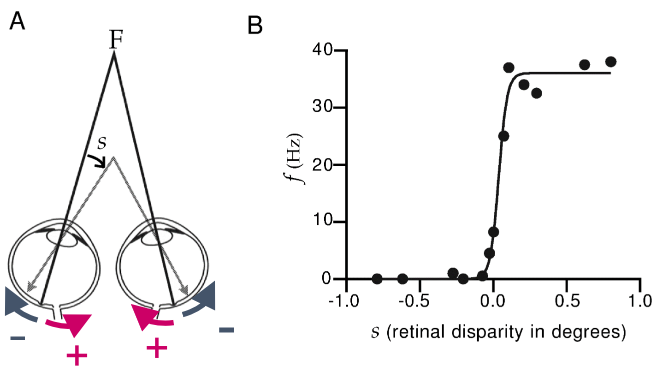
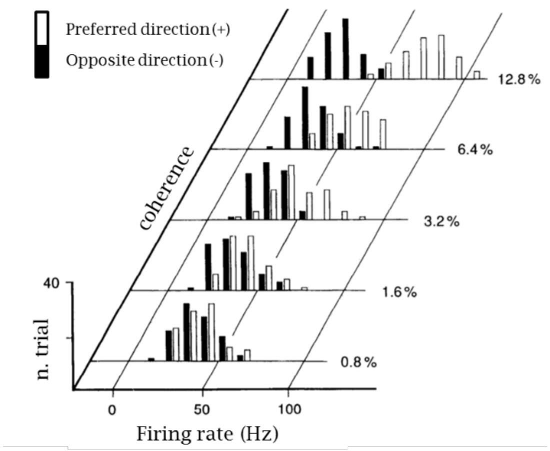
Neuroengineering 2021-2022

Exam 23 June 2022 – Part I

Solutions - *Odd seats*

Section A

	Question	Ans.	Explanation
1	An IPSP consists of a depolarization of the post-synaptic cell membrane.	F	*Being inhibitory, it consists of a hyperpolarization of the membrane.*
2	The voltage-gated Na^+ channel is responsible for the absolute refractory period.	T	
3	The most informative parameter of the spike train in output to a neuronal cell is the amplitude of the spikes.	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.	T	
5	The frontal lobe houses the primary visual function.	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.	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.	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.	T	
9	The EEG signal is mainly generated by action potentials.	F	*It is mainly generated by post-synaptic potentials.*
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).	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	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	In a Poisson process, when *r* increases, higher values of *n* are more likely	T	
13	The differences between the distribution of *isi* in real data and in simulated data produced by an (uncorrected) Poisson spike generator are due to the refractory periods	T	
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%	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	T	
16	The normalized Partial Directed Coherence ∈[0, 1]	T	
17	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure	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)	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	T	
20	Regular networks have a smaller Global Efficiency than random networks	T	
21	Regular networks have a smaller Local Efficiency than random networks	F	*They have a larger Local Efficiency.*
22	Undirected graphs produce symmetrical adjacency matrices	T	

Section B

	Question	Pts.	Ans.	Explanation
1	The proper (visual) alpha rhythm is generated in the frontal lobe of the cerebral cortex.	0.5	F	The primary visual area is located in the occipital cortex
2	The delta and theta frequency bands identify frequencies lower than those in the alpha band	0.5	T	True
3	The input impedance of a biosignal amplifier must be many orders of magnitude higher than the contact impedance of the electrodes. It is usual to have input impedances in the order of 10^8 Ω.	0.5	T	True
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	T	True. In fact, the series of the electrode impedance and input impedance act as a voltage divider. Only if the former is much lower than the latter, the voltage at the amplifier's input is approximately equal to the actual biological potential.
5	In the EEG terminology, impedance is a measure of the quality of the contact between electrode and scalp, through the conductive gel	0.5	T	True
6	In the electrode labels of the International 10-20 System, odd numbers designate electrodes on the right side of the head	0.5	F	False, the opposite is true
7	A sudden upwards movement of the eyes generates a positive deflection of EEG potentials (EOG) on the Fz channel.	0.5	T	
8	Sweating can affect the EEG, causing an increase of contact impedance and an increase of powerline noise	0.5	F	Sweating causes a slow changing and high amplitude artifact (below 0.5 Hz, up to a few mV)
9	Notch filters effectively remove powerline noise because they reject all signals above their corner frequency.	0.5	F	Notch filters selectively reject the narrow frequency band affected by the artifact
10	The SOA is always greater than the ISI	0.5	T	The SOA equals the ISI plus the duration of the stimulus
11	Synchronized averaging of N EEG trials produces N values each corresponding to the average value of the potential in each trial.	0.5	F	The number of samples of the waveform obtained by synchronized averaging is independent of the number N of trials (it equals the number of samples in each trial).

	Question	Pts.	Ans.	Explanation
12	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	T	True
13	Event-Related Desynchronization/Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	0.5	F	ERD/S quantify changes of the power of EEG relative to a baseline period
14	Aliasing can be prevented by applying a digital low-pass filter with cutoff frequency lower than the Nyquist frequency.	0.5	F	Aliasing must be prevented by applying an analog filter before ADC. Digital filters can only be applied after the signal is sampled, and thus aliasing has occurred. No digital filter can remove it at that point.
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	F	$f_1 = f_s - f_0 = 0.3\ f_s$
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	T	A NBITS Analog to digital converter has 2^{NBITS} possible levels, thus the input range is divided into $2^{NBITS} - 1$ intervals
17	The RMS is the average of the squared value of the samples of a signal	0.5	F	The RMS is the *square root of* the average of the squared value of the samples of a signal
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	T	The Gaussian probability distribution peaks at 0, thus probability is higher in an interval centered in 0 (when both intervals have the same width).
19	The probability distribution of the average of N independent and identically distributed random variables approaches zero for $N \to \infty$	0.5	F	The pdf of the average approaches a (non-zero) Gaussian distribution
20	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	T	

	Question	Pts.	Ans.	Explanation
21	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	F	IIR filters cannot be designed to have liner phase
22	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	F	Through motor imagery an individual can learn to modulate sensorimotor rhythms, not ERPs
	Total points	**11**		