

- Circle the correct answer, or write the answer in the box provided.
 - Only one answer is correct.
 - Show your working, if any, in the space next to the multiple choice answers.
 - Each question is worth 1 mark unless indicated otherwise.
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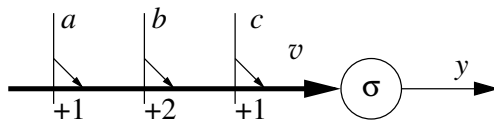
1. Which one of two vectors: $\mathbf{u} = \begin{bmatrix} -1 & 2 \end{bmatrix}$ and $\mathbf{v} = \begin{bmatrix} -2 & 0 & 1 \end{bmatrix}$ is longer?
 - (a) \mathbf{u}
 - (b) \mathbf{v}
 - (c) equal
2. Two column vectors, \mathbf{v} and \mathbf{u} , can be only added if
 - (a) they are orthogonal
 - (b) \mathbf{v} is the transpose of \mathbf{u}
 - (c) they have equal number of components
3. Inner product of two column vectors \mathbf{v} and \mathbf{u} is equal to
 - (a) $\mathbf{v} \cdot \mathbf{u}$
 - (b) $\mathbf{v}^T \cdot \mathbf{u}$
 - (c) $\mathbf{v} \cdot \mathbf{u}^T$
 - (d) $\mathbf{u} \cdot \mathbf{v}^T$
4. Given two vectors $\mathbf{u} = \begin{bmatrix} 1 & 0 & -2 \end{bmatrix}$ and $\mathbf{v} = \begin{bmatrix} 3 & 4 & 0 \end{bmatrix}$. Projection of \mathbf{u} on \mathbf{v} is equal to
 - (a) 3
 - (b) 0.6
 - (c) $\begin{bmatrix} 4 & 4 & -2 \end{bmatrix}$
5. Dimensionality of a vector is equal to its
 - (a) norm
 - (b) number of components
 - (c) length

6. Calculate a normalised vector \mathbf{u} which goes in the same direction as the vector $\mathbf{v} = \begin{bmatrix} 4 & 0 & 3 \end{bmatrix}$:

$$\mathbf{u} = \left[\begin{array}{|c|} \hline \square \\ \hline \end{array} \begin{array}{|c|} \hline \square \\ \hline \end{array} \begin{array}{|c|} \hline \square \\ \hline \end{array} \right]$$

7. Similarity between normalised vectors can be measure by their
- sum
 - outer product
 - inner product

8. Consider the following neuron

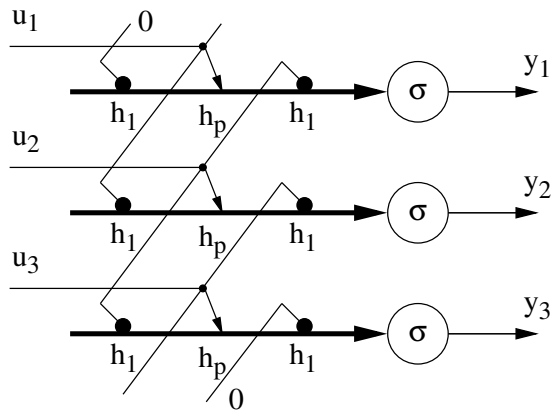


The activation potential is equal to

- $a + 2b + c$
 - $4abc$
 - $4(a + b + c)$
9. The sigmoidal function in a model of an artificial neuron is used to:
- enhance the afferent signals
 - limit the dynamic range of the efferent signal
 - balance inhibitory and excitatory action
10. In a neuron with a linear activation function the weight vector is $\mathbf{w} = \begin{bmatrix} -1 & 2 & 1 \end{bmatrix}$ and afferent signals are $\mathbf{x} = \begin{bmatrix} 1 & 1 & 2 \end{bmatrix}$. Calculate the efferent signal:

$$y = \square$$

11. (2 marks) Consider the following feedforward network



Complete the following expression writing in the weight matrix:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \\ & & & & & \end{bmatrix} \cdot \begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix}$$

