For a dynamical system of the following form,

$$\ddot{x} + f(x)\dot{x} + g(x) = 0,$$

to be a Lienard system, the condition on f(x) is: (pick the best answer from the 4 choices even though it may not be perfect)

- ○ f(x) must be an even function, and its indefinite integral F(x) must have 1 root
- ◉ f(x) must be an even function, and its indefinite integral F(x) must have 3 roots ✓
- ○ f(x) must be an odd function, which must be positive for positive x.
- ○ f(x) must be an odd function, with the only root at the origin

✓ Find the correct match for ' Metabotropic receptor' (1 mark) 1/1

- ○ Increased conduction velocity
- ◉ Second messenger signaling ✓
- ○ NMDA receptor
- ○ Axon hillock
- ○ Opens with increased membrane potential

If you inject current in the middle of an axon with homogeneous properties, which of the following best describes the nature of axonal propagation? (1 mark) 0/1

- Action potentials propagate only towards the axon collaterals and not towards the soma
- There will no action potential generation since they are generated only at the axon hillock
- Action potentials propagate towards both soma and axon collaterals from the point of injection 3
- None of the above

c a f b c b d

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

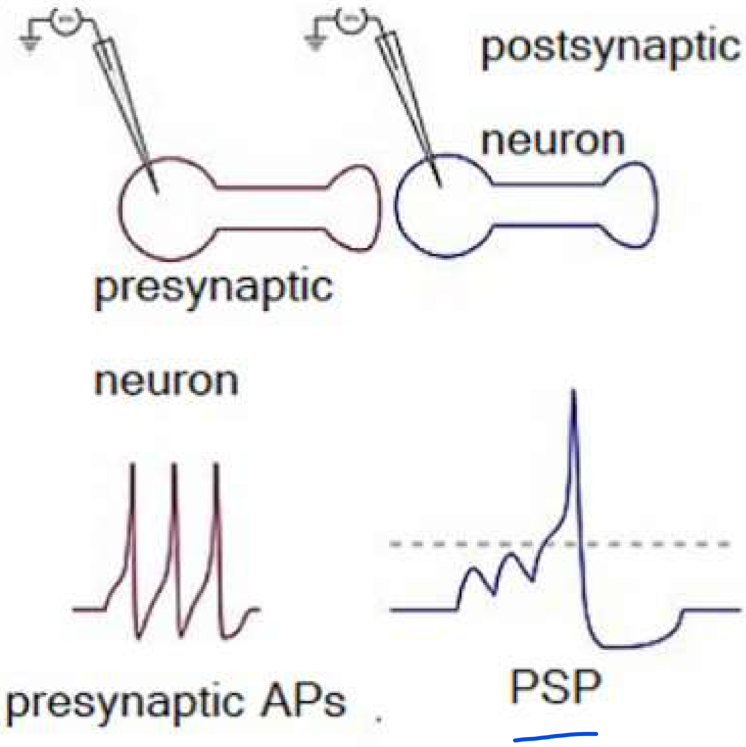
Put the following events in the correct temporal order:

a. entry of Ca2+ ions into the presynaptic terminal 2
b. opening of ion channels on the postsynaptic terminal 5
c. arrival of an action potential on the presynaptic terminal 1
d. EPSP/IPSP 6
e. binding of neurotransmitter with receptors on the postsynaptic terminal 4
f. release of neurotransmitter 3

- [ ] bdacfe
- [x] cafebd
- [ ] acefbd
- [ ] fabecd

The following experimental setup and recordings demonstrate which of the following phenomena? (1 mark) 1/1

The following experimental setup and recordings demonstrate which of the following phenomena?

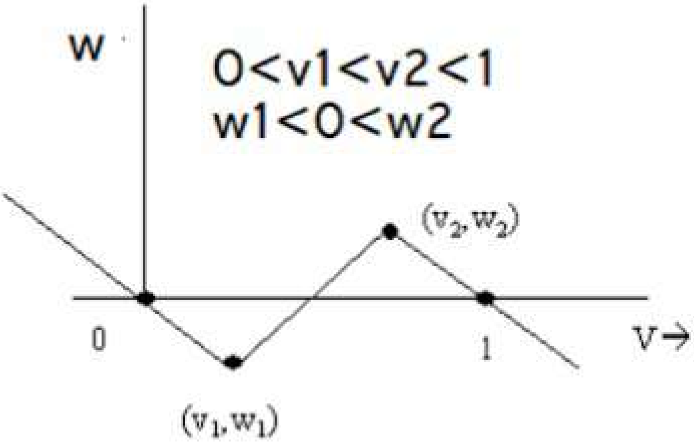


- (●) Temporal summation ✓
- ( ) Neurotransmission
- ( ) Spatial summation
- ( ) Axonal propagation

