Neuroengineering 2023-2024

Exam 19 October 2024

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.
```

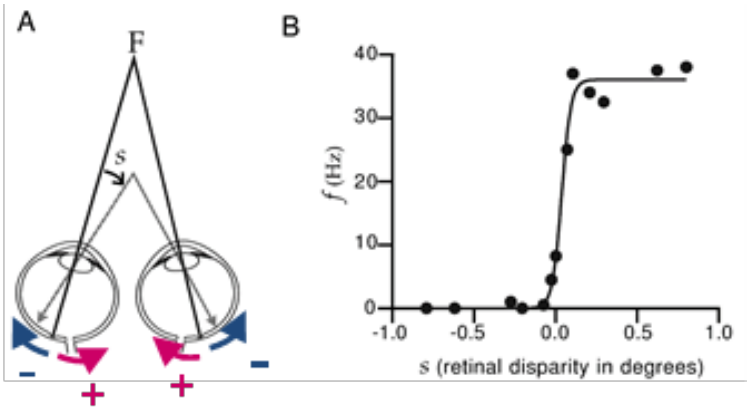
The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

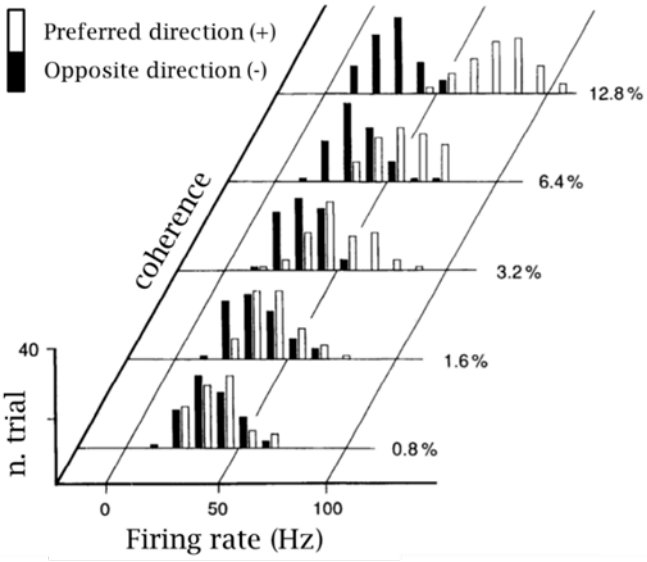
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points,
- a wrong T/F answer contributes -0.25 points.

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	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.

#	Question
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).
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.

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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 are EEG components that differ for their fundamental frequency of oscillation
2	The “waxing and waning” of the alpha rhythm is a change of amplitude whose duration is in the order of magnitue of 1 second.
3	Event-Related Desynchronization/ Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.
4	The CMRR of an EEG amplifier should be higher than 90 dB
5	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.
6	An EEG recording is said to be bipolar when it comprises exactly two channels
7	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.
8	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)
9	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, …).
10	Movements of the subject’s head produces EEG artifacts mainly in the lowest part of the spectrum.
11	When recording EPs, the spontaneous EEG is to be considered a noise that completely masks the EPs on the recorded waveform.
12	In ERP analysis, ‘trials’ are portions of the continuous EEG recording that start exactly at the time when a sensory stimulus was delivered
13	The N20 component of an EP occurs before the stimulus (negative latency) while the P300 occurs after the stimulus (positive latency).

#	Question
14	Event-Related Desynchronization/Synchronization (ERD/S) quantify phase-locked brain activity in response to an event
15	The reconstruction of an analog signal from its sampled version is equivalent to the linear interpolation of the samples.
16	Aliasing occurs when an artifact corrupts an otherwise healthy EEG recording.
17	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$
18	The Average Rectified Value (ARV) is a measure of the amplitude of a signal, and it is obtained by summing the absolute values of all samples and dividing the result by the number of samples.
19	The variance of a signal is estimated by summing the square of all deviations of the N sample values from the sample mean, and then dividing by $(N-1)$
20	The frequency spectrum of white noise is flat, i.e. it has the same power at any frequency.
21	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.
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	A FIR filter needs to be of a higher order to achieve the same quality specifications than a IIR filter.
24	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

(end of Part I)