12. Learning in neural networks is about

- (a) increasing the efferent signals in a way proportional to the afferent signals
- (b) modification of synaptic weights to capture essential feature of the afferent signals.
- (c) feeding back efferent signals to emphasize the afferent signals

13. A neuron implementing the Hebbian learning according to Oja's rule:

- (a) calculates the centre of the afferent shape
- (b) calculates the principal direction of the afferent signals
- (c) performs a winner-takes-all operation

14. The norm of the weight vector in the network implementing the Oja's rule:
 - (a) grows exponentially
 - (b) is proportional to the number of data points in the shape
 - (c) is close to unity
 - (d) is proportional to the efferent signal

15. In a competitive neural network the similarity layer calculates the similarity between:
 - (a) afferent vectors
 - (b) afferent and efferent vectors
 - (c) afferent vector and weight vectors
 - (d) efferent vectors and weight vectors

16. In a competitive neural network the competition layer finds:
 - (a) the largest efferent vectors
 - (b) the largest afferent vectors
 - (c) the neuron with the weight vector closest to the current afferent vector
 - (d) the neuron with the weight vector closest to the current efferent vector

17. In a competitive learning, for a given input vector \mathbf{x} , weights of the j th neuron are adjusted in a way proportional to
 - (a) the inner product of \mathbf{w}_j and \mathbf{x}
 - (b) the outer product of \mathbf{w}_j and \mathbf{x}
 - (c) the difference between \mathbf{w}_j and \mathbf{x}
 - (d) the sum of \mathbf{w}_j and \mathbf{x}

18. A feature map is a plot of
 - (a) synaptic weights in the input space
 - (b) synaptic weights in the output space
 - (c) the difference between \mathbf{w}_j and \mathbf{x}
 - (d) input vectors in the output space
 - (e) output vectors in the input space

19. A fundamental structural difference between competitive neural networks (CNNs) and self-organizing feature maps (SOFMs) is that in SOFM
 - (a) there is no competitive layer
 - (b) there is no similarity layer
 - (c) neurons are organized on a grid
 - (d) efferent signals are fed back

20. A fundamental difference in learning laws for the competitive neural networks (CNNs) and self-organizing feature maps (SOFMs) is that in SOFM
 - (a) in SOFM
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 - (a) in SOFM weights are updated for the winner only
 - (b) in SOFM all weights in the neighborhood of the winner are updated
 - (c) only weights of all neurons with lateral inhibition are updated

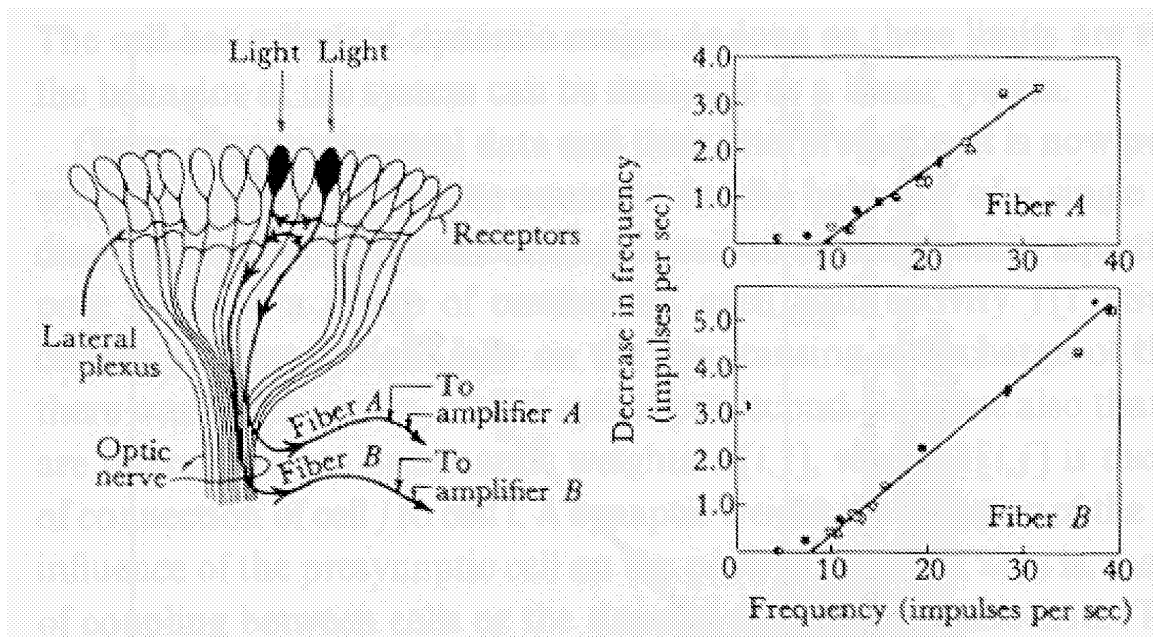
21. In an auto-associative memory network the weight vector is calculated:
 - (a) as an average of all fundamental memories
 - (b) as auto-correlation of all fundamental memories
 - (c) as an average inner product of fundamental memories and expected retrieved patterns

