


Pearson New International Edition

Physics for Scientists & Engineers Vol 2

Douglas C. Giancoli

Fourth Edition


Pearson Education Limited
Edinburgh Gate
Harlow
Essex CM20 2JE
England and Associated Companies throughout the world

Visit us on the World Wide Web at: www.pearsoned.co.uk

PEARSON®

ISBN 10: 1-292-03974-4
ISBN 13: 978-1-292-03974-9

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Printed in the United States of America

6. (II) A hair dryer draws 9.5 A when plugged into a 120-V line. (*a*) What is its resistance? (*b*) How much charge passes through it in 15 min? (Assume direct current.)

7. (II) A 4.5-V battery is connected to a bulb whose resistance is 1.6 Ω. How many electrons leave the battery per minute?

8. (II) A bird stands on a dc electric transmission line carrying 3100 A (Fig. 34). The line has $2.5 \times 10^{-5}\ \Omega$ resistance per meter, and the bird's feet are 4.0 cm apart. What is the potential difference between the bird's feet?

FIGURE 34 Problem 8.

Scott T. Smith/Bettmann/Corbis

9. (II) A 12-V battery causes a current of 0.60 A through a resistor. (*a*) What is its resistance, and (*b*) how many joules of energy does the battery lose in a minute?

10. (II) An electric device draws 6.50 A at 240 V. (*a*) If the voltage drops by 15%, what will be the current, assuming nothing else changes? (*b*) If the resistance of the device were reduced by 15%, what current would be drawn at 240 V?

4 Resistivity

11. (I) What is the diameter of a 1.00-m length of tungsten wire whose resistance is 0.32 Ω?

12. (I) What is the resistance of a 4.5-m length of copper wire 1.5 mm in diameter?

13. (II) Calculate the ratio of the resistance of 10.0 m of aluminum wire 2.0 mm in diameter, to 20.0 m of copper wire 1.8 mm in diameter.

14. (II) Can a 2.2-mm-diameter copper wire have the same resistance as a tungsten wire of the same length? Give numerical details.

15. (II) A sequence of potential differences V is applied across a wire (diameter = 0.32 mm, length = 11 cm) and the resulting currents I are measured as follows:

V (V)	0.100	0.200	0.300	0.400	0.500
I (mA)	72	144	216	288	360

(*a*) If this wire obeys Ohm's law, graphing I vs. V will result in a straight-line plot. Explain why this is so and determine the theoretical predictions for the straight line's slope and y-intercept. (*b*) Plot I vs. V. Based on this plot, can you conclude that the wire obeys Ohm's law (i.e., did you obtain a straight line with the expected y-intercept)? If so, determine the wire's resistance R. (*c*) Calculate the wire's resistivity and use Table 1 to identify the solid material from which it is composed.

TABLE 1 Resistivity and Temperature Coefficients (at 20°C)

Material	Resistivity, $\rho\ (\Omega \cdot \text{m})$	Temperature Coefficient, $\alpha\ (\text{C}°)^{-1}$
Conductors		
Silver	1.59×10^{-8}	0.0061
Copper	1.68×10^{-8}	0.0068
Gold	2.44×10^{-8}	0.0034
Aluminum	2.65×10^{-8}	0.00429
Tungsten	5.6×10^{-8}	0.0045
Iron	9.71×10^{-8}	0.00651
Platinum	10.6×10^{-8}	0.003927
Mercury	98×10^{-8}	0.0009
Nichrome (Ni, Fe, Cr alloy)	100×10^{-8}	0.0004
Semiconductors†		
Carbon (graphite)	$(3 – 60) \times 10^{-5}$	−0.0005
Germanium	$(1 – 500) \times 10^{-3}$	−0.05
Silicon	0.1 – 60	−0.07
Insulators		
Glass	$10^{9} – 10^{12}$	
Hard rubber	$10^{13} – 10^{15}$	

† Values depend strongly on the presence of even slight amounts of impurities.

16. (II) How much would you have to raise the temperature of a copper wire (originally at 20°C) to increase its resistance by 15%?

17. (II) A certain copper wire has a resistance of 10.0 Ω. At what point along its length must the wire be cut so that the resistance of one piece is 4.0 times the resistance of the other? What is the resistance of each piece?

