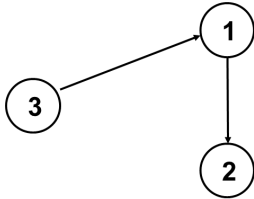


Neuroengineering 2023-2024
Exam 5 June 2025 – Part I

Section A

#	Question	Ans.	Explanation
1	The 4 main ion families having a role in the neuron functioning are Na ⁺ , K ⁺ , Br ⁻ and Ca ⁺⁺	F	They are Na ⁺ , K ⁺ , Cl ⁻ and Ca ⁺⁺
2	The resting membrane potential for the neural cell is equal to -90	F	<i>The resting membrane potential of a neural cell is typically around -70 mV. -90 mV is the typical resting membrane potential of a muscle cell.</i>
3	In an inhibitory synapse, the membrane current is always hyperpolarizing.	T	
4	In the Nernst equation, the ion valence can be either positive or negative	T	<i>Depending on the ion family, the valence can be positive (like in Na⁺) or negative (like in Cl⁻)</i>
5	The resting membrane potential is entirely due to the sum of the effects of diffusional forces and electrical forces acting on the ions.	F	<i>It is also due to the effect of the ion pumps (active membrane transport)</i>
6	If at a certain temperature T the equilibrium potential for a given ion family is equal to +30 mV, and the membrane potential is equal to -70 mV, the ion net current will be a hyperpolarizing one.	F	<i>The ion net current will tend to move the membrane potential toward its equilibrium, therefore, in this case, it will be a depolarizing one.</i>
7	The propagation speed for an action potential in an unmyelinated axon is slower than in a myelinated one	T	
8	The Thalamus, the Brainstem and the Penfield Homunculus are all subcortical areas.	F	<i>The Penfield Homunculus is a cortical region.</i>
9	In the short-term plasticity, there are no structural changes in the post-synaptic membrane.	T	

#	Question	Ans.	Explanation
10.	The following measures of brain electrical correlates are in the correct order, from the less detailed to the more detailed one: Scalp EEG, Local Field Potentials, Electrocorticography, Stereo EEG, Extracellular Recordings, Intracellular Recordings.	F	<i>LFPs are more spatially resolved than ECoG and S-EEG</i>
11	The main contributors to the amplitude of EEG are the post-synaptic potentials.	T	
12	The following factors all affect the amplitude of EEG signals: the neurons' orientation, the synchronicity of the neural activity, the distance between the neurons and the electrodes, the closed/open field generated by the neurons.	T	
13	If a time series is not Fourier-transformable, it is still possible to compute its power spectral density by means of the Wiener-Khinchin Theorem.	T	
14	Ordinary Coherence is directional.	F	<i>It is a measure of synchronicity, not causality.</i>
15	Anatomical connectivity can change over large time scales.	T	
16	Causality in the sense of physical influence can be tested by perturbing the brain activity.	T	.
17	Wiener-Granger Causality is based on the autoregressive modeling of time series.	T	
18	The Granger Causality Test is a spectral measure.	F	<i>It returns a single value for the entire time window on which it is computed.</i>
19	This is an example of the hidden source effect: 	F	<i>This is a cascade effect.</i>
20	Multivariate approaches are more accurate because they use the information from all the time series involved in a unique model.	T	

#	Question	Ans.	Explanation
21	A Density equal to 1.3 is a physiologically plausible result.	F	<i>Density $\in [0,1]$</i>
22	Local Efficiency is a local measure.	F	<i>Local Efficiency is the average of the Global Efficiencies computed on the subgraphs associated with each node in the network. It is a global measure, as it describes a property of the full graph.</i>
23	Divisibility and Modularity are measures of segregation.	T	
24	A Small-World Network properties are equidistant from those of Regular and Random Networks.	F	<i>In terms of Local Efficiency, a Small World Network is closer to a Regular than to a Random Network.</i>

Section B

#	Question	Ans.	Explanation
1	The mu rhythm and the alpha rhythm have approximately the same frequency of oscillation and originate in different lobes of the cerebral cortex	T	TRUE
2	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.	T	TRUE
3	Event-Related Desynchronization/ Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	F	ERD/S quantify changes of the power of EEG relative to a baseline period
4	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.	T	TRUE
5	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$	T	TRUE
6	The artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings	F	EOG artifacts can be two orders of magnitude higher than that.
7	The Central Limit Theorem (CLT) states that the average of N zero-mean independent identically distributed signals approaches zero for $N \rightarrow \infty$.	T	TRUE
8	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.	F	IIR filters cannot be designed to have linear phase
9	The CMRR of a bipolar amplifier measures the ratio between the gain of their average with respect to the electrical ground and the gain of the potential difference between the input electrodes.	F	Numerator and denominator are swapped

#	Question	Ans.	Explanation
10	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.	F	Aliasing occurs when an analog signal is sampled outside the conditions set by the Shannon's theorem. Clipping (saturation) occurs when the input range of the ADC is smaller than the amplitude of the input analog signal.
11	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.	F	Gold electrodes are polarizable, thus the opposite is true
12	In an EEG recording, a session contains one or more trials, each of which contains one or more runs	F	The order is wrong: Session -> Run -> Trial
13	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 $10^8 \Omega$.	T	TRUE
14	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of $\text{sinc}(\cdot)$ functions, one for each sample.	T	TRUE
15	The Inter-Stimulus Interval (ISI) measures the time interval between two successive stimuli in a train.	F	This is the definition of the Stimulus Onset Asynchrony (SOA)
16	It is more likely that samples of zero mean a gaussian noise will have amplitude in the range $[-0.5, 0]$ rather than in $[0, 0.5]$	F	The Gaussian probability distribution is symmetric, thus the two probabilities are equal
17	In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event	T	TRUE
18	The η (eta) rhythm is an oscillatory component of the spontaneous EEG	F	The main rhythms of the EEG are: delta, theta, alpha, beta, gamma. Other rhythms (such as mu and tau) are described, but no eta.
19	$ARV_x = \sqrt{\frac{1}{N} \sum_i (x[i])^2}$, where the sum extends on the N samples of the signal x[i]	F	$ARV_x = \frac{1}{N} \sum_i x_i $, ARV being the acronym of Average Rectified Value
20	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.	F	An individual can learn to modulate sensorimotor rhythms (not ERPs) through motor imagery

#	Question	Ans.	Explanation
21	The measurement of two monopolar EEG channels requires four electrodes – two collecting the potentials fed to the non-inverting input of the differential amplifier, one providing the reference potential and one providing the ground potential.	T	TRUE
22	The frequency response of a filter in the stopband should never be plotted in logarithmic units (i.e. with the gain is expressed in dB).	F	The opposite is true: the logarithmic scale allows to appreciate gain values spanning orders of magnitude below the passband gain.
23	The DFT of a signal represents the amplitude A_i and initial phases ϕ_i of sinewave components of the signal at frequencies f_i ranging from $0Hz$ (included) to the sampling frequency (excluded).	T	TRUE
24	A negative peak in a ERP recorded on a specific subject with a latency of $108ms$ may still be named N100, if it matches the physiological phenomenon of the nominal N100 component.	T	TRUE