Chapter 22: Current Electricity

Practice Problems

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1. The current through a light bulb connected across the terminals of a 120–V outlet is 0.5 A. At what rate does the bulb convert electric energy to light?

$P = VI = (120\ V)(0.5\ A) = 60\ J/s = 60\ W$

2. A car battery causes a current of 2.0 A to flow through a lamp while 12 V is across it.. What is the power used by the lamp?

$P = VI = (12\ V)(2.0\ A) = 24\ W$

3. What current flows through a 75–W light bulb connected to a 120–V outlet?

$P = VI,\ I = \frac{P}{V} = \frac{75\ W}{120\ V} = 0.63\ A$

4. The current through the starter motor of a car is 210 A. If the battery keeps 12 V across the motor, what electric energy is delivered to the starter in 10.0 s?

$P = VI = (12\ V)(210\ A) = 2500\ W$
In 10 s, $E = Pt = (2500\ J/s)(10\ s)$
$= 25000\ J = 2.5 \times 10^4\ J$

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5. An automobile headlight with a resistance of 30 Ω is placed across a 12–V battery. What is the current through the circuit?

$I = \frac{V}{R} = \frac{12\ V}{30\ \Omega} = 0.40\ A$

6. A motor with an operating resistance of 32 Ω is connected to a voltage source. The current in the circuit is 3.8 A. What is the voltage of the source?

$V = IR = (3.8\ A)(32\ \Omega) = 120\ V$

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7. A transistor radio uses 2×10^{-4} A of current when it is operated by a 3–V battery. What is the resistance of the radio circuit?

$R = \frac{V}{I} = \frac{3\ V}{2 \times 10^{-4}\ A} = 1.5 \times 10^4\ \Omega$
$= 2 \times 10^4\ \Omega$

8. A lamp draws a current of 0.5 A when it is connected to a 120–V source.

   a. What is the resistance of the lamp?

   $R = \frac{V}{I} = \frac{120\ V}{0.5\ A} = 240\ \Omega = 200\ \Omega$

   b. What is the power consumption of the lamp?

   $P = VI = (120\ V)(0.5\ A) = 60\ W$

9. A 75–W lamp is connected to 120 V.

   a. How much current flows through the lamp?

   $I = P/V = (75\ W)(120\ V) = 0.63\ A$

   b. What is the resistance of the lamp?

   $R = V/I = 120\ V/0.63\ A = 190\ \Omega$

10. A resistor is now added in series with the lamp to reduce the current to half of its original value.

    a. What is the potential difference across the lamp? Assume the lamp resistance is constant.

    The new value of the current is
    0.63 A/2 = 0.315 A, so
    $V = IR = (0.315\ A)(190\ \Omega) = 60\ V$

Practice Problems

b. How much resistance was added to the circuit?

The total resistance of the circuit is now $R_{total} = V/I = (120\ V)/(0.315\ A) = 380\ \Omega$.
Therefore, $R_{res} = R_{total} - R_{lamp}$
$= 380\ \Omega - 190\ \Omega = 190\ \Omega$.

c. How much power is now dissipated in the lamp?

$P = VI = (60\ V)(0.315\ A) = 19\ W$

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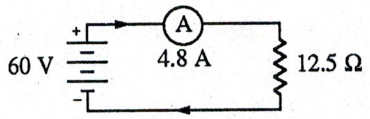
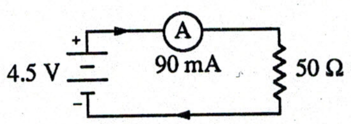
11. Draw a circuit diagram to include a 60–V battery, an ammeter, and a resistance of 12.5 Ω in series. Indicate the ammeter reading and the direction of current flow.

$$I = \frac{V}{R} = \frac{60\ V}{12.5\ \Omega} = 4.8\ A$$



12. Draw a series circuit diagram showing a 4.5–V battery, a resistor, and an ammeter reading 90 mA. Label the size of the resistor. Choose a direction for the conventional current and indicate the positive terminal of the battery.

