.37, find

- a. The currents i_1 and i_2 .
- b. The power delivered by the 3-A current source and by the 12-V voltage source.
- c. The total power dissipated by the circuit.

Let $R_1 = 25 \Omega$, $R_2 = 10 \Omega$, $R_3 = 5 \Omega$, $R_4 = 7 \Omega$, and express i_1 and i_2 as functions of v . (Hint: Apply KCL at the node between R_1 and R_3 .)

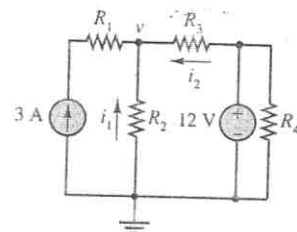


Figure P2.37

- 2.38** Determine the power delivered by the dependent source in the circuit of Figure P2.38.

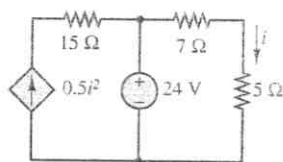


Figure P2.38

2.39 Consider NiMH hobbyist batteries shown in the circuit of Figure P2.39.

- If $V_1 = 12.0$ V, $R_1 = 0.15$ Ω and $R_L = 2.55$ Ω , find the load current I_L and the power dissipated by the load.
- If we connect a second battery in parallel with battery 1 that has voltage $V_2 = 12$ V and $R_2 = 0.28$ Ω , will the load current I_L increase or decrease? Will the power dissipated by the load increase or decrease? By how much?

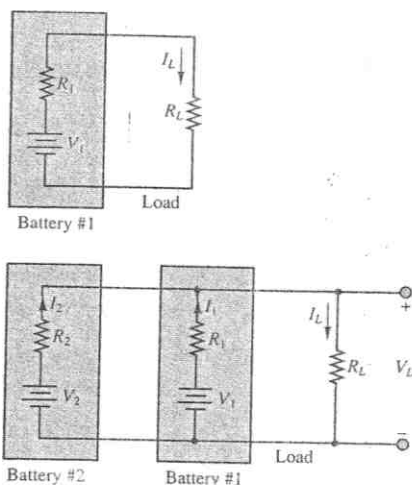


Figure P2.39

2.40 With no load attached, the voltage at the terminals of a particular power supply is 50.8 V. When a 10-W load is attached, the voltage drops to 49 V.

- Determine v_S and R_S for this nonideal source.
- What voltage would be measured at the terminals in the presence of a 15- Ω load resistor?
- How much current could be drawn from this power supply under short-circuit conditions?

2.41 A 220-V electric heater has two heating coils which can be switched such that either coil can be used independently or the two can be connected in series or parallel, yielding a total of four possible configurations. If the warmest setting corresponds to 2,000-W power dissipation and the coolest corresponds to 300 W, find

- The resistance of each of the two coils.
- The power dissipation for each of the other two possible arrangements.

Sections 2.5, 2.6: Resistance and Ohm's Law

2.42 For the circuits of Figure P2.42, determine the resistor values (including the power rating) necessary to achieve the indicated voltages. Resistors are available in $1/8$ -, $1/4$ -, $1/2$ -, and 1-W ratings.

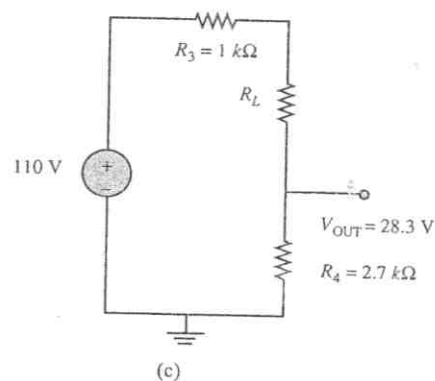
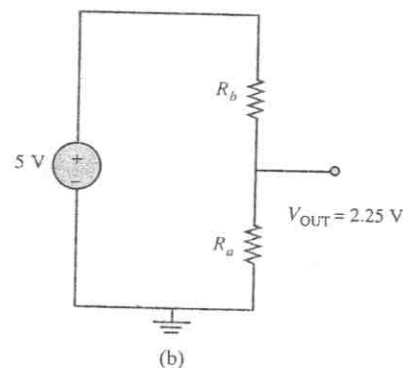
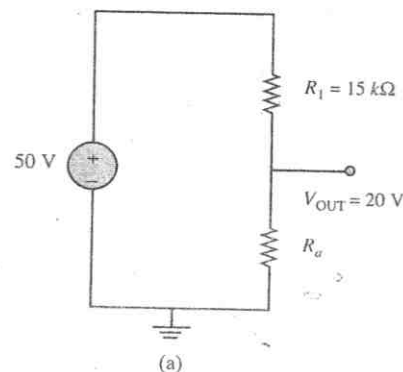


