*60. (II) A battery with $\mathscr{E} = 12.0\,\text{V}$ and internal resistance $r = 1.0\,\Omega$ is connected to two 9.0-kΩ resistors in series. An ammeter of internal resistance $0.50\,\Omega$ measures the current, and at the same time a voltmeter with internal resistance $15\,\text{k}\Omega$ measures the voltage across one of the 9.0-kΩ resistors in the circuit. What do the ammeter and voltmeter read?

*61. (III) Two 9.4-kΩ resistors are placed in series and connected to a battery. A voltmeter of sensitivity $1000\,\Omega/\text{V}$ is on the 3.0-V scale and reads 2.0 V when placed across either resistor. What is the emf of the battery? (Ignore its internal resistance.)

*62. (III) What internal resistance should the voltmeter of Example 19–15 have to be in error by less than 3%?

*63. (III) When the resistor R in Fig. 19–59 is $35\,\Omega$, the high-resistance voltmeter reads 9.7 V. When R is replaced by a $9.0\text{-}\Omega$ resistor, the voltmeter reading drops to 8.1 V. What are the emf and internal resistance of the battery?

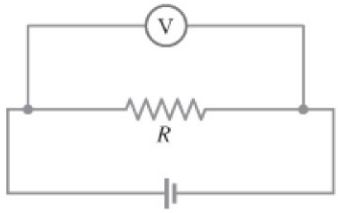

FIGURE 19–59
Problem 63.

General Problems

64. Suppose that you wish to apply a 0.25-V potential difference between two points on the human body. The resistance is about $2000\,\Omega$, and you only have a 9.0-V battery. How can you connect up one or more resistors to produce the desired voltage?

65. A **three-way lightbulb** can produce 50 W, 100 W, or 150 W, at 120 V. Such a bulb contains two filaments that can be connected to the 120 V individually or in parallel. (*a*) Describe how the connections to the two filaments are made to give each of the three wattages. (*b*) What must be the resistance of each filament?

66. Suppose you want to run some apparatus that is 95 m from an electric outlet. Each of the wires connecting your apparatus to the 120-V source has a resistance per unit length of $0.0065\,\Omega/\text{m}$. If your apparatus draws 3.0 A, what will be the voltage drop across the connecting wires and what voltage will be applied to your apparatus?

67. Electricity can be a hazard in hospitals, particularly to patients who are connected to electrodes, such as an ECG. For example, suppose that the motor of a motorized bed shorts out to the bed frame, and the bed frame's connection to a ground has broken (or was not there in the first place). If a nurse touches the bed and the patient at the same time, she becomes a conductor and a complete circuit can be made through the patient to ground through the ECG apparatus. This is shown schematically in Fig. 19–60. Calculate the current through the patient.

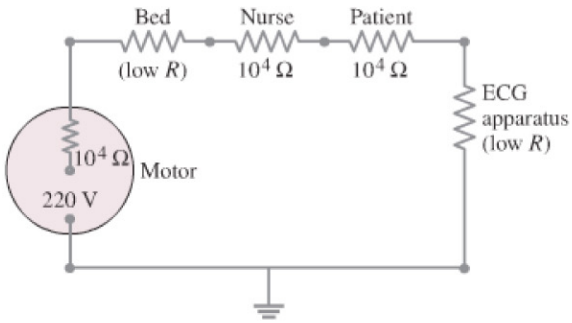

FIGURE 19–60 Problem 67.

68. How much energy must a 45-V battery expend to charge a $0.40\text{-}\mu\text{F}$ and a $0.60\text{-}\mu\text{F}$ capacitor fully when they are placed (*a*) in parallel, (*b*) in series? (*c*) How much charge flowed from the battery in each case?

69. A heart pacemaker is designed to operate at 72 beats/min using a $7.5\text{-}\mu\text{F}$ capacitor in a simple RC circuit. What value of resistance should be used if the pacemaker is to fire (capacitor discharge) when the voltage reaches 63% of maximum?

70. Suppose that a person's body resistance is $950\,\Omega$. (*a*) What current passes through the body when the person accidentally is connected to 110 V? (*b*) If there is an alternative path to ground whose resistance is $45\,\Omega$, what current passes through the person? (*c*) If the voltage source can produce at most 1.5 A, how much current passes through the person in case (*b*)?

71. A **Wheatstone bridge** is a type of "bridge circuit" used to make measurements of resistance. The unknown resistance to be measured, R_x, is placed in the circuit with accurately known resistances R_1, R_2, and R_3 (Fig. 19–61). One of these, R_3, is a variable resistor which is adjusted so that when the switch is closed momentarily, the ammeter Ⓐ shows zero current flow. (*a*) Determine R_x in terms of R_1, R_2, and R_3. (*b*) If a Wheatstone bridge is "balanced" when $R_1 = 630\,\Omega$, $R_2 = 972\,\Omega$, and $R_3 = 42.6\,\Omega$, what is the value of the unknown resistance?

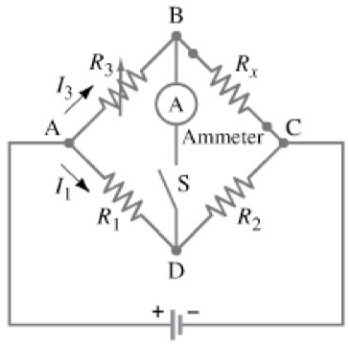

FIGURE 19–61
Problems 71 and 72.
Wheatstone bridge.

72. An unknown length of platinum wire 0.920 mm in diameter is placed as the unknown resistance in a Wheatstone bridge (see Problem 71; Fig. 19–61). Arms 1 and 2 have resistance of $38.0\,\Omega$ and $46.0\,\Omega$, respectively. Balance is achieved when R_3 is $3.48\,\Omega$. How long is the platinum wire?