

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

where " $\Omega$ " 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.

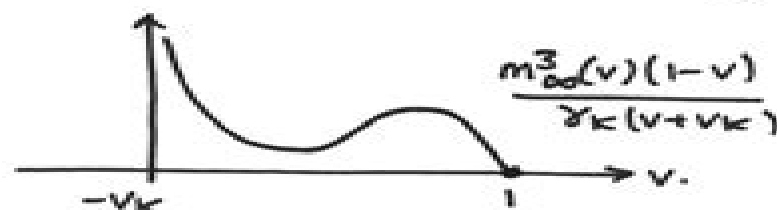
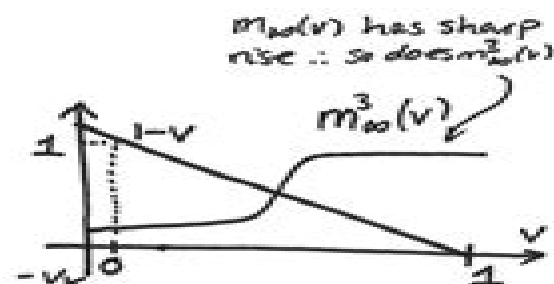
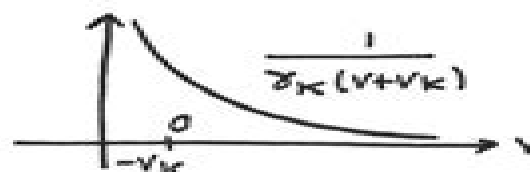
Plotting nullclines.  $I_{ext} = 0$ .

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

$\gamma_L$  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

**James Keener, James Sneyd**



## **Mathematical Physiology:**

**Mathematical Physiology** James Keener, James Sneyd, 2010-06-04 Divided into two volumes the book begins with a pedagogical presentation of some of the basic theory with chapters on biochemical reactions diffusion excitability wave propagation and cellular homeostasis The second more extensive part discusses particular physiological systems with chapters on calcium dynamics bursting oscillations and secretion cardiac cells muscles intercellular communication the circulatory system the immune system wound healing the respiratory system the visual system hormone physiology renal physiology digestion the visual system and hearing New chapters on Calcium Dynamics Neuroendocrine Cells and Regulation of Cell Function have been included Reviews from first edition Keener and Sneyd's Mathematical Physiology is the first comprehensive text of its kind that deals exclusively with the interplay between mathematics and physiology Writing a book like this is an audacious act Society of Mathematical Biology Keener and Sneyd's is unique in that it attempts to present one of the most important subfields of biology and medicine physiology in terms of mathematical language rather than organizing materials around mathematical methodology SIAM review

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*Mathematical Physiology: Cellular physiology* James P. Keener, 2009

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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

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**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

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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 discuss 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.



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