Figure P2.42

- 2.43** For the circuit shown in Figure P2.43, find
- The equivalent resistance seen by the source.
 - The current i .
 - The power delivered by the source.
 - The voltages v_1 , v_2 .
 - The minimum power rating required for R_1 .

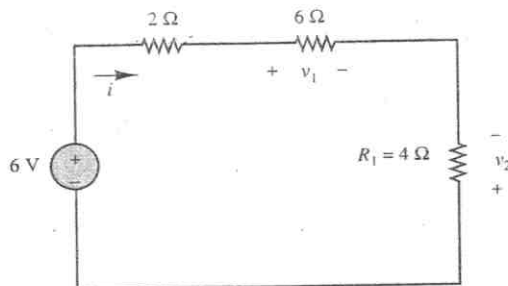


Figure P2.43

- 2.44** Find the equivalent resistance seen by the source in Figure P2.44, and use result to find i , i_1 , and v .

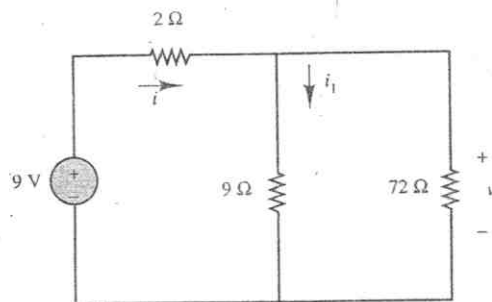


Figure P2.44

- 2.45** Find the equivalent resistance seen by the source and the current i in the circuit of Figure P2.45.

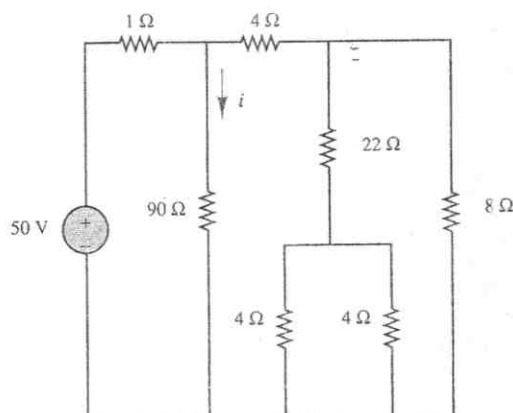


Figure P2.45

- 2.46** In the circuit of Figure P2.46, the power absorbed by the 15-Ω resistor is 15 W. Find R .

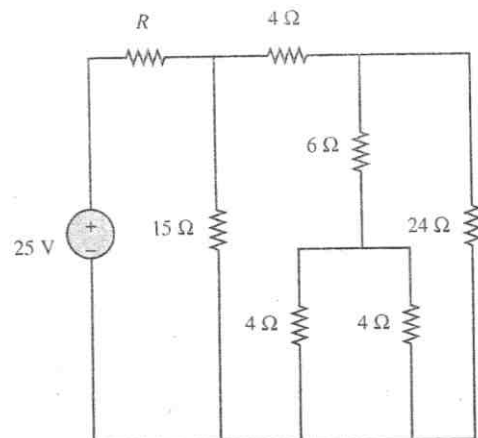


Figure P2.46

- 2.47** Find the equivalent resistance between terminals a and b in the circuit of Figure P2.47.

