13. Can the terminal voltage of a battery ever exceed its emf? Explain.
14. Explain in detail how you could measure the internal resistance of a battery.
15. In an *RC* circuit, current flows from the battery until the capacitor is completely charged. Is the total energy supplied by the battery equal to the total energy stored by the capacitor? If not, where does the extra energy go?
16. Given the circuit shown in Fig. 19–38, use the words "increases," "decreases," or "stays the same" to complete the following statements:
(*a*) If R_7 increases, the potential difference between A and E _____. Assume no resistance in Ⓐ and ℰ.
(*b*) If R_7 increases, the potential difference between A and E _____. Assume Ⓐ and ℰ have resistance.
(*c*) If R_7 increases, the voltage drop across R_4 _____.
(*d*) If R_2 decreases, the current through R_1 _____.
(*e*) If R_2 decreases, the current through R_6 _____.
(*f*) If R_2 decreases, the current through R_3 _____.
(*g*) If R_5 increases, the voltage drop across R_2 _____.
(*h*) If R_5 increases, the voltage drop across R_4 _____.
(*i*) If R_2, R_5, and R_7 increase, ℰ ($r = 0$) _____.

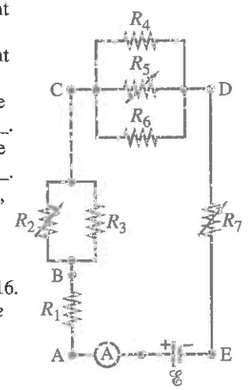

FIGURE 19–38 Question 16. R_2, R_5, and R_7 are *variable* resistors (you can change their resistance), given the symbol -WWW-.

17. Design a circuit in which two different switches of the type shown in Fig. 19–39 can be used to operate the same lightbulb from opposite sides of a room.

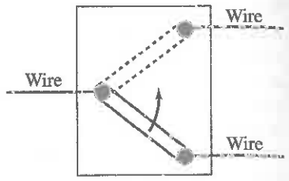

FIGURE 19–39 Question 17.

18. Why is it more dangerous to turn on an electric appliance when you are standing outside in bare feet than when you are inside wearing shoes with thick soles?
19. What is the main difference between an analog voltmeter and an analog ammeter?
20. What would happen if you mistakenly used an ammeter where you needed to use a voltmeter?
21. Explain why an ideal ammeter would have zero resistance and an ideal voltmeter infinite resistance.
22. A voltmeter connected across a resistor always reads *less* than the actual voltage (i.e., when the meter is not present). Explain.
23. A small battery-operated flashlight requires a single 1.5-V battery. The bulb is barely glowing. But when you take the battery out and check it with a digital voltmeter, it registers 1.5 V. How would you explain this?

MisConceptual Questions

1. In which circuits shown in Fig. 19–40 are resistors connected in series?

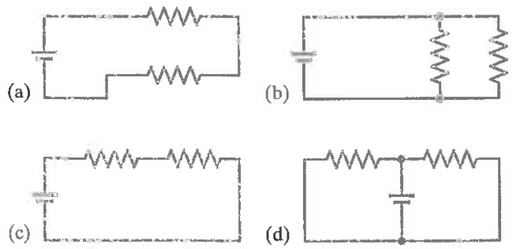

FIGURE 19–40 MisConceptual Question 1.

2. Which resistors in Fig. 19–41 are connected in parallel?
(*a*) All three.
(*b*) R_1 and R_2.
(*c*) R_2 and R_3.
(*d*) R_1 and R_3.
(*e*) None of the above.

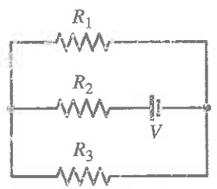

FIGURE 19–41 MisConceptual Question 2.

3. A 10,000-Ω resistor is placed in series with a 100-Ω resistor. The current in the 10,000-Ω resistor is 10 A. If the resistors are swapped, how much current flows through the 100-Ω resistor?
(*a*) >10 A. (*b*) <10 A. (*c*) 10 A.
(*d*) Need more information about the circuit.
4. Two identical 10-V batteries and two identical 10-Ω resistors are placed in series as shown in Fig. 19–42. If a 10-Ω lightbulb is connected with one end connected between the batteries and other end between the resistors, how much current will flow through the lightbulb?
(*a*) 0 A.
(*b*) 1 A.
(*c*) 2 A.
(*d*) 4 A.

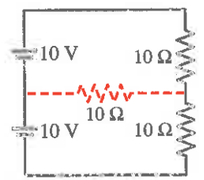

FIGURE 19–42 MisConceptual Question 4.

5. Which resistor shown in Fig. 19–43 has the greatest current going through it? Assume that all the resistors are equal.
(*a*) R_1. (*d*) R_5.
(*b*) R_1 and R_2. (*e*) All of them the same.
(*c*) R_3 and R_4.

