Total Marks : 40 (26 x0.5(marks) + 27 x 1(mark)). Exam Duration : 10:00 am - 11:15 am
Negative: 50% marks reduction on each wrongly attempted question

One of the weaknesses of contemporary computational neuroscience that prevents it from creating good systems neuroscience models is the philosophy of: (0.5 marks)

- ○ Objectivism,
- ○ reductionism,
- ◉ empiricism,
- ○ dualism

Weightage 0.5 marks

The number of fixed points of the system given below,
$\dot{x} = x - y$, $\dot{y} = x^2 - 4$

- ○ 1
- ◉ 2
- ○ 3
- ○ 4

Weightage 0.5 marks

How many limit cycles does the following system exhibit?
$\dot{r} = r(1-r^2)(4-r^2)$
$\dot{\theta} = 2 - r^2$

- ○ 1
- ◉ 2
- ○ 3
- ○ 4

Weightage 0.5 marks

In a real. linear two-dimensional dynamical system, a "star" type of fixed point is obtained when, the eigenvalues (λ_1 and λ_2) satisfy the following condition,

A) λ_1 and λ_2 are both real and non-zero
B) λ_1 and λ_2 are complex conjugates and non-zero
C) λ_1 and λ_2 are both equal and non-zero
D) One of the eigenvalues is 0

- ○ A
- ○ B
- ◉ C
- ○ D

Weightage 0.5 marks

An activation gate is one that:

A) OPENS with increased membrane potential
B) CLOSES with increased membrane potential
C) OPENS and CLOSES rapidly with increased membrane potential
D) CLOSES and OPENS rapidly with increased membrane potential

- ◉ A
- ○ B
- ○ C
- ○ D

Weightage 0.5 marks

The number of activation (p) and inactivation (q) gates of the K+ channel in Hodgkin-Huxley model are:

A) p = 1, q = 3, B) p=q=2, C) p = 3, q = 1), D) p = 4, q = 0.

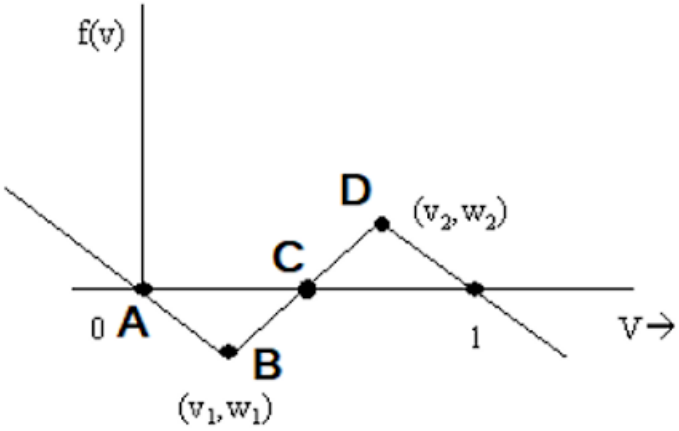
- ○ A

- B
- C
- D

Weightage 0.5 marks

Figure below shows a simplified schematic of the v-nullcline of the FitzHugh-Nagumo neuron model. Which of the marked points denotes the threshold of excitation of the neuron?

A) A, B) B, C) C, D) D



- A
- B
- C
- D

Weightage 0.5 marks

If a constant current is injected into an infinite cable with uniform diameter, d, and space constant, λ, which of the following expressions denotes the voltage distribution along the length of the cable? (Note that the point of injection is taken to be the origin).

A) $V(x) = Ae^{|x|/\lambda}$, B) $V(x) = Ae^{-|x|/\lambda}$, C) $V(x) = Ae^{-|x|/\lambda}\sin(kx)$, D) $V(x) = A\coth(kx)$

- A

- (●) B
- ( ) C
- ( ) D

Weightage 0.5 marks

Which of the following is the correct formula for R_∞ ?

