

## 2 Chapter 9: Current and Resistance

1. An ECG monitor must have an RC time constant less than  $100\mu\text{s}$  to be able to measure variations in voltage over small time intervals. (a) If the resistance of the circuit (due mostly to that of the patient's chest) is  $1.00\text{ k}\Omega$ , what is the maximum capacitance of the circuit? (b) Would it be difficult in practice to limit the capacitance to less than the value found in (a)? (c) If the patient's resistance really is  $1.00\text{ k}\Omega$ , and the typical maximum amplitude of the patient's heartbeat is  $60\text{ mV}$ , when does the voltage rise to  $30\text{ mV}$  in the EKG monitor (using the C you found in (a))?

a.]  $\tau = RC$

$$100\mu\text{s} > RC$$

$$C < \frac{100 \times 10^{-6} \text{ sec}}{1000 \Omega}$$

$$C < 1 \times 10^{-7} \text{ F}$$

b.] In practice, it would not be difficult to limit the capacitance

c.]  $V_c(t) = \mathcal{E}_1 (1 - e^{(-t/\tau)})$

$$30 \times 10^{-3} \text{ V} = (60 \times 10^{-3} \text{ V}) (1 - e^{(-t/100\mu\text{s})}) (1 \times 10^{-7} \text{ F})$$

$$\ln\left(\frac{-30 \times 10^{-3} \text{ V}}{60 \times 10^{-3} \text{ V}} + 1\right) = \ln(e^{(-t/1 \times 10^{-4})})$$

$$(1 \times 10^{-4}) \ln\left(\frac{-30 \times 10^{-3} \text{ V}}{60 \times 10^{-3} \text{ V}} + 1\right) = -t$$

$$(\ln 1/2) (-1 \times 10^{-4}) = t = -6.93 \times 10^{-5} \text{ s}$$

2. Imagine an *alternating current* (AC) system, as opposed to the DC systems we normally consider. In AC circuits, the voltage follows a form

$$V(t) = V_0 \sin(2\pi ft + \phi) \quad (1)$$

The wall outlets in the USA have  $f = 60\text{ Hz}$  and  $V_0 = 120\text{ V}$ . We have the freedom to choose  $\phi$  in this example, much like choosing the zero-point of voltage. (a) Suppose  $\phi = 0$ . At what times will  $V(t) = 0$ ? (b) What is the max power delivered to a  $1\text{ k}\Omega$  resistor? (c) What is the *average* power delivered to a  $1\text{ k}\Omega$  resistor?

a.]  $V(t) = V_0 \sin(2\pi ft + \phi)$

$$0 = \sin(2\pi ft + \phi)$$

$$0 = \sin(2\pi ft)$$

$$= \sin(2\pi 60t)$$

$$\frac{1}{120} = t, \quad t = 0, \frac{1}{120}, \frac{1}{100}$$

real numbers  
 $t = \frac{x}{120}$

b.]  $OV = iR$

$$\frac{120 \text{ V}}{1000 \Omega} = i$$

$$12 \text{ V}/\Omega = i$$

$$P = iV$$

$$P = (12)(120 \text{ V})$$

$$P = 1440 \text{ W}$$

c.]  $OV = iR$

$$i = \frac{60 \text{ V}}{1000 \Omega} = .06 \text{ V}/\Omega$$

$$P = iV$$

$$P = .06(60) = 3.6 \text{ W}$$

3. For those of us stuck at home! A physics student has a single-occupancy dorm room. The student has a small refrigerator that runs with a current of  $3.00\text{ A}$  and a voltage of  $110\text{ V}$ , a lamp that contains a  $100\text{-W}$  bulb, an overhead light with a  $60\text{-W}$  bulb, and various other small devices adding up to  $3.00\text{ W}$ . In Southern California, electricity costs about  $0.2$  dollars per kiloWatt-hour. How much money does this student spend if the total wattage is on for  $12$  hours per day for one month?

$$I = 3 \text{ A}$$

$$W = VA = 110 \text{ V}(3 \text{ A}) = 330 \text{ W}$$

$$330 \text{ W} + 100 \text{ W} + 60 \text{ W} + 3 \text{ W} = 493 \text{ W}$$

$$\rightarrow 493 \text{ W} \cdot \frac{12 \text{ hr}}{1 \text{ day}} \cdot \frac{30 \text{ day}}{1 \text{ month}} \cdot \frac{1 \text{ kW}}{1000 \text{ W}} \cdot \frac{\$0.2}{1 \text{ kW}} = \$35.96 \text{ per month}$$

## 3 Chapter 10: Direct-Current (DC) Circuits

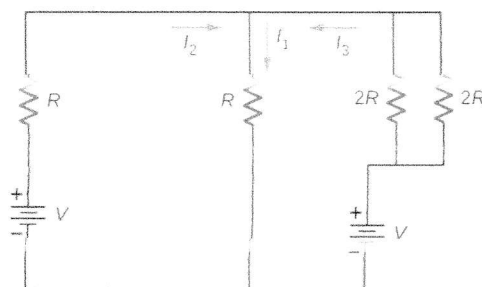


Figure 1: A circuit with two batteries and three resistors.

1. Solve for  $i_1$ ,  $i_2$ , and  $i_3$  in Fig. 1, if  $R = 1\text{ k}\Omega$ , and  $V = 12.0\text{ Volts}$ . What power is consumed in the resistors?