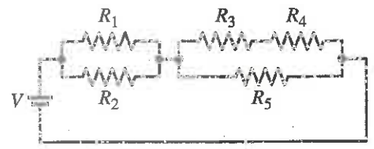

FIGURE 19–43 MisConceptual Question 5.

6. Figure 19–44 shows three identical bulbs in a circuit. What happens to the brightness of bulb A if you replace bulb B with a short circuit?
(*a*) Bulb A gets brighter.
(*b*) Bulb A gets dimmer.
(*c*) Bulb A's brightness does not change.
(*d*) Bulb A goes out.

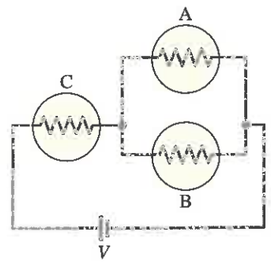

FIGURE 19–44 MisConceptual Question 6.

7. When the switch shown in Fig. 19–45 is closed, what will happen to the voltage across resistor R_4? It will
(*a*) increase. (*b*) decrease. (*c*) stay the same.

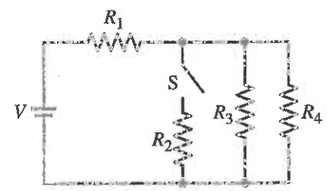

FIGURE 19–45 MisConceptual Questions 7 and 8.

8. When the switch shown in Fig. 19–45 is closed, what will happen to the voltage across resistor R_1? It will
(*a*) increase. (*b*) decrease. (*c*) stay the same.
9. As a capacitor is being charged in an *RC* circuit, the current flowing through the resistor is
(*a*) increasing. (*c*) constant.
(*b*) decreasing. (*d*) zero.
10. For the circuit shown in Fig. 19–46, what happens when the switch S is closed?
(*a*) Nothing. Current cannot flow through the capacitor.
(*b*) The capacitor immediately charges up to the battery emf.
(*c*) The capacitor eventually charges up to the full battery emf at a rate determined by R and C.
(*d*) The capacitor charges up to a fraction of the battery emf determined by R and C.
(*e*) The capacitor charges up to a fraction of the battery emf determined by R only.

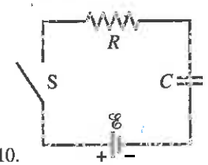

FIGURE 19–46 MisConceptual Question 10.

11. The capacitor in the circuit shown in Fig. 19–47 is charged to an initial value Q. When the switch is closed, it discharges through the resistor. It takes 2.0 seconds for the charge to drop to $\frac{1}{2}Q$. How long does it take to drop to $\frac{1}{4}Q$?
(*a*) 3.0 seconds.
(*b*) 4.0 seconds.
(*c*) Between 2.0 and 3.0 seconds.
(*d*) Between 3.0 and 4.0 seconds.
(*e*) More than 4.0 seconds.

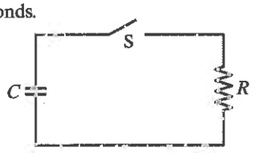

FIGURE 19–47 MisConceptual Question 11.

12. A resistor and a capacitor are used in series to control the timing in the circuit of a heart pacemaker. To design a pacemaker that can double the heart rate when the patient is exercising, which statement below is true? The capacitor
(*a*) needs to discharge faster, so the resistance should be decreased.
(*b*) needs to discharge faster, so the resistance should be increased.
(*c*) needs to discharge slower, so the resistance should be decreased.
(*d*) needs to discharge slower, so the resistance should be increased.
(*e*) does not affect the timing, regardless of the resistance.
13. Why is an appliance cord with a three-prong plug safer than one with two prongs?
(*a*) The 120 V from the outlet is split among three wires, so it isn't as high a voltage as when it is only split between two wires.
(*b*) Three prongs fasten more securely to the wall outlet.
(*c*) The third prong grounds the case, so the case cannot reach a high voltage.
(*d*) The third prong acts as a ground wire, so the electrons have an easier time leaving the appliance. As a result, fewer electrons build up in the appliance.
(*e*) The third prong controls the capacitance of the appliance, so it can't build up a high voltage.
14. When capacitors are connected in series, the effective capacitance is _____ the smallest capacitance; when capacitors are connected in parallel, the effective capacitance is _____ the largest capacitance.
(*a*) greater than; equal to. (*d*) equal to; less than.
(*b*) greater than; less than. (*e*) equal to; equal to.
(*c*) less than; greater than.
15. If ammeters and voltmeters are not to significantly alter the quantities they are measuring,
(*a*) the resistance of an ammeter and a voltmeter should be much higher than that of the circuit element being measured.
(*b*) the resistance of an ammeter should be much lower, and the resistance of a voltmeter should be much higher, than those of the circuit being measured.
(*c*) the resistance of an ammeter should be much higher, and the resistance of a voltmeter should be much lower, than those of the circuit being measured.
(*d*) the resistance of an ammeter and a voltmeter should be much lower than that of the circuit being measured.
(*e*) None of the above.