22. In an associative memory network spurious attractors
 - (a) are patterns stored to increase capacity of the memory
 - (b) are retrieved patterns that correlate with fundamental memories
 - (c) are retrieved patterns that are not fundamental memories

23. In the physical limulus eye, wraparound
 - (a) provides for wider peripheral vision
 - (b) allows for the neurons to inhibit further
 - (c) produces Mach bands
 - (d) is nonexistent
 - (e) is responsible for lateral inhibition

24. According to the Cajal neuron doctrine
- (a) Calculations are performed in dendritic subdomains
 - (b) Coincident firing of pre- and postsynaptic cells will lead to increased synaptic strength between them
 - (c) Dendrites are inputs and axons are outputs
 - (d) Signals back-propagate up dendrites
 - (e) Calculations are done in a neuropil syncytium
25. The physiological basis for the rate coding interpretation of the squashing function is:
- (a) neurons fire faster as input increases then reach a maximum firing state and decrease their rate at higher levels
 - (b) neural firing shows monotonic decrease in rate with increasing input
 - (c) neurons cannot fire faster than a certain rate and there is no negative firing rate
 - (d) the slow potential of the neuron nullifies the summation procedure, resulting in a paradigm conflict which may continue unresolved for generations, ultimately terminating with Mach bands
 - (e) neurons are binary: either they fire or don't fire at any given time
26. All of the following are properties of a Hopfield network EXCEPT
- (a) Ability to clean up noisy inputs.
 - (b) Ability to function despite minor damage to the network.
 - (c) Ability to perform pattern completion.
 - (d) Attractor dynamics.
 - (e) Feedforward information flow.
27. According to Hebb's rule
- (a) Calculations are performed in dendritic subdomains
 - (b) Coincident firing of pre- and postsynaptic cells will lead to increased synaptic strength between them
 - (c) Dendrites are inputs and axons are outputs
 - (d) Signals back-propagate up dendrites
 - (e) Calculations are done in a neuropil syncytium

28. Which of the following is NOT true about lateral inhibition?
- In the limulus eye, inhibitory effects add up linearly
 - Lateral inhibition produces Mach bands because highly excited cells at one side of a steep luminance gradient strongly inhibit neighboring weakly stimulated cells on the other side and are in turn weakly inhibited by these cells
 - Lateral inhibition is an effective model for edge detection.
 - Inhibition between receptors in the lateral inhibition network of the limulus eye is primarily from medial receptors to more lateral receptors.
 - Lateral inhibition can clean up messy input (i.e. spill over of light to neighboring receptors.)
29. When viewing a portion of a particular object, we can recall or visualize the entire object (i.e. I see rosy cheeks and a button nose and I think of Santa). This is an example of
- hetero-associative memory
 - auto-associative memory
 - pattern completion
 - lateral inhibition
 - graceful degradation
30. The following figure presents a limulus experiment



and illustrates:

- (a) One way inhibition $A \rightarrow B$
 - (b) One way inhibition $B \rightarrow A$
 - (c) Mutual inhibition
 - (d) Wraparound inhibition
 - (e) Mutual excitation
31. A cell in the limulus eye more strongly inhibits those cells that are
- (a) at greater distance from it
 - (b) nearest to it
 - (c) at intermediate distance
 - (d) even multiples of units away
 - (e) odd multiples of units away
32. Biological systems are typically adapted to have maximal responsiveness to particular types or patterns of stimuli that are salient (important) for the organism. From what we know of limulus eye physiology, which of the following is likely to be particularly salient:
- (a) Diffuse light
 - (b) A strongly focused point of light
 - (c) Infrared light
 - (d) A pulsating light
 - (e) A strongly contrasted edge
33. The original Hebb's rule states that ONLY coincident activity in pre and postsynaptic neurons produces an augmentation in synaptic strength between the neurons. Which of the following is not consistent with the original Hebb's rule in the context of an outer product associative memory model:
- (a) Use of a sigmoidal activation function.
 - (b) Use of a sharp threshold for an activation function.
 - (c) Use of $\{1, 1\}$ vectors
 - (d) Use of positive weights
 - (e) Use of $\{0, 1\}$ vectors
34. According to rate coding theory, neurons can encode negative values so long as they have:

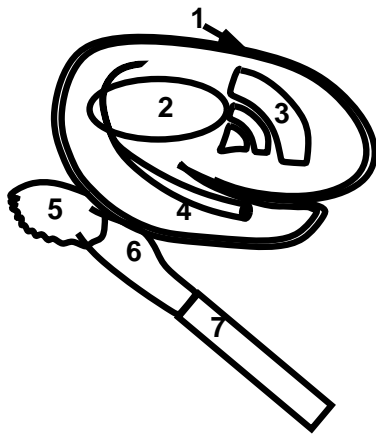
- (a) dendrites
 - (b) slow potentials
 - (c) IPSPs
 - (d) a spontaneous rate
 - (e) Hebbian synapses
35. In an heteroassociative memory, what property of multiple vector pairs prevents crosstalk between memories?
- (a) Orthogonality of input vectors
 - (b) Orthogonality of output vectors
 - (c) Orthogonality between each input vector and its corresponding output vector
 - (d) An inner product between each input vector and its corresponding output vector equal to 0
 - (e) An outer product between each input vector and its corresponding output vector equal to 0
36. Maximum rate of neuron firing is limited by the duration of the action potential. An approximate value for maximum rate would be:
- (a) 50 Hz
 - (b) 100 Hz
 - (c) 200 Hz
 - (d) 1000 Hz
 - (e) 5000 Hz
37. Which of the following is not an accurate orderofmagnitue measure?
- (a) Dendrite: $1\text{mm} \times 5\mu\text{m}$
 - (b) Soma diameter: $30\mu\text{m}$
 - (c) Synaptic cleft: $< 1\mu\text{m}$
 - (d) Axon: $1\text{m} \times 5\mu\text{m}$
 - (e) Brain: 10cm across
38. Which of the following is indicative of reduced activity [according to neurobiology/rate coding theory/slow potential theory.]

- (a) depolarization
 - (b) GABA transmitter release
 - (c) decrease in interspike intervals (spike firing period)
 - (d) an excitatory postsynaptic potential (EPSP)
 - (e) increase in firing frequency
39. Dale's law states that each neuron only uses 1 primary neurotransmitter for all of its projections. An easy way to address Dale's law in an artificial neural network is:
- (a) Use a sigmoidal activation function.
 - (b) Use a sharp threshold for an activation function.
 - (c) Use $\{1, 1\}$ vectors so that multiplication yields a Hebb's rule variant with synaptic augmentation based on coincident inactivity
 - (d) Assume that all processing units are excitatory and add an interneuron in synaptic series for negative projections
 - (e) Use $\{0, 1\}$ vectors so that multiplication yields the classical Hebb's rule.
40. Which of the following sequences would NOT represent the ordering of sensory transduction in the limulus eye?
- (a) Generator potential before action potentials
 - (b) Physical stimulus before chemical reaction
 - (c) Activation of the spiking eccentric cell after activation of the nonspiking photoreceptor
 - (d) Spike firing before lateral inhibition
 - (e) Change in spike frequency in a cell before a voltage change in that cell.
41. If depolarization of the membrane allows calcium ions to enter the dendrite at a rate of $6e10$ ions/s·cm² what will be the average concentration of ions (in ions/ μm^3) in the cytoplasm after 25 ms (assume uniform distribution and no diffusion out of the dendrite)
- (a) 2
 - (b) 5
 - (c) 10
 - (d) 15
 - (e) 20

