

Perus funktionlaskin (ei graaffinen/ohjelmoitava) sallittu tentissä.  
 Basic Scientific calculator (no graphing/programmable) accepted in exam.

BME-2706 Analysis of Bioelectric Phenomena  
 Exam 16.12.2010 at 9.00-12.00

1) Figure 1 shows the model applied by Burger and Van Milaan. They applied this model to define the lead vectors for the ECG limb leads. Describe the direct and reciprocal methods to define the limb lead vectors with this model. (20%)

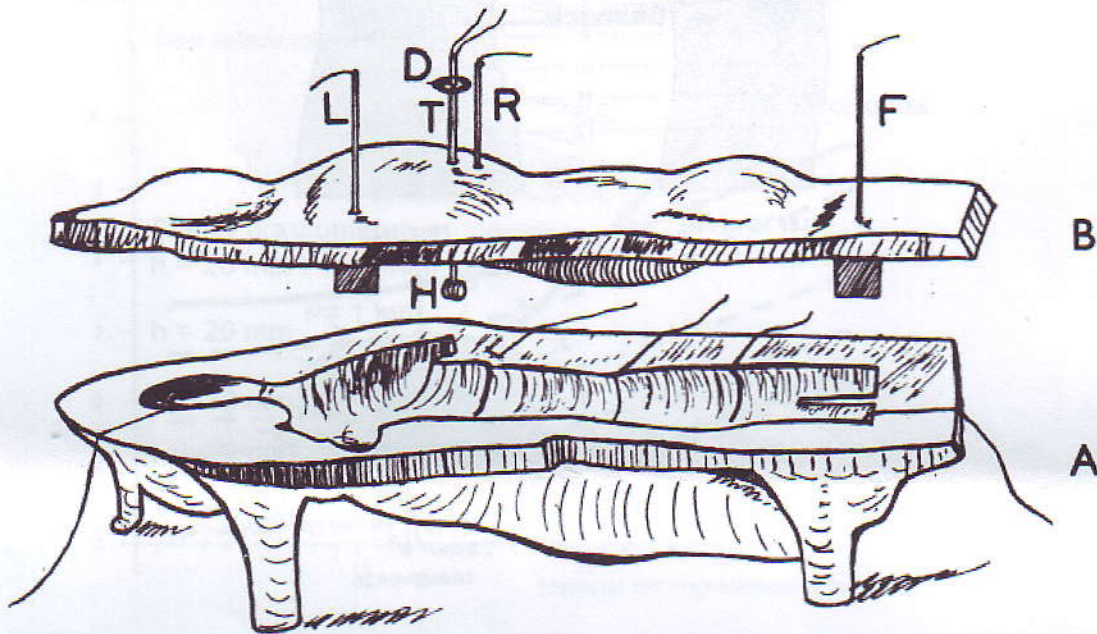


FIG. 1.—Phantom to measure the coefficients in the relation between heart-vector and leads.  
 (A) chest-side. (B) back-side.  
 L, R, and F: extremity electrodes.  
 H: artificial heart with protruding glass tube (T) with dial (D).

Fig. 1 Burger HC, van Milaan JB (1947): Heart vector and leads - II. *Br. Heart J.* 9: 154-60.

2) There are pill (capsule) sized cameras that patients can swallow to video image a patient's digestive tract. Consider that an electric dipole source was placed inside the pill such that it's orientation is parallel to the length of the pill (Fig. 2).



Fig. 2. Camera & dipole pill/capsule.

Devise a magnetic OR electric lead system to detect the pill inside the patient's stomach (you can assume that the stomach is located on levels 7-9 in Fig. 3). Discuss the following points (a) - (b) in your answer. Label electrode positions according to Fig. 3. For example 6E places an electrode in the center of your chest in front of your heart. It is not necessary to use Frank's coordinate system, but if you are not satisfied with this number & letter method, devise your own carefully and clearly.

a) Design your lead system. Explain why you designed it this way. (Hint: read part c). (10%)

b) What happens to the measured voltages at your chosen electrodes as the pill moves around inside the stomach? Consider the pill moving vertically, horizontally, and rotationally. (10%)

