

Neuroengineering 2024-2025

Exam 10 September 2025

SOLUTIONS – Part 1

Section A

#	Question	Ans.	Explanation
1	The sodium-potassium pump is a passive transportation mechanism.	F	<i>The sodium-potassium pump works against the electrochemical forces, and it requires energy expenditure by the cell. Therefore, it is an active transportation mechanism.</i>
2	The resting membrane potential for the neural cell is typically around +70 mV.	F	<i>The resting membrane potential of a neural cell is typically around -70 mV.</i>
3	In an excitatory synapse, the post-synaptic membrane current is always hyperpolarizing.	F	<i>It is depolarizing.</i>
4	In the Nernst equation, the temperature is expressed in Celsius degrees	F	<i>It is expressed in Kelvin.</i>
5	The resting membrane potential is entirely due to the sum of the effects of the electrical forces acting on the ions and of the ion pumps.	F	<i>It is also due to diffusional forces.</i>
6	Given an ion family with negative valence, if at a given temperature T its equilibrium potential is equal to -90 mV and the membrane potential is equal to -70 mV, the ions net current will be directed from the outside of the cell toward the inside.	T	<i>The ion net current will tend to move the membrane potential toward its equilibrium: therefore, in this case, negative ions will move to the inside of the cell.</i>
7	The spatial and temporal summations of post-synaptic potentials are mutually exclusive.	F	<i>They can occur simultaneously</i>
8	The primary visual region, the primary auditory region and both Penfield Homunculi are all cortical areas.	T	
9	Long-term synaptic plasticity involves structural changes in the post-synaptic membrane.	T	
10.	Local Field Potentials are noninvasive correlates of brain activity.	F	<i>LFPs cannot be acquired noninvasively.</i>

#	Question	Ans.	Explanation
11	The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.	F	<i>The synchronous variations of post-synaptic potentials (and their extracellular counterpart) are the main contributors to EEG signals.</i>
12	Scalp EEG is mainly produced by deep (subcortical) regions.	F	<i>It is mainly produced by cortical regions.</i>
13	If a time series is not Fourier-transformable, it is impossible to compute its power spectral density.	F	<i>The PSD can be still computed by means of the Wiener-Khinchin Theorem.</i>
14	Partial Directed Coherence is directional.	T	
15	Anatomical connectivity can be estimated noninvasively.	T	
16	The only way to estimate Causality in the sense of temporal precedence is to perturb the brain activity.	F	<i>It can be estimated through Wiener-Granger concept of causality, which is observational (model-based)</i>
17	Wiener-Granger Causality is based on the autoregressive modeling of time series.	T	
18	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>
19	The hidden source problem can be completely solved by using multivariate approaches.	F	<i>If one or more sources are not accessible/available, even using multivariate approaches we can incur in the hidden source problem.</i>
20	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>
21	A Modularity equal to -0.3 is a plausible result.	T	

#	Question	Ans.	Explanation
22	A Divisibility equal to 0 is a plausible result.	F	<i>According to the most used normalization, the minimum Divisibility is equal to 0.5. More generally, even with different choices of the term k, D can never be equal to zero.</i>
23	Random networks have a smaller Local Efficiency than regular (lattice) networks.	T	
24	In terms of Local Efficiency, a Small World Network is closer to a Regular than to a Random Network.	T	

Section B

#	Question	Ans.	Explanation
1	The “waxing and waning” of the alpha rhythm is a change of amplitude whose duration is in the order of magnitude of 1 second.	T	True. Not to be confused with the oscillations of the alpha rhythm, which occur an order of magnitude faster.
2	The SOA is always greater than the ISI	T	The SOA equals the ISI plus the duration of the stimulus. Since stimulus duration must be positive, SOA is always greater than ISI.
3	The CMRR of a bipolar amplifier measures how much higher is the gain of the potential difference between the input electrodes with respect to the gain of their average with respect to the electrical ground.	T	TRUE
4	Appropriate application of a high-pass digital filter may prevent saturation by removing high amplitude slow artifacts.	F	False, saturation can be prevented only by applying an analog filter before A/D conversion
5	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
6	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
7	The purpose a filter is to allow desired spectral component of a signal to pass almost unaltered, while attenuating undesired spectral components	T	TRUE
8	Increasing the Inter-Electrode Distance (IED) in a bipolar recording decreases the signal amplitude and increases selectivity.	F	Increasing the IED expands the detection volume, which increases signal amplitude by capturing activity from more muscle fibers. However, this larger volume decreases selectivity, making the recording less localized and more prone to cross-talk.

#	Question	Ans.	Explanation
9	A 'run' is a portion of recording in an experimental protocol that contains no breaks, i.e. all samples contained therein have been acquired $1/f_s$ seconds after the previous (f_s being the sampling frequency)	T	TRUE
10	It is more likely that samples of zero mean a gaussian noise will have amplitude in the range [-0.5,+0.5] rather than in [0.5,1.5]	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).
11	The EEG electrode Fz is located to the left of electrode Cz	F	False, they both lay along the midline, Fz being more anterior than Cz
12	In a typical single-trial recording, the peak amplitude of an Evoked Potential is larger than the amplitude of the background spontaneous EEG.	F	False. With very rare exceptions (mostly in the field of pathology) EPs are one or more orders of magnitude smaller than the spontaneous EEG.
13	Notch filters effectively remove powerline noise because they reject all signals above their corner frequency.	F	Notch filters selectively reject the narrow frequency band affected by the artifact
14	The synchronized average of N trials containing only spontaneous EEG whose variance is $var_{trial} = \sigma^2$ is a signal whose variance is $var_{avg} = \sigma^2/N$	T	TRUE
15	When sampling at 100 Hz, a 75 Hz analog signal component will alias and appear at 25 Hz.	T	The aliased frequency is calculated as $f_{aliased} = f_s - f_0 = 100 \text{ Hz} - 75 \text{ Hz} = 25 \text{ Hz}$. (This simplified formula is valid for $f_s/2 \leq f_0 \leq f_s$).
16	In ERP analysis where preserving the exact shape of the waveform is critical, a linear-phase FIR filter is generally a better choice than an IIR filter.	T	TRUE
17	Event-Related Desynchronization/Synchronization (ERD/S) quantify phase-locked brain activity in response to an event	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.

#	Question	Ans.	Explanation
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	Spectral leakage spreads each frequency sample of the original spectrum with a pattern defined by the DFT of the windowing function, and thus is characterized by a main lobe and several side lobes.	T	TRUE
20	Raw EMG amplitude in millivolts can be directly compared between different subjects without any normalization.	F	Raw EMG amplitude is not comparable across subjects due to confounding factors like subcutaneous fat thickness and precise electrode placement. To allow for valid comparisons, the signal must be normalized to a standard reference, such as a Maximal Voluntary Contraction (MVC).
21	A sudden upwards movement of the eyes generates a positive deflection of EEG potentials (EOG) on the Fz channel.	T	TRUE
22	A single cell of the muscular tissue is known as a muscle fiber.	T	TRUE
23	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	T	TRUE
24	The reconstruction of an analog signal from its sampled version is equivalent to the linear interpolation of the samples.	F	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.