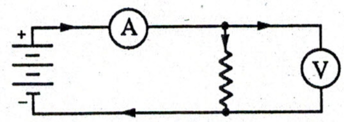
$R = V/I = (4.5\ V)(0.090\ A) = 50\ \Omega$



Practice Problems

13. Add a voltmeter that measures the potential difference across the resistors in each of the Practice Problems above.

Both circuits will take the form



Since the ammeter resistance is assumed zero the voltmeter readings will be
practice problem 11 60 V
practice problem 12 4.5 V.

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14. A 15–Ω electric heater operates on a 120–V outlet.

a. What is the current through the heater?

$I = V/R = (120\ V)(15\ \Omega) = 8.0\ A$

b. How much energy is used by the heater in 30.0 s?

$E = I^2Rt = (8.0\ A)^2(15\ \Omega)(30.0\ s)$
$= 2.9 \times 10^4\ J$

c. How much thermal energy is liberated by the heater in this time?

2.9×10^4 J since all electrical energy is converted to thermal energy

15. A 30–Ω resistor is connected to a 60–V battery.

a. What is the current in the circuit?

$I = V/R = (60\ V)/(30\ \Omega) = 2.0\ A$

b. How much energy is used by the resistor in 5 min?

$E = I^2Rt = (2.0\ A)^2(30\ \Omega)(5\ min)(60\ s/min)$
$= 3.6 \times 10^4\ J$

Practice Problems

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16. A 100.0–W lightbulb is 20.0% efficient. That means 20.0% of the electric energy is converted to light energy.

a. How many joules does the light bulb convert into light each minute it is in operation?

$E = (0.200)(100.0 \text{ J/s})(60.0 \text{ s})$
$= 1.20 \times 10^3 \text{ J}$

b. How many joules of thermal energy does the light bulb produce each minute?

$E = (0.800)(100.0 \text{ J/s})(60.0 \text{ s})$
$= 4.80 \times 10^3 \text{ J}$

17. The resistance of an electric stove element at operating temperature is 11 Ω.

a. 220 V are applied across it. What is the current through the stove element?

$I = V/R = (220 \text{ V})/(11\ \Omega) = 20 \text{ A}$

b. How much energy does the element convert to thermal energy in 30.0 s?

$E = I^2Rt = (20\ A)^2(11\ \Omega)(30.0 \text{ s})$
$= 1.3 \times 10^5 \text{ J}$

c. The element is being used to heat a kettle containing 1.20 kg of water. Assume that 70% of the heat is absorbed by the water. What is its increase in temperature during the 30.0 s?

$Q = mC\Delta T$ with $Q = 0.70\ E$
$\Delta T = 0.70\ E/mC$

$$= \frac{(0.70)(1.3 \times 10^5 \text{ J})}{(1.20 \text{ kg})(4180 \text{ J/kg}\cdot\text{C°})} = 18°\text{C}$$

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18. An electric space heater draws 15.0 A from a 120–V source. It is operated, on the average, for 5.0 h each day.

a. How much power does the heater use?

$P = IV = (15.0 \text{ A})(120 \text{ V})$
$= 1800 \text{ W} = 1.80 \text{ kW}$

Practice Problems

b. How much energy in kWh does it consume in 30 days?

$E = Pt = (1.8 \text{ kW})(5 \text{ h/day})(30 \text{ days})$
$= 270 \text{ kWh}$

c. At $0.11 per kWh, what does it cost to operate it for 30 days?

Cost = (0.11 $/kWh)(270 kWh) = $29.70

19. A digital clock has an operating resistance of 12 000 Ω and is plugged into a 115–V outlet. Assume the clock obeys Ohm's law.

a. How much current does it draw?

$$I = \frac{V}{R} = \frac{(115 \text{ V})}{(12{,}000\ \Omega)} = 9.6 \times 10^{-3} \text{ A}$$

b. How much power does it use?

$P = VI = (115 \text{ V})(9.6 \times 10^{-3} \text{ A}) = 1.10 \text{ W}$

c. If the owner of the clock pays $0.09 per kWh, what does it cost to operate the clock for 30 days?

