The University Of Sheffield.

DEPARTMENT OF PHYSICS AND ASTRONOMY

Spring Semester 2006-2007

PROCESSING OF PHYSIOLOGICAL SIGNALS 1 **2 HOURS**

The paper is divided into two sections: A and B.

The student should answer all questions in section A. One sentence answers are sufficient for all questions in this section.

The student should answer two questions from section B.

TURN OVER

SECTION A

Answer <u>all</u> questions: 2 marks for each question

(1) What two features of a nerve are the primary determinants of transmembrane potential?

(2) What electrical characteristic of a nerve fibre does myelin alter and how?

(3) Why does the sinusoidal current required to stimulate a nerve increase with frequency below about 20 Hz?

(4) What anatomical structure is the major factor in determining the amplitude of the current which flows through the body when connected to an external voltage source via surface electrodes and why is this the case?

(5) Why does stimulation of a nerve occur under the cathode, rather than the anode electrode?

(6) How does an instrumentation amplifier differ from an operational amplifier?

(7) Give two advantages of magnetic stimulation over electrical stimulation.

(8) Name two methods that can be utilised to provide a screened environment for Biomagnetism measurements.

(9) By what mechanisms can high amplitude radiofrequency current and low amplitude d.c. current damage tissue?

(10) On what does a piece of Class I electromedical equipment rely to provide electrical safety?

(11) Give reasons why a click stimulus gives a larger evoked electrical response from the cochlea and the brainstem compared to a 1 kHz tone pip.

(12) The auditory brainstem response consists of a series of 5 waves but not all of these waves are present in normals. Why is this?

(13) Filters are used when recording the auditory brainstem response to reject unwanted background noise. State the effect of an increase in the low frequency filter on the auditory brainstem response waveform.

(14) What changes to the evoked electrical response used in spinal monitoring will occur with a reduction in blood supply to the spinal cord (as may occur during surgery)?

(15) Briefly describe two components of the electrocochleogram.

(16) Briefly describe the origin of the evoked otoacoustic emission.

(17) Otoacoustic emissions have a sound pressure level (SPL) of around 0 to 10 dBSPL. State two methods by which the background noise is reduced so that it is possible to observe the otoacoustic emission above the background noise.

(18) State two limitations of otoacoustic emissions in the assessment of hearing.

(19) What is the range of amplitudes in μV for evoked electrical potentials to auditory stimuli?

(20) What is the relationship between the amplitude of the cortical electric response and the strength of the acoustic stimulus?

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SECTION B

Answer two questions each worth 30 marks

B1

(i) Estimate the voltage due to 50 Hz electric fields that would be present on an unearthed subject in a typical room. Include all assumptions made and the method of calculation. What current will pass through the body in such circumstances? [15]

(ii) Describe a recording configuration which makes practical the recording of small electrophysiological signals in the presence of these large interfering voltages. [5]

(iii) A pair of electrodes are used to connect the body to this recording configuration. Their contact impedance to the body differs by 10 kΩ. The recording amplifier has an input resistance of 10 MΩ. Calculate the maximum common mode rejection ratio that can be achieved in this situation. If a common mode voltage of 1V is present on the body, discuss the practicality of recording the ECG with such a system and how the system might be improved. [10]

B2

(i) Sketch the time course of a transmembrane nerve action potential, including the relevant voltage and time scales. Why can this signal be detected at the surface of the body? [5]

(ii) If a node of Ranvier has a capacitance of 10 pF, calculate the directly injected charge required to stimulate it, stating any assumptions made. What is the maximum number of such stimuli that could theoretically be delivered from a watch battery with a capacity of 10 mAh using transmembrane stimulating electrodes? [10]

(iii) Describe the relationship between the amplitude of the stimulus and the amplitude of the transient evoked otoacoustic emission. Describe the process by which otoacoustic emission equipment records only the non linear component of the otoacoustic emission . Include a discussion of how the elimination of the linear components from the recorded response helps to improve reliability and confidence in the recorded emission. [15]

B3

(i) Describe, with the aid of a diagram, the components of a system for recording auditory evoked electrical potentials. The purpose of each of the components should be described, giving examples of typical settings where appropriate. [20]

(ii) Describe two examples of the clinical application of auditory evoked electrical potentials, one for measuring hearing threshold and one for the detection of changes to the auditory pathway. Include in your answer a discussion of the limitations of each application in providing accurate clinical information. [10]

END OF QUESTION PAPER