Neuroengineering 2021-2022

Exam 23 June 2022 – Part I (even seats)

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 answer 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:

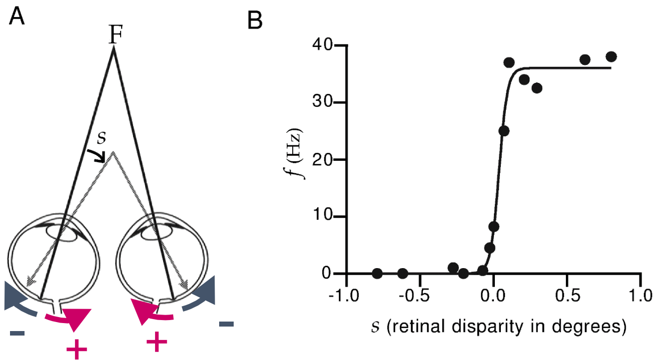
- correct and complete answer will contribute the maximum score
- partially correct or incomplete answers will contribute a fraction of the maximum score
- missing answers will not contribute
- wrong answers to the closed-ended questions (T/F, multiple choice, etc) will contribute with a negative score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

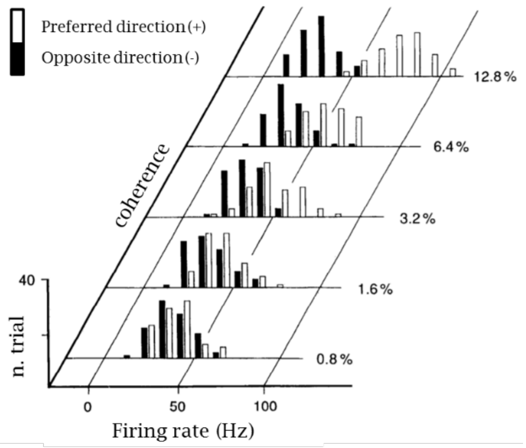
For instance:

- 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	An IPSP consists of a depolarization of the post-synaptic cell membrane.	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 frontal lobe houses the primary visual function.	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 positive *s* (far-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 ∈[0, 1]	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	

(follows on the next page)

For all answers: Type True/False unless otherwise specified

#	Question – Section B	Points (max)
1.	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 $10^8\ \Omega$.	0.5
2.	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.	0.5
3.	In the EEG terminology, impedance is a measure of the quality of the contact between electrode and scalp, through the conductive gel	0.5
4.	The proper (visual) alpha rhythm is generated in the frontal lobe of the cerebral cortex.	0.5
5.	The delta and theta frequency bands identify frequencies lower than those in the alpha band	0.5
6.	Notch filters effectively remove powerline noise because they reject all signals above their corner frequency.	0.5
7.	The SOA is always greater than the ISI	0.5
8.	In the electrode labels of the International 10-20 System, odd numbers designate electrodes on the right side of the head	0.5
9.	A sudden upwards movement of the eyes generates a positive deflection of EEG potentials (EOG) on the Fz channel.	0.5
10.	Sweating can affect the EEG, causing an increase of contact impedance and an increase of powerline noise	0.5
11.	Event-Related Desynchronization/Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	0.5
12.	Aliasing can be prevented by applying a digital low-pass filter with cutoff frequency lower than the Nyquist frequency.	0.5
13.	When aliasing occurs in ADC, a sinusoidal component with frequency $f_0 = 0.7\ f_s$ is reconstructed as a sinusoidal component at $f_1 = 0.2\ f_s$ (f_s is the sampling frequency)	0.5
14.	Synchronized averaging of N EEG trials produces N values each corresponding to the average value of the potential in each trial.	0.5
15.	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.	0.5
16.	The probability distribution of the average of N independent and identically distributed random variables approaches zero for $N \to \infty$	0.5
17.	Spectral analysis is well suited at identifying narrowband useful signals in (approximately) white noise, because a peak in the spectrum may still be detected even when the low signal-to-noise ratio (SNR) prevents the signal's waveform to be recognized among the noise samples.	0.5

#	Question – Section B	Points (max)
18.	Quantization divides the input range of the ADC into (approximately) 2^{NBITS} intervals, where NBITS is the number of bits of the ADC.	0.5
19.	The RMS is the average of the squared value of the samples of a signal	0.5
20.	It is more likely that samples of zero mean a gaussian noise will have amplitude in $[-0.5, +0.5]$ rather than $[0.5,1.5]$	0.5
21	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.	0.5
22	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.	0.5
	Total points for Section B (max)	**11**

(End of the test)