18. (II) Determine at what temperature aluminum will have the same resistivity as tungsten does at 20°C.

19. (II) A 100-W lightbulb has a resistance of about 12 Ω when cold (20°C) and 140 Ω when on (hot). Estimate the temperature of the filament when hot assuming an average temperature coefficient of resistivity $\alpha = 0.0045\ (\text{C}°)^{-1}$.

20. (II) Compute the voltage drop along a 26-m length of household no. 14 copper wire (used in 15-A circuits). The wire has diameter 1.628 mm and carries a 12-A current.

21. (II) Two aluminum wires have the same resistance. If one has twice the length of the other, what is the ratio of the diameter of the longer wire to the diameter of the shorter wire?

22. (II) A rectangular solid made of carbon has sides of lengths 1.0 cm, 2.0 cm, and 4.0 cm, lying along the x, y, and z axes, respectively (Fig. 35). Determine the resistance for current that passes through the solid in (*a*) the x direction, (*b*) the y direction, and (*c*) the z direction. Assume the resistivity is $\rho = 3.0 \times 10^{-5}\ \Omega \cdot \text{m}$.

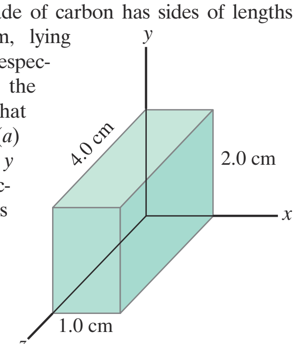

FIGURE 35 Problem 22.

23. (II) A length of aluminum wire is connected to a precision 10.00-V power supply, and a current of 0.4212 A is precisely measured at 20.0°C. The wire is placed in a new environment of unknown temperature where the measured current is 0.3818 A. What is the unknown temperature?

24. (II) Small changes in the length of an object can be measured using a **strain gauge** sensor, which is a wire with undeformed length ℓ_0, cross-sectional area A_0, and resistance R_0. This sensor is rigidly affixed to the object's surface, aligning its length in the direction in which length changes are to be measured. As the object deforms, the length of the wire sensor changes by $\Delta\ell$, and the resulting change ΔR in the sensor's resistance is measured. Assuming that as the solid wire is deformed to a length ℓ, its density (and volume) remains constant (only approximately valid), show that the strain $(= \Delta\ell/\ell_0)$ of the wire sensor, and thus of the object to which it is attached, is $\Delta R/2R_0$.

25. (II) A length of wire is cut in half and the two lengths are wrapped together side by side to make a thicker wire. How does the resistance of this new combination compare to the resistance of the original wire?

26. (III) For some applications, it is important that the value of a resistance not change with temperature. For example, suppose you made a 3.70-kΩ resistor from a carbon resistor and a Nichrome wire-wound resistor connected together so the total resistance is the sum of their separate resistances. What value should each of these resistors have (at 0°C) so that the combination is temperature independent?

27. (III) Determine a formula for the total resistance of a spherical shell made of material whose conductivity is σ and whose inner and outer radii are r_1 and r_2. Assume the current flows radially outward.

28. (III) The filament of a lightbulb has a resistance of 12 Ω at 20°C and 140 Ω when hot (as in Problem 19). (*a*) Calculate the temperature of the filament when it is hot, and take into account the change in length and area of the filament due to thermal expansion (assume tungsten for which the thermal expansion coefficient is $\approx 5.5 \times 10^{-6}\ \mathrm{C^{\circ -1}}$). (*b*) In this temperature range, what is the percentage change in resistance due to thermal expansion, and what is the percentage change in resistance due solely to the change in ρ? Use Eq. 5.

$$\rho_T = \rho_0[1 + \alpha(T - T_0)] \qquad \textbf{(5)}$$

29. (III) A 10.0-m length of wire consists of 5.0 m of copper followed by 5.0 m of aluminum, both of diameter 1.4 mm. A voltage difference of 85 mV is placed across the composite wire. (*a*) What is the total resistance (sum) of the two wires? (*b*) What is the current through the wire? (*c*) What are the voltages across the aluminum part and across the copper part?

