Physics 111 Homework Solutions Week #3 - Friday

Tuesday, January 21, 2014

Chapter 16

Questions

- None

Multiple-Choice

- None

Problems

16.2 The current is given by the average charge per unit interval of time. Here, 5 μC flows in 2 μs, so $I = \frac{\Delta Q}{\Delta t} = \frac{5\times10^{-6}C}{2\times10^{-6}s} = 2.5A.$

16.3 To calculate the average current that flows across this muscle membrane, I need to know how many sodium channels there are over this area. Then knowing the number of ions that flow per millisecond I can calculate the average current. To start I'm going to calculate the total number of sodium channels over this patch of membrane: $\#\,\text{Na Channels} = \frac{50\,\text{Na Channels}}{\mu m^2}\times 100\mu m^2 = 5000\,\text{Na Channels}$. If there are *1000 Na* ions per channel flowing per millisecond, then the average current is given by:

$$I_{avg} = (5000\text{channels}\times\frac{1000\,{}^{\text{ions}}\!/_{\text{channel}}}{1\times10^{-3}s})\times\frac{1e}{\text{ion}}\times\frac{1.6x10^{-19}C}{1e} = 8\times10^{-10}A = 0.8nA.$$

16.17 Using $V(t) = \frac{V_0}{2} = V_0 e^{-\frac{t}{RC}}$ gives for a time, called the half time, $\ln\left(\frac{1}{2}\right) = \frac{-t_{\frac{1}{2}}}{RC} \rightarrow t_{\frac{1}{2}} = RC\ln(2)$. Thus, a single measurement of the half-time will give the value of the time constant (RC) in a single measurement.

16.20 A defibrillator

a. The time constant is $\tau = RC = 47\times10^3\Omega\times32\times10^{-6}F = 1.5s$

b. The maximum charge is $Q_{\max} = CV_{\max} = 32\times10^{-6}F\times5000V = 0.16C$.

c. The maximum current is given by Ohm's Law

$$I_{\max} = \frac{V_{\max}}{R} = \frac{5000V}{47\times10^3\Omega} = 0.106A = 106mA$$

d. The charge as a function of time is given as

$Q(t) = Q_{\max}\left(1 - e^{-\frac{t}{\tau}}\right) = 0.160C\left(1 - e^{-\frac{t}{1.5s}}\right)$. The current as a function of time is

$I(t) = I_{\max}\left(1 - e^{-\frac{t}{\tau}}\right) = 0.106A\left(1 - e^{-\frac{t}{1.5s}}\right)$

e. The maximum energy is $E = \frac{1}{2}CV^2 = \frac{1}{2} \times 32 \times 10^{-6} F \times (5000V)^2 = 400J$.

Wednesday, January 22, 2014

Chapter 16

Questions

- None

Multiple-Choice

- None

Problems

- None