Cost = $(1.10 \times 10^{-3} \text{ kW})(\$0.09/\text{kWh})$
$\cdot(30 \text{ days})(24 \text{ h/day}) = \$0.07$

Chapter Review Problems

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1. The current through a toaster connected to a 120–V source is 8.0 A. What power is dissipated by the toaster?

$P = VI = (120 \text{ V})(8.0 \text{ A}) = 9.6 \times 10^2 \text{ W}$

2. A current of 1.2 A flows through a light bulb when it is connected across a 120–V source. What power is dissipated by the bulb?

$P = VI = (120 \text{ V})(1.2 \text{ A}) = 1.4 \times 10^2 \text{ W}$

Chapter Review Problems

3. A lamp draws 0.50 A from a 120–V generator.

a. How much power does the generator deliver?

$P = VI = (120\ \text{V})(0.50\ \text{A}) = 60\ \text{W}$

b. How much energy does the lamp convert in 5.0 min?

The definition of power is $P = \frac{E}{t}$, so

$$E = Pt = 60\ \text{W}\left[\frac{5.0\ \text{min}}{1}\right]\left[\frac{60\ \text{s}}{\text{min}}\right]$$

$$= 18\ 000\ \text{J} = 1.8 \times 10^4\ \text{J}$$

4. A 12–V automobile battery is connected to an electric starter motor. The current through the motor is 210 A.

a. How many joules of energy does the battery deliver to the motor each second?

$P = IV = (210\ \text{A})(12\ \text{V}) = 2500\ \text{J/s}$,
so $2.5 \times 10^3\ \text{J/s}$

b. What power in watts does the motor use?

$P = 2.5 \times 10^3\ \text{W}$

5. A 4000–W clothes dryer is connected to a 220–V circuit. How much current does the dryer draw?

$$P = VI, \text{ so } I = \frac{P}{V} = \frac{4000\ \text{W}}{220\ \text{V}} = 18.2\ \text{A}$$

6. A flashlight bulb is connected across a 3.0–V difference in potential. The current through the lamp is 1.5 A.

a. What is the power rating of the lamp?

$P = VI = (3.0\ \text{V})(1.5\ \text{A}) = 4.5\ \text{W}$

b. How much electric energy does the lamp convert in 11 min?

The definition for power is $P = \frac{E}{t}$, so

$$E = Pt = 4.5\ \text{W}\left[\frac{10\ \text{min}}{1}\right]\left[\frac{60\ \text{s}}{\text{min}}\right]$$

$$= 3.0 \times 10^3\ \text{J}$$

7. How much energy does a 60.0–W light bulb use in half an hour? If the light bulb is 12% efficient, how much thermal energy does it generate during the half hour?

$P = \frac{E}{t}$, so

$$E = Pt = (60.0\ \text{W})(30\ \text{min})\left[\frac{60\ \text{s}}{\text{min}}\right]$$

$$= 1.08 \times 10^5\ \text{J}$$

If the bulb is 12% efficient, 88% of the energy is lost to heat, so
$Q = 0.88(1.08 \times 10^5\ \text{J}) = 9.5 \times 10^4\ \text{J}$

8. A resistance of 60 Ω has a current of 0.40 A through it when it is connected to the terminals of a battery. What is the voltage of the battery?

$V = IR = (0.40\ \text{A})(60\ \Omega) = 24\ \text{V}$

9. What voltage is applied to a 4.0–Ω resistor if the current is 1.5 A?

$V = IR = (1.5\ \text{A})(4.0\ \Omega) = 6.0\ \text{V}$

10. What voltage is placed across a motor of 15 Ω operating resistance if the current is 8.0 A?

$V = IR = (8.0\ \text{A})(15\ \Omega) = 1.2 \times 10^2\ \text{V}$

11. A voltage of 75 V is placed across a 15–Ω resistor. What is the current through the resistor?

$V = IR$, so $I = V/R = (75\ \text{V})/(15\ \Omega) = 5.0\ \text{A}$

12. A 20.0–Ω resistor is connected to a 30.0–V battery. What is the current in the resistor?

$$V = IR, \text{ so } I = \frac{V}{R} = \frac{30.0\ \text{V}}{20.0\ \Omega} = 1.50\ \text{A}$$

13. A 12–V battery is connected to a device and 24 mA, 24×10^{-3} A, of current flows through it. If the device obeys Ohm's law, how much current will flow when a 24–V battery is used?