30. (III) A hollow cylindrical resistor with inner radius r_1 and outer radius r_2, and length ℓ, is made of a material whose resistivity is ρ (Fig. 36). (*a*) Show that the resistance is given by

$$R = \frac{\rho}{2\pi\ell}\ln\frac{r_2}{r_1}$$

for current that flows radially outward. [*Hint*: Divide the resistor into concentric cylindrical shells and integrate.] (*b*) Evaluate the resistance R for such a resistor made of carbon whose inner and outer radii are 1.0 mm and 1.8 mm and whose length is 2.4 cm. (Choose $\rho = 15 \times 10^{-5}\ \Omega\cdot\mathrm{m}$.) (*c*) What is the resistance in part (*b*) for current flowing *parallel* to the axis?

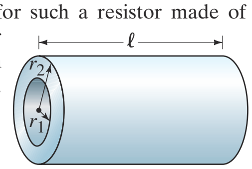

FIGURE 36 Problem 30.

5 and 6 Electric Power

31. (I) What is the maximum power consumption of a 3.0-V portable CD player that draws a maximum of 270 mA of current?

32. (I) The heating element of an electric oven is designed to produce 3.3 kW of heat when connected to a 240-V source. What must be the resistance of the element?

33. (I) What is the maximum voltage that can be applied across a 3.3-kΩ resistor rated at $\frac{1}{4}$ watt?

34. (I) (*a*) Determine the resistance of, and current through, a 75-W lightbulb connected to its proper source voltage of 110 V. (*b*) Repeat for a 440-W bulb.

35. (II) An electric power plant can produce electricity at a fixed power P, but the plant operator is free to choose the voltage V at which it is produced. This electricity is carried as an electric current I through a transmission line (resistance R) from the plant to the user, where it provides the user with electric power P'. (*a*) Show that the reduction in power $\Delta P = P - P'$ due to transmission losses is given by $\Delta P = P^2R/V^2$. (*b*) In order to reduce power losses during transmission, should the operator choose V to be as large or as small as possible?

36. (II) A 120-V hair dryer has two settings: 850 W and 1250 W. (*a*) At which setting do you expect the resistance to be higher? After making a guess, determine the resistance at (*b*) the lower setting; and (*c*) the higher setting.

37. (II) A 115-V fish-tank heater is rated at 95 W. Calculate (*a*) the current through the heater when it is operating, and (*b*) its resistance.

38. (II) You buy a 75-W lightbulb in Europe, where electricity is delivered to homes at 240 V. If you use the lightbulb in the United States at 120 V (assume its resistance does not change), how bright will it be relative to 75-W 120-V bulbs? [*Hint*: Assume roughly that brightness is proportional to power consumed.]

39. (II) How many kWh of energy does a 550-W toaster use in the morning if it is in operation for a total of 6.0 min? At a cost of 9.0 cents/kWh, estimate how much this would add to your monthly electric energy bill if you made toast four mornings per week.

40. (II) At \$0.095/kWh, what does it cost to leave a 25-W porch light on day and night for a year?

41. (II) What is the total amount of energy stored in a 12-V, 75-A·h car battery when it is fully charged?

42. (II) An ordinary flashlight uses two D-cell 1.5-V batteries connected in series (Fig. 37). The bulb draws 380 mA when turned on. (*a*) Calculate the resistance of the bulb and the power dissipated. (*b*) By what factor would the power increase if four D-cells in series were used with the same bulb? (Neglect heating effects of the filament.) Why shouldn't you try this?

Jim Wehtje/Photodisc/Getty Images

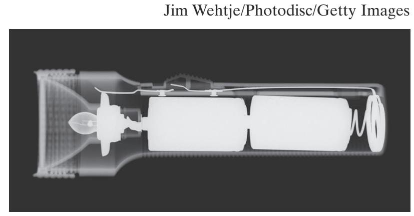

FIGURE 37 Problem 42.

43. (II) How many 75-W lightbulbs, connected to 120 V as in Fig. 20, can be used without blowing a 15-A fuse?

