Neuroengineering 2023-2024

Exam 10 January 2025

Part I

How to submit your answers.

Type your answers in the provided text file.

Write the answers in the same sequence as the questions. Use a separate line for each question. Start the line with the question number. Use dashes ('--') to indicate skipped answers. For example:

```
Section A
1. T
2. F
3. F
4. --
5. T
…
Section B
1. …
```

In the exceptional case that one or more of your answers require specific assumptions that were omitted in the question, you can add short comments **at the end of each section**. Start the **optional** comment with the number of the question it refers to. For example:

```
…

Comments
Q7: I assumed that the sinewave frequency is lower than the Nyquist frequency.
```

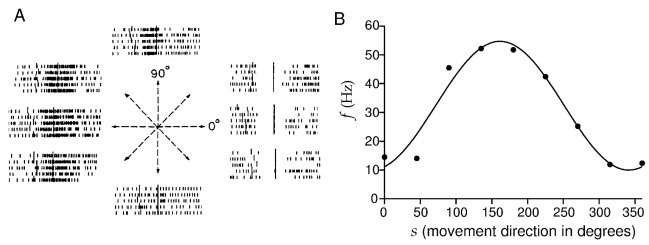
The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

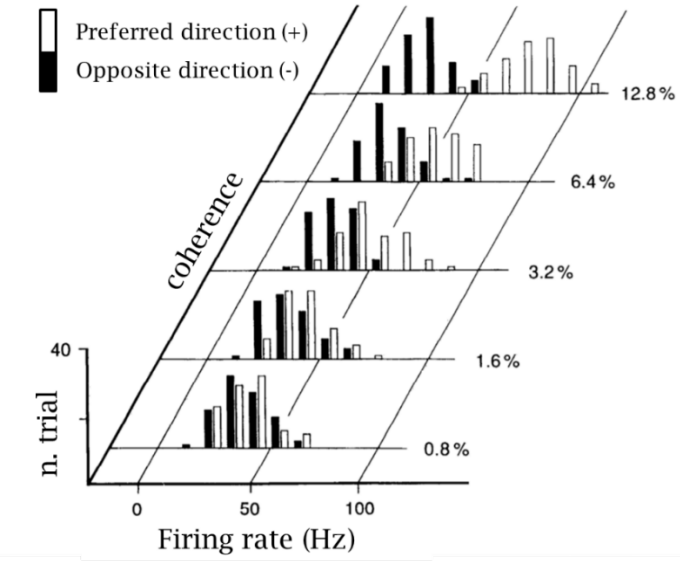
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

The maximum total score for part I is 24.
A minimum score of 14 points in Part I is required to pass the exam.

Section A

Unless stated otherwise, each correct answer will contribute 0.5 points to the grade (yielding a maximum of 12 points for Section A). Wrong answers will receive a penalty of -0.25 points.

#	Question
1	In the Nernst equation for the electrochemical equilibrium there is a term referred to diffusional forces and a term referred to electrical forces.
2	Given that at a certain temperature *T* the Cl- equilibrium potential is equal to -80 mV, and the membrane potential is equal to -70 mV, the Cl- net current will be a depolarizing one.
3	The temporal summation of PSPs does not depend on the temporal distance between subsequent action potentials in the presynaptic cell.
4	A hyperpolarization with respect to the resting membrane potential can cause the generation of an action potential.
5	The motor homunculus is located in the frontal lobe.
6	The short-term synaptic plasticity can involve a structural change in the post-synaptic membrane.
7	To measure the membrane potential over the soma of a neural cell *in vitro*, the correct procedure is to record extracellular measures.
8	In a cortical pyramidal neuron, thalamo-cortical synapses are located in the apical portion of its dendritic tree.
9	Radially symmetric neurons produce a closed field and therefore do not significantly contribute to scalp EEG.
10	Potentials recorded by electrodes which are at a close distance on the scalp are mutually independent.
11	Given the following tuning curve, showing the spike trains obtained - for different trials - from a neuron of the primary motor cortex in correspondence to an arm movement (panel A), and the firing rate *f* of the same neuron as a function of the angle *s* of the same movement direction (panel B):  The maximum neural response is obtained for a movement direction with an angle of 350 degrees.
12	In reference to the previous figure: from the curve, I can conclude that this neuron is tuned to be more active in correspondence to a specific movement direction.