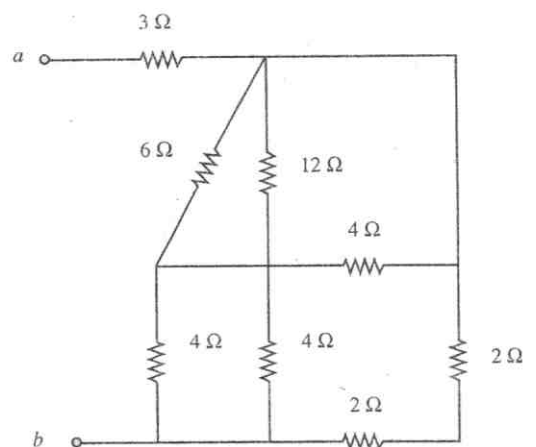


Figure P2.47

- 2.48** For the circuit shown in Figure P2.48, find the equivalent resistance seen by the source. How much power is delivered by the source?

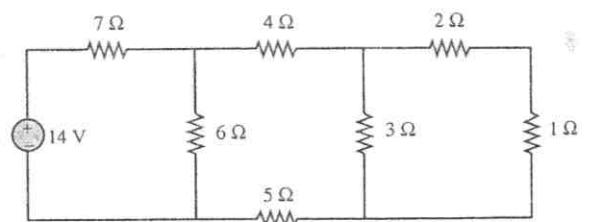


Figure P2.48

- 2.49** For the circuit shown in Figure P2.49, find the equivalent resistance, where $R_1 = 5\ \Omega$, $R_2 = 1\ \text{k}\Omega$, $R_3 = R_4 = 100\ \Omega$, $R_5 = 9.1\ \Omega$ and $R_6 = 1\ \text{k}\Omega$.

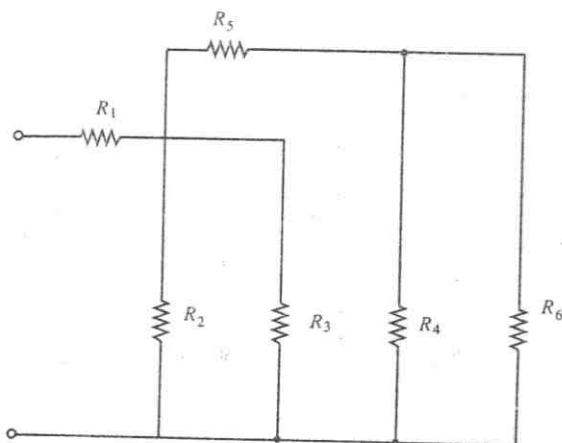


Figure P2.49

- 2.50** Cheap resistors are fabricated by depositing a thin layer of carbon onto a nonconducting cylindrical substrate (see Figure P2.50). If such a cylinder has radius a and length d , determine the thickness of the film required for a resistance R if

$$a = 1\ \text{mm} \quad R = 33\ \text{k}\Omega$$

$$\sigma = \frac{1}{\rho} = 2.9\ \text{M}\frac{\text{S}}{\text{m}} \quad d = 9\ \text{mm}$$

Neglect the end surfaces of the cylinder and assume that the thickness is much smaller than the radius.

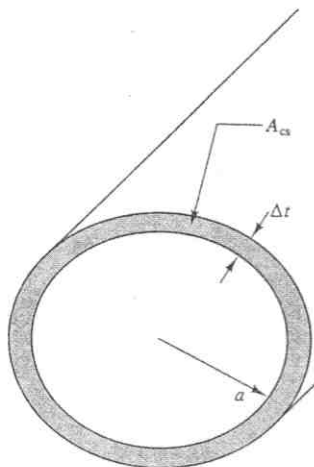


Figure P2.50

- 2.51** The resistive elements of fuses, lightbulbs, heaters, etc., are significantly nonlinear (i.e., the resistance is dependent on the current through the element).

Assume the resistance of a fuse (Figure P2.51) is given by the expression $R = R_0[1 + A(T - T_0)]$ with $T - T_0 = kP$; $T_0 = 25^\circ\text{C}$; $A = 0.7[^\circ\text{C}]^{-1}$; $k = 0.35^\circ\text{C}/\text{W}$; $R_0 = 0.11\ \Omega$; and P is the power dissipated in the resistive element of the fuse. Determine the rated current at which the circuit will melt and open, that is, "blow" (Hint: The fuse blows when R becomes infinite.)

