Neuroengineering 2023-2024

Exam 4 June 2024 – Part I (even)

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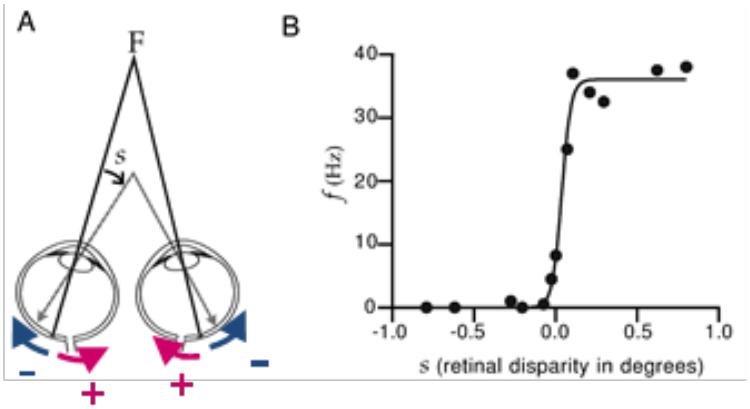
The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

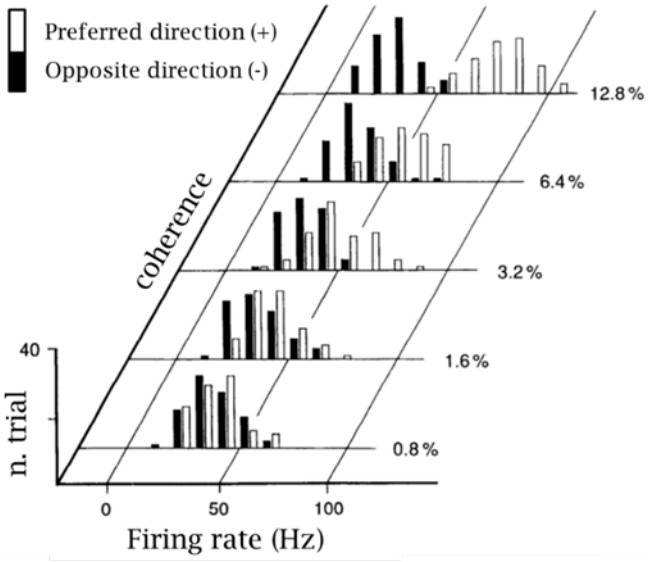
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

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	Ion pumps are based on a passive membrane transportation mechanism.
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 directed from the inside of the cell toward the outside.
3	In chemical synapses, when a neurotransmitter opens the K^+ gated channels, the resulting PSP is an inhibitory one.
4	The continuous conduction is faster than the saltatory (myelinated) one.
5	Two ipsilateral regions belong to the same hemisphere.
6	The unmasking of latent synaptic connections is part of the mechanisms behind brain plasticity.
7	To detect a sequence of action potentials over the axon of a neural cell *in vivo*, the correct procedure is to record extracellular measures.
8	The cortical pyramidal neurons are oriented tangentially to the cortical surface.
9	Synchronously activated neurons produce a larger EEG signal than the same group of neurons when they are asynchronous.
10	Deep (subcortical) regions of the brain produce a less blurred scalp EEG than cortical ones.
11	Given the following tuning curve, showing the firing rate *f* of a neuron in the primary visual cortex (panel B) as a function of the retinal disparity angle *s* (panel A):  From the figure, we can infer that the neuron responds mainly to negative *s* (closed-tuned neuron).
12	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.
13	In reference to the previous figure: there are retinal disparity angles to which this neuron is “blind” (i.e., it doesn’t show any response).

#	Question
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 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 $\in [0, 1]$.
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	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]
2	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.
3	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.
4	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.
5	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.
6	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.
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	In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event
9	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.
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 artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings
12	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.
13	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.
14	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.

#	Question
15	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$
16	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
17	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.
18	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).
19	Evoked potential is synonymous of Event-Related Potentials
20	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).
21	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)
22	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.
23	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.
24	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.

(end of Part I)