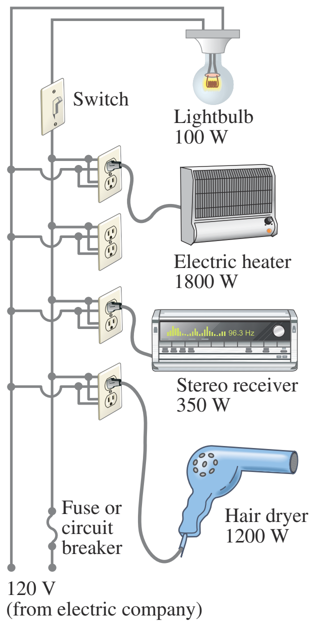

FIGURE 20 Connection of household appliances.

44. (II) An extension cord made of two wires of diameter 0.129 cm (no. 16 copper wire) and of length 2.7 m (9 ft) is connected to an electric heater which draws 15.0 A on a 120-V line. How much power is dissipated in the cord?

45. (II) A power station delivers 750 kW of power at 12,000 V to a factory through wires with total resistance 3.0 Ω. How much less power is wasted if the electricity is delivered at 50,000 V rather than 12,000 V?

46. (III) A small immersion heater can be used in a car to heat a cup of water for coffee or tea. If the heater can heat 120 mL of water from 25°C to 95°C in 8.0 min, (*a*) approximately how much current does it draw from the car's 12-V battery, and (*b*) what is its resistance? Assume the manufacturer's claim of 75% efficiency.

47. (III) The current in an electromagnet connected to a 240-V line is 17.5 A. At what rate must cooling water pass over the coils if the water temperature is to rise by no more than 6.50 C°?

48. (III) A 1.0-m-long round tungsten wire is to reach a temperature of 3100 K when a current of 15.0 A flows through it. What diameter should the wire be? Assume the wire loses energy only by radiation (emissivity $\epsilon = 1.0$, Section 19–10) and the surrounding temperature is 20°C.

7 Alternating Current

49. (I) Calculate the peak current in a 2.7-kΩ resistor connected to a 220-V rms ac source.

50. (I) An ac voltage, whose peak value is 180 V, is across a 380-Ω resistor. What are the rms and peak currents in the resistor?

51. (II) Estimate the resistance of the 120-V_{rms} circuits in your house as seen by the power company, when (*a*) everything electrical is unplugged, and (*b*) there are two 75-W lightbulbs burning.

52. (II) The peak value of an alternating current in a 1500-W device is 5.4 A. What is the rms voltage across it?

53. (II) An 1800-W arc welder is connected to a 660-V_{rms} ac line. Calculate (*a*) the peak voltage and (*b*) the peak current.

54. (II) (*a*) What is the maximum instantaneous power dissipated by a 2.5-hp pump connected to a 240-V_{rms} ac power source? (*b*) What is the maximum current passing through the pump?

55. (II) A heater coil connected to a 240-V_{rms} ac line has a resistance of 44 Ω. (*a*) What is the average power used? (*b*) What are the maximum and minimum values of the instantaneous power?

56. (II) For a time-dependent voltage $V(t)$, which is periodic with period T, the rms voltage is defined to be $V_{rms} = \left[\frac{1}{T}\int_0^T V^2\,dt\right]^{\frac{1}{2}}$. Use this definition to determine V_{rms} (in terms of the peak voltage V_0) for (*a*) a sinusoidal voltage, i.e., $V(t) = V_0 \sin(2\pi t/T)$ for $0 \le t \le T$; and (*b*) a positive square-wave voltage, i.e.,

$$V(t) = \begin{cases} V_0 & 0 \le t \le \frac{T}{2} \\ 0 & \frac{T}{2} \le t \le T \end{cases}.$$

8 Microscopic View of Electric Current

57. (II) A 0.65-mm-diameter copper wire carries a tiny current of 2.3 μA. Estimate (*a*) the electron drift velocity, (*b*) the current density, and (*c*) the electric field in the wire.

58. (II) A 5.80-m length of 2.0-mm-diameter wire carries a 750-mA current when 22.0 mV is applied to its ends. If the drift velocity is 1.7×10^{-5} m/s, determine (*a*) the resistance R of the wire, (*b*) the resistivity ρ, (*c*) the current density j, (*d*) the electric field inside the wire, and (*e*) the number n of free electrons per unit volume.

