2 Chapter 9: Current and Resistance

1. An ECG monitor must have an RC time constant less than 100μs 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 patients chest) is 1.00 kΩ, 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 kΩ, and the typical maximum amplitude of the patient's heartbeat is 60 mV, when does the voltage rise to 30 mV in the EKG monitor (using the C you found in (a))?

a. $C = \frac{\tau}{R}$

$100\times10^{-6} = 10^{3}\times C$

$=1\times10^{-7}$ F

b. No it would not b/c the time constant is at its max and you can scale it

c. $V_c(t) = \mathcal{E}.(1-\exp(-t/\tau))$

$30 = 60(1-e^{-(\frac{t}{100\times10^{-6}})})$

$0.5 = e^{-(t/(100\times10^{-6}))}$

$0.693 = \frac{t}{100\times10^{-6}}$ $\quad t = 6.93\times10^{-5}$ sec

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

$$V(t) = V_0\sin(2\pi f t + \phi) \qquad (1)$$

The wall outlets in the USA have $f = 60$ Hz and $V_0 = 120$ V. *We have the freedom to choose ϕ 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 1kΩ resistor? (c) What is the *average* power delivered to a 1kΩ resistor?

a. $V(t) = 120\sin(120\pi t)$

$V(t)=0$ when $\sin(2\pi f t)=0$

$2\pi f t = \pm n\pi,\ n=0,1,2,\to$

$V(t)=0$

$t = \pm\frac{n}{2f}$

$n=0,1,2,\to$

b. $=\frac{(120)^2}{1000}$

$=14.4$ W

$P=\frac{V^2}{R}$

c. integral would be 0. Area under the curve would cancel b/c +120 and -120.

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 A and a voltage of 110 V, a lamp that contains a 100-W bulb, an overhead light with a 60-W bulb, and various other small devices adding up to 3.00 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?

$3(110) = 330$W

$330+100+60+3$

$=493$W $\to$ 0.493kWh

1month ≈ 30 days

$12\times30 = 360$ hrs

$360\times0.493 = 177.48$kWh

$177.48(0.2) = \$35.49$

3 Chapter 10: Direct-Current (DC) Circuits

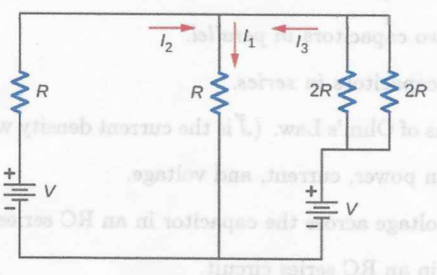

Figure 1: A circuit with two batteries and three resistors.

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

$\frac{n-12}{1000} + \frac{n}{1000} + \frac{n-12}{1000} = 0$

$3n = 24$

$=8$V

$i_1 = \frac{8}{1000} = 8$mA $= 0.008$A

$i_2 = \frac{12-8}{1000} = 4$mA $= 0.004$A

$i_3 = \frac{12-8}{1000} = 4$mA $= 0.004$A

Resistor in i_1: $(0.008)^2(1000) = 0.064$ W

Resistor in i_2: $(0.004)^2(1000) = 0.016$W

Resistor in i_3: $(0.002)^2(2000) = 0.008$ W/each resistor