A) $\frac{r_a}{\lambda}$ B) $\sqrt{\frac{r_a}{r_m}}$ C) $r_a\lambda$ D) $r_a r_m$

- ( ) A
- ( ) B
- (●) C
- ( ) D

Weightage 0.5 marks

Given that the input resistance of a cable of finite length, L, is given by,

$$R_{in} = R_\infty \frac{R_\infty \tanh(L) + R_L}{R_L \tanh(L) + R_\infty}$$

The input resistance of the same cable with killed end boundary condition is:
A) $R_\infty \tanh(L)$, B) $R_\infty \coth(L)$, C) $R_\infty \sinh(L)$, D) $R_\infty \cosh(L)$

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 0.5 marks

Given that the input resistance of a cable of finite length, L, is given by,

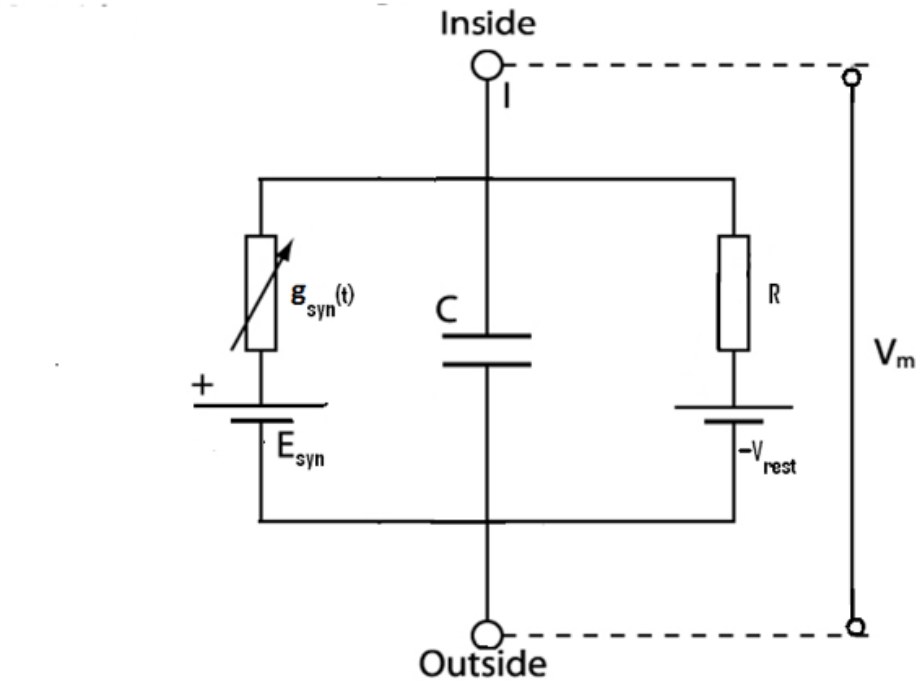
$$R_{in} = R_{\infty} \frac{R_{\infty} \tanh(L) + R_L}{R_L \tanh(L) + R_{\infty}}$$

The input resistance of the same cable with sealed end boundary condition is:
A) $R_{\infty} \tanh(L)$, B) $R_{\infty} \coth(L)$, C) $R_{\infty} \sinh(L)$, D) $R_{\infty} \cosh(L)$

- A
- B
- C
- D

Weightage 0.5 marks

Figure below shows a simple circuit diagram of a fast chemical synapse.



The condition for the synapse to be an excitatory synapse is:
A) $E_{syn} > V_{rest}$ B) $E_{syn} < V_{rest}$ C) $E_{syn} = V_{rest}$ D) none of the above

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 0.5 marks

Shunting inhibition occurs when,
(A) When the Nernst potential of synaptic channel conductance equals resting membrane potential
(B) When synapse is inhibitory
(C) When the Nernst potential of synaptic channel conductance is much lesser than resting membrane potential
(D) When the Nernst potential of synaptic channel conductance is much greater than resting membrane potential

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 0.5 marks

Which of the following is NOT one of the 4 components of signaling in a neuron:
(A) Dendritic processing, (B) spatio-temporal summation, (C) axon remodeling, (D) neurotransmission

- ( ) A
- ( ) B
- (●) C
- ( ) D

Weightage 0.5 marks

Dynamics of the neuron model used in continuous Hopfield network may be described as: $\dot{u} = -u + \tanh(\lambda u)$.