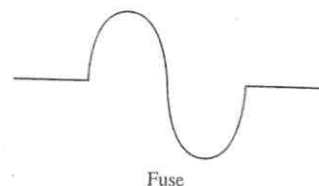


Figure P2.51

- 2.52** Use Kirchhoff's current law and Ohm's law to determine the current in each of the resistors R_4 , R_5 , and R_6 in the circuit of Figure P2.52. $V_S = 10\ \text{V}$, $R_1 = 20\ \Omega$, $R_2 = 40\ \Omega$, $R_3 = 10\ \Omega$, $R_4 = R_5 = R_6 = 15\ \Omega$.

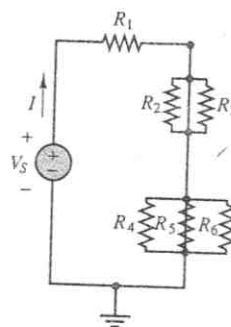


Figure P2.52

- 2.53** With reference to Problem 2.13, use Kirchhoff's current law and Ohm's law to find the resistances R_1 , R_2 , R_3 , R_4 , and R_5 if $R_0 = 2\ \Omega$. Assume $R_4 = \frac{2}{3}R_1$ and $R_2 = \frac{1}{3}R_1$.
- 2.54** Assuming $R_1 = 2\ \Omega$, $R_2 = 5\ \Omega$, $R_3 = 4\ \Omega$, $R_4 = 1\ \Omega$, $R_5 = 3\ \Omega$, $I_2 = 4\ \text{A}$, and $V_S = 54\ \text{V}$ in the circuit of Figure P2.13, use Kirchhoff's current law and Ohm's law to find
- I_0 , I_1 , I_3 , and I_5 .
 - R_0 .
- 2.55** Assuming $R_0 = 2\ \Omega$, $R_1 = 1\ \Omega$, $R_2 = 4/3\ \Omega$, $R_3 = 6\ \Omega$, and $V_S = 12\ \text{V}$ in the circuit of Figure P2.55, use Kirchhoff's voltage law and Ohm's law to find
- i_a , i_b , and i_c .
 - The current through each resistance.

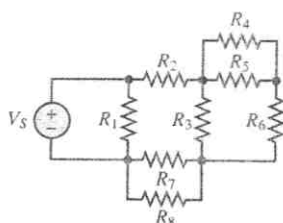


Figure P2.63

- 2.64** In the circuit of Figure P2.64, find the equivalent resistance looking in at terminals a and b if terminals c and d are open and again if terminals c and d are shorted together. Also, find the equivalent resistance looking in at terminals c and d if terminals a and b are open and if terminals a and b are shorted together.

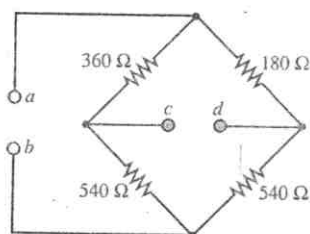


Figure P2.64

- 2.65** At an engineering site which you are supervising, a 1-horsepower motor must be sited a distance d from a portable generator (Figure P2.65). Assume the generator can be modeled as an ideal source with the voltage given. The nameplate on the motor gives the following rated voltages and the corresponding full-load current:

$$V_G = 110 \text{ V}$$

$$V_{M \min} = 105 \text{ V} \rightarrow I_{M \text{ FL}} = 7.10 \text{ A}$$

$$V_{M \max} = 117 \text{ V} \rightarrow I_{M \text{ FL}} = 6.37 \text{ A}$$

If $d = 150 \text{ m}$ and the motor must deliver its full-rated power, determine the minimum AWG conductors which must be used in a rubber-insulated cable. Assume that the only losses in the circuit occur in the wires.

