

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

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.

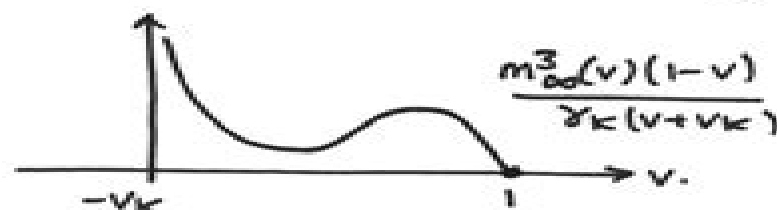
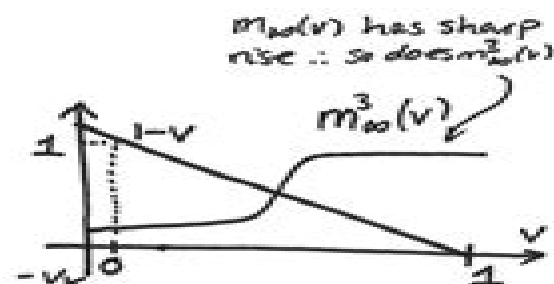
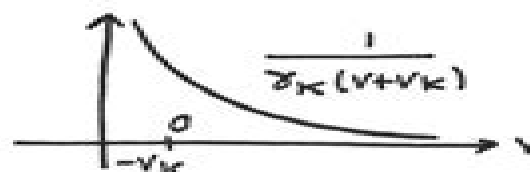
Plotting nullclines. $I_{ext} = 0$.

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

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

**Johnny T. Ottesen, Mette S.
Olufsen, Jesper K. Larsen**



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Differential Equations for Studies in Computational Electrophysiology Karoline Horgmo Jæger, Aslak Tveito, 2023-05-27 This open access text aims at giving you the simplest possible introduction to differential equations that are used in models of electrophysiology It covers models at several spatial and temporal scales with associated numerical methods The text demonstrates that a very limited number of fundamental techniques can be used to define numerical methods for equations ranging from ridiculously simple to extremely complex systems of partial differential equations Every method is implemented in Matlab and the codes are freely available online By using these codes the reader becomes familiar with classical models of electrophysiology like the cable equation the monodomain model and the bidomain model But modern models that have just started to gain attention in the field of computational electrophysiology are also presented If you just want to read one book it should probably not be this one but if you want a simple introduction to a complex field it is worth considering the present text

Mathematical Physiology; Blood Flow and Electrically Active Cells H. Melvin Lieberstein, 1973 **An Introduction to Undergraduate Research in Computational and Mathematical Biology** Hannah Callender Highlander, Alex Capaldi, Carrie Diaz Eaton, 2020-02-17 Speaking directly to the growing importance of research experience in undergraduate mathematics programs this volume offers suggestions for undergraduate appropriate research projects in mathematical and computational

biology for students and their faculty mentors The aim of each chapter is twofold for faculty to alleviate the challenges of identifying accessible topics and advising students through the research process for students to provide sufficient background additional references and context to excite students in these areas and to enable them to successfully undertake these problems in their research Some of the topics discussed include Oscillatory behaviors present in real world applications from seasonal outbreaks of childhood diseases to action potentials in neurons Simulating bacterial growth competition and resistance with agent based models and laboratory experiments Network structure and the dynamics of biological systems Using neural networks to identify bird species from birdsong samples Modeling fluid flow induced by the motion of pulmonary cilia Aimed at undergraduate mathematics faculty and advanced undergraduate students this unique guide will be a valuable resource for generating fruitful research collaborations between students and faculty

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