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 (see figure below) 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 $I_a = 0$)



A) $b < \frac{w_2}{v_2}$, B) $b > \frac{w_2}{v_2}$ C) $b < \frac{w_2 - w_1}{v_2 - v_1}$ D) $b > \frac{w_2 - w_1}{v_2 - v_1}$

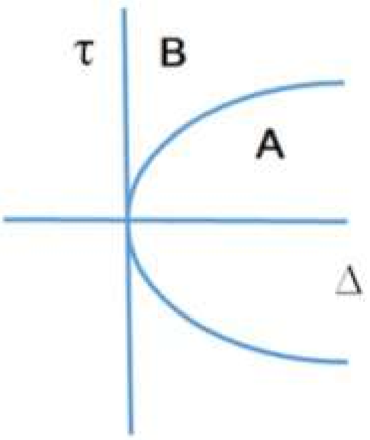
- (●) A ✓
- ( ) B
- ( ) C
- ( ) D

What kind of fixed points are obtained on the positive delta axis? (1 mark) 1/1

A linear dynamical system given by

$\dot{x} = Ax$, where $x \in R^2$

has the following bifurcation map described on the $\tau - \Delta$ axis.



What kind of fixed points are obtained on the positive Δ axis?

- Stars
- Centers
- Stable spirals
- Line of attractors

For the following 2D dynamical system,

$$\dot{x} = x^2 - y$$

$$\dot{y} = y^2 - x$$

the number and type of the fixed points are:

- ○ 2 fixed points – one saddle, one stable node
- ◉ 2 fixed points – one saddle, one unstable node ✓
- ○ 2 fixed points – one stable node, one unstable node
- ○ 3 fixed points – all stable nodes

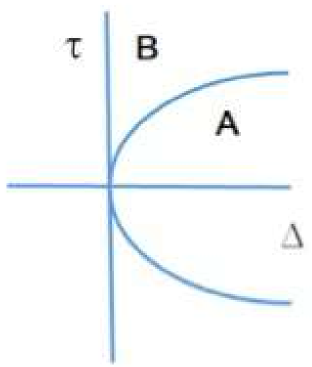
✓ Find the correct match for ' Myelin sheath' (1 mark) 1/1

- ○ Second messenger signaling
- ○ Opens with increased membrane potential
- ○ Axon hillock
- ◉ Increased conduction velocity ✓
- ○ NMDA receptor

What happens to the eigenvalues when we go from region A to region B? (1 1/1 mark)

A linear dynamical system given by
$\dot{x} = Ax$, where $x \in R^2$

has the following bifurcation map described on the $\tau - \Delta$ axis.



What happens to the eigenvalues when we go from region A to region B?

- (selected) Their imaginary parts go from non-zero to zero ✓
- Their real parts change from negative to positive
- Their imaginary parts go from zero to non-zero
- Their real parts change from positive to negative

B The number and type of activation/inactivation gates of Na+ and K+ channels of Hodgkin-Huxley model are: (1 mark)

1/1

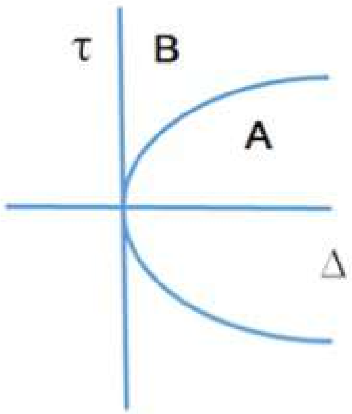
- [x] 3 activation gates and 1 inactivation gate for Na+; 4 activation gates for K+
- [ ] 3 activation gates and 1 inactivation gate for Na+; 4 inactivation gates for K+
- [ ] 3 inactivation gates and 1 activation gate for Na+; 4 inactivation gates for K+
- [ ] 3 inactivation gates and 1 activation gate for Na+; 4 activation gates for K+

✕ What kind of fixed points are obtained on the positive TAU axis ? (1 mark) 0/1

A linear dynamical system given by

$\dot{x} = Ax$, where $x \in R^2$

has the following bifurcation map described on the $\tau - \Delta$ axis.