I is proportional to *V*, so doubling *V* doubles *I* to 48 mA.

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14. The damage caused by electric shock depends on the current flowing through the body. 1 mA can be felt. 5 mA are painful. Above 15 mA, a person loses muscle control, and 70 mA can be fatal. A person with dry skin has a resistance from one arm to the other of about $1 \times 10^5\ \Omega$. When skin is wet, the resistance drops to about $5 \times 10^3\ \Omega$.

a. What is the minimum voltage placed across the arms that would produce a current that could be felt by a person with dry skin?

$$V = IR = (1 \times 10^{-3}\ \text{A})(1 \times 10^5\ \Omega) = 1 \times 10^2\ \text{V}$$

b. What effect would the same voltage have if the person had wet skin?

$V = IR$, so

$$I = \frac{V}{R} = \frac{1 \times 10^2\ \text{V}}{5 \times 10^3\ \Omega} = 2 \times 10^{-2}\ \text{A}$$

= 20 mA, loss of muscle control

c. What would be the minimum voltage that would produce a current that could be felt when the skin is wet?

$$V = IR = (1 \times 10^{-3}\ \text{A})(5 \times 10^3\ \Omega) = 5\ \text{V}$$

15. A lamp draws a 66–mA current when connected to a 6.0–V battery. When a 9.0–V battery is used, the lamp draws 75 mA.

a. Does the lamp obey Ohm's law?

No. The voltage is increased by a factor of (9.0)/(6.0) = 1.5, but the current is increased by a factor of (75)/(66) = 1.1

b. How much power does the lamp dissipate at 6.0 V?

$$P = IV = (66 \times 10^{-3}\ \text{A})(6.0\ \text{V}) = 0.40\ \text{W}$$

c. How much power does it dissipate at 9.0 V?

$$P = IV = (75 \times 10^{-3}\ \text{A})(9.0\ \text{V}) = 0.68\ \text{W}$$

Chapter Review Problems

16. Table 22–1 shows data taken by students. They connected a length of nichrome wire to a variable power supply that could produce a voltage variable from 0 V to 10 V across the wire. They then measured the current through the wire for several voltages. The data table shows the voltages used and currents measured.

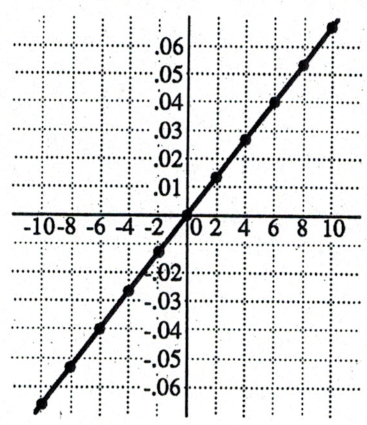
Voltage and Current Measurements for Nichrome Wire

Voltage V (volts)	Current I (amps)	Resistance R (ohms)
2.00	0.014	
4.00	0.027	
6.00	0.040	
8.00	0.052	
10.00	0.065	
−2.00	−0.014	
−4.00	−0.028	
−6.00	−0.039	
−8.00	−0.051	
−10.00	−0.064	

a. For each measurement, calculate the resistance.

R = 143 Ω, 148 Ω, 150 Ω, 154 Ω, 154 Ω, 143 Ω, 143 Ω, 154 Ω, 157 Ω, 156 Ω.

b. Graph I versus V.



c. Does the nichrome wire obey Ohm's law? If not, for all the voltages, specify the voltage range for which Ohm's law holds.

Nichrome wire does not obey Ohm's law for all voltages. It obeys for voltages of +8.00 V to +10.00 V and in the − 2.00 V to − 4.00 V range.