59. (II) At a point high in the Earth's atmosphere, He^{2+} ions in a concentration of $2.8 \times 10^{12}/\text{m}^3$ are moving due north at a speed of 2.0×10^6 m/s. Also, a $7.0 \times 10^{11}/\text{m}^3$ concentration of O_2^- ions is moving due south at a speed of 6.2×10^6 m/s. Determine the magnitude and direction of the current density $\vec{\mathbf{j}}$ at this point.

*10 Nerve Conduction

***60.** (I) What is the magnitude of the electric field across an axon membrane 1.0×10^{-8} m thick if the resting potential is −70 mV?

***61.** (II) A neuron is stimulated with an electric pulse. The action potential is detected at a point 3.40 cm down the axon 0.0052 s later. When the action potential is detected 7.20 cm from the point of stimulation, the time required is 0.0063 s. What is the speed of the electric pulse along the axon? (Why are two measurements needed instead of only one?)

***62.** (III) During an action potential, Na^+ ions move into the cell at a rate of about $3 \times 10^{-7}\ \text{mol/m}^2\cdot\text{s}$. How much power must be produced by the "active Na^+ pumping" system to produce this flow against a +30-mV potential difference? Assume that the axon is 10 cm long and 20 μm in diameter.

General Problems

63. A person accidentally leaves a car with the lights on. If each of the two headlights uses 40 W and each of the two taillights 6 W, for a total of 92 W, how long will a fresh 12-V battery last if it is rated at $85\ \text{A}\cdot\text{h}$? Assume the full 12 V appears across each bulb.

64. How many coulombs are there in 1.00 ampere-hour?

65. You want to design a portable electric blanket that runs on a 1.5-V battery. If you use copper wire with a 0.50-mm diameter as the heating element, how long should the wire be if you want to generate 15 W of heating power? What happens if you accidentally connect the blanket to a 9.0-V battery?

66. What is the average current drawn by a 1.0-hp 120-V motor? $(1\ \text{hp} = 746\ \text{W}.)$

67. The *conductance G* of an object is defined as the reciprocal of the resistance *R*; that is, $G = 1/R$. The unit of conductance is a *mho* $(= \text{ohm}^{-1})$, which is also called the *siemens* (S). What is the conductance (in siemens) of an object that draws 480 mA of current at 3.0 V?

68. The heating element of a 110-V, 1500-W heater is 3.5 m long. If it is made of iron, what must its diameter be?

69. (*a*) A particular household uses a 1.8-kW heater 2.0 h/day ("on" time), four 100-W lightbulbs 6.0 h/day, a 3.0-kW electric stove element for a total of 1.0 h/day, and miscellaneous power amounting to 2.0 kWh/day. If electricity costs \$0.105 per kWh, what will be their monthly bill (30 d)? (*b*) How much coal (which produces 7500 kcal/kg) must be burned by a 35%-efficient power plant to provide the yearly needs of this household?

70. A small city requires about 15 MW of power. Suppose that instead of using high-voltage lines to supply the power, the power is delivered at 120 V. Assuming a two-wire line of 0.50-cm-diameter copper wire, estimate the cost of the energy lost to heat per hour per meter. Assume the cost of electricity is about 9.0 cents per kWh.

71. A 1400-W hair dryer is designed for 117 V. (*a*) What will be the percentage change in power output if the voltage drops to 105 V? Assume no change in resistance. (*b*) How would the actual change in resistivity with temperature affect your answer?

72. The wiring in a house must be thick enough so it does not become so hot as to start a fire. What diameter must a copper wire be if it is to carry a maximum current of 35 A and produce no more than 1.5 W of heat per meter of length?

73. Determine the resistance of the tungsten filament in a 75-W 120-V incandescent lightbulb (*a*) at its operating temperature of about 3000 K, (*b*) at room temperature.

74. Suppose a current is given by the equation $I = 1.80 \sin 210t$, where I is in amperes and t in seconds. (*a*) What is the frequency? (*b*) What is the rms value of the current? (*c*) If this is the current through a 24.0-Ω resistor, write the equation that describes the voltage as a function of time.

