

$$v_{Na} = 115\text{mV}, \quad v_K = -12\text{mV}, \quad v_{Na} = 10.6\text{mV}, \quad C = 1\mu\text{Farad/cm}^2,$$

where " Ω " is one Ohm, the unit of resistance.

Non-dimensionalise with $v = v/v_{Na}$ and $\tau = t/[5\text{ms}]$, as $\tau_n(v) \sim O(5\text{ms})$, and we have

$$\begin{aligned} \epsilon \frac{dv}{d\tau} &= I_{ext} - g(v, n) \stackrel{\text{def}}{=} I_{ext} - [m_{\infty}^3(v)(0.85 - n)(v - 1) + \gamma_K n^4(v + v_K) + \gamma_L(v - v_L)] \\ \frac{dn}{d\tau} &= k(v, n) \stackrel{\text{def}}{=} \frac{1}{\tau_n^*(v)} [n_{\infty}(v) - n], \end{aligned} \quad (21)$$

with

$$\epsilon = \frac{C}{G_{Na}[5\text{ms}]} = 2 \times 10^{-3}, \quad \gamma_K = \frac{G_K}{G_{Na}} \sim 0.3, \quad \gamma_L = \frac{G_L}{G_{Na}} \sim 3 \times 10^{-3},$$

$$I_{ext} = \frac{I_{ext}}{G_{Na}v_{Na}}, \quad v_K = -\frac{v_K}{v_{Na}} \sim 0.1, \quad v_L = -\frac{v_L}{v_{Na}} \sim 0.1, \quad \tau_n^*(v) = \tau_n(v)/[5\text{ms}] \sim O(1).$$

We can now sketch the nullclines, and noting the different timescales of the membrane potential response to the gating variable response (as $\epsilon \ll 1$) we can consider the phase plane trajectories in terms of fast and slow dynamics.

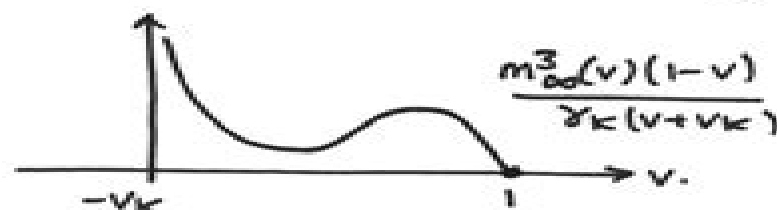
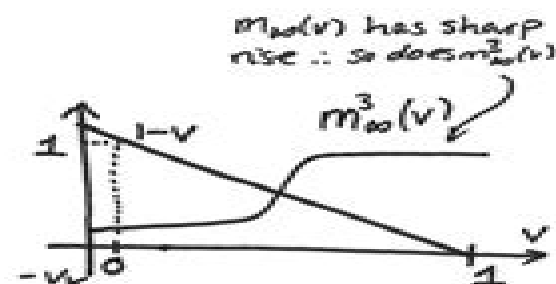
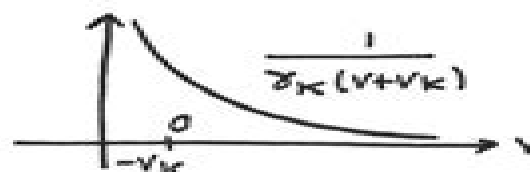
Plotting nullclines. $I_{ext} = 0$.

$$\begin{aligned} -\epsilon dv/d\tau = g &= m_{\infty}^3(v)(0.85 - n)(v - 1) + \gamma_K n^4(v + v_K) + \gamma_L(v - v_L) \\ dn/d\tau = k &= \frac{1}{\tau_n^*(v)} [n_{\infty}(v) - n] \end{aligned}$$

γ_L small: neglect this below.

v nullcline

$$\frac{n^4}{0.85 - n} = \frac{m_{\infty}^3(v)(1 - v)}{\gamma_K(v + v_K)}$$



Mathematical Physiology

**P.Bilgin, P.D. Williams, M. Sekiguchi, J.
K. Galbraith, S. T. Inayatullah, J.
Wiener, R. A. Schrire, I.L. Murphy**

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Models in Human Physiology Johnny T. Ottesen, Mette S. Olufsen, Jesper K. Larsen, 2004-02-01 This book introduces mathematicians to real applications from physiology Using mathematics to analyze physiological systems the authors discuss models reflecting current research in cardiovascular and pulmonary physiology In particular they present models describing blood flow in the heart and the cardiovascular system as well as the transport of oxygen and carbon dioxide through the respiratory system and a model for baroreceptor regulation This is the only book available that analyzes up to date models of the physiological system at several levels of detail both simple real time models that can be directly used in larger systems and more detailed reference models that show the underlying physiological mechanisms and provide parameters for and validation of simpler models The book also covers two dimensional modeling of the fluid dynamics in the heart and its ability to pump and includes a discussion of modeling wave propagation throughout the systemic arteries *Introduction to Mathematical Physiology and Biology*, 1999

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