#	Question
13	In reference to the previous figure: the firing rate *f* in panel B was computed as the average of the neural response function across trials.
14	Given the firing rate distribution in the figure, obtained for a neuron of the primary visual cortex in response to the motion direction of dots on the screen in two possible directions (+ and -) and with different levels of coherence between the dots:  Discriminability *d'* is higher when the coherence level is equal to 6.4% than when it is equal to 12.8%.
15	In reference to the previous figure: the histogram obtained for the preferred direction (+) is less affected by the coherence level than the distribution (-).
16	In reference to the previous figure: there is an optimal value *z* that can be used as a threshold for classification at all coherence levels
17	If a time series is not Fourier-transformable, it is impossible to compute its PSD.
18	A necessary condition for a linear autoregressive (AR) model is that the time series to be modeled is wide-sense stationary.
19	PDC is a spectral, bivariate (pairwise) method.
20	The use of Ordinary Coherence can mitigate the problem of the common source.
21	A negative value of the Granger Index $G_{x\to y}$ should never occur if the two AR models that are compared to compute the index are correct.
22*	In a graph, the distance *d(i,j)* between two nodes is given by the average length of the paths that link them.
23*	In a graph, the Global Efficiency $\in[0, 1]$.

#	Question
24*	In an undirected graph, I cannot compute the indegree and the outdegree.

(continues on the next page)

Section B

Unless stated otherwise, each correct answer will contribute 0.5 points to the grade (yielding a maximum of 12 points for Section B). Wrong answers will receive a penalty of -0.25 points.

#	Question
1	The purpose a filter is to allow desired spectral component of a signal to pass almost unaltered, while attenuating undesired spectral components
2	The DFT of a signal represents the amplitude A_i and initial phases ϕ_i of sinewave components of the signal at frequencies f_i ranging from $0Hz$ (included) to the sampling frequency (excluded).
3	In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event
4*	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.
5	A negative peak in a ERP recorded on a specific subject with a latency of $108ms$ may still be named N100, if it matches the physiological phenomenon of the nominal N100 component.
6	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.
7	EEG electrodes whose first letter of the label is “C” (e.g. “Cz”) are located on the central region of the head, i.e. the region between the left and the right hemisphere
8	Ensuring a contact impedance below 5 kis not relevant when the input impedance of the EEG amplifier is below 50 k
9	The artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings
10	The Central Limit Theorem (CLT) states that the average of N zero-mean independent identically distributed signals approaches zero for $N \to \infty$.
11	The measurement of two monopolar EEG channels requires four electrodes – two collecting the potentials fed to the non-inverting input of the differential amplifier, one providing the reference potential and one providing the ground potential.
12	In analog-to-digital conversion, each spectral component of the analog signal should have frequency below the Nyquist frequency
13	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.
14	The alpha rhythm can be observed by filtering the spontaneous EEG signal using a narrowband filter, with cutoff frequencies at 14 and 30 Hz (approximately)

#	Question
15	The synchronized average of N trials containing only spontaneous EEG whose variance is var_{trial} *is a signal whose variance is* $var_{avg} = var_{avg}/N$
16	The proper (visual) alpha rhythm is modulated (synchronized, desynchronized) by opening and closing the eyes. This phenomenon is best observed on the frontal EEG channels.
17	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$
18	As a preliminary step to EEG data analysis, one or more channels can be removed from the dataset if they are extensively contaminated by artifacts
19	A BCI system may replace functions that are physiologically subserved by nerves and muscles, by directly measuring brain activity and converting it to an artificial output.
20	The CMRR of a bipolar amplifier measures the ratio between the gain of their average with respect to the electrical ground and the gain of the potential difference between the input electrodes.
21	The frequency response of a filter in the stopband should be plotted in a graph whose vertical axis has a logarithmic scale (i.e. the gain is expressed in dB).
22	Evoked potential is synonymous of Event-Related Potentials
23	The RMS is the square root of the average of the squared value of the samples of a signal
24	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.

(end of Part I)