The number of stable fixed points the neuron has are for $\lambda \geq 1$:
A) 1, B) 2, C) 3, D) 4

- A
- (•) B
- C
- D

Weightage 0.5 marks

Dynamics of the neuron model used in continuous Hopfield network may be described as: $\dot{u} = -u + \tanh(\lambda u)$.

The number of stable fixed points the neuron has are for $\lambda < 1$:
A) 1, B) 2, C) 3, D) 4

- (•) A
- B
- C
- D

Weightage 0.5 marks

The dynamics of quadratic-integrate-and-fire neuron is described as follows:
$\frac{dV}{dt} = V^2 + I$ Resetting mechanism: if ($V \geq V_{peak}$) V = V_{reset}.

If, I < 0 and $V_{reset} < -\sqrt{-I} < \sqrt{-I} < V_{peak}$, the dynamics of the neuron can be described as:

A) Has a single stable state which is the resting state
B) Has bistability consisting of the resting state and spiking state
C) Has bistability consisting of the resting state and limit cycle oscillations
D) Has a single stable state which is the spiking state

- A

B

C

D

Weightage 0.5 marks

Which of the following types of dynamics can be expressed by Morris-Lecarr model?

A) Excitability and limit cycles but not bistability
B) Excitability and bistability but not limit cycles
C) Bistability and limit cycles but not excitability
D) Excitability, limit cycles and bistability

A

B

C

D

Weightage 0.5 marks

What is the key deficiency of the Leaky integrate and fire neuron model for spike generation?

A) There is no explicit spike in the model
B) The neuron responds only if the input current crosses a threshold
C) The firing rate grows indefinitely with increasing current
D) The firing rate saturates with increasing current

A

B

C

D

Weightage 0.5 marks

Consider the multilayer perceptron defined as y = g(w1*V1 + w2*V2 – b); V1 = g(w11*x1 + w12*x2 – b1); V2 = g(w21*x1 + w22*x2 – b2), where x1 and x2 are inputs and y is the output. For which of the following weight patterns does the network simulate an EXOR gate? (g() = step function).

(A)w11 = w12 = 1; b1 = 0.4; w21 = w22 = 1; b2 = 1.6; w1 = 1 =-w2; b = 0.1.
(B)w11 = w12 = -1; b1 = 0.4; w21 = w22 = 1; b2 = -1.6; w1 = -1 =w2; b = 0.1.
(C)w11 = w12 = 1; b1 = -0.4; w21 = w22 = -1; b2 = 1.6; w1 = -1 =-w2; b = 0.1.
(A)w11 = w12 = 1; b1 = 0.6; w21 = w22 = 1; b2 = 1.4 ; w1 = 1 =-w2; b = 0.9.

- (●) A ✓
- ( ) B
- ( ) C
- ( ) D

Weightage 0.5 marks

Which of the following is NOT a merit of a multilayer perceptron?
(A) Local minima, (B) parallelizable training, (C) universal approximation, (D) non-unique solutions

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 0.5 marks

In a Hopfield network, a spin-glass state is:
A) A state that has high correlation to any of the stored patterns
B) A state obtained by performing a spin on all the bits of a stored pattern
C) A state that has low correlation to any of the stored patterns
D) A state that can be expressed as a linear combination of any two stored patterns

- ( ) A
- ( ) B
- (●) C

- ○ D

Weightage 0.5 marks

In a discrete Hopfield network, if two states S1 and S2 are stable,

A) S1+S2 is also stable

B) S1-S2 is also stable

C) –S1 and –S2 are stable

D) Min(S1, S2) is stable

- ○ A
- ○ B
- ◉ C
- ○ D

Weightage 0.5 marks

The conduction velocity of an unmyelinated axon varies as a function of the axon diameter, d, as:

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

- ◉ A
- ○ B
- ○ C
- ○ D

Weightage 0.5 marks

The pseudo-velocity of a dendritic cable varies as a function of the dendrite dimeter, d, as:

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

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 0.5 marks

According to the theories of Michael Hasselmo and others, the site of memory storage within the hippocampal complex is:

A) Dentate gyrus, B) subiculum, C) CA1, D) CA3.