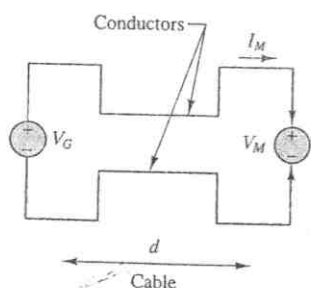


Figure P2.65

- 2.66** In the bridge circuit in Figure P2.66, if nodes (or terminals) C and D are shorted and

$$R_1 = 2.2 \text{ k}\Omega \quad R_2 = 18 \text{ k}\Omega$$

$$R_3 = 4.7 \text{ k}\Omega \quad R_4 = 3.3 \text{ k}\Omega$$

determine the equivalent resistance between the nodes or terminals A and B .

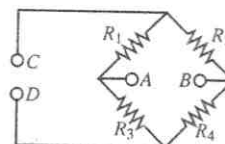


Figure P2.66

- 2.67** Determine the voltage between nodes A and B in the circuit shown in Figure P2.67.

$$V_S = 12 \text{ V}$$

$$R_1 = 11 \text{ k}\Omega \quad R_3 = 6.8 \text{ k}\Omega$$

$$R_2 = 220 \text{ k}\Omega \quad R_4 = 0.22 \text{ m}\Omega$$

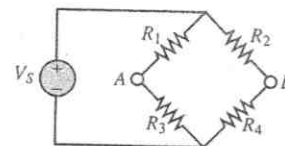


Figure P2.67

- 2.68** Determine the voltage between nodes A and B in the circuit shown in Figure P2.67.

$$V_S = 5 \text{ V}$$

$$R_1 = 2.2 \text{ k}\Omega \quad R_2 = 18 \text{ k}\Omega$$

$$R_3 = 4.7 \text{ k}\Omega \quad R_4 = 3.3 \text{ k}\Omega$$

- 2.69** Determine the voltage across R_3 in Figure P2.69.

$$V_S = 12 \text{ V} \quad R_1 = 1.7 \text{ m}\Omega$$

$$R_2 = 3 \text{ k}\Omega \quad R_3 = 10 \text{ k}\Omega$$

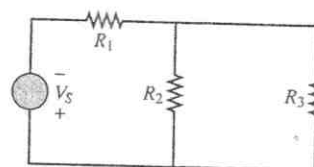


Figure P2.69

Sections 2.7, 2.8: Practical Sources and Measuring Devices

2.70 A *thermistor* is a nonlinear device which changes its terminal resistance value as its surrounding temperature changes. The resistance and temperature generally have a relation in the form of

$$R_{th}(T) = R_0 e^{-\beta(T - T_0)}$$

where R_{th} = resistance at temperature T , Ω

R_0 = resistance at temperature $T_0 = 298$ K, Ω

β = material constant, K^{-1}

T, T_0 = absolute temperature, K

- If $R_0 = 300 \Omega$ and $\beta = -0.01 K^{-1}$, plot $R_{th}(T)$ as a function of the surrounding temperature T for $350 \leq T \leq 750$.
- If the thermistor is in parallel with a $250\text{-}\Omega$ resistor, find the expression for the equivalent resistance and plot $R_{th}(T)$ on the same graph for part a.

2.71 A moving-coil meter movement has a meter resistance $r_M = 200 \Omega$, and full-scale deflection is caused by a meter current $I_m = 10 \mu A$. The movement must be used to indicate pressure measured by the sensor up to a maximum of 100 kPa. See Figure P2.71.

- Draw a circuit required to do this, showing all appropriate connections between the terminals of the sensor and meter movement.
- Determine the value of each component in the circuit.
- What is the linear range, that is, the minimum and maximum pressure that can accurately be measured?

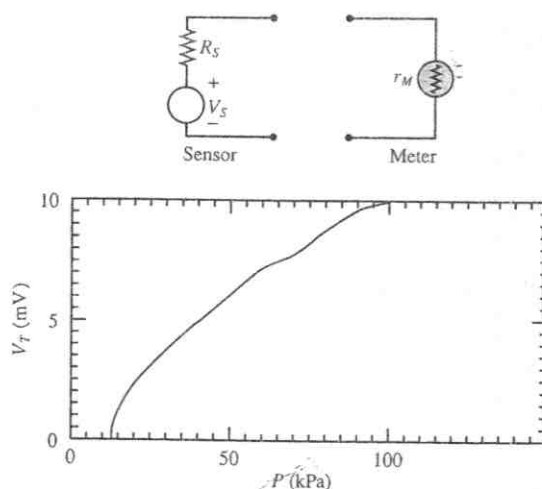


Figure P2.71

2.72 The circuit of Figure P2.72 is used to measure the internal impedance of a battery. The battery being tested is a NiMH battery cell.

