Neuroengineering 2021-2022

January 11th 2023 – Part I

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. True
> 2. A
> 3. B and D
> 4. ---
> 5. 500 ms
> …
> 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
> 7. 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:

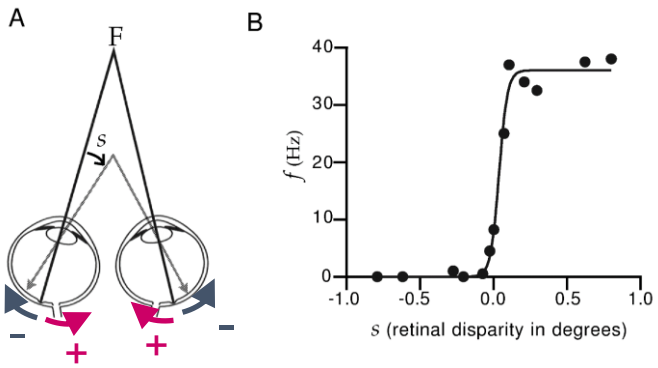
- correct and complete answer will contribute the maximum score
- partially correct or incomplete answers will contribute a fraction of the maximum score
- missing answers will not contribute
- wrong answers to the closed-ended questions (T/F, multiple choice, etc) will contribute with a negative score equal to –(max/N), where N is the number of possible choices.

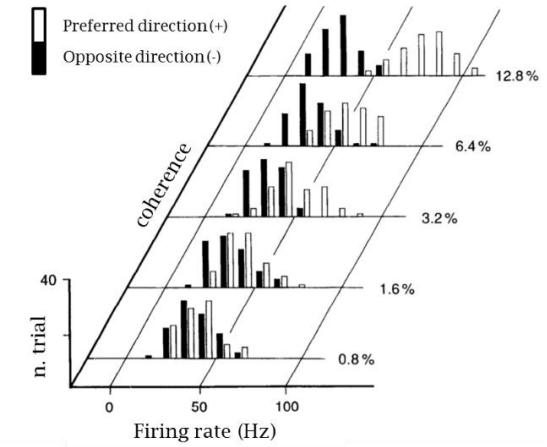
For instance:

- 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 22.

Section A

	Question	Points (correct)	Points (wrong)
1	Temporal and spatial summation can occur simultaneously.	0.5	-0.25
2	The voltage-gated Na^+ channel is responsible for the absolute refractory period.	0.5	-0.25
3	The most informative parameter of the spike train in output to a neuronal cell is the amplitude of the spikes.	0.5	-0.25
4	The firing rate of the pre-synaptic neuron influences the temporal summation of the PSPs in the post-synaptic cell.	0.5	-0.25
5	The primary visual area is located in the cortex.	0.5	-0.25
6	In the brain primary motor cortex (Penfield homunculus) the extension of the cortical region which controls a specific body region is proportional to that body region's volume.	0.5	-0.25
7	The short-term synaptic plasticity involves an irreversible change in the post-synaptic membrane.	0.5	-0.25
8	To record in vivo measures of the membrane potential over the axon of a single neural cell, you will use extracellular measures.	0.5	-0.25
9	The EEG signal is mainly generated by action potentials.	0.5	-0.25
10	The tuning curve in the figure shows (panel B) the firing rate *f* of a neuron in the primary visual cortex 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).	0.5	-0.25
11	In reference to the previous figure (question 10): from the curve, if the neuron firing rate is equal to 0 Hz I can exactly infer which retinal disparity produced that response	0.5	-0.25
12	In a Poisson process, when *r* increases, higher values of *n* are more likely	0.5	-0.25
13	The differences between the distribution of *isi* in real data and in simulated data produced by an (uncorrected) Poisson spike generator are due to the refractory periods	0.5	-0.25

14	Given the distribution of firing rates in the figure:  The discriminability *d'* when the coherence=3.2% is higher than when it's =12.8%	0.5	-0.25
15	In reference to the previous figure (question 14), among the two distributions (r_+ or r_-), r_+ is the one affected by the coherence level	0.5	-0.25
16	The normalized Partial Directed Coherence $\in[0, +\infty]$	0.5	-0.25
17	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure	0.5	-0.25
18	If Cxy(f) is the ordinary coherence between x and y, Cxy(f)=Cyx(f)	0.5	-0.25
19	The difference between the Wiener's and Granger's definitions of causality in the statistical sense is that Granger indicated a modeling framework to be used to test causality	0.5	-0.25
20	Regular networks have a smaller Global Efficiency than random networks	0.5	-0.25
21	Regular networks have a smaller Local Efficiency than random networks	0.5	-0.25
22	Undirected graphs produce symmetrical adjacency matrices	0.5	-0.25
TOT		11	

For all answers: Type True/False unless otherwise specified

#	Question – Section B	Points (max)
1.	In the EEG terminology, impedance is a measure of the ability of an experimental subject to carry on an experiment.	0.5
2.	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances such as powerline (50 Hz) noise.	0.5
3.	The difference of contact impedances of electrodes should be small compared to the input difference of the differential amplifier, otherwise the resulting unbalance compromises its common-mode rejection capability.	0.5
4.	The amplitude of the mu rhythm is increased at the beginning of a motor task	0.5
5.	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.	0.5
6.	Movements of the subject's head produces artifacts only in the gamma band.	0.5
7.	The potential at the peak of the EP component P20 is lower than the potential at the peak of the N100 component	0.5
8.	The position of the reference electrode can strongly influence the shape and amplitude of EEG potentials. The profile (i.e. disregarding the actual potential value) of scalp topographies are not influenced.	0.5
9.	Digital processing can remove all significant artifacts, and thus it is not worth using the measurement time to reduce their presence on the raw recording.	0.5
10.	Powerline noise is an artifact caused by the capacitive coupling between the power supply conductors and the recording setup including the subject.	0.5
11.	In analog-to-digital conversion, each spectral component of the analog signal should have frequency below the Nyquist frequency.	0.5
12.	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval: $\sigma_{quant} = 1/\sqrt{12}\ LSB$	0.5
13.	The Inter-Stimulus Interval (ISI) measures the time interval between the end of a stimulus and the beginning of the following one.	0.5
14.	Brain activity in response to a stimulus can be non-phase-locked, meaning that they show variable latency (jitter) at each repetition. This activity is called *induced*.	0.5
15.	Event-Related Desynchronization/Synchronization (ERD/S) quantify relative changes of the power of the EEG rhythm in a predefined frequency range, relative to a baseline period.	0.5
16.	In a gaussian noise, the probability density that a sample has a given amplitude value follows the normal distribution with zero mean.	0.5
17.	Given 100 independent and identically distributed random variables with variance equal to 4, the variance of their average is 0.04?	0.5
18.	The spectral leakage phenomenon is observed, for instance, when comparing the spectrum of a signal with the spectrum of a short section of the same signal.	0.5

#	Question – Section B	Points (max)
19.	Appropriate application of a high-pass digital filter may prevent saturation by removing high amplitude slow artifacts.	0.5
20.	The sample variance of a signal is given by $s_X^2 = \frac{1}{N-1}\sum_i (x_i - \bar{X})^2$, where the sum extends on the N samples of the signal X	0.5
21	A BCI is a system that measures brain activity and converts it to an artificial output.	0.5
22	The output of FIR filters is the linear combination of samples of the input. The output of IIR filters combines both samples of the input and past samples of the output.	0.5
	Total points for Section B (max)	**11**

(End of the test)