17. The current through a lamp connected across 120 V is 0.40 A when the lamp is on.

a. What is its resistance when it is on?

$V = IR$, so

$$R = \frac{V}{I} = \frac{120\ \text{V}}{0.40\ \text{A}} = 3.0 \times 10^2\ \Omega$$

b. When the lamp is cold, its resistance is one fifth as large as when the lamp is hot. What is its cold resistance?

$$\frac{1}{5}(3.0 \times 10^2\ \Omega) = 60\ \Omega$$

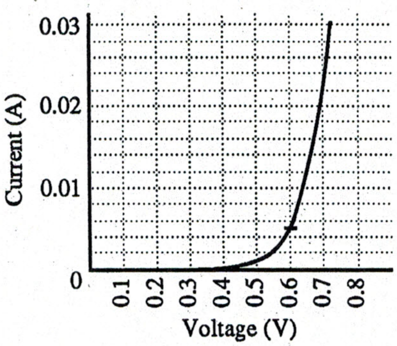
c. What is the current through the lamp as it is turned on if it is connected to a potential difference of 120 V?

$V = IR$, so

$$I = \frac{V}{R} = \frac{120\ \text{V}}{60\ \Omega} = 2.0\ \text{A}$$

18. The graph in Figure 22–17 shows the current that flows through a device called a silicon diode.

a. A potential difference of +0.70 V is placed across the diode. What resistance would be calculated?



Chapter Review Problems

From the graph, I = 22 mA, and $V = IR$, so $R = V/I = (0.70\ \text{V})/(2.2 \times 10^{-2}\ \text{A}) = 32\ \Omega$

b. What resistance would be calculated if a +0.60 V potential difference was used?

From the graph, I = 5.2 mA and $R = V/I = (0.60\ \text{V})/(5.2 \times 10^{-3}\ \text{A})$
$= 1.2 \times 10^2\ \text{A}$

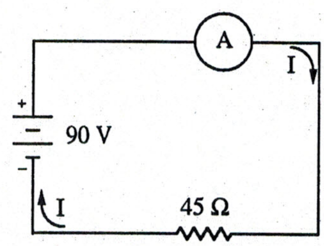
c. Does the diode obey Ohm's law?

No. Resistance depends on voltage.

19. Draw a schematic diagram to show a circuit that includes a 90–V battery, an ammeter, and a resistance of 45 Ω connected in series. What is the ammeter reading? Draw arrows showing the direction of conventional current flow.

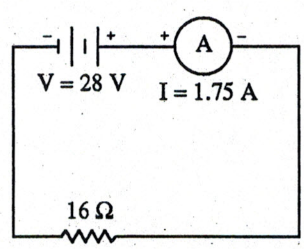
$V = IR$, so

$$I = \frac{V}{R} = \frac{90\ \text{V}}{45\ \Omega} = 2.0\ \text{A}$$



20. Draw a series circuit diagram to include a 16 Ω resistor, a battery, and an ammeter that reads 1.75 A. Current flows through the meter from left to right. Indicate the positive terminal and the voltage of the battery.

$V = IR = (1.75\ \text{A})(16\ \Omega) = 28\ \text{V}$



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Chapter Review Problems

21. What is the maximum current that should be allowed in a 5.0–W, 220–Ω resistor?

$$P = I^2R, \text{ so } I = \sqrt{\frac{P}{R}} = \sqrt{\frac{5.0\text{ W}}{220\ \Omega}} = 0.15\text{ A}$$

22. The wire in a house circuit is rated at 15.0 A that has a resistance of 0.15 Ω.

a. What is its power rating?

$$P = I^2R = (15.0\text{ A})^2(0.15\ \Omega) = 34\text{ W}$$

b. How much heat does the wire give off in 10.0 min?

$$Q = E = I^2Rt$$
$$= (15.0\text{ A})^2(0.15\ \Omega)(10\text{ min})\left[\frac{60\text{ s}}{\text{min}}\right]$$
$$= 2.0 \times 10^4\text{ J}$$

23. A current of 1.2 A flows through a 50–Ω resistor for 5.0 min. How much heat was generated by the resistor?

$$Q = E = I^2Rt$$
$$= (1.2\text{ A})^2(50\ \Omega)(5.0\text{ min})\left[\frac{60\text{ s}}{\text{min}}\right]$$
$$= 2.2 \times 10^4\text{ J}$$

24. A 6.0–Ω resistor is connected to a 15 V battery.

a. What is the current in the circuit?