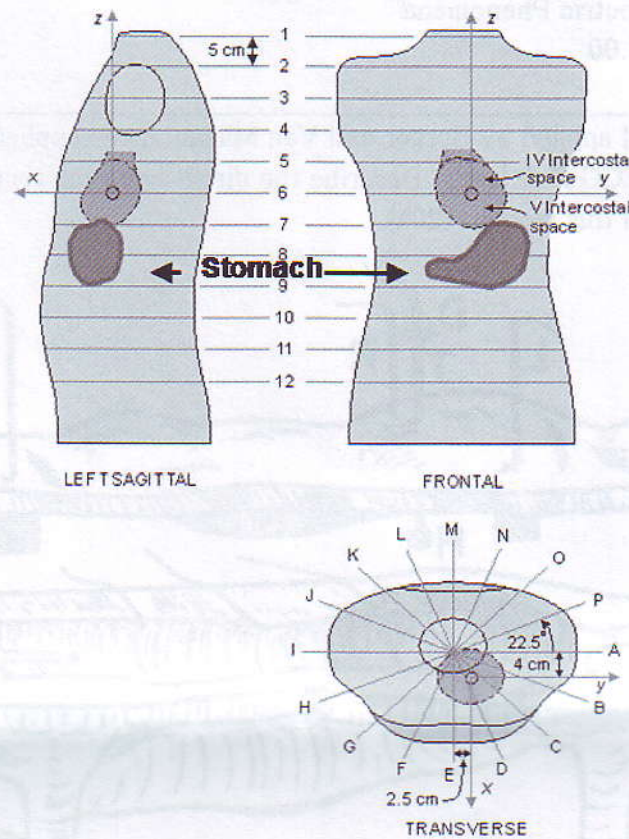


Fig. 3 Use the number & letter combinations to explain your electrode locations. Figure modified from [book, Fig 11.14].

3) You have a young child patient (e.g. Bart Simpson) coming to a magnetoencephalography (MEG) study and you are asked to measure those signals related to visual stimuli that are generated on the cortex at the back of the head. Assume he has a normal sized brain unlike his father, Homer Simpson. The signals measured with magnetic sensors are called visual evoked fields. The corresponding signals measured with electric sensors are called visual evoked potentials. Unfortunately you only have a MEG helmet designed for adult studies available. This helmet includes 64 sensors and you have a possibility to use either axial gradiometers or planar gradiometers. (Hint: read question 4).

a) Describe what kinds of problems arise due to use of an adult helmet on a child? Describe the problems separately for axial and planar gradiometers. (10%)

b) What would be the optimal measurement setup (coils, sensor placement etc.)? (10%)



c) What would the MEG helmet detect on his father's head, Homer Simpson, for both the axial and planar gradiometers? Remember Homer's brain is not normal (see figure above). (10%)

4) Explain the significance of Fig 4A regarding the electrodes and gradiometers in Fig 4B-E. (20%)

