Neuroengineering 2019-2020

Exam 17 September 2020 – 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:

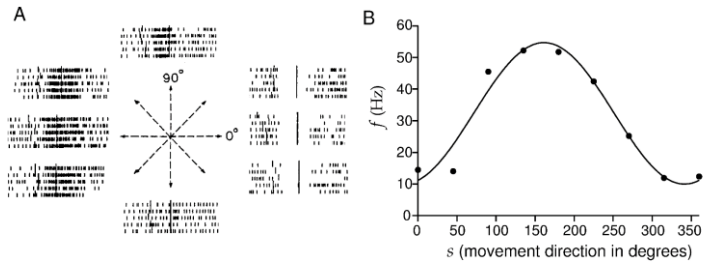
- correct and complete answer will contribute the maximum score
- partially correct or incomplete answers will contribute a fraction of the maximum score
- missing answers will not contribute
- wrong answers to the closed-ended questions (T/F, multiple choice, etc) will contribute with a negative score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

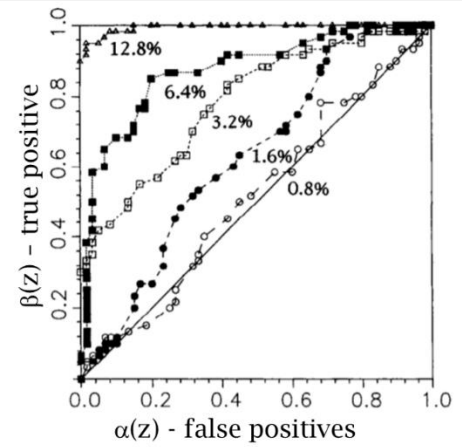
For instance:

- 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.

For all answers: Type True/False unless otherwise specified

#	Question – Section A	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 the 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 process, when r increases, higher values of n are less likely.	0.5	-0.25
14	In a Poisson spike generator, the program generates a fixed threshold and, at each time step, compares the variable *r* with the fixed threshold	0.5	-0.25

15	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 diagonal.	0.5	-0.25
16	In reference to the previous figure (question 15): the Area Under the Curve (AUC) for each level of coherence is proportional to the discriminability of the two conditions.	0.5	-0.25
17	Causation is equivalent to correlation.	0.5	-0.25
18	Given the Ordinary Coherence C_{xy} between two time series x and y, $C_{xy} \in [0, \infty]$.	0.5	-0.25
19	Given the Granger Index G_{xy} between two time series x and y, G_{xy} is a function of frequency.	0.5	-0.25
20	In a graph representing a network of brain regions, the distance *d(i,j)* between two nodes is proportional to the physical distance between the two regions.	0.5	-0.25
21	In a graph, the index Divisibility is a measure of the segregation between two communities.	0.5	-0.25
22	A small-word network has fewer nodes than a regular network.	0.5	-0.25
	Total points for Section A (max)	**11**	

(Section B on the following pages)

For all answers: Type True/False unless otherwise specified

#	Question – Section B	Points (max)
1.	The "waxing and waning" of the alpha rhythm is a change of amplitude occurring about 10 times a second.	0.5
2.	The delta and gamma frequency bands identify frequencies lower than those in the alpha band	0.5
3.	The CMRR of an EEG amplifier should be lower than 60 dB	0.5
4.	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
5.	Contact impedance of the electrodes is measured in kiloOhm ($k\Omega$) and must be measured using an alternating current.	0.5
6.	In the electrode labels of the International 10-20 System, odd numbers designate electrodes on the left side of the head	0.5
7.	The eye's potential is more negative in its frontal part than its posterior part, and thus its movements can generate large positive artifacts on the EEG.	0.5
8.	Sweating can affect the EEG, causing an increase of contact impedance and an increase of powerline noise	0.5
9.	Notch filters effectively remove powerline noise because they reject all signals above their corner frequency.	0.5
10.	The SOA is always greater than the ISI	0.5
11.	Synchronized averaging of N EEG trials produces N values each corresponding to the average value of the potential in each trial.	0.5
12.	Induced activity is best analyzed by applying the synchronized averaging to the EEG trials.	0.5
13.	Event-Related Desynchronization/Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	0.5
14.	Aliasing can be prevented by applying a digital low-pass filter with cutoff frequency lower than the Nyquist frequency.	0.5
15.	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
16.	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
17.	The RMS is the average of the squared value of the samples of a signal	0.5
18.	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
19.	The probability distribution of the average of N independent and identically distributed random variables approaches zero for $N \to \infty$	0.5
20.	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

#	Question – Section B	Points (max)
21	For a signal sampled with sampling interval $\Delta T_s = 0.002s$, the spectrum has a frequency range of: A. $[-500, +500]\ Hz$ B. $[-200, +200]\ Hz$ C. $[-0.002, 0.002]\ kHz$ D. None of the above Type the letter corresponding to the correct answer (A-D)	1
	Total points for Section B (max)	**11**

(End of the test)