Neuroengineering 2024-2025

# Exam 5 June 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:

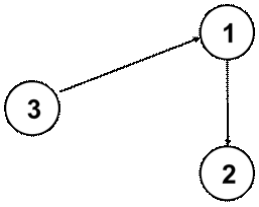
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

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 | The 4 main ion families having a role in the neuron functioning are Na+, K+, Br- and Ca++ |
| 2 | The resting membrane potential for the neural cell is equal to –90. |
| 3 | In an inhibitory synapse, the membrane current is always hyperpolarizing. |
| 4 | In the Nernst equation, the ion valence can be either positive or negative. |
| 5 | The resting membrane potential is entirely due to the sum of the effects of diffusional forces and electrical forces acting on the ions. |
| 6 | If at a certain temperature T the equilibrium potential for a given ion family is equal to +30 mV, and the membrane potential is equal to -70 mV, the ion net current will be a hyperpolarizing one. |
| 7 | The propagation speed for an action potential in an unmyelinated axon is slower than in a myelinated one. |
| 8 | The Thalamus, the Brainstem and the Penfield Homunculus are all subcortical areas. |
| 9 | In the short-term plasticity, there are no structural changes in the post-synaptic membrane. |
| 10. | The following measures of brain electrical correlates are in the correct order, from the less detailed to the more detailed one: Scalp EEG, Local Field Potentials, Electrocorticography, Stereo EEG, Extracellular Recordings, Intracellular Recordings. |
| 11 | The main contributors to the amplitude of EEG are the post-synaptic potentials. |
| 12 | The following factors all affect the amplitude of EEG signals: the neurons' orientation, the synchronicity of the neural activity, the distance between the neurons and the electrodes, the closed/open field generated by the neurons. |
| 13 | If a time series is not Fourier-transformable, it is still possible to compute its power spectral density by means of the Wiener-Khinchin Theorem. |
| 14 | Ordinary Coherence is directional. |
| 15 | Anatomical connectivity can change over large time scales. |

| # | Question |
|---|---|
| 16 | Causality in the sense of physical influence can be tested by perturbing the brain activity. |
| 17 | Wiener-Granger Causality is based on the autoregressive modeling of time series. |
| 18 | The Granger Causality Test is a spectral measure. |
| 19 | This is an example of the hidden source effect:   |
| 20 | Multivariate approaches are more accurate because they use the information from all the time series involved in a unique model. |
| 21 | A Density equal to 1.3 is a physiologically plausible result. |
| 22 | Local Efficiency is a local measure. |
| 23 | Divisibility and Modularity are measures of segregation. |
| 24 | A Small-World Network properties are equidistant from those of Regular and Random Networks. |

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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 mu rhythm and the alpha rhythm have approximately the same frequency of oscillation and originate in different lobes of the cerebral cortex |
| 2 | The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head. |
| 3 | Event-Related Desynchronization/ Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels. |
| 4 | Induced activity is often examined by analyzing the envelope of the EEG in a relevant frequency band, i.e. by rectifying or squaring the pass-band filtered trials before averaging them. |
| 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 artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings |
| 7 | The Central Limit Theorem (CLT) states that the average of $N$ zero-mean independent identically distributed signals approaches zero for $N \to \infty$. |
| 8 | An IIR filter can be designed to have “linear phase”, so that they do not introduce time-domain distortions in the waveform of the output signal. |
| 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 | In an EEG recording, a session contains one or more trials, each of which contains one or more runs |
| 13 | The input impedance of a biosignal amplifier must be many orders of magnitude higher than the contact impedance of the electrodes. It is usual to have input impedances in the order of $10^8\Omega$. |
| 14 | The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of $sinc(\cdot)$ functions, one for each sample. |

| # | Question |
|---|---|
| 15 | The Inter-Stimulus Interval (ISI) measures the time interval between two successive stimuli in a train. |
| 16 | It is more likely that samples of zero mean a gaussian noise will have amplitude in the range $[-0.5,0]$ rather than in $[0,0.5]$ |
| 17 | In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event |
| 18 | The $\eta$ (eta) rhythm is an oscillatory component of the spontaneous EEG |
| 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 | The amplitude of a P300 event related potential be voluntarily modulated through the exercise of motor imagery, to build a cursor control based on a BCI. |
| 21 | 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. |
| 22 | The frequency response of a filter in the stopband should never be plotted in logarithmic units (i.e. with the gain is expressed in dB). |
| 23 | The DFT of a signal represents the amplitude $A_i$ and initial phases $\phi_i$ of sinewave components of the signal at frequencies $f_i$ ranging from $0Hz$ (included) to the sampling frequency (excluded). |
| 24 | 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. |

(end of Part I)