Neuroengineering 2019-2020

Exam 7 July 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. …
```

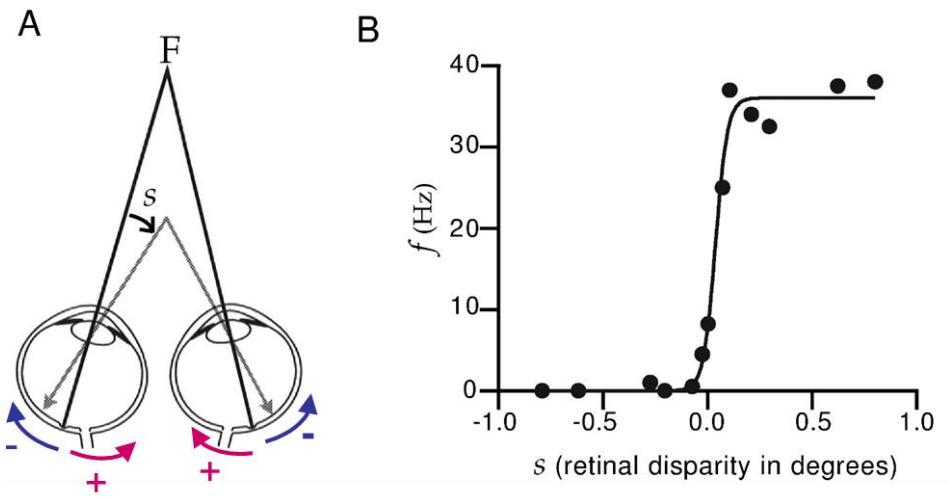
In the exceptional case that one or more of your answer require specific assumptions that were omitted in the question, you can add short comments at the end of each section. Start the optional comment with the number of the question it refers to. For example:

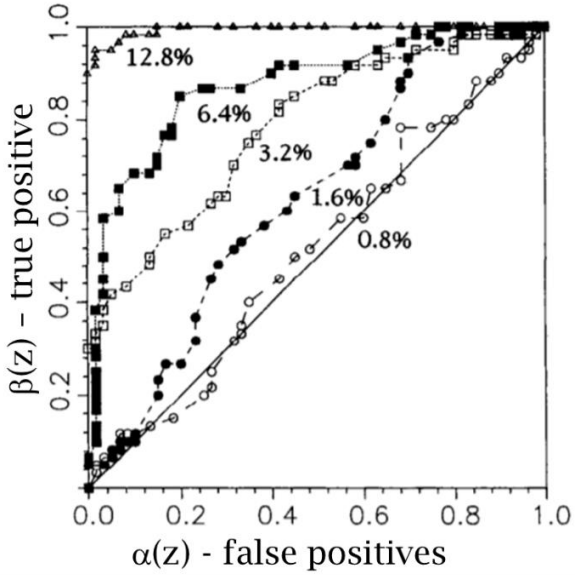
```
…

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 -1/N, where N is the number of possible choices.

The maximum total score for part I is 22.

#	Question	Points (max)
1.	What are the four main ion families having a role in the neuron electrical activity? Type a brief answer, max 1 line.	0.5
2.	We need to measure the amplitude and duration of an action potential each time it occurs to understand the cell behavior. Type True/False	0.5
3.	Indicate which of the brain lobes houses the primary visual cortex: A. Frontal B. Occipital C. Parietal D. Temporal Type the letter corresponding to the correct answer	0.5
4.	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. Type True/False	0.5
5.	Indicate what is the different contribution of cortical and deep brain regions to the scalp EEG, explaining why. Type a brief answer, max 6 lines.	1
6.	Given the tuning curve in Fig. B, which refers to the retinal disparity shown in Fig. A, indicate, for **each** of the following independent sentences, if they are **true or false**:  A. When the firing rate is zero, I can infer the exact angle of retinal disparity *s* B. If the firing rate is equal to 40 Hz, I can conclude that the stimulus position was further than the fixation point F C. From the curve I can conclude that this neuron is tuned to respond to far objects D. If I have a single trial, the firing rate *f* can be computed as the time average of the neural response function over the duration of the trial Type True/False **for each sentence.**	2

#	Question	Points (max)
7.	What are the differences between the distribution of *isi* (inter spike interval) in real data and in simulated data produced by a Poisson generator? What are they caused by? Type a brief answer, max 5 lines.	1
8.	The neural decoding consists of determining the probability of a stimulus with property *s*, given that the neural response has a firing rate *r*. Type True/False.	0.5
9.	Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation:  The Area Under the Curve associated to each level of coherence is proportional to the discriminability of the two conditions. Type True/False.	0.5
10.	Given the Partial Directed Coherence (PDC) estimator, indicate, for **each** of the following sentences, if they are **true or false**: A. The normalized PDC ∈ [0,1] B. $PDC_{i\to j}$ is always equal to $PDC_{j\to i}$ C. PDC(f_1) can be ≠ from PDC (f_2) D. PDC can always avoid the problem of the "hidden source" Type True/False **for each sentence.**	2
11.	Indicate how the values of Global Efficiency and Local Efficiency of a real brain network compare to those of a regular network and those of a random network. Type a brief answer, max 3 lines.	2
	Total points (max)	11

(Section B on the following pages)

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.	The oscillations of mu rhythm are more “arc-shaped”, rather than resembling a regular sinewave	0.5
3.	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances such as powerline (50 Hz) noise.	0.5
4.	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
5.	Contact impedance of the electrodes can be measured using a direct (non-alternating) current.	0.5
6.	The EEG electrode F8 is located to the left of electrode F7	0.5
7.	An eyeblink produces an artifact which often interferes with the analysis of the beta band of the EEG.	0.5
8.	Powerline noise is accentuated by asymmetries in the recording electrode pairs, such as impedances and cable path, because asymmetries prevent the noise to be rejected by the amplifier’s common-mode rejection capabilities.	0.5
9.	Notch filters effectively remove powerline noise because they selectively reject the narrow band affected by the artifact, preserving almost entirely the useful signal.	0.5
10.	The potential at the peak of the EP component P20 is higher than the potential at the peak of the N100 component	0.5
11.	One can never remove one of the channels from the raw EEG recording prior to analysis. Rather all epochs contaminated from artifacts will be rejected.	0.5
12.	Evoked brain activity is phase-locked to the stimulus to which it is a response.	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.	In Analog to Digital Conversion, the Nyquist frequency equals half of the sampling frequency.	0.5
15.	Appropriate application of an analog filter (i.e. before the analog signal is converted) may prevent saturation by removing high amplitude artifacts in specific frequency bands.	0.5
16.	Quantization divides the input range of the ADC into (approximately) $NBITS$ intervals, where NBITS is the number of bits of the ADC.	0.5
17.	The RMS and the standard deviation of a zero-mean signal have the same value (assume that the number of samples $N \to \infty$).	0.5
18.	The frequency spectrum of white noise is flat, i.e. it has the same power at any frequency.	0.5
19.	The Central Limit Theorem (CLT) states that the average of N independent identically distributed signals tends to zero for $N \to \infty$.	0.5

#	Question – Section B	Points (max)
20.	The method of the averaged periodogram to estimate the spectrum of a stochastic signal is applied when a lower variability of the PSD estimate at each frequency sample is desirable, while the spectral resolution Δf is higher than required.	0.5
21	The Butterworth filter is a design method in the family of FIR	0.5
22	The amplitude of sensorimotor rhythms can 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)