Neuroengineering 2020-2021

Exam 21 July 2021 – 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 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:

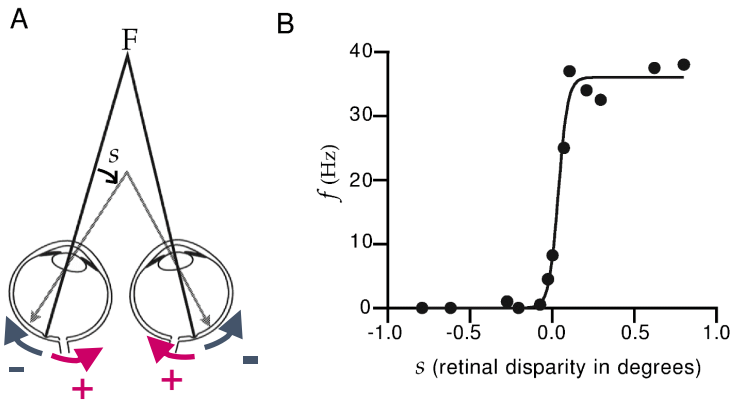
- correct and complete answer will contribute the maximum score
- partially correct or incomplete answers will contribute a fraction of the maximum score
- missing answers will not contribute
- wrong answers to the closed-ended questions (T/F, multiple choice, etc) will contribute with a negative score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

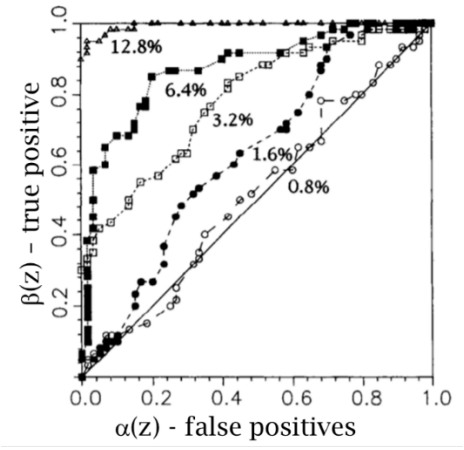
For instance:

- 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 EPSP consists of a membrane depolarization.	0.5	-0.25
2	The voltage-gated K^+ 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 saltatory conduction along myelinated axons is faster than the continuous conduction along unmyelinated ones.	0.5	-0.25
5	The primary visual cortex is located in the occipital lobe.	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 long-term synaptic plasticity involves a structural change in the post-synaptic membrane.	0.5	-0.25
8	The part of the pyramidal neuron that acts as a current dipole is the axon.	0.5	-0.25
9	The neurons' spatial orientation affects the amplitude of EEG signals.	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 only to negative s (close-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 representing the generation of spike trains in a neuron, long inter-spike intervals (*isi*) have a probability that falls with their duration according to an exponential law.	0.5	-0.25
13	In a Poisson spike generator, the program generates a fixed threshold and, at each time step, compares the variable $r_{est}\Delta t$ with the fixed threshold.	0.5	-0.25

14	Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation:  The best curve is the one closer to the upper left corner.	0.5	-0.25
15	In reference to the previous figure (question 14): the Area Under the Curve (AUC) for each level of coherence is proportional to the discriminability of the two conditions.	0.5	-0.25
16	If $C_{xy}(f)$ is the Ordinary Coherence between x and y, $C_{xy}(f)=C_{yx}(f)$.	0.5	-0.25
17	Given the Granger Index G_{xy} between two time series x and y, a negative value of $G_{x\to y}$ means an inverse precedence between the two time series.	0.5	-0.25
18	In the event of data paucity, the Partial Directed Coherence (PDC) is the most accurate estimator of causality in the statistical sense.	0.5	-0.25
19	In an undirected graph, I cannot compute the indegree and the outdegree.	0.5	-0.25
20	Random networks have a smaller Local Efficiency than regular (lattice) networks.	0.5	-0.25
21	In a graph, the Divisibility $\in [0, 1]$.	0.5	-0.25
22	Local Efficiency, Divisibility and Modularity are measures of segregation of a network.	0.5	-0.25
TOT		11	

For all answers: Type True/False unless otherwise specified

#	Question – Section B	Points (max)
1.	The frequency of oscillation of the beta rhythm is around 10 Hz	0.5
2.	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.	0.5
3.	EEG electrodes made of gold allow recording of extremely slow-changing potentials.	0.5
4.	The CMRR is usually expressed in decibel (dB) and high values characterizes better amplifiers.	0.5
5.	The difference of contact impedances of electrodes should be large compared to the input difference of the differential amplifier, otherwise the amplitude of the signal would be reduced (shortcut).	0.5
6.	In monopolar EEG recordings, the reference electrode is placed on scalp position that are *assumed* to be far from the electrical sources of interest, such as the earlobes.	0.5
7.	The amplitude of the electromyogram (EMG) originated from muscles never exceed $10\ \mu V$.	0.5
8.	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, …).	0.5
9.	Movement of the subject's head may produce slow artifacts that are less pronounced when non-polarizable electrodes are used	0.5
10.	The amplitude of ERPs is measured with respect to a baseline epoch (usually preceding the stimulus), in which the amplitude is assumed to be zero.	0.5
11.	The SOA is always smaller than the ISI	0.5
12.	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
13.	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
14.	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of a set of $sinc()$ functions, one for each sample.	0.5
15.	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
16.	Appropriate application of a high-pass digital filter may prevent saturation by removing high amplitude slow artifacts.	0.5
17.	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
18.	In a gaussian noise, the probability density that a sample has a given amplitude value follows the normal distribution with zero mean.	0.5
19.	The synchronized average of N trials containing only spontaneous EEG whose $RMS_{trial} = \sigma^2$ is a signal $RMS_{avg} = \sigma^2/N$	0.5

#	Question – Section B	Points (max)
20.	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
21	The Butterworth filter is a design method in the family of Finite Impulse Response filters	0.5
22	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	0.5
	Total points for Section B (max)	**11**

(End of the test)