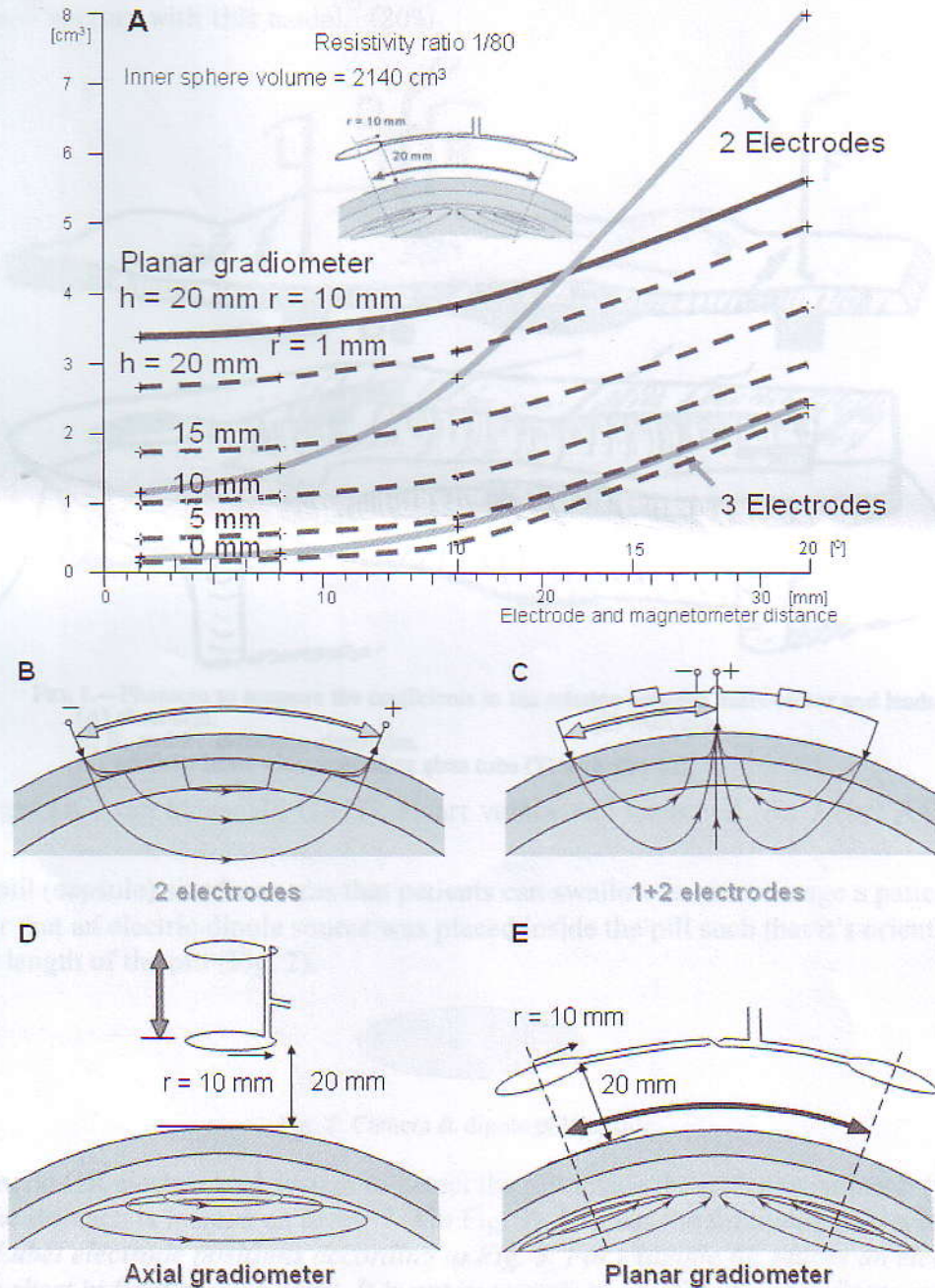


Fig. 4 (A) Half-sensitivity volumes for two- and three-electrode electric leads (yellow lines), planar gradiometers of 10 mm coil radius (blue line) and 1 mm coil radius (dashed blue lines) as a function of electrode distance/gradiometer baseline. (The half-sensitivity volume of the axial gradiometer falls outside the figure.) The measurement situations are shown (B) for the two-electrode and (C) for the three-electrode electric leads, (D) for the axial gradiometer and (E) for the planar



gradiometers. The head model is the inhomogeneous spherical model of Rush and Driscoll. (Suikko and Malmivuo, 1993).

- 5) Explain one practical application of impedance plethysmography and how it works. (10%)  
Happy Holidays!!!

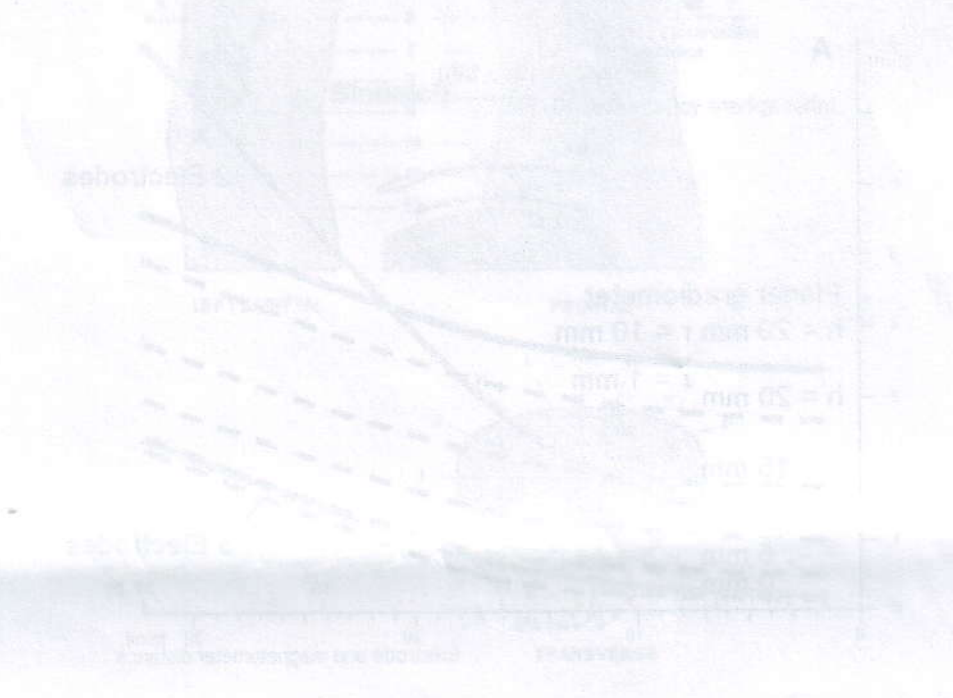


Fig. 4 (A) Half-sensitivity volume for two- and three-electrode arrays (yellow lines) for a planar gradiometer of 10 mm coil radius (blue lines) and 1 mm coil radius (dashed blue lines) as a function of electrode distance (gradiometer baseline). (B) The half-sensitivity volume of the axial gradiometer falls outside the figure. The measurement conditions are shown in (A). (C) The half-sensitivity volume of the axial gradiometer falls outside the figure. The measurement conditions are shown in (A). (D) The half-sensitivity volume of the axial gradiometer falls outside the figure. The measurement conditions are shown in (A). (E) The half-sensitivity volume of the axial gradiometer falls outside the figure. The measurement conditions are shown in (A).