$V = IR$, so

$$I = \frac{V}{R} = \frac{15\text{ V}}{6.0\ \Omega} = 2.5\text{ A}$$

b. How much thermal energy is produced in 10 min.?

$$Q = E = I^2Rt$$
$$= (2.5\text{ A})^2(6.0\ \Omega)(10\text{ min})\left[\frac{60\text{ s}}{\text{min}}\right]$$
$$= 2.3 \times 10^4\text{ J}$$

25. A 110–V electric iron draws 3.0 A of current. How much heat is developed per hour?

$$V = IR, \text{ so } R = \frac{V}{I} = \frac{110\text{ V}}{3.0\text{ A}} = 37\ \Omega \text{ and}$$

$$Q = E = I^2Rt = (3.0\text{ A})^2(37\ \Omega)(1\text{ h})\left[\frac{3600\text{ s}}{\text{h}}\right]$$
$$= 1.2 \times 10^6\text{ J}$$

26. An electric motor operates a pump that irrigates a farmer's crop by pumping 10 000 L of water a vertical distance of 8.0 m into a field each hour. The motor has an operating resistance of 22.0 Ω and is connected across a 110–V source.

a. What current does it draw?

$$V = IR, \text{ so } I = \frac{V}{R} = \frac{110\text{ V}}{22.0\ \Omega} = 5.0\text{ A}$$

b. How efficient is the motor?

$$E_W = mgd$$
$$= (1.0 \times 10^4\text{ kg})(9.8\text{ m/s}^2)(8.0\text{ m})$$
$$= 7.8 \times 10^5\text{ J}$$

$$E_m = IVt = (5.0\text{ A})(110\text{ V})(3600\text{ s})$$
$$= 2.0 \times 10^6\text{ J}$$

$$Eff = \frac{E_W}{E_m} \times 100\% = \frac{7.8 \times 10^5\text{ J}}{2.0 \times 10^6\text{ J}} \times 100\%$$
$$= 39\%$$

27. A transistor radio operates by means of a 9.0–V battery that supplies it with a 50–mA current.

a. If the cost of the battery is \$0.90 and it lasts for 300 h, what is the cost per kWh to operate the radio in this manner?

$$P = IV = (0.050\text{ A})(9.0\text{ V}) = 0.45\text{ W}$$
$$= 4.5 \times 10^{-4}\text{ k}$$

$$\frac{Cost}{\text{kWh}} = \frac{\$0.90}{(4.5 \times 10^{-4}\text{ kW})(300\text{ h})} = \$6.70$$

b. The same radio, by means of a converter, is plugged into a household circuit by a homeowner who pays \$0.08 per kWh. What does it now cost to operate the radio for 300 h?

$$Cost = \frac{\$0.08}{\text{kWh}}(0.1\text{ kWh}) = 1\text{ cent}$$

Chapter Review Problems

28. A heating coil has a resistance of 4.0 Ω and operates on 120 V.

a. What is the current in the coil while it is operating?

$$V = IR, \text{ so } I = \frac{V}{R} = \frac{120\text{ V}}{4.0\ \Omega} = 30\text{ A}$$

b. What energy is supplied to the coil in 5.0 min?

$$E = I^2Rt = (30\text{ A})^2(4.0\ \Omega)(5.0\text{ min})\left[\frac{60\text{ s}}{\text{min}}\right]$$

$$= 1.1 \times 10^6\text{ J}$$

c. If the coil is immersed in an insulated container holding 20.0 kg of water, what will be the increase in the temperature of the water? Assume that 100% of the heat is absorbed by the water.

