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

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

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

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

with

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

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

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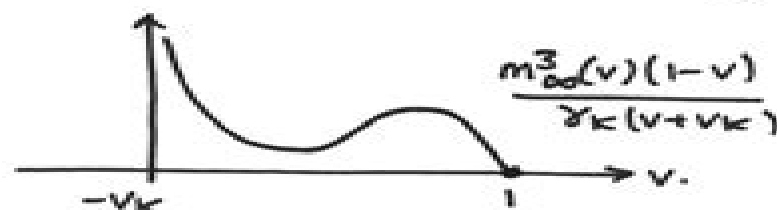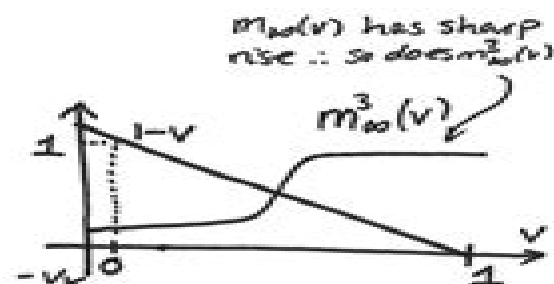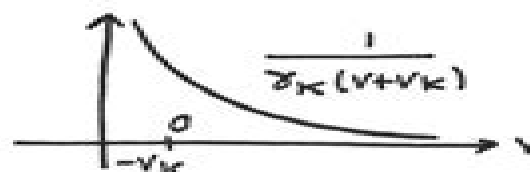
Plotting nullclines. $I_{ext}^* = 0$.

$$-\epsilon \, dv/d\tau = g = m_\infty^3(v)(0.85 - n)(v-1) + \gamma_K n^4(v + v_K) + \gamma_L(v - v_L)$$

γ_L small $\therefore$ neglect this below.

$$dn/d\tau = k = \frac{1}{\tau_n^\#(v)} \left[n_\infty(v) - n \right]$$

v nullcline

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

$m_\infty(v)$ has sharp rise $\therefore$ so does $m_\infty^3(v)$

$$\frac{n^4}{0.85 - n}$$

$$\frac{1}{\gamma_K(v + v_K)}$$

$$m_\infty^3(v)$$

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

Mathematical Physiology

James P. Keener

Mathematical Physiology:

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Applied Mathematical 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   An Introduction to Mathematical Modeling in Physiology, Cell Biology, and Immunology James Sneyd,2002 In many respects biology is the new frontier for applied mathematicians This book demonstrates the important role mathematics plays in the study of some biological problems It introduces mathematicians to the biological sciences and provides enough mathematics for bioscientists to appreciate the utility of the modelling approach The book presents a number of diverse topics such as neurophysiology cell biology immunology and human genetics It examines how research is done what mathematics is used what the outstanding questions are and how to enter the field Also given is a brief historical survey of each topic putting current research into perspective The book is suitable for mathematicians and biologists interested in mathematical methods in biology

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   Modeling Human Atrial Patho-Electrophysiology from Ion Channels to ECG - Substrates, Pharmacology, Vulnerability, and P-Waves Loewe, Axel,2016-08-03 Half of the patients suffering from atrial fibrillation AF cannot be treated adequately today This book presents multi scale computational methods to advance our understanding of patho mechanisms to improve the diagnosis of