75. A microwave oven running at 65% efficiency delivers 950 W to the interior. Find (*a*) the power drawn from the source, and (*b*) the current drawn. Assume a source voltage of 120 V.

76. A 1.00-Ω wire is stretched uniformly to 1.20 times its original length. What is its resistance now?

77. 220 V is applied to two different conductors made of the same material. One conductor is twice as long and twice the diameter of the second. What is the ratio of the power transformed in the first relative to the second?

78. An electric heater is used to heat a room of volume $54\ \text{m}^3$. Air is brought into the room at 5°C and is completely replaced twice per hour. Heat loss through the walls amounts to approximately 850 kcal/h. If the air is to be maintained at 20°C, what minimum wattage must the heater have? (The specific heat of air is about $0.17\ \text{kcal/kg}\cdot\text{C}°$.)

79. A 2800-W oven is connected to a 240-V source. (*a*) What is the resistance of the oven? (*b*) How long will it take to bring 120 mL of 15°C water to 100°C assuming 75% efficiency? (*c*) How much will this cost at 11 cents/kWh?

80. A proposed electric vehicle makes use of storage batteries as its source of energy. Its mass is 1560 kg and it is powered by 24 batteries, each 12 V, $95\ \text{A}\cdot\text{h}$. Assume that the car is driven on level roads at an average speed of 45 km/h, and the average friction force is 240 N. Assume 100% efficiency and neglect energy used for acceleration. No energy is consumed when the vehicle is stopped, since the engine doesn't need to idle. (*a*) Determine the horsepower required. (*b*) After approximately how many kilometers must the batteries be recharged?

81. A 12.5-Ω resistor is made from a coil of copper wire whose total mass is 15.5 g. What is the diameter of the wire, and how long is it?

82. A fish-tank heater is rated at 95 W when connected to 120 V. The heating element is a coil of Nichrome wire. When uncoiled, the wire has a total length of 3.8 m. What is the diameter of the wire?

83. A 100-W, 120-V lightbulb has a resistance of 12 Ω when cold (20°C) and 140 Ω when on (hot). Calculate its power consumption (*a*) at the instant it is turned on, and (*b*) after a few moments when it is hot.

84. In an automobile, the system voltage varies from about 12 V when the car is off to about 13.8 V when the car is on and the charging system is in operation, a difference of 15%. By what percentage does the power delivered to the headlights vary as the voltage changes from 12 V to 13.8 V? Assume the headlight resistance remains constant.

85. The Tevatron accelerator at Fermilab (Illinois) is designed to carry an 11-mA beam of protons traveling at very nearly the speed of light $(3.0 \times 10^8\ \text{m/s})$ around a ring 6300 m in circumference. How many protons are in the beam?

86. Lightbulb A is rated at 120 V and 40 W for household applications. Lightbulb B is rated at 12 V and 40 W for automotive applications. (*a*) What is the current through each bulb? (*b*) What is the resistance of each bulb? (*c*) In one hour, how much charge passes through each bulb? (*d*) In one hour, how much energy does each bulb use? (*e*) Which bulb requires larger diameter wires to connect its power source and the bulb?

87. An air conditioner draws 14 A at 220-V ac. The connecting cord is copper wire with a diameter of 1.628 mm. (*a*) How much power does the air conditioner draw? (*b*) If the total length of wire is 15 m, how much power is dissipated in the wiring? (*c*) If no. 12 wire, with a diameter of 2.053 mm, was used instead, how much power would be dissipated in the wiring? (*d*) Assuming that the air conditioner is run 12 h per day, how much money per month (30 days) would be saved by using no. 12 wire? Assume that the cost of electricity is 12 cents per kWh.

88. Copper wire of diameter 0.259 cm is used to connect a set of appliances at 120 V, which draw 1750 W of power total. (*a*) What power is wasted in 25.0 m of this wire? (*b*) What is your answer if wire of diameter 0.412 cm is used?

89. Battery-powered electricity is very expensive compared with that available from a wall receptacle. Estimate the cost per kWh of (*a*) an alkaline D-cell (cost $1.70) and (*b*) an alkaline AA-cell (cost $1.25). These batteries can provide a continuous current of 25 mA for 820 h and 120 h, respectively, at 1.5 V. Compare to normal 120-V ac house current at $0.10/kWh.

