Neuroengineering 2022-2023

Exam 28 March2024 – 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. T
2. F
3. F
4. --
5. T
…
Section B
1. …
```

In the exceptional case that one or more of your answers 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:

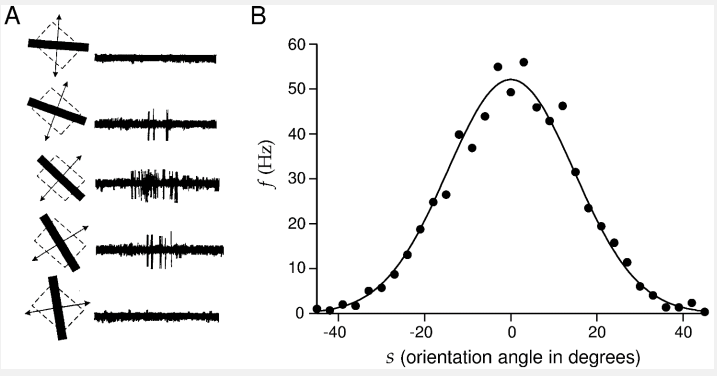
```
…

Comments
7. I assumed that the sinewave frequency is lower than the Nyquist frequency.
```

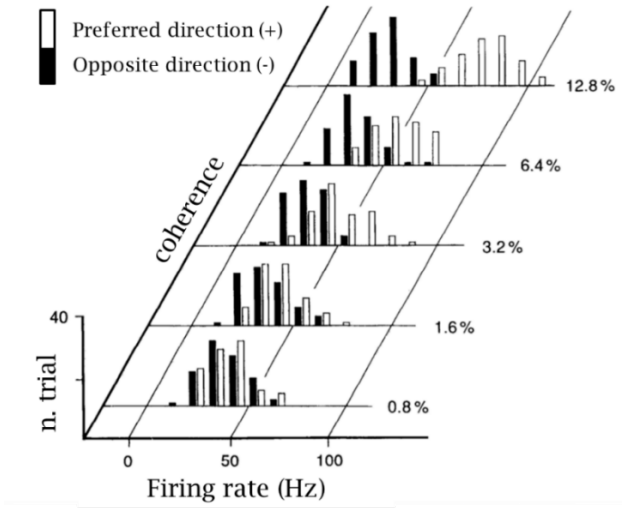
The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

- 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 26.

Section A

	Question	Points (correct)	Points (wrong)
1	The voltage-gated Na^+ channel opening is responsible for the repolarization phase of the action potential.	0.5	-0.25
2	The voltage-gated K^+ channel is responsible for the absolute refractory period.	0.5	-0.25
3	The part of the pyramidal neuron that acts as a current dipole is the dendritic tree.	0.5	-0.25
4	The firing rate influences the temporal summation of the PSPs.	0.5	-0.25
5	Each brain lobe contains several Brodmann areas.	0.5	-0.25
6	Axonal sprouting and pruning are part of the mechanisms behind brain plasticity.	0.5	-0.25
7	The synchronicity of the neural activity in a region affects the amplitude of the EEG signals it produces.	0.5	-0.25
8	The distance between the neurons and the electrodes does not affect the amplitude of the EEG signals they produce.	0.5	-0.25
9	To record *in vivo* measures of the membrane potential over the axon of a neural cell, you will use intracellular recordings.	0.5	-0.25
10	Potentials recorded by electrodes which are at a close distance on the scalp are mutually independent.	0.5	-0.25
11	Given the following tuning curve, reporting the firing rate of a neuron of the primary visual cortex (B) in response to the orientation angle of a visual stimulus (A):  If the measured firing rate is 20 Hz, I can infer a univocal orientation angle that produced that response.	0.5	-0.25
12	In reference to the previous figure: from the curve I can conclude that there is a preferred stimulus orientation for which this neuron is designed to respond.	0.5	-0.25

	Question	Points (correct)	Points (wrong)
13	In reference to the previous figure: there are stimulus orientation angles to which this neuron is “blind” (i.e., it doesn’t show any response).	0.5	-0.25
14	Given the firing rate distribution in the figure, obtained for a neuron of the primary visual cortex in response to the motion direction of dots on the screen in two possible directions (+ and -) and with different levels of coherence between the dots:  Discriminability *d’* is higher when the coherence level is equal to 0.8% than when it is equal to 6.4%.	0.5	-0.25
15	In reference to the previous figure: the distribution (-) is less affected by the coherence level than the distribution (+).	0.5	-0.25
16	In reference to the previous figure: there is an optimal value *z* that can be used as a threshold for classification at all coherence levels	0.5	-0.25
17	The Granger Causality Index G_{xy} is a multivariate estimator of brain connectivity.	0.5	-0.25
18	The normalized $PDC_{xy}(f)$ between two time series *x* and *y* $\in[0, \infty]$.	0.5	-0.25
19	The Ordinary Coherence between two time series *x* and *y* is a function of the frequency.	0.5	-0.25
20	In a graph, the distance *d(i,j)* between two nodes is given by the average length of the paths that link them.	0.5	-0.25
21	In a graph, the Global Efficiency $\in[0, 1]$.	0.5	-0.25
22	A regular network has fewer nodes than a random network.	0.5	-0.25
23	Random networks have a smaller Local Efficiency than regular (lattice) networks.	0.5	-0.25

	Question	Points (correct)	Points (wrong)
24	In a graph, the minimum Divisibility is equal to zero.	0.5	-0.25
25	Divisibility and Modularity are measures of integration of a network.	0.5	-0.25
26	Modularity belongs to the interval [0, 1]	0.5	-0.25
	Total points	**13**	

(continues on the next page)

Section B

N.B. Wrong answers will receive a penalty equal to 50% of the correct question's points.

#	Question	Pts.
1	The proper (visual) alpha rhythm is generated in the frontal lobe of the cerebral cortex.	0.5
2	The delta and theta frequency bands identify frequencies lower than those in the alpha band	0.5
3	Event-Related Desynchronization/ Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	0.5
4	Ag/AgCl electrodes allow recording of extremely slow-changing EEG potentials.	0.5
5	The CMRR of a bipolar amplifier measures how much higher is the gain of the potential difference between the input electrodes with respect to the gain of their average with respect to the electrical ground.	0.5
6	The measurement of a single EEG signal requires four electrodes – two as input to the differential amplifier, one connected to the reference electrode and one to provide the ground potential.	0.5
7	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
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	The heart activity can contaminate an EEG recording because a ballistocardiographic artifact is indirectly generated by the pulse of a blood vessel causing movements of a nearby electrode.	0.5
11	Notch filters effectively remove powerline noise because they reject all signals above their corner frequency.	0.5
12	Synchronized averaging of N EEG trials produces N values each corresponding to the average value of the potential in each trial.	0.5
13	The SOA is always greater than the ISI	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	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 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
17	When aliasing occurs in ADC, a sinusoidal component with frequency $f_0 = 0.7f_s$ is reconstructed as a sinusoidal component at $f_1 = 0.2f_s$ (f_s is the sampling frequency)	0.5
18	Aliasing can be prevented by applying a digital low-pass filter with cutoff frequency lower than the Nyquist frequency.	0.5

#	Question	Pts.
19	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
20	The RMS is the average of the squared value of the samples of a signal	0.5
21	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
22	The probability distribution of the average of N independent and identically distributed random variables approaches zero for $N \to \infty$	0.5
23	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
24	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
25	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
26	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	**13**