Neuroengineering 2023-2024

Exam 4 June 2024 – Part I (odd)

How to submit your answers.

Type your answers in the Exam.net editor.

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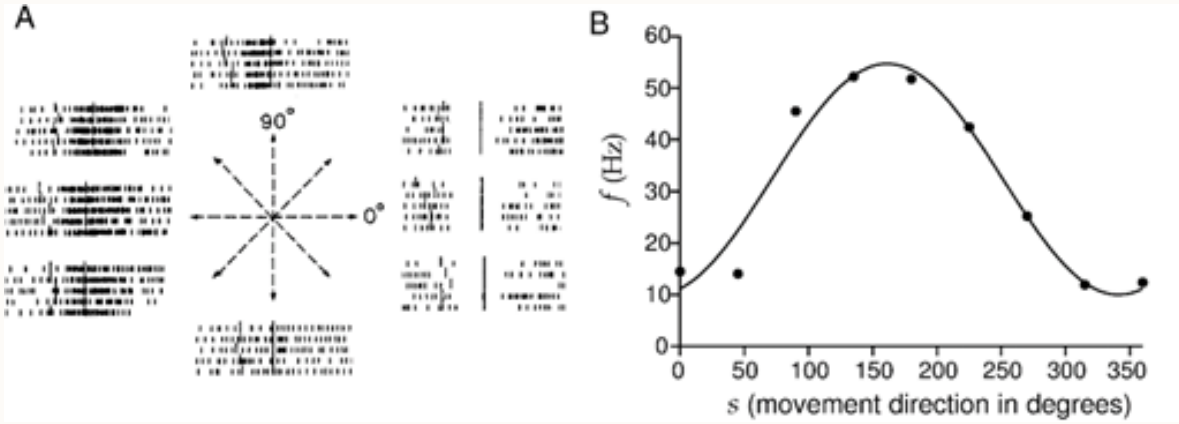
The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

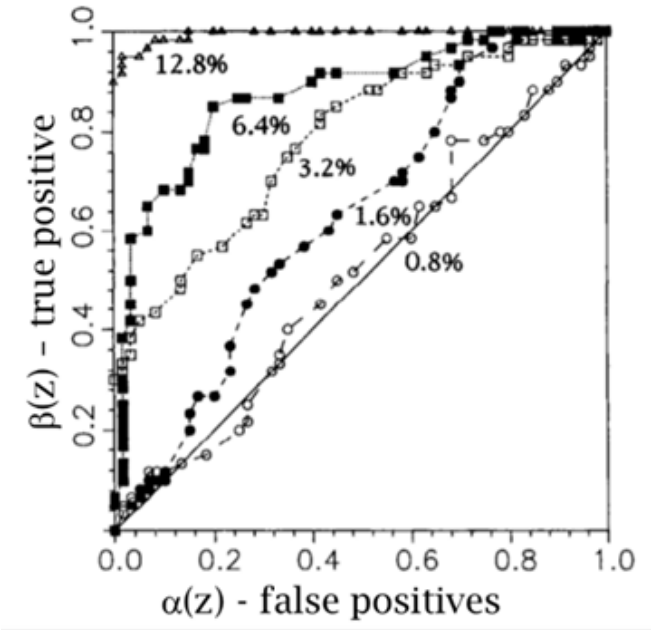
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

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	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.

#	Question
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.
13	In reference to the previous figure (question 10): the firing rate *f* in panel B was computed as the average of the neural response function across trials.
14	Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation (different curves):  The best curve is the one closer to the diagonal.
15	In reference to the previous figure: the Area Under the Curve (AUC) for each level of coherence is proportional to the discriminability of the two conditions.
16	In reference to the previous figure: by considering only the true positives and false positives, and neglecting the true negatives and false negatives, we miss part of the results of the classification.
17	The Spectral Matrix computed for any given pair of time series is always symmetrical.
18	Given two time series x and y, the Granger Causality Index $G_{x\to y} \in [-\infty, \infty]$.
19	When we have a limited amount of data, the Partial Directed Coherence (PDC) is the most accurate estimator of causality in the statistical sense.
20	The Ordinary Coherence is defined in the time domain.
21	A multivariate approach to the estimation of brain networks can always prevent the occurrence of the common source problem.
22	In a graph, when no path links two nodes, the distance between them is infinite.
23	In a graph, the Density $\in [0, 1]$.
24	The Global Efficiency is normalized to the number N of nodes in the graph.

(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	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.
2	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.
3	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.
4	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
5	It is more likely that samples of zero mean a gaussian noise will have amplitude in the range [-0.5,+0.5] rather than in [0.5,1.5]
6	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).
7	$ARV_x = \sqrt{\frac{1}{N}\sum_i (x[i])^2}$, where the sum extends on the N samples of the signal x[i]
8	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.
9	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.
10	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.
11	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.
12	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.
13	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of $sinc(\square)$ functions, one for each sample.

#	Question
14	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).
15	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.
16	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.
17	The Central Limit Theorem (CLT) states that the average of N zero-mean independent identically distributed signals approaches zero for $N \to \infty$.
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	If the electrodes' contact impedance is not much lower than the amplifier's input impedance, the amplitude of the measured potential is closer to zero than the actual value.
20	The artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings
21	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$
22	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)
23	In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event
24	Evoked potential is synonymous of Event-Related Potentials

(end of Part I)