90. How far does an average electron move along the wires of a 550-W toaster during an alternating current cycle? The power cord has copper wires of diameter 1.7 mm and is plugged into a standard 60-Hz 120-V ac outlet. [*Hint*: The maximum current in the cycle is related to the maximum drift velocity. The maximum velocity in an oscillation is related to the maximum displacement.]

91. A copper pipe has an inside diameter of 3.00 cm and an outside diameter of 5.00 cm (Fig. 38). What is the resistance of a 10.0-m length of this pipe?

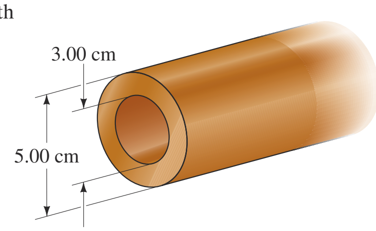

FIGURE 38
Problem 91.

92. For the wire in Fig. 39, whose diameter varies uniformly from a to b as shown, suppose a current $I = 2.0\text{ A}$ enters at a. If $a = 2.5\text{ mm}$ and $b = 4.0\text{ mm}$, what is the current density (assume uniform) at each end?

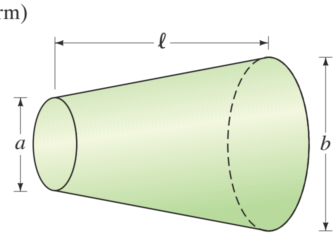

FIGURE 39
Problems 92 and 93.

93. The cross section of a portion of wire increases uniformly as shown in Fig. 39 so it has the shape of a truncated cone. The diameter at one end is a and at the other it is b, and the total length along the axis is ℓ. If the material has resistivity ρ, determine the resistance R between the two ends in terms of a, b, ℓ, and ρ. Assume that the current flows uniformly through each section, and that the taper is small, i.e., $(b - a) \ll \ell$.

94. A tungsten filament used in a flashlight bulb operates at 0.20 A and 3.2 V. If its resistance at 20°C is 1.5 Ω, what is the temperature of the filament when the flashlight is on?

95. The level of liquid helium (temperature $\leq 4\text{ K}$) in its storage tank can be monitored using a vertically aligned niobium–titanium (NbTi) wire, whose length ℓ spans the height of the tank. In this level-sensing setup, an electronic circuit maintains a constant electrical current I at all times in the NbTi wire and a voltmeter monitors the voltage difference V across this wire. Since the superconducting transition temperature for NbTi is 10 K, the portion of the wire immersed in the liquid helium is in the superconducting state, while the portion above the liquid (in helium vapor with temperature above 10 K) is in the normal state. Define $f = x/\ell$ to be the fraction of the tank filled with liquid helium (Fig. 40) and V_0 to be the value of V when the tank is empty ($f = 0$). Determine the relation between f and V (in terms of V_0).

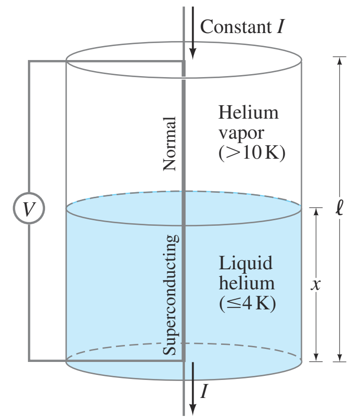

FIGURE 40
Problem 95.

*Numerical/Computer

***96.** (II) The resistance, R, of a particular thermistor as a function of temperature T is shown in this Table:

T (°C)	*R* (Ω)	*T* (°C)	*R* (Ω)
20	126,740	36	60,743
22	115,190	38	55,658
24	104,800	40	51,048
26	95,447	42	46,863
28	87,022	44	43,602
30	79,422	46	39,605
32	72,560	48	36,458
34	66,356	50	33,591

Determine what type of best-fit equation (linear, quadratic, exponential, other) describes the variation of R with T. The resistance of the thermistor is 57,641 Ω when embedded in a substance whose temperature is unknown. Based on your equation, what is the unknown temperature?