- ( ) A
- ( ) B
- ( ) C
- (●) D

Weightage 1 mark

Deep neural networks as models of perceptual systems are known to attain human-level performance in which of the following tasks? (Research paper based question)

A) Text Recognition

B) Speech Recognition

C) Handwriting generation

D) All of the above

- ( ) A
- (●) B
- ( ) C
- ( ) D

Weightage 1 mark

In a typical deep convolutional neural network the operation that enables units in the later layers gain access to a greater proportion of the stimulus is ? (Research paper based question)

A) Receptive Field

B) Relu Activation

C) Maxpooling

D) Gradient Descent

The sampling theorem dictates that if signals are not lowpass filtered before downsampling, they will be 'aliased' — low frequencies will be corrupted by high frequencies present in the signal before downsampling. Because contemporary deep networks typically employ downsampling operations (max pooling and/orstrided convolution) without the constraint of a preceding lowpass filter, aliasing is likely to occur

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 1 mark

The gap between Artificial neural networks and Human sensory systems can be reduced to some extent by incorporating the following minor modification to standard Deep neural network architectures.

A) Biological Learning

B) Add Recurrent connections to feedforward networks

C) Enhanced backpropagation algorithms

D) Action potentials and Neuromodulators

- ( ) A
- (●) B
- ( ) C
- ( ) D

Weightage 1 mark

Down sampling operations without the constraint of preceding low pass filter leads to

A) Aliasing

B) Bad classification

C) Optimization

D) Efficient processing

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 1 mark

Stimuli generated by Gradients of output units of a network with respect to its input to generate small perturbations to an input signal that cause it to be misclassified is known as

(Research paper-based question)

A) Cumulative Stimuli

B) Adversarial Stimuli

C) Gradient Stimuli

D) Effective Stimuli

- ( ) A
- (●) B
- ( ) C
- ( ) D

Weightage 1 mark

At present, it is easily possible to generate adversarial stimuli for a human perceptual system (Research paper-based question)

A) TRUE

B) FALSE

A

B

Weightage 1 mark

The 'feature similarity gain' model of Visual attention proposes the following:

(Research paper-based question)

A) Attention scales a neuron's activity inversely proportional to its preference for the attended stimuli

B) Attention scales a neuron's activity proportional to its preference for the attended stimuli

C) Attention has no impact on the neural activity

D) None of the above

A

B

C

D

Weightage 1 mark

In a DNN trained to recognize spoken words and musical genres, the frequency spectrum of a sound was best estimated from the (Research paper-based question)

A) Early Layers

B) Intermediate Layers spectrotemporal

C) Deep Layers

D) All of the above

A

B

C

D

Weightage 1 mark

Neural predictions from very high-performing networks have plateaued or even declined in accuracy, as if the networks have begun to diverge from biologically relevant solutions. This divergence could reflect differences between the specific tasks used to optimize current DNNs and those that may have constrained biological systems over the course of evolution and development. (Research paper-based question)

A) True

B) False

- (●) A
- ( ) B

Weightage 1 mark

The example given in the paper where a retinal receptor lattice used for a simple visual search task illustrates (Research paper-based question)

A) How task constraints shape behavior and the brain

B) Saccadic eye movements shift the image across retina

C) Division of auditory cortex into at least two stages

D) Actions like zooming is present in primate visual system

- ( ) A
- (●) B
- ( ) C
- ( ) D

Weightage 1 mark

According to the article by Buzsaki and Draghun (2004), the ideal intermediate representation between single neuron activity and behavior is: (Research paper-based question)

A) Ion channel dynamics
B) Synaptic activity
C) Blood flow patterns
D) Synchronized neural oscillations

- ○ A
- ○ B
- ○ C
- ◉ D

Weightage 1 mark

Existence of 1/f power law in cortical dynamics does NOT imply which of the following: (Research paper-based question)

A) Power density is inversely proportional to frequency
B) Level of synchronization increases with increasing distance over the cortex
C) Slower frequencies can cause downstream effects spreading to higher frequencies
D) Slower frequencies are widespread, while faster frequencies are more local

- ○ A
- ◉ B
- ○ C
- ○ D

Weightage 1 mark

In a relaxation oscillator the information receiving phase and information transmission phase are segregated because, (Research paper-based question)