What kind of fixed points are obtained on the positive τ axis?

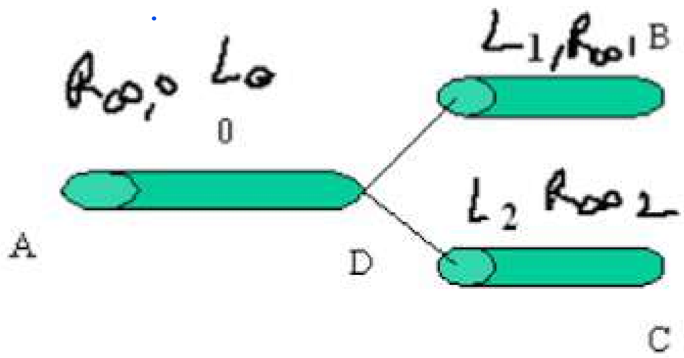
- Stable spirals
- Centers
- Line of attractors
- Stars

Find the correct match for ' Site of summation in a neuron' (1 mark) 1/1

- NMDA receptor
- Increased conduction velocity
- Axon hillock
- Opens with increased membrane potential
- Second messenger signaling

What is the expression for the loading resistance, RL, of the main cable? (3 marks) 3/3

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



A) If $R_{in1} = R_{\infty 1}\coth(L_1)$ and $R_{in2} = R_{\infty 2}\coth(L_2)$, $R_L = R_{in1} \| R_{in2}$
B) If $R_{in1} = R_{\infty 1}\tanh(L_1)$ and $R_{in2} = R_{\infty 2}\tanh(L_2)$, $R_L = R_{in1} \| R_{in2}$
C) If $R_{in1} = R_{\infty 1}\cosh(L_1)$ and $R_{in2} = R_{\infty 2}\cosh(L_2)$, $R_L = R_{in1} \| R_{in2}$
D) If $R_{in1} = R_{\infty 1}\sinh(L_1)$ and $R_{in2} = R_{\infty 2}\sinh(L_2)$, $R_L = R_{in1} \| R_{in2}$

- [x] A
- [ ] B
- [ ] C
- [ ] D

The dependency of conduction velocity, v, of an unmyelinated axon on the diameter, d, is described as,

A) $v \propto \sqrt{d}$, B) $v \propto d$, C) $v \propto d^{2/3}$, D) $v \propto d^2$

- (•) A ✓
- ( ) B
- ( ) C
- ( ) D

✓ In a supercritical Andronov-Hopf bifurcation, if mu is the bifurcation parameter and mu = 0 is the bifurcation point, the radius of the limit cycle, R, grows as which of the following laws, near the bifurcation point? (1 mark) 1/1

In a supercritical Andronov-Hopf bifurcation, if μ is the bifurcation parameter and $\mu = 0$ is the bifurcation point, the radius of the limit cycle, R, grows as which of the following laws, near the bifurcation point?

A) $R \propto \sqrt{\mu}$, B) $R \propto \mu$, C) $R \propto \mu^{2/3}$, D) $R \propto \mu^2$

- (•) A ✓
- ( ) B
- ( ) C
- ( ) D

Find the correct match for ' Activation gate' (1 mark) 1/1

- Axon hillock
- Opens with increased membrane potential
- Increased conduction velocity
- Second messenger signaling
- NMDA receptor

Find the correct match for ' Glutamate neurotransmitter' (1 mark) 1/1

- NMDA receptor
- Axon hillock
- Opens with increased membrane potential
- Second messenger signaling
- Increased conduction velocity

✓ For a finite dendritic cable of electrotonic length L, the killed end and sealed end boundary conditions respectively can be defined as, (1 mark) 1/1

- ○ Vm at far end is 1, Ii at far end is 0 respectively
- ○ Vm at far end is 0, Ii at far end is 1 respectively
- ◉ Vm at far end is 0, Ii at far end is 0 respectively ✓
- ○ Ii at far end is 0, Vm at far end is 0 respectively

✓ The dependency of pseudo-velocity, v, of a passive (dendritic) cable on the diameter, d, is described as, (1 mark) 1/1

The dependency of pseudo-velocity, v, of a passive (dendritic) cable on the diameter, d, is described as,

A) $v \propto \sqrt{d}$, B) $v \propto d$, C) $v \propto d^{2/3}$, D) $v \propto d^2$

- ◉ A ✓
- ○ D
- ○ C
- ○ B