Pitch and Loudness

Basic Problems

1. How many octaves cover the frequency range of the human ear?
2. What interval can be heard when a major third is followed by a minor third?
3. Show that the notes in a just major triad (major third, minor third, fourth) add up to an octave.
4. Calculate the frequency of the tone one equally tempered halftone above a^1 (standard pitch 440 Hz).
5. Estimate the power arriving at the ear drum when the intensity level at its position is 100 dB.
6. By how many decibels does the intensity level decrease when the distance to a loudspeaker with conical radiation characteristic is increased by 10 %?
7. Simple ear protectors made of foam reduce the intensity level by some 30 dB. What fraction of the sound intensity can pass them?
8. Calculate the increase in intensity level when the sound intensity is doubled.
9. Two machines produce noises with intensity levels of 78 dB and 81 dB respectively. What is the intensity level when they are running at the same time?

Additional Problems

10. What is the maximum pitch which can be produced with a 1 m long steel string before it breaks?
11. A siren has a isotropic radiation characteristic. At a distance of 150 m from the siren the intensity level is measured to be 85 dB.
    a) What is the minimum power of the emitted sound waves?
    b) How far away is a person for whom the sound intensity is below the hearing threshold? Why is this result not correct?
12. A loudspeaker emits sound waves with a power of 300 mW into a cone with cone angle 30°. Calculate the intensity level at 2 m from the loudspeaker.
13. A SUVA regulation demands that for a weekly working time of 40 hours the average intensity level must not surpass 87 dB. Increasing the level by 3 dB leads to a reduction of the allowed exposure time by 50 %.
    a) Show that this rule of thumb corresponds to a constant total energy arriving at the ear-drums.
    b) Is a weekly exposure to 90 dB during 10 hours and to 92 dB during 8 hours still acceptable?
14. The maximum intensity level at rock concerts is 100 dB (measured at the centre of the venue). At an open air concert the intensity level at 3.2 km from the stage is 56 dB. The sound absorption in air is some 3 dB/km. Calculate the intensity level at 10 m from the stage.

Solutions to Basic Problems: 1. 10 octaves; 2. fifth; 4. 466 Hz; 5. 2 µW; 6. -0.8 dB; 7. 1 ‰; 8. 3 dB; 9. 82.8 dB