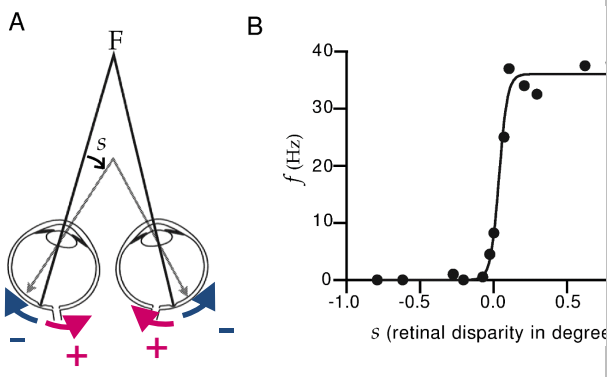
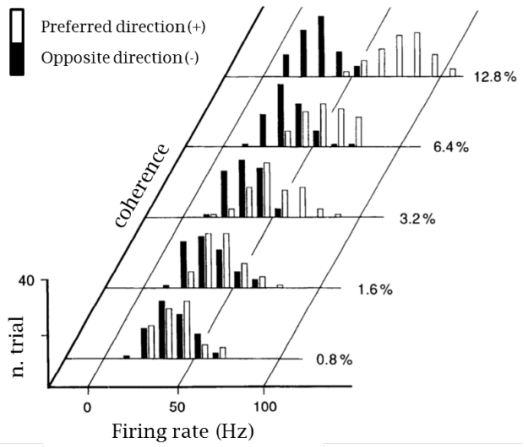
Neuroengineering 2022-2023

Exam 1 February 2024 – Part I
Solutions

Section A

	Question	Pts.	Ans.	Explanation
1	An IPSP consists of a depolarization of the post-synaptic cell membrane.	0.5	F	*Being inhibitory, it consists of a hyperpolarization of the membrane.*
2	The voltage-gated Na^+ channel is responsible for the absolute refractory period.	0.5	T	
3	The most informative parameter of the spike train in output to a neuronal cell is the amplitude of the spikes.	0.5	F	*The amplitude of all the spikes is the same, so this is not an informative parameter.*
4	The firing rate of the pre-synaptic neuron influences the temporal summation of the PSPs in the post-synaptic cell.	0.5	T	
5	The frontal lobe houses the primary visual function.	0.5	F	*The primary visual cortex is located in the occipital lobe.*
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.	0.5	F	*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.*
7	The short-term synaptic plasticity involves an irreversible change in the post-synaptic membrane.	0.5	F	*The short-term changes are temporary.*
8	To record in vivo measures of the membrane potential over the axon of a single neural cell, you will use extracellular measures.	0.5	T	
9	The EEG signal is mainly generated by action potentials.	0.5	F	*It is mainly generated by post-synaptic potentials.*

	Question	Pts.	Ans.	Explanation
10	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).  From the figure, we can infer that the neuron responds mainly to positive *s* (far-tuned neuron).	0.5	T	
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	0.5	F	*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.*
12	To record in vitro measures of the membrane potential over the dendrites of a neural cell, you will use extracellular measures	0.5	F	*Extracellular measures are able to capture only the sequence of APs, not he E/IPSPs that occur over the dendrites. To this purpose, we will use intracellular recordings.*
13	The part of the pyramidal neuron that acts as a current dipole is the axon	0.5	F	*It's the dendritic tree.*
14	Given the distribution of firing rates in the figure:  The discriminability *d'* when the coherence=3.2% is higher than when it's =12.8%	0.5	F	*The discriminability d' is higher for higher values of the coherence level.*
15	In reference to the previous figure (question 14), among the two distributions (r_+ or r_-), r_+ is the one affected by the coherence level	0.5	T	
16	The normalized Partial Directed Coherence $\in[0, 1]$	0.5	T	

