ELEC ENG 3BB3 – Cellular Bioelectricity (2014)

Tutorial #2

1. Consider an excitable cell with $C_m = 1\,\mu\text{F}/\text{cm}^2$, sodium equilibrium potential and resting conductance respectively of $E_{\text{Na}} = 90\text{ mV}$ and $g_{\text{Na}} = 0.2\text{ mS}/\text{cm}^2$, and potassium equilibrium potential and respective conductance respectively of $E_{\text{K}} = -90\text{ mV}$ and $g_{\text{K}} = 1.6\text{ mS}/\text{cm}^2$.

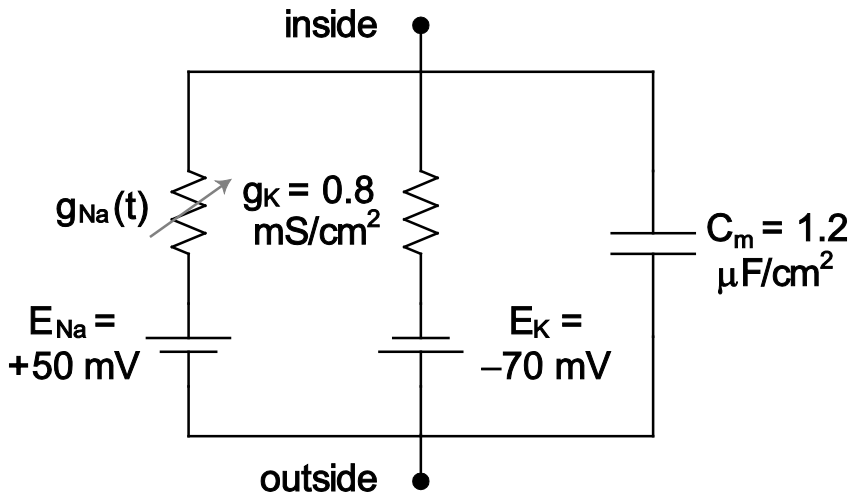
   a. Find V_{rest}.

   b. If $V_m(t) = V_{\text{rest}}$ and $I_m(t) = 0$ for $t < 0$, and $I_m(t) = 36\,\mu\text{A}/\text{cm}^2$ for $t \geq 0$, then find $V_m(t)$ for $t \geq 0$.

   c. If $V_m(t) = V_{\text{rest}}$, $I_m(t) = 0$ and $g_{\text{Na}}(t) = 0.2\text{ mS}/\text{cm}^2$ for $t < 0$, and $I_m(t) = 0$ and $g_{\text{Na}}(t) = 0.4\text{ mS}/\text{cm}^2$ for $t \geq 0$, then find $V_m(t)$ for $t \geq 0$.

   d. What is $V_m(t \to \infty)$ if $I_m(t) = -36\,\mu\text{A}/\text{cm}^2$ and $g_{\text{Na}}(t) = 0.2\text{ mS}/\text{cm}^2$ for $t \geq 0$?
   What is $V_m(t \to \infty)$ if $I_m(t) = -36\,\mu\text{A}/\text{cm}^2$ and $g_{\text{Na}}(t) = 0.4\text{ mS}/\text{cm}^2$ for $t \geq 0$?

2. An excitable cell has the parallel-conductance model for a membrane patch shown below.



   Consider the case where the membrane is at rest for time $t < 0$, and the resting sodium conductance g_{Na} is 0.05 mS/cm^2. If the membrane is then subjected to an intracellular current injection of $I_0 = -15\,\mu\text{A}/\text{cm}^2$ for time $t \geq 0$ **and** at $t = 2\text{ ms}$ the sodium conductance switches instantaneously to a new value of 1.0 mS/cm^2 and stays at that conductance for $t \geq 2\text{ ms}$, find the membrane potential response $V_m(t)$ for all $t \geq 0$.