- A fresh battery is being tested, and it is found that the voltage V_{out} is 2.28 V with the switch open and 2.27 V with the switch closed. Find the internal resistance of the battery.
- The same battery is tested one year later, and V_{out} is found to be 2.2 V with the switch open but 0.31 V with the switch closed. Find the internal resistance of the battery.

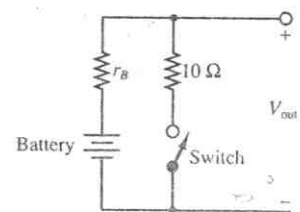


Figure P2.72

2.73 Consider the practical ammeter, described in Figure P2.73, consisting of an ideal ammeter in series with a $1\text{-k}\Omega$ resistor. The meter sees a full-scale deflection when the current through it is $30 \mu A$. If we desire to construct a multirange ammeter reading full-scale values of 10 mA, 100 mA, and 1 A, depending on the setting of a rotary switch, determine appropriate values of R_1 , R_2 , and R_3 .

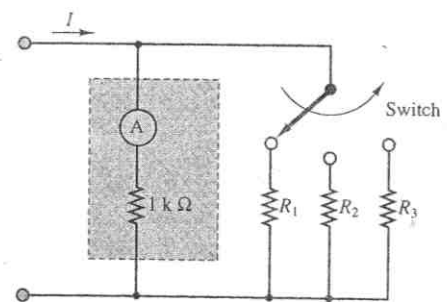


Figure P2.73

2.74 A circuit that measures the internal resistance of a practical ammeter is shown in Figure P2.74, where $R_S = 50,000 \Omega$, $V_S = 12$ V, and R_p is a variable resistor that can be adjusted at will.

- Assume that $r_a \ll 50,000 \Omega$. Estimate the current i .
- If the meter displays a current of $150 \mu A$ when $R_p = 15 \Omega$, find the internal resistance of the meter r_a .

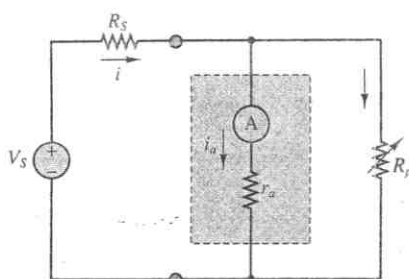


Figure P2.74

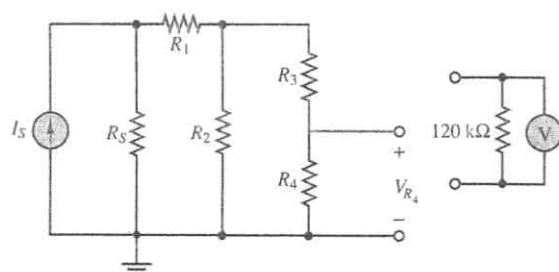


Figure P2.77

- 2.75** A practical voltmeter has an internal resistance r_m . What is the value of r_m if the meter reads 11.81 V when connected as shown in Figure P2.75.

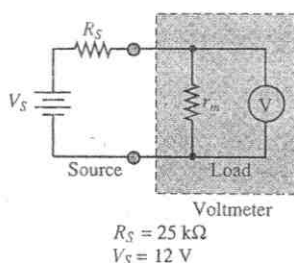


Figure P2.75

- 2.76** Using the circuit of Figure P2.75, find the voltage that the meter reads if $V_S = 24$ V and R_S has the following values:

$R_S = 0.2r_m, 0.4r_m, 0.6r_m, 1.2r_m, 4r_m, 6r_m$, and $10r_m$. How large (or small) should the internal resistance of the meter be relative to R_S ?

