TAMPERE UNIVERSITY OF TECHNOLOGY
Ragnar Granit Institute

71210 Bioelektroniikka - Bioelectromagnetism
Laskuharjoitus 9 – Exercise 9, 24.11.2004

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1. In a homogeneous anisotropic medium the conductivity is a function of direction. From this follows:

$$J_x = \sigma_x \frac{\partial \Phi}{\partial x}, \quad J_y = \sigma_y \frac{\partial \Phi}{\partial y}, \quad J_z = \sigma_z \frac{\partial \Phi}{\partial z}.$$

The problem can be transferred to isotropic medium using the following transformation:

$$x' = \sqrt{\frac{\sigma_y \sigma_z}{\sigma}} x, \quad y' = \sqrt{\frac{\sigma_x \sigma_z}{\sigma}} y, \quad z' = \sqrt{\frac{\sigma_x \sigma_y}{\sigma}} z \qquad \text{and}$$

$$\Phi'(x', y', z') = \Phi(x, y, z); \sigma = \sigma'_x = \sigma'_y = \sigma'_z.$$

Terms with prime are related to the new coordinate system. Derive the Laplace equation in this coordinate system.

2. How is the interpretation of measured data changed if the media is anisotropic ($\rho_x = \rho_y = 280\ \Omega$cm, $\rho_z = 2300\ \Omega$cm) instead of isotropic ($\rho = 280\ \Omega$cm)?

3. A coil (1 cm high, 5 cm inner diameter) with 10000 turns of 0,3 mm Cu wire is used for measuring the magnetic field. Calculate the signal to noise ratio of the coil ($\rho_{Cu} = 0.017\ \Omega mm^2/m$, change in magnetic dipole during the QRS-complex: 50 pT in 50 ms).

4. MCG lead field can be described by the following equation

$$J_{LM} = \frac{1}{\rho 2y}\left(1 - \frac{d}{\sqrt{y^2 + d^2}}\right)\mu_0 RN \frac{di}{dt}$$

where d = distance from the center of the coil
R = radius of the magnoid
N = number of turns in the coil

Source is a double layer of 40 cm^2 in location (0, 10 cm, 0) and its strength is changing 100 mV in 50 ms. Thorax is thought to be homogeneous (ρ = 1000Ωcm). Also, it is known that *d* is 7.5 cm and *R* is 2 cm. Determine the induced potential in one turn of the coil (N=1).

5. Figure 1 represents a transversal view of a three-concentric-spheres model of the head. A measurement coil is located directly above the center of the model and its normal is directed parallel to the normal of the viewing plane. Current dipoles P1, P2 and P3 have the same magnitude. Which dipole gives the largest signal?

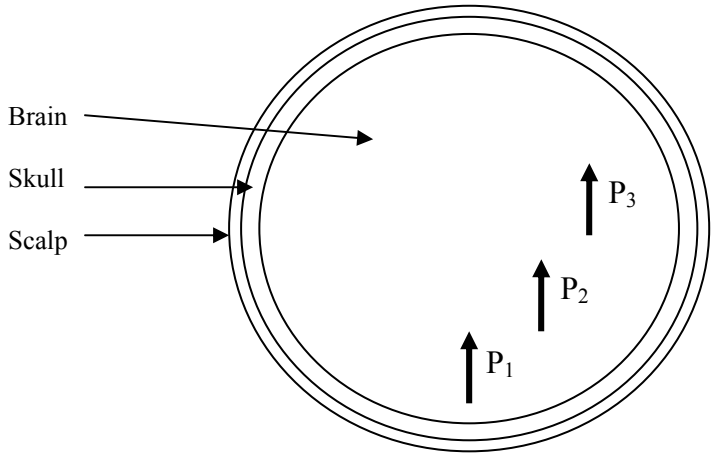

Figure 1. Transversal view of the three-concentric-spheres model and the dipoles.

6 Concept maps. At the exercises assistant will present a concept map on EEG. Based on that at the last exercise session you will do your own concept map on electric and magnetic stimulation of the brain.