Neuroengineering 2024-2025

Exam 3 July 2025

SOLUTIONS

Section A

#	Question	Ans.	Explanation
1	Ion pumps are based on a passive membrane transportation mechanism.	F	*They require an energy expenditure by the cell, therefore they are based on an active mechanism.*
2	Given that at a certain temperature *T* the Cl^- equilibrium potential is equal to -80 mV, and the membrane potential is equal to -70 mV, the Cl^- net current will be directed from the inside of the cell toward the outside.	F	*If the ion equilibrium potential is more negative than the membrane potential, the ion net current will be a hyperpolarizing one. Since Cl^- is a negative ion family, its net hyperpolarizing current will be directed from the outside of the cell toward the inside.*
3	In chemical synapses, when a neurotransmitter opens the K^+ gated channels, the resulting PSP is an inhibitory one.	T	*K^+ gated channels allow the flow of a hyperpolarizing ion current, which in turn produces an inhibitory PSP.*
4	The continuous conduction is faster than the saltatory (myelinated) one	F	*The myelinated conduction is faster than the continuous one.*
5	Two ipsilateral regions belong to the same hemisphere.	T	
6	The unmasking of latent synaptic connections is part of the mechanisms behind brain plasticity.	T	
7	To detect a sequence of action potentials over the axon of a neural cell *in vivo*, the correct procedure is to record extracellular measures.	T	
8	The cortical pyramidal neurons are oriented tangentially to the cortical surface.	F	*They are oriented normally to the cortical surface.*
9	Synchronously activated neurons produce a larger EEG signal than the same amount of neurons when they are asynchronous.	T	

#	Question	Ans.	Explanation
10.	Deep (subcortical) regions of the brain produce a less blurred scalp EEG than cortical ones.	F	*Due to their position and their distance from the electrodes, and because of volume conduction effects, subcortical sources produce a more blurred scalp EEG than cortical ones.*
11	(Not available)	-	
12	(Not available)	-	
13	(Not available)	-	
14	(Not available)	-	
15	(Not available)	-	
16	(Not available)	-	
17	If a time series is not Fourier-transformable, it is impossible to compute its PSD.	F	*The PSD can be computed by means of the Wiener-Khinchin Theorem even if the time series is not Fourier-transformable.*
18	A necessary condition for a linear autoregressive (AR) model is that the time series to be modeled is wide-sense stationary.	T	
19	PDC is a spectral, bivariate method.	F	*It is a spectral, multivariate method.*
20	The use of Ordinary Coherence can mitigate the problem of the common source.	F	Being a pairwise method, the Ordinary Coherence cannot mitigate nor solve the problem of the common source.
21	A negative value of the Granger Index $G_{x \to y}$ should never occur if the two AR models that are compared to compute the index are correct.	T	
22	In a graph, the distance *d(i,j)* between two nodes is given by the average length of the paths that link them.	F	*It corresponds to the shortest (oriented) path between the nodes.*
23	In a graph, the Global Efficiency $\in [0, 1]$.	T	

#	Question	Ans.	Explanation
24	In an undirected graph, I cannot compute the indegree and the outdegree.	T	*The concept of "in-degree" and "out-degree" is based on directionality.*

Section B

#	Question	Ans.	Explanation
1	The oscillations of mu rhythm are more "arc-shaped" than the alpha rhythm's, which is comparatively a more symmetrical sinewave	T	TRUE
2	The potential at the peak of the EP component P20 is higher than the potential at the peak of the N100 component	T	TRUE
3	The CMRR of an EEG amplifier should be higher than 90 dB	T	TRUE
4	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 $f_{aliased} = \lvert f_s - f_0 \rvert = \lvert 100 \text{ Hz} - 75 \text{ Hz} \rvert = 25$ Hz. (This simplified formula is valid for $f_s/2 \leq f_0 \leq f_s$).
5	The RMS and the standard deviation of a zero-mean signal have the same value (assume that the number of samples $N \to \infty$).	T	TRUE
6	Synchronized averaging of N EEG trials produces N values each corresponding to the average value of the potential in each trial.	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).
7	A rectangular window is always the best choice for spectral analysis because it has the narrowest main lobe and no sidelobes.	F	A rectangular window has the largest sidelobes, which causes significant spectral leakage.
8	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	T	TRUE
9	In a 3-channel EEG recording, if the potentials at a given instant are $+10\mu V$, $-5\mu V$, and $-15\mu V$, the Common Average Reference (CAR) value is $+10\mu V$.	F	The CAR value is the average of all channels: $\text{CAR} = \frac{+10\mu V - 5\mu V - 15\mu V}{3} \approx -3.33\mu V$
10	The RMS is the average of the squared value of the samples of a signal	F	The RMS is the *square root of* the average of the squared value of the samples of a signal

#	Question	Ans.	Explanation
11	The measurement of a single EMG signal requires three electrodes – two as input to the differential amplifier and one to provide the ground potential.	T	TRUE
12	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
13	An eyeblink produces an artifact which often interferes with the analysis of the beta band of the EEG.	F	An eyeblink artifact is a slow wave lasting several tens of a second (i.e. well below 10 Hz)
14	Quantization divides the input range of the ADC into (approximately) NBITS intervals, where NBITS is the number of bits of the ADC.	F	Quantization divides the input range of the ADC into (approximately) 2^{NBITS} intervals
15	The most common and theoretically perfect method for reconstructing an analog signal from its samples is by connecting the sample points with straight lines (linear interpolation).	F	The theoretically perfect method for signal reconstruction is *sinc interpolation*, not linear interpolation.
16	The DFT of a digital signal with N samples yields N/2 values of the signal's spectrum.	F	The DFT will contain N complex values, of which the first half is enough to completely define the signal.
17	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.
18	The proper (visual) alpha rhythm is generated in the frontal lobe of the cerebral cortex.	F	The primary visual area is located in the occipital cortex
19	Given 100 independent and identically distributed random variables with variance equal to 4, the variance of their average is 0.04?	T	$\sigma_{avg}^2 = \frac{\sigma^2}{N} = \frac{4}{100} = 0.04$
20	A single cell of the muscular tissue is known as a muscle fiber.	T	TRUE
21	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
22	A key advantage of FIR filters is their ability to be designed with linear phase, thus avoiding the introduction of time-domain waveform distortions.	T	TRUE

#	Question	Ans.	Explanation
23	The Butterworth filter is a design method in the family of Finite Impulse Response filters	F	A Butterworth filter is a IIR filter.
24	Averaging raw EEG trials before computing the power spectrum is the standard method for analyzing non-phase-locked induced activity.	F	This method is used for evoked activity. For non-phase-locked induced activity, this would cancel out the response. Power must be computed before averaging.