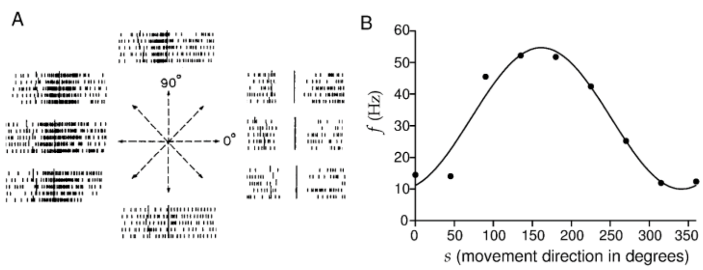
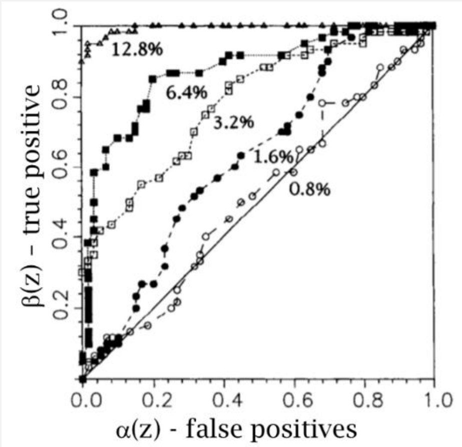
Neuroengineering 2019-2020

Exam 17 September 2020 – Part I

Solutions

Section A

	Question	Answer	Points (correct)	Points (wrong)
1	The voltage-gated K^+ channel inactivation state is responsible for the absolute refractory period.	F	0.5	-0.25
2	The voltage-gated Na^+ channel is responsible for the repolarization phase of the action potential.	F	0.5	-0.25
3	Temporal and spatial summation can occur simultaneously.	T	0.5	-0.25
4	The firing rate influences the amplitude of the resulting action potential in the post-synaptic cell.	F	0.5	-0.25
5	The long-term synaptic plasticity involves a structural change in the post-synaptic membrane.	T	0.5	-0.25
6	The brain operates at the temporal scale of milliseconds.	T	0.5	-0.25
7	The synchronicity of the neural activity affects the amplitude of EEG signals.	T	0.5	-0.25
8	Scalp EEG is mainly produced by the deep (subcortical) regions.	F	0.5	-0.25
9	The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.	F	0.5	-0.25
10.	The tuning curve in the figure shows (panel A) the spike trains obtained - for different trials - from a neuron of the primary motor cortex in correspondence to an arm movement, and (panel B) the firing rate *f* of the same neuron as a function of the angle *s* of the same movement direction:  When the firing rate is 55 Hz, I can infer which movement direction produced that response.	T	0.5	-0.25
11	In reference to the previous figure (question 10): from the curve I can conclude that this neuron is tuned to be active in correspondence to a given movement direction.	T	0.5	-0.25
12	In reference to the previous figure (question 10): the firing rate *f* in panel B was computed as the average of the neural response function across trials.	T	0.5	-0.25
13	In a Poisson process, when r increases, higher values of n are less likely.	F	0.5	-0.25

	Question	Answer	Points (correct)	Points (wrong)
14	In a Poisson spike generator, the program generates a fixed threshold and, at each time step, compares the variable *r* with the fixed threshold	F	0.5	-0.25
15	Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation:  The best curve is the one closer to the diagonal.	F	0.5	-0.25
16	In reference to the previous figure (question 15): the Area Under the Curve (AUC) for each level of coherence is proportional to the discriminability of the two conditions.	T	0.5	-0.25
17	Causation is equivalent to correlation.	F	0.5	-0.25
18	Given the Ordinary Coherence C_{xy} between two time series x and y, $C_{xy} \in [0, \infty]$.	F	0.5	-0.25
19	Given the Granger Index G_{xy} between two time series x and y, G_{xy} is a function of frequency.	F	0.5	-0.25
20	In a graph representing a network of brain regions, the distance *d(i,j)* between two nodes is proportional to the physical distance between the two regions.	F	0.5	-0.25
21	In a graph, the index Divisibility is a measure of the segregation between two communities.	T	0.5	-0.25
22	A small word network has fewer nodes than a regular network.	F	0.5	-0.25
TOT		**11**		

Section B

	Question	Pts.	Ans.	Explanation
1	The “waxing and waning” of the alpha rhythm is a change of amplitude occurring about 10 times a second.	0.5	F	The oscillation of the alpha rhythm occurs approximately 10 times a second. On the other hand, “waxing and waning” describes the amplitude modulation of the rhythm, which occurs about an order of magnitude more slowly.
2	The delta and gamma frequency bands identify frequencies lower than those in the alpha band	0.5	F	The delta frequency band ($< 3.5\ Hz$) is lower than the alpha band ($8 - 13\ Hz$). The gamma band ($< 30\ Hz$) is not.
3	The CMRR of an EEG amplifier should be lower than 60 dB	0.5	F	An instrumentation amplifier should have a high CMRR. Good values are 90 dB and up.
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. (“closer to zero” means that it its absolute value is lower)
5	Contact impedance of the electrodes is measured in kiloOhm ($k\Omega$) and must be measured using an alternating current.	0.5	T	True
6	In the electrode labels of the International 10-20 System, odd numbers designate electrodes on the left side of the head	0.5	T	True
7	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)
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 ISI equals the SOA plus the duration of the stimulus

	Question	Pts.	Ans.	Explanation
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).
12	Induced activity is best analyzed by applying the synchronized averaging to the EEG trials.	0.5	F	Synchronized averaging is used to analyze evoke activity. Induced activity is canceled out by synchronized averaging because it is not time locked to the event.
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 <u>analog</u> 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	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

	Question	Pts.	Ans.	Explanation
21	For a signal sampled with sampling interval $\Delta T_s = 0.002s$, the spectrum has a frequency range of: A. $[-500, +500]\ Hz$ B. $[-200, +200]\ Hz$ C. $[-0.002, 0.002]\ kHz$ D. None of the above	1	D	The frequency range of the spectrum equals the sampling frequency $f_s = 1/\Delta T_s = \frac{1}{0.002s} = 500Hz$, thus spanning $f \in [-250, +250]$ or $f \in [0, +500]$ (Answer A has been considered partially correct.)
	Total points	**11**		