$Q = mc\Delta T$, so

$$\Delta T = \frac{Q}{mc} = \frac{(1.1 \times 10^6\text{ J})}{(20.0\text{ kg})(4180\text{ J/kg}\cdot\text{C}^\circ)}$$

$$= 13^\circ\text{C}$$

d. At $0.08 per kWh, what does it cost to operate the heating coil 30 min per day for 30 days?

$$Cost = \left[\frac{1.1 \times 10^6\text{ J}}{5\text{ min}}\right]\left[\frac{30\text{ min}}{\text{dy}}\right](30\text{ dy})$$

$$\left[\frac{1\text{ kWh}}{3.6 \times 10^6\text{ J}}\right]\left[\frac{\$0.08}{\text{kWh}}\right]$$

$$= \$4.40$$

29. An electric heater is rated at 500 W.

a. How much energy is delivered to the heater in half an hour?

$$E = Pt = (5.00 \times 10^2\text{ W})(30\text{ min})\left[\frac{60\text{ s}}{\text{min}}\right]$$

$$= 9.00 \times 10^5\text{ J}$$

b. The heater is being used to heat a room containing 50.0 kg of air. If the specific heat of air is 1.10 kJ/kg·C°, 1100 J/kg·C°, and 50% of the thermal energy heats the air in the room, what is the change in air temperature?

$Q = mc\Delta T$, so

$$\Delta T = \frac{Q}{mc} = \frac{(0.5)(9 \times 10^5\text{ J})}{(50.0\text{ kg})(1100\text{ J/kg}\cdot\text{C}^\circ)} = 8^\circ\text{C}$$

c. At $0.08 per kWh, what does it cost to run the heater 6.0 hours per day for 30 days?

$$Cost = \left[\frac{500\text{ J}}{\text{s}}\right]\left[\frac{6.0\text{ h}}{\text{dy}}\right]\left[\frac{3600\text{ s}}{\text{h}}\right](30\text{ dy})$$

$$\left[\frac{1\text{ kWh}}{3.6 \times 10^6\text{ J}}\right]\left[\frac{\$0.08}{\text{kWh}}\right] = \$7.20$$

Supplemental Problems (Appendix B)

1. How many amperes of current flow in a wire through which 1.00 × 10^18 electrons pass per second?

$$(1.00 \times 10^{18}\text{ e/s})\left[\frac{1.60 \times 10^{-19}\text{ C}}{e}\right] = 0.160\text{ c/s}$$

$$= 0.160\text{ A}$$

2. A current of 5.00 A flowed in a copper wire for 20.0 s. How many coulombs of charge passed through the wire in this time?

$I = \frac{q}{t}$, so

$$q = It = (5.00\text{ A})(20.0\text{ s}) = 1.00 \times 10^2\text{ C}$$

3. What power is supplied to a motor that operates on a 120–V line and draws 1.50 A of current?

$$P = IV = (1.5\text{ A})(120\text{ V}) = 180\text{ W}$$

4. An electric lamp is connected to a 110–V source. If the current through the lamp is 0.75 A, what is the power consumption of the lamp?

$$P = IV = (0.75\text{ A})(110\text{ V}) = 83\text{ W}$$

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5. A lamp is labeled 6.0 V and 12 W.

a. What current flows through the lamp when it is operating?

$$P = IV, \text{ so } I = \frac{P}{V} = \frac{120\text{ W}}{6.0\text{ V}} = 2.0\text{ A}$$

b. How much energy is supplied to the lamp in 1.000×10^3 s?

$$P = \frac{E}{t}, \text{ so}$$

$$E = Pt = (12\text{ W})(1000\text{ s}) = 1.2 \times 10^4\text{ J} = 12\text{ kJ}$$

6. A current of 3.00 A flows through a resistor when it is connected to a 12.0–V battery. What is the resistance of the resistor?