42. A content addressable memory
- (a) Uses pointers to access information
 - (b) Can perform pattern completion
 - (c) Is exemplified by random access computer memory
 - (d) Must use attractor dynamics
 - (e) Is a necessary property of a parallel distributed processing (PDP) system
43. The delta rule reduces error in a memory matrix by:
- (a) Minimizing crosstalk
 - (b) Gradually increasing the strength of all matrix elements
 - (c) Utilizing an outer product of outputs and inputs
 - (d) Changing the strength of matrix elements depending on an error between desired and target outputs
 - (e) Backpropagating error through the layers of a feedforward network
44. Increasing the length constant of inhibition in the limulus model will tend to have the following effect following stimulation by a spatial step luminance function (low light level on one side with sharp boundary to high light level on other side)
- (a) Reduced activity in strongly stimulated units only
 - (b) Reduced activity in weakly stimulated units only
 - (c) Increased activity in weakly stimulated units only
 - (d) Increased activity in strongly stimulated units only
 - (e) Reduced activity in all units
45. The following are all likely to be aspects of central nervous system function EXCEPT
- (a) asynchronous updating
 - (b) content addressability
 - (c) analog signals
 - (d) labelled lines
 - (e) random access memory
46. The linearity observed in the limulus retina is relatively unusual for sensory systems. A logarithmic relation is more common. What is the primary advantage of the logarithmic relation?

- (a) It improves the response to strong contrasts across the sensory field
 - (b) A given magnitude of sensory stimulus increase will always produce the same magnitude increase in response
 - (c) Doubling the sensory stimulus will still produce the same magnitude increase in response even with a strong initial stimulus.
 - (d) The response to a greater stimulus will be less than the response to a lesser stimulus.
 - (e) There will be a threshold above which sensory responses are strongly increased.
47. The point attractors of a Hopfield network represent
- (a) Initial stimuli that serve as inputs to the system.
 - (b) The stored memories.
 - (c) Continuous repeating cycles in the dynamics of the network.
 - (d) The activation functions for the individual units.
 - (e) Final fixed values for the weights between the units.
48. The primary cause of crosstalk in an associative network is:
- (a) nonorthogonal input vectors
 - (b) nonorthogonal input/output pairs
 - (c) using $\{0, 1\}$ vectors instead of $\{-1, 1\}$ vectors
 - (d) lateral inhibition
 - (e) iterative solution
49. Mach bands in the limulus simulation demonstrate the phenomenon of
- (a) edge enhancement
 - (b) crosstalk
 - (c) analog inaccuracy of neuron coding
 - (d) the limulus is old. it needs to evolve.
 - (e) nonlinear squashing

The next questions refer to the following figure



50. A motor area involved in sequencing

- (a) structure #1
- (b) structure #2
- (c) structure #3
- (d) structure #4
- (e) structure #5

51. structure #1

- (a) thalamus
- (b) basal ganglia
- (c) hippocampus
- (d) cortex
- (e) cerebellum

52. structure #5

- (a) thalamus
- (b) basal ganglia
- (c) hippocampus
- (d) cortex
- (e) cerebellum

53. Control of the face and a passageway from brain to body:
- (a) structure #2
 - (b) structure #3
 - (c) structure #4
 - (d) structure #5
 - (e) structure #6
54. Relaying of sensation up to consciousness:
- (a) structure #1
 - (b) structure #2
 - (c) structure #3
 - (d) structure #4
 - (e) structure #5
55. Electron microscopy but not light microscopy can be used to see which of the following:
- (a) Dendrite
 - (b) Action potential
 - (c) Synapse
 - (d) Axon
 - (e) Dendritic spine
56. Which of the following supports the hypothesis that the central nervous system uses rate coding?
- (a) The existence of tonic and phasic responses.
 - (b) Burst firing
 - (c) Synchronous firing of different neurons
 - (d) Neurons that fire rarely
 - (e) Neurons that fire regularly at rest