**EE 4BD4 Midterm Exam**
October 29, 2013 6:30 - 8:00

1. Let's assume that you have to measure a differential biopotential using Ag/AgCl electrodes built by you in the lab. Let's assume for simplicity that the sensor can be modeled as a resistor. Let's assume further that the resistance is proportional with the surface of the electrode. The nominal value is 10 KOhms / cm^2. However, since these electrodes are home-made, one has a surface of $1cm^2$ while the other one has a surface of $1.5cm^2$. The head-stage of your amplifier is built using a AD620; the gain of the head-stage is 100. Assume pure common mode excitation with Vcm = 500mV and that the common mode gain of the AD620 is zero, Ric = 10GOhms. Compute Voc. See figure. (**7 marks**)
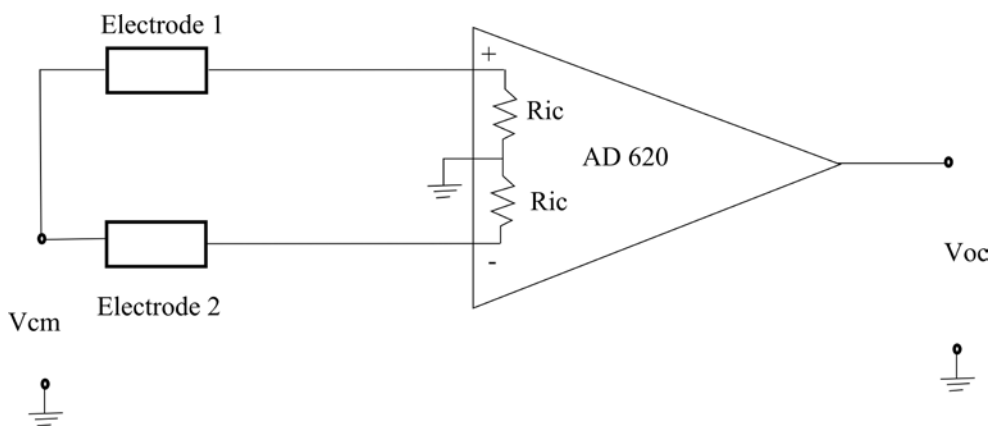
2. Give the equivalent circuit of the current path through an electrode applied to the surface of the skin and describe what each circuit component represents. Why does sweaty skin make a person more susceptible to electrical shocks? (**10 marks**)

3. Describe Einthoven's triangle and how it is used to measure and interpret the Lead I ECG signal. What are the assumptions made to validate this view of the electrical field in the body resulting from the electrical activity of the heart? (**8 marks**)

4. The electroretinogram (ERG) is recorded by placing a ring electrode (gold or stainless steel) on the cornea of the eye with a reference electrode (Ag-AgCl) on the forehead and a ground on the neck. The resulting signal shown in Fig. 1 has an amplitude of 0 – 900 µV and a bandwidth of 0 – 50 Hz (the total time for Fig 1 is 150 ms). The signal is caused by flashing a light (time 0 in Fig 1) of different intensities and colours and recording the response of the retina. The important features are times to the peaks of the a-wave and b-wave and the amplitudes from the baseline of each of these waves. Design a measurement system to record the ERG which removes enough noise to allow us to measure these features and record the signal and results. Use a block diagram approach giving the specifications for each block from transducers to final display(s). Consider patient safety and comfort. (**20 marks**)
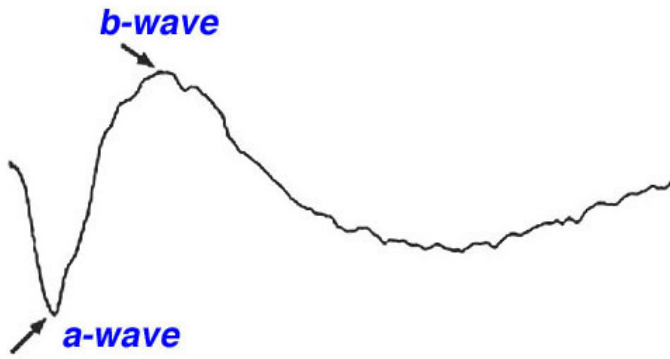
b-wave

a-wave

Fig.1 The biphasic waveform of the ERG of a normal patient.