$$R = \frac{V}{I} = \frac{12.0\text{ V}}{3.00\text{ A}} = 4.00\ \Omega$$

7. A small lamp is designed to draw a current of 3.00×10^2 mA in a 6.00–V circuit. What is the resistance of the lamp?

$$R = \frac{V}{I} = \frac{6.00\text{ V}}{3.00 \times 10^{-1}} = 20.0\ \Omega$$

8. What potential difference is required if you want a current of 8.00 mA in a load having a resistance of 50.0 Ω?

$$R = \frac{V}{I}, \text{ so}$$

$$V = IR = (8.00 \times 10^{-3}\text{ A})(50.0\ \Omega) = 0.400\text{ V}$$

9. In common metals, resistance increases as the temperature increases. An electric toaster has a resistance of 12.0 Ω when hot.

a. What current will flow through it when it is connected to 125 V?

$$R = \frac{V}{I}, \text{ so I} = \frac{V}{R} = \frac{125\text{ V}}{12.0\ \Omega} = 10.4\text{ A}$$

b. When the toaster is first turned on, will the current be more or less than during operation?

When the toaster is first turned on, its temperature is low and its resistance is low, so the current is greater.

10. The resistance of a lamp is 230 Ω. The voltage is 115 V when the lamp is turned on.

a. What is the current in the lamp?

$$R = \frac{V}{I}, \text{ so } I = \frac{V}{R} = \frac{115\text{ V}}{230\ \Omega} = 0.500\text{ A}$$

b. If the voltage rises to 120 V, what is the current?

$$I = \frac{V}{R} = \frac{120\text{ V}}{230\ \Omega} = 0.522\text{ A}$$

11. What should be the resistance of the lamp in part **a** of the previous problem if the lamp is to draw the same current, but in a 230–V circuit?

$$R = \frac{V}{I} = \frac{230\text{ V}}{0.500\text{ A}} = 460\ \Omega$$

12. A 110–W lamp draws 0.909 A. What is the lamp's resistance?

$$P = I^2R, \text{ so } R = \frac{P}{I^2} = \frac{110\text{ W}}{(0.909\text{ A})^2} = 133\ \Omega$$

13. Each coil in a resistance box is capable of dissipating heat at the rate of 4.00 W.

$$P = I^2R, \text{ so } I^2 = \frac{P}{R}, \text{ and } I = \sqrt{\frac{P}{R}}.$$

What is the maximum current that should be allowed across a coil to avoid overheating if the coil has a resistance of

a. 2.00 Ω

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{4.00\text{ W}}{2.00\ \Omega}} = 1.41\text{ A}$$

b. 20.0 Ω

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{4.00\text{ W}}{20.0\ \Omega}} = 0.447\text{ A}$$

14. What is the power supplied to a lamp that is operated by a battery having a 12 V potential difference across its terminals when the resistance lamp is 6.0 Ω?

$P = I^2R$ and $R = \frac{V}{I}$, so $I = \frac{V}{R}$. Therefore,

$$P = \left[\frac{V}{R}\right]^2 R = \frac{V^2}{R} = \frac{(12\ \text{V})^2}{6.0\ \Omega} = 24\ \text{W}$$

15. How much does it cost to run a 2.00 W clock for one year (365.25 days) if it costs 3.53 cents/kWh?

$$Cost = \frac{3.53\ ¢}{\text{kWh}}(2.00\ \text{W})\left[\frac{\text{kw}}{1000\ \text{W}}\right]\left[\frac{365.25\ \text{dy}}{1\ \text{yr}}\right]\left[\frac{24\ \text{h}}{1\ \text{dy}}\right] = 62\ ¢/\text{yr}$$

16. A small electric furnace that expends 2.00 kW of power is connected across a potential difference of 120 Volts.

a. What is the current in the circuit?

$P = IV$, so

$$I = \frac{P}{V} = \frac{2.00 \times 10^3\ \text{W}}{120\ \text{V}} = 16.7\ \text{A}$$

b. What is the resistance of the furnace?

$$R = \frac{V}{I} = \frac{120\ \text{V}}{16.7\ \text{A}} = 7.19\ \Omega$$

c. What is the cost of operating the furnace for 24.0 h at 7.00 cents/kWh?

$$Cost = \frac{7.00\ ¢}{\text{kWh}}(2.00\ \text{kW})(24\ \text{h}) = \$3.36$$

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