patients harboring an arrhythmogenic substrate and to tailor therapy The modeling pipeline ranges from ion channels on the subcellular level up to the ECG on the body surface The tailored therapeutic approaches carry the potential to reduce the burden of AF **Democratic Global Governance** Irene Lyons Murphy,2010-09-28 Democratic Global Governance is a component of Encyclopedia of Institutional and Infrastructural Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias The theme on Democratic Global Governance relates the critical international issues of the post war era to the major decisions of the UN and its IGO network It is divided into two topics the first concerns global governance and the collective decision processes of the UN system while the second reviews and analyzes the impact of the nongovernmental sector as it has grown in strength and become part of a nascent global civil society This volume is aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs Range and Animal Sciences and Resources Management - Volume II Victor R. Squires,2010-07-07 Range and Animal Sciences and Resources Management is a component of Encyclopedia of Food and Agricultural Sciences Engineering and Technology Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias Rangelands comprise over forty percent of the earth s land surface and as one of the most prevalent land systems on the planet rangelands are critical habitats for myriad plant and animal species and form many of the world s major watersheds Rangelands are categorized in two distinct ways a as a type of land or b a type of land use This theme with contributions from distinguished experts in the field discusses about Range and Animal Sciences and Resources Management in several related topics These two volumes are aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs *GLOBAL SECURITY AND INTERNATIONAL POLITICAL ECONOMY – Volume I* P.Bilgin, P.D. Williams, M. Sekiguchi, J. K. Galbraith, S. T. Inayatullah, J. Wiener, R. A. Schrire, I.L. Murphy,2010-09-19 Global Security and International Political Economy is a component of Encyclopedia of Social Sciences and Humanities in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias This 6 volume set contains several chapters each of size 5000 30000 words with perspectives issues of great relevance to our world such as Global Security Global Security and the International System The Regional Dimension of Global Security The National Dimension Of Global Security The Societal Dimension Of Global Security The Human Security Agenda In World Politics History Of Empires And Conflicts The Myth Of The Clash Of Civilizations In Dialogical Historical Context Causes And Prevention Of Armed Conflict International Development Policies And Global Security Environment And Global Security Political Economy Of International Security Political Issues In Human Resource Development Globalization And The Consumer Society These volumes are aimed at the following five major target audiences University and College students Educators Professional

practitioners Research personnel and Policy analysts managers and decision makers and NGOs   *SOLAR ENERGY CONVERSION AND PHOTOENERGY SYSTEMS: Thermal Systems and Desalination Plants-Volume II* Julian Blanco Gálvez, Sixto Malato Rodríguez, E. Delyannis, Vassilis G. Belessiotis, S. C. Bhattacharya and S. Kumar,2010-11-20 Solar Energy Conversion and Photoenergy Systems Thermal Systems and Desalination Plants theme in five volumes is a component of Encyclopedia of Energy Sciences Engineering and Technology Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty one Encyclopedias The Theme on Solar Energy Conversion and Photoenergy Systems Thermal Systems and Desalination Plants with contributions from distinguished experts in the field discusses solar energy renewable energy thermal systems and desalination systems some of which are already in commercial and practical applications and others are under research and testing level The volumes provide an analysis and discussion about the reasons behind the current efforts of our society considering both developed and developing countries to accelerate the exploitation of the huge solar energy potential in our normal daily lives The five volumes also provide some basic information about the solar energy potential history and the amazing trip of a photon from its creation in the Sun until its arrival to the Earth These five volumes are aimed at the following five major target audiences University and College Students Educators Professional Practitioners Research Personnel and Policy Analysts Managers and Decision Makers NGOs and GOs   **Soils, Plant Growth and Crop Production - Volume II** Willy H. Verheye,2010-11-30 Soils Plant Growth and Crop Production is a component of Encyclopedia of Food and Agricultural Sciences Engineering and Technology Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty Encyclopedias Plants and crops in particular grow and develop through the uptake of water and nutrients by the root system in soils and their transformation into biomass through processes governed by photosynthesis The quality and amount of products harvested from this biomass depend largely on the intrinsic properties of the soil i e the moisture and nutrients made available for uptake by the roots These volumes describe in a synthetic form the impact of the most important soil properties on general agronomy crop production cultivation methods and yields including the specific management aspects which take away some production constraints Changes in general agronomy as a result of plant breeding climatic change and competition between newly introduced crops are discussed The three volumes with contributions from distinguished experts in the field discusses about soils plant growth and crop production in several related topics These volumes are aimed at the following five major target audiences University and College students Educators Professional practitioners Research personnel and Policy analysts managers and decision makers and NGOs   Soils, Plant Growth and Crop Production - Volume I Willy H. Verheye,2010-11-30 Soils Plant Growth and Crop Production is a component of Encyclopedia of Food and Agricultural Sciences Engineering and Technology Resources in the global Encyclopedia of Life Support Systems EOLSS which is an integrated compendium of twenty Encyclopedias Plants and crops in particular grow and develop through the uptake of

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