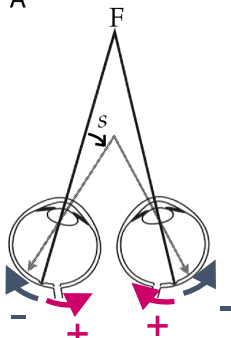
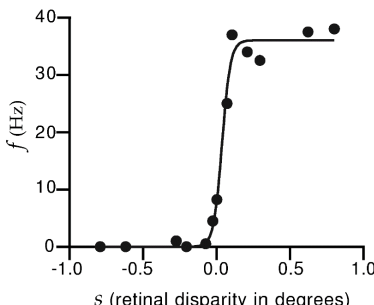


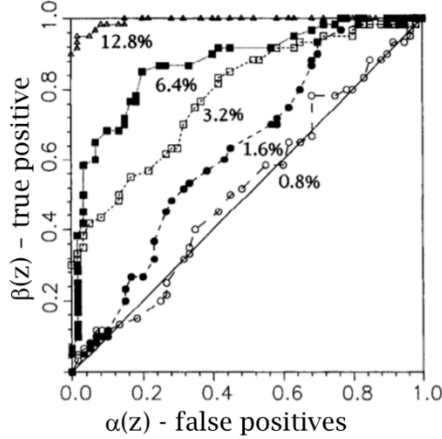
Neuroengineering 2020-2021

Exam 21 July 2021 – Part I

Solutions

Section A

	Question	Ans.	Explanation
1	An EPSP consists of a membrane depolarization.	T	
2	The voltage-gated K^+ channel is responsible for the absolute refractory period.	F	<i>The voltage-gated K^+ channel is responsible for the relative refractory period, not the absolute one.</i>
3	The most informative parameter of the spike train in output to a neuronal cell is the amplitude of the spikes.	F	<i>The amplitude of the spikes is the same for all of them, so this is not an informative parameter.</i>
4	The saltatory conduction along myelinated axons is faster than the continuous conduction along unmyelinated ones.	T	
5	The primary visual cortex is located in the occipital lobe.	T	
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.	F	<i>The extension of the cortical region which controls a specific body region is proportional to the number of motor nerves, not to the body region's volume.</i>
7	The long-term synaptic plasticity involves a structural change in the post-synaptic membrane.	T	
8	The part of the pyramidal neuron that acts as a current dipole is the axon.	F	<i>It is the dendritic tree.</i>
9	The neurons' spatial orientation affects the amplitude of EEG signals.	T	
10	<p>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).</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>A</p>  </div> <div style="text-align: center;"> <p>B</p>  </div> </div> <p>From the figure, we can infer that the neuron responds only to negative s (close-tuned neuron).</p>	F	<i>No, because for negative s the firing rate is zero. This is a far-tuned neuron.</i>

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	F	<i>The retinal disparity in degrees cannot be inferred when the firing rate is equal to 0, because a large range of negative values would produce the same response.</i>
12	In a Poisson process representing the generation of spike trains in a neuron, long inter-spike intervals (<i>isi</i>) have a probability that falls with their duration according to an exponential law.	T	
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.	F	<i>The threshold is randomly variable, while $r_{est}\Delta t$ is a constant for a given value of s.</i>
14	<p>Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation:</p>  <p>The best curve is the one closer to the upper left corner.</p>	T	
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.	T	
16	If $C_{xy}(f)$ is the Ordinary Coherence between x and y , $C_{xy}(f)=C_{yx}(f)$.	T	
17	Given the Granger Index G_{xy} between two time series x and y , a negative value of $G_{x \rightarrow y}$ means an inverse precedence between the two time series.	F	<i>A negative value of $G_{x \rightarrow y}$ means that the residual of the bivariate model is higher than in the simple model, which is probably due to an incorrect modeling.</i>
18	In the event of data paucity, the Partial Directed Coherence (PDC) is the most accurate estimator of causality in the statistical sense.	F	<i>When we have a limited amount of data, PDC returns inaccurate results due to the low ratio between data samples and model parameters.</i>

19	In an undirected graph, I cannot compute the indegree and the outdegree.	T	<i>In an undirected graph, there cannot be indegrees nor outdegrese, since direction is not implied.</i>
20	Random networks have a smaller Local Efficiency than regular (lattice) networks.	T	
21	In a graph, the Divisibility $\in [0, 1]$.	F	<i>Divisibility $\in [0.5, 1]$.</i>
22	Local Efficiency, Divisibility and Modularity are measures of segregation of a network.	T	

Section B

	Question	Pts.	Ans.	Explanation
1	The frequency of oscillation of the beta rhythm is around 10 Hz	0.5	F	The minimum conventional oscillation frequency of the beta rhythm is 14 Hz
2	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.	0.5	T	True
3	EEG electrodes made of gold allow recording of extremely slow-changing potentials.	0.5	F	Gold electrodes are <i>polarizable</i> , thus the opposite is true
4	The CMRR is usually expressed in decibel (dB) and high values characterizes better amplifiers.	0.5	T	True
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	F	False, the contact impedances must be lower than the amplifier's input impedance, to help keeping the circuit balanced (higher CMRR)
6	In monopolar EEG recordings, the reference electrode is placed on scalp position that are <i>assumed</i> to be far from the electrical sources of interest, such as the earlobes.	0.5	T	True
7	The amplitude of the electromyogram (EMG) originated from muscles never exceed $10\ \mu V$.	0.5	F	EMG can be ten times higher than EEG, and exceed 1 mV
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	T	True
9	Movement of the subject's head may produce slow artifacts that are less pronounced when non-polarizable electrodes are used	0.5	T	True
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	T	True
11	The SOA is always smaller than the ISI	0.5	F	False, The SOA equals the ISI plus the duration of the stimulus
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 <i>induced</i> .	0.5	T	True
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	T	True
14	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of a set of <i>sinc()</i> functions, one for each sample.	0.5	T	True

	Question	Pts.	Ans.	Explanation
15	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval: $\sigma_{quant} = 1/\sqrt{12} \text{ LSB}$	0.5	T	True
16	Appropriate application of a high-pass digital filter may prevent saturation by removing high amplitude slow artifacts.	0.5	F	False, saturation can be prevented only by applying an analog filter before A/D conversion
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	T	True
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	T	A gaussian noise has normal distribution of amplitude of the samples. [A white noise has a flat spectrum.]
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	T	True
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	T	True
21	The Butterworth filter is a design method in the family of Finite Impulse Response filters	0.5	F	A Butterworth filter is a IIR filter.
22	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	0.5	T	True
	Total points	11		