

BT 6220 Introduction to Computational Neuroscience

Class : Btech/MTech/MS/PhD

Date : 30-10-2020

Time : 12 noon – 1:00 PM

Midsemester Examination

Marks: 30

1. If Δ and τ denote the discriminant and trace of the Jacobian of a 2-D dynamical system at a fixed point, find the type of the fixed point in the following two cases:

a. $\Delta < 0, \tau > 0, \tau^2 - 4\Delta > 0$

b. $\Delta > 0, \tau > 0, \tau^2 - 4\Delta > 0$ (4 marks)

2. A modified FitzHugh-Nagumo neuron model is given by the following equations:

$$\dot{v} = f(v) - w + I_a$$

$$\dot{w} = bv - w$$

where $f(v)$ is a piecewise linear approximation (fig. 1) of the cubic nonlinearity given in the original model. Find the range of values of the parameter 'b', for the model to exhibit bistability (let $b > 0$). Express your answer in terms of the properties of $f(v)$. (Assume $I_a = 0$)

(6 marks)

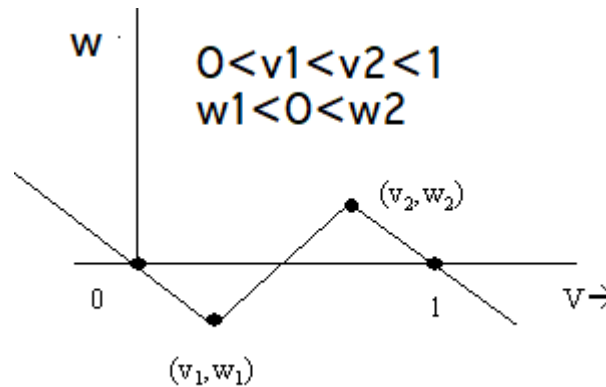


figure 1

3. Draw the phase plots (null-clines) of the system defined as:

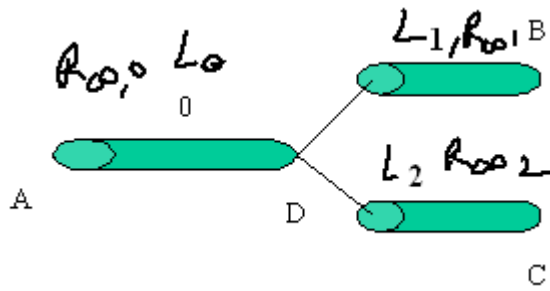
$$\dot{x} = -x + x^3$$

$$\dot{y} = -y - x$$

Find the fixed points and classify them.

(8 marks)

4. For the cable system shown below, R_∞ and electrotonic lengths, L , are indicated. What is the expression for the loading resistance of the main cable? (4 marks)



5. Put the following events in the correct temporal order: (3 marks)

- entry of Ca^{2+} ions into the presynaptic terminal
- opening of ion channels on the postsynaptic terminal
- arrival of an action potential on the presynaptic terminal
- EPSP/IPSP
- binding of neurotransmitter with receptors on the postsynaptic terminal
- release of neurotransmitter

6. Match the following

A) Site of summation in a neuron	1) NMDA receptor
B) Glutamate neurotransmitter	2) opens with increased membrane potential
C) Myelin sheath	3) Second messenger signaling
D) Activation gate	4) Axon hillock
E) Metabotropic receptor	5) Increased conduction velocity