	Question	Pts.	Ans.	Explanation
17	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure	0.5	F	*The Granger Test is not a spectral measure.*
18	If Cxy(f) is the ordinary coherence between x and y, Cxy(f)=Cyx(f)	0.5	T	
19	The difference between the Wiener's and Granger's definitions of causality in the statistical sense is that Granger indicated a modeling framework to be used to test causality	0.5	T	
20	Regular networks have a smaller Global Efficiency than random networks	0.5	T	
21	Regular networks have a smaller Local Efficiency than random networks	0.5	F	*They have a larger Local Efficiency.*
22	Undirected graphs produce symmetrical adjacency matrices	0.5	T	
23	Given the Granger Index Gxy between two time series x and y, a negative value of Gx->y means an inverse precedence between the two time	0.5	F	*A negative value of $G_{x \to y}$ means that the residual of the bivariate model is higher than in the simple model, which is probably due to an incorrect modeling.*
24	The long-term synaptic plasticity involves a structural change in the post-synaptic membrane.	0.5	T	
25	In an undirected graph, I cannot compute the indegree and the outdegree.	0.5	T	*In an undirected graph, there are no directions. Therefore, the concept of "in-degree" and "out-degree" is meaningless.*
26	The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.	0.5	F	*The synchronous variations of post-synaptic potentials (and their extracellular counterpart) are the main contributors to EEG signals. The action potentials are more difficult to be summed up across different neurons, due to their short duration.*
	Total points	13		

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	The mu rhythm is generated in the central regions of the cerebral cortex	0.5	T	TRUE
3	The oscillations of mu rhythm are more "arc-shaped" than the alpha rhythm's, which is comparatively a more symmetrical sinewave	0.5	T	TRUE
4	In the EEG terminology, impedance is a measure of the ability of an experimental subject to carry on an experiment	0.5	F	Impedance is a measure of the quality of the contact between electrode and scalp, through the conductive gel
5	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances such as powerline (50 Hz) noise.	0.5	T	TRUE
6	The contact impedances of a pair of electrodes should be large compared to the input impedance of the differential amplifier connected to them, otherwise the amplitude of the signal would be reduced as effect of the potential divider.	0.5	F	False, the contact impedances must be *lower* than the amplifier's input impedance, mainly to help keeping the circuit balanced (higher CMRR)
7	The EEG electrode Fz is located to the left of electrode Cz	0.5	F	False, they both lay along the midline, Fz being more anterior than Cz
8	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	F	The eye is more positive in its frontal part (cornea) than its posterior part (retina)
9	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	T	TRUE
10	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	T	TRUE
11	Movement of the subject's head may produce slow artifacts that are less pronounced when non-polarizable electrodes are used	0.5	T	TRUE
12	The potential at the peak of the EP component P20 is higher than the potential at the peak of the N100 component	0.5	T	TRUE

	Question	Pts.	Ans.	Explanation
13	The ISI is always greater than the SOA	0.5	F	The SOA equals the ISI plus the duration of the stimulus
14	The averaging procedure can reliably uncover components of an ERP corresponding to evoked activity of the brain.	0.5	T	TRUE
15	Event-Related Desynchronization/Synchronization (ERD/S) quantify phase-locked brain activity in response to an event	0.5	F	Event-Related Desynchronization/Synchronization (ERD/S) quantify relative changes of the power of the EEG rhythm in a predefined frequency range; phase locked activity is estimated using the synchronized averaging.
16	In analog-to-digital conversion, each spectral component of the analog signal should have frequency below the Nyquist frequency	0.5	T	TRUE
17	When aliasing occurs in ADC, a sinusoidal component with frequency $f_0 = 0.7 \cdot f_s$ is reconstructed as a sinusoidal component at $f_1 = 0.2 \cdot f_s$ (f_s is the sampling frequency)	0.5	F	$f_1 = f_s - f_0 = 0.3 \cdot f_s$
18	Quantization divides the input range of the ADC into (approximately) NBITS intervals, where NBITS is the number of bits of the ADC.	0.5	F	Quantization divides the input range of the ADC into (approximately) 2^{NBITS} intervals
19	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
20	The Average Rectified Value (ARV) is a measure of the amplitude of a signal, and it is obtained by summing the absolute values of all samples and dividing the result by the number of samples.	0.5	T	TRUE
21	The frequency spectrum of white noise is flat, i.e. it has the same power at any frequency.	0.5	T	TRUE
22	The Central Limit Theorem (CLT) states that the average of N independent identically distributed signals approaches zero for $N \to \infty$.	0.5	F	This is only true if the mean of the signals is zero itself
23	Given 100 independent and identically distributed random variables with variance equal to 4, the variance of their average is 0.2?	0.5	F	$\sigma_{avg}^2 = \sigma^2/N = 4/100 = 0.04$ $\sigma_{avg} = \sqrt{\sigma_{avg}^2} = 0.2$
24	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	T	TRUE

	Question	Pts.	Ans.	Explanation
25	The Butterworth filter is a design method in the family of FIR	0.5	F	The Butterworth filter is an Infinite Impulse Response (IIR) filter
26	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	T	TRUE
	Total Points	**13**		Explanation