A) the amplitude of oscillation depends on the initial condition
B) excitability varies with the time at which stimulus is presented
C) the amplitude of oscillation does not depend on the initial condition
D) excitability does not vary with the time at which stimulus is presented

- ○ A
- ○ B
- ○ C
- ○ D

Weightage 1 mark

The presence of a small number of long-range connections in the brain, make the neuronal networks resemble: (Research paper-based question)

A) small-world networks
B) scale free networks
C) random networks
D) none of the above

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 1 mark

In the brain, which of the following is the most effective mechanism for amplification of weak signals? (Research paper-based question)

A) Low pass filtering
B) Coherent summation of oscillators
C) Nonlinear properties of voltage dependent ion channels
D) Neural oscillators with resonance

- ( ) A
- (●) B
- ( ) C
- ( ) D

Weightage 1 mark

Larger brains have smaller fractions of long range connections (Research paper-based question)

A) True
B) False

- (●) A
- ( )

B

Weightage 1 mark

While the spiking activity of single cortical neurons is oscillatory, activity of clusters of such neurons has Poisson statistics. (Research paper-based question)
A) True
B) False

A

B

Weightage 1 mark

Both chemical and electrical forms of coupling contribute to neural synchronization. (Research paper-based question)
A) True
B) False

A

B

Weightage 1 mark

By adjusting the phase of the afferent oscillation with the phase of the intrinsic oscillation it is possible to control the sign of synaptic plasticity. (Research paper-based question)
A) True
B) False

A

B

Weightage 1 mark

By the right combination of neurons with low pass filtering and high pass filtering properties, it is possible to construct band-stop filters but not resonators. (Research paper-based question)

A) True

B) False

- ○ A
- ○ B

Weightage 1 mark

Though algorithmic process of Back-propagation algorithm used in artificial neural network appears simple enough, the key issue and problem with implementing it in biology is? (Research paper-based question)

A) Lack of Local Error Representation

B) Symmetry of forwards and backwards weights

C) Unrealistic models of neurons

D) All of the above

- ○ A
- ○ B
- ○ C
- ◉ D

Weightage 1 mark

Consider a network with L layers. In which of the following network model, the propagation time needed to make a prediction is proportional to 2L-1? (Research paper-based question)

A) Contrastive Learning

B) Continuous update

C) Predictive Coding

D) Dendritic error

- ○ A

B

C

D

Weightage 1 mark

In which of the network models, does the error back propagation involve updating weights twice - once during prediction according to anti-Hebbian plasticity and another according to Hebbian plasticity once the target is provided? (Research paper-based question)

A) Contrastive Learning

B) Explicit-error model

C) Predictive Coding

D) Dendritic error

A

B

C

D

Weightage 1 mark

In the continuous update model, the error signal for weight updation is typically encoded in which of the following? (Research paper-based question)

A) Difference in activity between separate phases

B) Rate of change of activity

C) Activity of specialized neurons

D) Apical dendrites of pyramidal neurons

A

B

C

D

Weightage 1 mark

One of the main drawbacks of contrastive learning model is that, (Research paper-based question)

A) It requires an explicit global control signal to determine the learning phase.

B) The synaptic connections are modified to minimize cost function.

C) An activation function is applied to each neuron to allow for nonlinear computations.

D) Synaptic weight modifications are proportional to the negative product of the activity of the pre- and postsynaptic neurons.

- (●) A
- ( ) B
- ( ) C
- ( ) D

Weightage 1 mark

Under the equilibrium propagation framework, the predictive coding model is known to minimize which function during their dynamics? (Research paper-based question)

A) Hopfield Energy

B) Free Energy

C) Plateau Potential

D) All of the above

- ( ) A
- (●) B
- ( ) C
- ( ) D

Weightage 1 mark

Recurrently connected networks of excitatory neurons, such as the temporal-error models, while converging to an equilibrium, minimize a function that summarizes the dissimilarity in the activity of strongly connected nodes, called the- (Research paper-based question)

A) Hopfield Energy

B) Free Energy

C) Plateau Potential

D) All of the above

- (●) A
- ( ) B
- ( ) C
- ( ) D