Example exam Acoustics 2010 – (English version)

Maximum of the exam is 60 p. For passing the course 30 p is needed.

1. A solution to the wave equation in air is $p(x,t) = \hat{p}e^{i(\omega t + kx)}$, where $\omega = 2\pi/T$ and $k = 2\pi/\lambda$. $T = 1$ ms and $\hat{p} = 0.1\text{Pa}$. (10 p)
a) Show that $p(x,t)$ satisfies the wave equation.
b) Plot the solution to the wave equation with $x = 0$ and give an example, a physical interpretation, of where this can appear or be observed.
c) Plot the solution to the wave equation with $t = 0$ and give an example, a physical interpretation, of where this can appear.
d) Calculate the effective value of the sound pressure.
e) Calculate the sound pressure level.

2. Calculate the amount of sound energy (in per cent and in dB) that is being transmitted in the following interface
a) Air to water
b) Water to air
c) Which of the cases is present in the ears tranduction of sound? How does the ear compensate for the energy loss of the sound?
(Z_{air} = 415 Pa·s/m and $Z_{water} = 1.48 \cdot 10^6$ Pa·s/m)

3. In the standing wave laboration, the formulas to calculate α are (10 p)

$$F = \frac{\hat{p}_i - \hat{p}_r}{\hat{p}_i + \hat{p}_r} \text{ and } \alpha = \frac{2F}{(1+F)^2}$$

where F is the ratio between the maximum and the minimum of the standing wave in the tube and $\hat{p}_i$ and $\hat{p}_r$ are amplitudes of the incoming an reflective wave, respectively.

Show that these expressions are correct by assuming an incoming and a reflected wave.

4. You and a friend are standing on the ice of a lake with a distance between you. She throws a rock on the ice, and after a moment you hear the sound of the impact which goes something like: “Piiiieeeeeoooo” instead of just “Tock”. Explain why and feel free to try the experiment whenever you get near a frozen lake. (10 p)

5. An apartment is exposed to noise from a neighbor. The sound pressure level in the apartment’s bedroom is 36 dBA (always). The measure of the square sized bedroom is $4.0 \times 4.0 \times 2.5$ m^3 and the current reverberation time is 1.5 s (mean value over all

frequencies). Calculate the amount of absorbents (in m^2) that is needed to get the sound level down to 30 dBA. The absorbents have an average absorption coefficient of $\alpha = 0.7$. Neglect flanking transmission. (10 p)

6. The sound in the bedroom (previous task) is dominated by a frequency of 340 Hz.
a) Where do you not want to place your head when sleeping?
b) At what distance from the wall should a thin absorber be placed in order to get maximum sound reduction? (10 p)

(neglect all practical aspects of the problem)

Solutions will come!