

UNIVERSITY OF BRISTOL

Sample 2022 Examination Period

FACULTY OF ENGINEERING

**M Level Examination for the Degree of
Master of Engineering / Masters of Science**

**COMSM0094-J
Learning, Computation and the Brain**

**TIME ALLOWED:
2 hours**

This paper contains 25 questions, all questions should be attempted and all carry equal marks; the first ten questions are multiple choice, the next ten require very short answers, typically a number or a few words; the final five questions require two to four sentences.

Other Instructions:

You may use your own notes and you can use your computer to do calculations, but you should not use the internet while you are doing this exam. Please submit your solution as a single PDF; you can add your answers by annotating the pdf, by printing out the pdf and writing in your answers or by writing on a blank sheet, numbering your answers clearly.

Multiple choice questions.

These questions have one correct answer, please pick A, B, C or D.

Q1. Neurotransmitter are found in the

- A soma
- B chemical synapses
- C electrical synapses
- D glial cells

Q2. ionotropic and metabotropic are examples of

- A neurotransmitters
- B neuromodulators
- C receptors
- D neurons

Q3. Damage to Werknike's area causes

- A expressive aphasia
- B fluent aphasia
- C episodic ataxia
- D spinocebellar ataxia

Q4. Parkinson's disease is associated with cell death in

- A the frontal lobe
- B the hippocampus
- C the basal ganglia
- D the amygdala

Q5. Purkinje cells are found in

- A the cerebellar cortex
- B the cerebellar nucleus
- C the frontal cortex
- D the hippocampus

Q6. Which line of code is correct Python

- A `a<-[1,2,3]`
- B `a=[1,2,3]`
- C `a<-Vector{1,2,3}`
- D `a=Vector{1,2,3}`

Q7. In the integrate and fire equation

$$\tau \frac{dV}{dt} = E_l - V + R_m I_e$$

the constant R_m has the units of

- A voltage
- B resistance
- C time
- D conductance

Q8. When modelling neurons, where does the most important nonlinearity arise?

- A somatic spikes
- B synaptic transmission
- C axonal transmission
- D dendritic spikes

Q9. For a Hopfield network with symmetric weights there exist

- A false wells
- B stable states
- C fluctuations in the energy landscape
- D peaks of attraction

Q10. What cell type might we describe using difference-of-Gaussians tuning curve?

- A retinal ganglion cell
- B V1 simple cell
- C V1 complex cell
- D V4 cell

Short answer questions

These question expect an answer that is a number, or a few words, no marks will be given for workings.

Q1. What is the value of f for differential equation

$$\tau \frac{df}{dt} = a - f$$

at time $t = 1$ if $f(0) = 1.0$ where $\tau = 0.25$ and $a = 2.0$. You can write your answer in terms of the exponential.

Q2. What are the steady-state values of the differential equation

$$dy/dt = -\sin y$$

Q3. Give a typical value of the resting potential of a neuron.

Q4. The flow of which ions are described in the original Hodgkin-Huxley equation?

Q5. What function is typically attributed to the dentate gyrus

Q6. In the Taylor expansion of $f(x) = \exp x$ around $x = 0$ we have $f(x) = 1 + x + ax^2 + \dots$. What is the value of a ?

Q7. Consider the delta rule, where we initially have $w = (0, 1)$. We then do TWO delta-rule updates, with $x = (1, -1)$, a target of $y^* = 2$, and a learning rate of $\nu = 0.2$. What are the final weights?

Q8. Name two unusual features of cerebellar Purkinje cells

Q9. Name the process in which two Gaussians are combined to produce a Bayes optimal estimate.

- Q10.** One percent of pound coins are fake, ninety percent of fake coins melt, the melting device has a fluctuating temperature which means eight percent of real coins also melt. If a coin melts what is probability it was fake.

Long answer questions

These questions expect an answer that is two to four lines long.

- Q1.** What is meant by saying the Integrate and Fire neuron is non-linear, what about the Hodgkin and Huxley model?

- Q2.** Write a short programme in Python, MATLAB or Julia that will perform Euler integration for the equation $df/dt = a - f$.

- Q3.** Describe the Ernst and Banks experiment.

Q4. Which experimental stimulus might a V1 simple cell respond most strongly to?

Q5. How might Kalman filtering describe cerebellar control of movement.