- 2.77** A voltmeter is used to determine the voltage across a resistive element in the circuit of Figure P2.77. The instrument is modeled by an ideal voltmeter in parallel with a 120-kΩ resistor, as shown. The meter is placed to measure the voltage across R_4 . Assume $R_1 = 8$ kΩ, $R_2 = 22$ kΩ, $R_3 = 50$ kΩ, $R_S = 125$ kΩ, and $I_S = 120$ mA. Find the voltage across R_4 with and without the voltmeter in the circuit for the following values:

- $R_4 = 100$ Ω
- $R_4 = 1$ kΩ
- $R_4 = 10$ kΩ
- $R_4 = 100$ kΩ

- 2.78** An ammeter is used as shown in Figure P2.78. The ammeter model consists of an ideal ammeter in series

with a resistance. The ammeter model is placed in the branch as shown in the figure. Find the current through R_5 both with and without the ammeter in the circuit for the following values, assuming that $R_S = 20$ Ω, $R_1 = 800$ Ω, $R_2 = 600$ Ω, $R_3 = 1.2$ kΩ, $R_4 = 150$ Ω, and $V_S = 24$ V.

- $R_5 = 1$ kΩ
- $R_5 = 100$ Ω
- $R_5 = 10$ Ω
- $R_5 = 1$ Ω

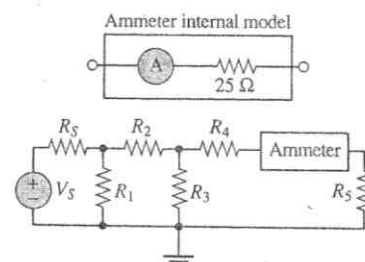


Figure P2.78

- 2.79** Shown in Figure P2.79 is an aluminum cantilevered beam loaded by the force F . Strain gauges R_1, R_2, R_3 , and R_4 are attached to the beam as shown in Figure P2.79 and connected into the circuit shown. The force causes a tension stress on the top of the beam that causes the length (and therefore the resistance) of R_1 and R_4 to increase and a compression stress on the bottom of the beam that causes the length (and therefore the resistance) of R_2 and R_3 to decrease. This causes a voltage of 50 mV at node B with respect to node A. Determine the force if

$$\begin{array}{lll} R_o = 1 \text{ k}\Omega & V_S = 12 \text{ V} & L = 0.3 \text{ m} \\ w = 25 \text{ mm} & h = 100 \text{ mm} & Y = 69 \text{ GN/m}^2 \end{array}$$

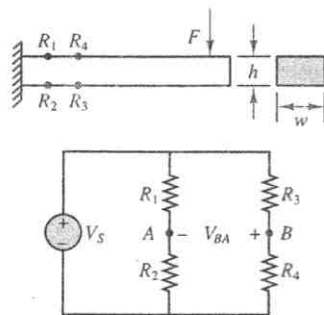


Figure P2.79

- 2.80** Shown in Figure P2.80 is a structural steel cantilevered beam loaded by a force F . Strain gauges R_1 , R_2 , R_3 , and R_4 are attached to the beam as shown and connected into the circuit shown. The force causes a tension stress on the top of the beam that causes the length (and therefore the resistance) of R_1 and R_4 to

increase and a compression stress on the bottom of the beam that causes the length (and therefore the resistance) of R_2 and R_3 to decrease. This generates a voltage between nodes B and A . Determine this voltage if $F = 1.3 \text{ MN}$ and

$$R_o = 1 \text{ k}\Omega \quad V_S = 24 \text{ V} \quad L = 1.7 \text{ m} \\ w = 3 \text{ cm} \quad h = 7 \text{ cm} \quad Y = 200 \text{ GN/m}^2$$

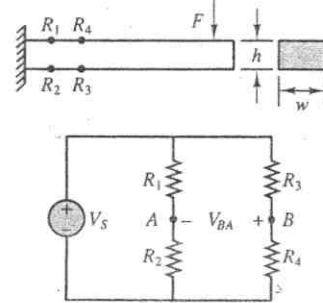


Figure P2.80