Tfy-99.4280 Medical Imaging Methods

Problems for examination on August 29, 2008

1. Positron Emission Tomography is an efficient imaging tool in current cancer diagnostics. Explain the physical and technical working principle of a PET scanner. How does it identify the cancer cells?

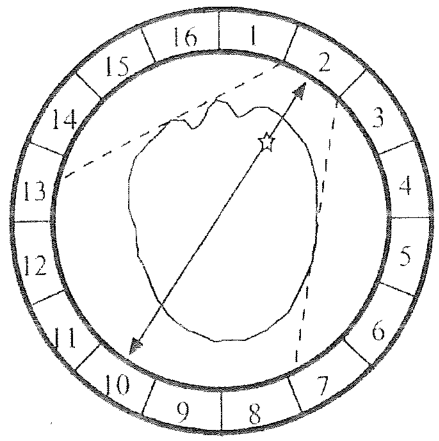
2. Compare core strengths and weaknesses of ultrasound, CT, MRI and PET in most important medical imaging applications.

3. Name two modern imaging modalities which do not require use of contrast agents to simultaneously generate anatomical images of blood vessels and measure the blood flows inside. Explain the physical working principles they are based on.

4. You would like to apply an ultrasonic imaging device for measuring the volume of a spherical cyst (cavity filled with water) inside muscle tissue. What are the related challenges due to the physical laws defining reflection and refraction ultrasound.

5. Sketch the Radon transform $p(r,\phi)$ of function $f(x,y)$ for $\phi = 0 \rightarrow 360^\circ$ for an object made of lead and having a cross-section with shape of capital letter Z. In which imaging method is this transform used and why?

- **The attached selected lecture material is at your disposal**
- **You may answer in English, Finnish or Swedish**



Sound wave reflection and transmission

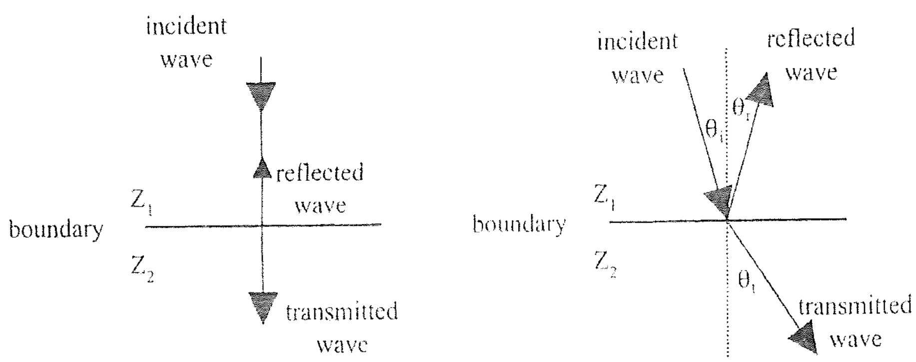


Fig 3.3. /Webb

In the case where the angle between the incident beam and boundary is not 90°, as shown on the right-hand side of Figure 3.3, the equations governing the angles of reflection and transmission are given by

$$\theta_i = \theta_r \tag{3.15}$$

$$\frac{\sin\theta_i}{\sin\theta_t} = \frac{c_1}{c_2} \quad \text{(eqv. to Snell's law in optics!)} \tag{3.16}$$

where c_1 and c_2 are the speed of sound in tissues 1 and 2, respectively. If the values of c_1 and c_2 are not equal, then the transmitted signal is refracted. This angular deviation from the original direction of propagation can cause misregistration artifacts in the image (Section 3.7). The pressure and intensity reflection and transmission coefficients are given by

$$R_p = \frac{p_r}{p_i} = \frac{Z_2\cos\theta_i - Z_1\cos\theta_t}{Z_2\cos\theta_i + Z_1\cos\theta_t} \tag{3.17}$$

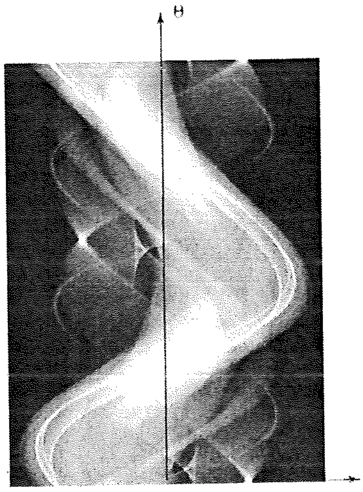
$$T_p = \frac{p_t}{p_i} = \frac{2Z_2\cos\theta_i}{Z_2\cos\theta_i + Z_1\cos\theta_t} \tag{3.18}$$

$$R_I = \frac{I_r}{I_i} = \frac{(Z_2\cos\theta_i - Z_1\cos\theta_t)^2}{(Z_2\cos\theta_i + Z_1\cos\theta_t)^2} \tag{3.19}$$

$$T_I = \frac{I_t}{I_i} = \frac{4Z_2Z_1\cos^2\theta_i}{(Z_2\cos\theta_i + Z_1\cos\theta_t)^2} \tag{3.20}$$

TABLE 3.1. Acoustic Properties of Biological Tissues

	Characteristic Acoustic Impedance $\times 10^5$(g cm^{-2} s^{-1})	Speed of Sound (m s^{-1})
Air	0.0004	330
Blood	1.61	1550
Bone	7.8	3500
Fat	1.38	1450
Brain	1.58	1540
Muscle	1.7	1580
Vitreous humor (eye)	1.52	1520
Liver	1.65	1570
Kidney	1.62	1560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