Neuroengineering 2023-2024

Exam 3 February 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.
```

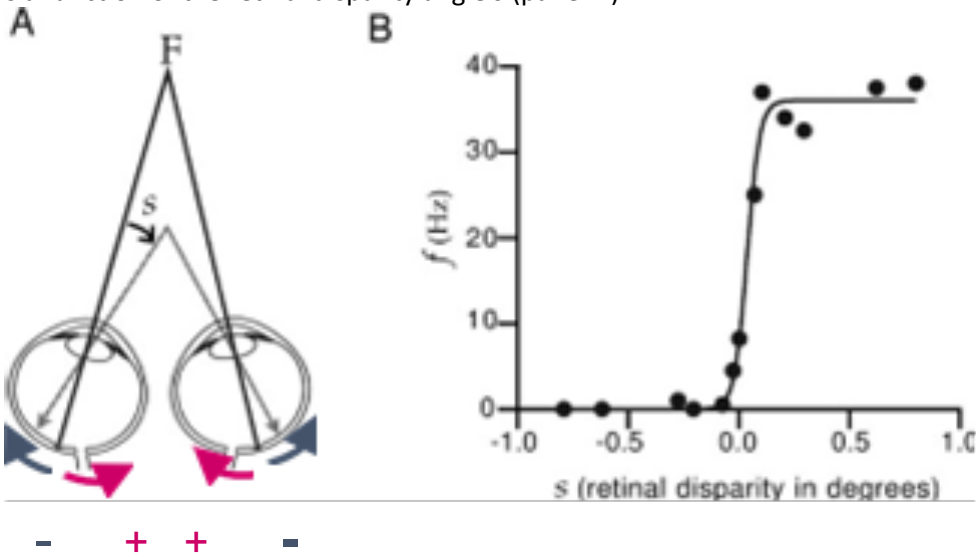
The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

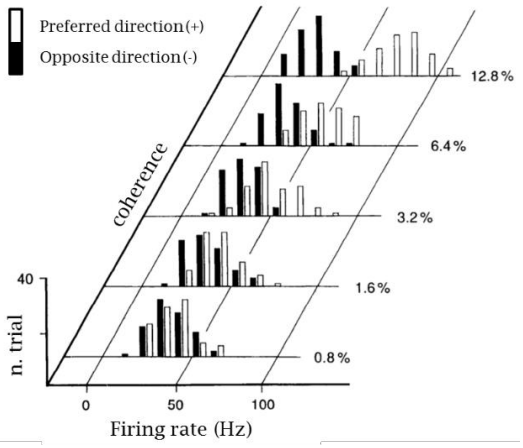
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

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	An IPSP consists of a depolarization of the post-synaptic cell membrane.
2	The inactivation of the voltage-gated Na^+ channel is responsible for the absolute refractory period.
3	The most informative parameter of the spike train in output to a neuronal cell is the amplitude of the spikes.
4	The firing rate of the pre-synaptic neuron influences the temporal summation of the PSPs in the post-synaptic cell.
5	The frontal lobe houses the primary visual function.
6	In the primary motor cortex (Penfield homunculus) the extension of the cortical region which controls a specific body region is proportional to that body region's volume.
7	To record in vivo measures of the membrane potential over the axon of a single neural cell, you will use extracellular measures.
8	The EEG signal is mainly generated by action potentials.
9	The tuning curve in the figure shows (panel B) the firing rate *f* of a neuron in the primary visual cortex as a function of the retinal disparity angle *s* (panel A).  From the figure, we can infer that the neuron responds mainly to positive *s* (far-tuned neuron).
10	In reference to the previous figure: from the curve, if the retinal disparity is equal to -0.5, I can infer which firing rate will be produced by the neuron.
11	In reference to the previous figure: from the curve, if the neuron firing rate is equal to 0 Hz I can exactly infer which retinal disparity produced that response.

#	Question
12	To record in vitro measures of the membrane potential over the dendrites of a neural cell, you will use extracellular measures
13	The part of the pyramidal neuron that acts as a current dipole is the axon
14	Given the distribution of firing rates in the figure:  The discriminability *d'* when the coherence=3.2% is higher than when it's =12.8%
15	In reference to the previous figure (question 14), among the two distributions (r_+ or r_-), r_+ is the one affected by the coherence level
16	The normalized Partial Directed Coherence $\in[0, 1]$
17	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure
18	If Cxy(f) is the ordinary coherence between x and y, Cxy(f)=Cyx(f)
19	The difference between the Wiener's and Granger's definitions of causality in the statistical sense is that Granger indicated a modeling framework to be used to test causality
20	Regular networks have a smaller Global Efficiency than random networks
21	Regular networks have a smaller Local Efficiency than random networks
22	Undirected graphs produce symmetrical adjacency matrices
23	Given the Granger Index Gxy between two time series x and y, a negative value of Gx->y means an inverse precedence between the two time
24	Using Partial Directed Coherence completely solves the problem of the hidden (common) source

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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 alpha rhythm can be observed by filtering the spontaneous EEG signal using a narrowband filter, with cutoff frequencies at 14 and 30 Hz (approximately)
2	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.
3	Evoked potential is synonymous of Event-Related Potentials
4	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.
5	In an ADC, quantization introduces a noise whose amplitude is proportional to the number L of discrete amplitude levels: $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot L = \frac{1}{\sqrt{12}} \cdot 2^{NBIT}$
6	The artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings
7*	The synchronized average of N trials containing only spontaneous EEG whose variance is $var_{trial} = \sigma^2$ *is a signal whose variance* $var_{avg} = \sigma^2/N$
8	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).
9	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.
10	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.
11	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.
12	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
13	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.
14	In analog-to-digital conversion, each spectral component of the analog signal should have frequency below the Nyquist frequency

#	Question
15	In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event
16	The Central Limit Theorem (CLT) states that the average of N zero-mean independent identically distributed signals approaches zero for $N \to \infty$.
17	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
18	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.
19*	Given two ranges of equal width A=[-0.1,+0.1] and B=[0.8,1.0], it is less likely that samples of a sinewave $x = sin(t)$ will have amplitude in A rather than B.
20	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.
21	The advantage of a high CMRR amplifier is that it suppresses high frequency disturbance.
22	The purpose a filter is to allow desired spectral component of a signal to pass almost unaltered, while attenuating undesired spectral components
23	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).
24	The Inter-Stimulus Interval (ISI) equals the SOA minus the ITI.

(end of Part I)