Neuroengineering 2023-2024

Exam 4 April 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.
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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:

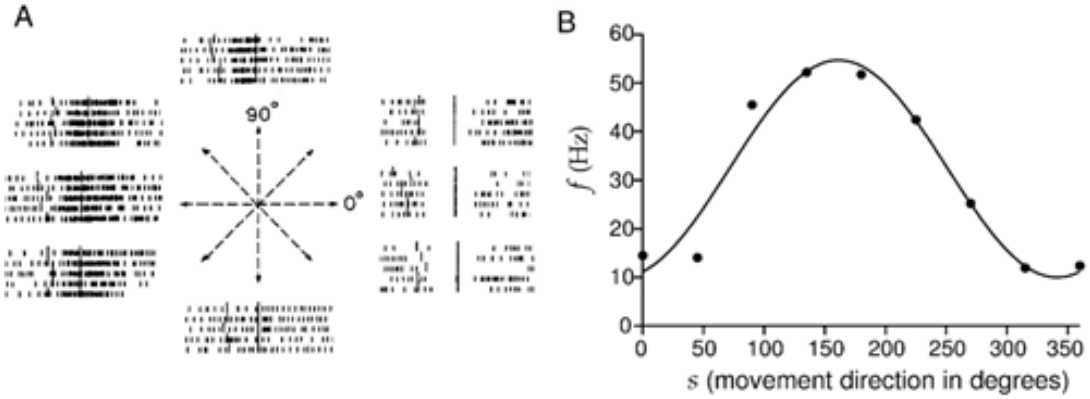
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

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	The voltage-gated K^+ channel inactivation state is responsible for the absolute refractory period.
2	The voltage-gated Na^+ channel is responsible for the depolarization phase of the action potential.
3	When temporal summation occurs, spatial summation cannot.
4	The firing rate influences the amplitude of the resulting action potential in the post-synaptic cell.
5	The frontal lobe houses the primary motor function.
6	In the brain primary somatosensory cortex (Penfield homunculus) the extension of the cortical region which maps a specific body region is proportional to that body region's volume.
7	The short-term synaptic plasticity involves a structural change in the post-synaptic membrane.
8	The brain operates at the temporal scale of milliseconds.
9	The neurons' spatial orientation affects the amplitude of EEG signals
10.	The synchronicity of the neural activity affects the amplitude of EEG signals.
11	Scalp EEG is mainly produced by deep (subcortical) regions.
12	The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.

#	Question
13	 The tuning curve in the figure shows (panel A) the spike trains obtained - for different trials - from a neuron of the primary motor cortex in correspondence to an arm movement, and (panel B) the firing rate *f* of the same neuron as a function of the angle *s* of the same movement direction. When the firing rate is 55 Hz, I can infer which movement direction produced that response.
14	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.
15	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.
16	If $C_{xy}(f)$ is the Ordinary Coherence between *x* and *y*, $C_{xy}(f)=C_{yx}(f)$.
17	Given the Granger Index G_{xy} between two time series *x* and *y*, a negative value of $G_{x\to y}$ means an inverse precedence between the two time series.
18	In the event of data paucity, the Partial Directed Coherence (PDC) is the most accurate estimator of causality in the statistical sense.
19	In a directed graph, all indices are doubled with respect to a corresponding undirected one (i.e., the graph where all the directions have been removed).
20	Random networks have a smaller Local Efficiency than regular (lattice) networks.
21	In a graph, the minimum Divisibility is equal to zero.
22	Divisibility and Modularity are measures of segregation of a network.
23	Regular networks have a smaller Global Efficiency than random networks.
24	Modularity values belong to the interval [0,1]

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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	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.
2	Movements of the subject's head produces artifacts only in the gamma band.
3	Event-Related Desynchronization/ Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.
4	Event-Related Desynchronization/Synchronization (ERD/S) quantify phase-locked brain activity in response to an event
5	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$
6	The powerline noise affects a very narrow frequency band of the recorded signal around 50 Hz (in Europe) and odd multiples of (150 Hz, 250 Hz, …).
7	The frequency spectrum of white noise is flat, i.e. it has the same power at any frequency.
8	A FIR filter needs to be of a higher order to achieve the same quality specifications than a IIR filter.
9	The contact impedances of a pair of electrodes should be large compared to the input impedance of the differential amplifier connected to them, otherwise the amplitude of the signal would be reduced as effect of the potential divider.
10	Aliasing occurs when an artifact corrupts an otherwise healthy EEG recording.
11	The CMRR of a bipolar amplifier measures how much higher is the gain of the potential difference between the input electrodes with respect to the gain of their average with respect to the electrical ground.
12	A 'run' is a portion of recording in an experimental protocol that contains no breaks, i.e. all samples contained therein have been acquired $1/f_s$ seconds after the previous (f_s being the sampling frequency)
13	EEG signals recorded in monopolar configuration can be re-referenced to the Common Average Reference (CAR), by subtracting from each channel the instantaneous average of all channels. In ideal conditions, this would approximate taking the reference potential at infinity.

#	Question
14	The Shannon's theorem states that a continuous signal can be properly sampled only if it does not contain frequency components above the sampling rate.
15	The N20 component of an EP occurs before the stimulus (negative latency) while the P300 occurs after the stimulus (positive latency).
16	The RMS and the ARV of a zero-mean signal have the same value (assume that the number of samples $N \to \infty$).
17	In ERP analysis, 'trials' are portions of the continuous EEG recording that start exactly at the time when a sensory stimulus was delivered
18	The mu rhythm and the alpha rhythm are EEG components that differ for their fundamental frequency of oscillation
19	$ARV_x = \sqrt{\frac{1}{N}\sum_i (x[i])^2}$, where the sum extends on the N samples of the signal x[i]
20	In a P300-based BCI, the user subjectively assigns saliency (relevance) to a stimulus so that their brain produces a P300 ERP every time the stimulus is administered
21	An EEG recording is said to be bipolar when it comprises exactly two channels
22	The roll-off of a filter is the slope of its frequency response in the transition band. It is high when the transition band is narrow.
23	The Short Time Fourier Transform (STFT) is a simple method to estimate a spectrogram, i.e. the representation of the time-varying spectrum of a non-stationary signal.
24	The amplitude of an ERP is measured with respect to its value at the time of the event.

(end of Part I)