Neuroengineering 2021-2022

Exam 21 July 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:

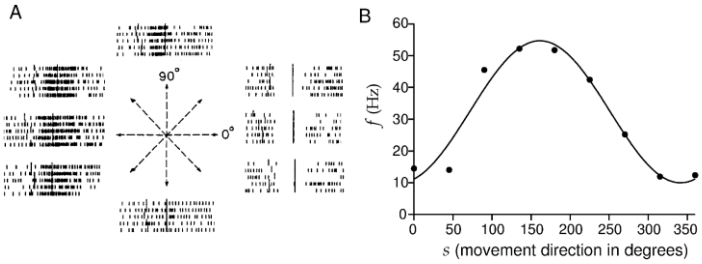
- correct and complete answer will contribute the maximum score
- partially correct or incomplete answers will contribute a fraction of the maximum score
- missing answers will not contribute
- wrong answers to the closed-ended questions (T/F, multiple choice, etc) will contribute with a negative score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

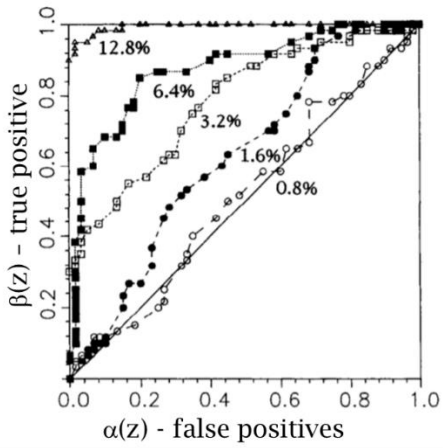
For instance:

- 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	The voltage-gated K^+ channel inactivation state is responsible for the absolute refractory period.	0.5	-0.25
2	The voltage-gated Na^+ channel is responsible for the repolarization phase of the action potential.	0.5	-0.25
3	Temporal and spatial summation can occur simultaneously.	0.5	-0.25
4	The firing rate influences the amplitude of the resulting action potential in the post-synaptic cell.	0.5	-0.25
5	The long-term synaptic plasticity involves a structural change in the post-synaptic membrane.	0.5	-0.25
6	The brain operates at the temporal scale of milliseconds.	0.5	-0.25
7	The synchronicity of the neural activity affects the amplitude of EEG signals.	0.5	-0.25
8	Scalp EEG is mainly produced by deep (subcortical) regions.	0.5	-0.25
9	The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.	0.5	-0.25
10	The tuning curve in the figure shows (panel A) the spike trains obtained - for different trials - from a neuron of the primary motor cortex in correspondence to an arm movement, and (panel B) the firing rate *f* of the same neuron as a function of the angle *s* of the same movement direction:  When the firing rate is 55 Hz, I can infer which movement direction produced that response.	0.5	-0.25
11	In reference to the previous figure (question 10): from the curve I can conclude that this neuron is tuned to be active in correspondence to a given movement direction.	0.5	-0.25
12	In reference to the previous figure (question 10): the firing rate *f* in panel B was computed as the average of the neural response function across trials.	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 minimum Divisibility is equal to zero.	0.5	-0.25
22	Divisibility and Modularity are measures of segregation of a network.	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.	Ag/AgCl electrodes allow recording of extremely slow-changing EEG potentials.	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.	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
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
19.	Appropriate application of a high-pass digital filter may prevent saturation by removing high amplitude slow artifacts.	0.5

#	Question – Section B	Points (max)
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	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	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)