**Models of the Neuron**

**EN.580.439**

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**Course Description:** Single-neuron modeling, emphasizing the use of computational models as links between the properties of neurons at several levels of detail. Topics include thermodynamics of ion flow in aqueous environments, biology and biophysics of ion channels, gating, nonlinear dynamics as a way of studying the collective properties of channels in a membrane, synaptic transmission, and integration of electrical activity in multi-compartment dendritic tree models. Point process statistical modeling will also be covered.

**Supplementary Readings:**

1. B. Hille (1992) Ionic Channels of Excitable Membranes, Sinauer Assoc
2. D. Johnston & S. M-S Wu (1995) Foundations of Cellular Neurophysiology, MIT Press
3. C. Koch (1999), Biophysics of Computation: Information processing in single neurons, Oxford University Press
4. H. R. Wilson (1999). Spikes, Decisions and Actions: Dynamical Foundations of Neuroscience, Oxford University Press

**Recommended Course Background:** calculus 1, calculus 2, introduction to probability and statistics (preferred) AS.110.302 or equivalent. Meets with EN.580.639

**Credits:** 4

**Blackboard will be used for the following resources:**

1. Syllabus
2. Homework Sets, to be posted each Fri., due on blackboard the following Fri.
3. Solutions to homework sets
4. Sample midterms and exams
5. Supplemental readings

**Course Schedule:**

1. **Lectures:** MWF 10:00-10:50am in Hodson 211
2. **TA Sections:** T 9:00-9:50am in Croft Hall G02

**Office Hours: (Hackerman 316)**

* Tuesdays and Fridays at 2-3 pm

**Lecturers:**

* Rai Winslow ([rwinslow@jhu.edu](mailto:rwinslow@jhu.edu)), Hackerman Hall, Room 208C

**TAs:**

* Macauley Breault (mbreaul1@jhu.edu)

**Course Syllabus:**

**Thursday, Aug 31:** Introductory Lecture & Assign Review of the Nernst Potential

**Friday, Sept 1**: Failures of the Nernst Membrane Model (Lect. 1A)

**Wednesday, Sept 6**: Ion Channels - Two-State Model (Lect 1B)

Hwk1 assignment due Mon Sept 11

**Friday, Sept. 8**: The Hodgkin-Huxley Model of Membrane Currents (Lect 1C)

**Monday, Sept 11**: Introduction to Non-Linear Dynamical Systems (Lect 2)

Hwk2 assignment due Mon Sept 18

**Wed, Sept 13**: Introduction to Non-Linear Dynamical Systems (Lect 2)

**Friday, Sept. 15**: Morris-LeCar Model of Excitable Cells (Lect 3)

**Mon, Sept. 18**: Complete Morris-LeCar (Lect 3)

Synapses (Lect 4)

Hwk3 assignment due Mon Sept 25

**Wed, Sept 20**: The Cable Eq. and Finite-length Dendritic Cables (Lect 5A)

**Fri, Sept 22**: Passive Models of Neuronal Dendrites (Lect 5B)

**Mon, Sept 25**: Compartmental Modeling (Lect 5C)

Hwk4 assignment due Mon Oct 2

**Wed, Sept 27**: Neuronal Computation - Shunting Inhibition (Lect 6)

**Fri, Sept 29**: Neuronal Computation - Shunting Inhibition (Lect 6)

**Mon, Oct 2**: Neuronal Computation – Selective Processing in the Auditory System to Extend Dynamic Range of Encoding (Lect 7)

Hwk5 assignment due Mon Oct 9

**Wed, Oct 4**: Neuronal Computation – Coincidence Detection (Lect 8)

**Fri, Oct 6**: Neuronal Computation – Coincidence Detection (Lect 8)

**Mon, Oct 9**: Neuronal Computation – Dendritic Spines (Lect 9)

Hwk6 assignment due Mon Oct 16

**Wed, Oct 11**: Neuronal Computation – Dendritic Spines (Lect 9)

**Fri, Oct 13**: Active Dendritic Trees (Lect 10)

-------- I haven’t planned further than this yet ---------------