Exercise 0 (General/Basics/Refreshment……)

In a laboratory room there are 7 (weak) sound sources producing sound in the 500 Hz octave band and the 2 kHz 1/3-octave band only. At one position in the room the sound pressure level L_p is measured using an ultra-sensitive level meter. The sound energy in the 500 Hz octave band is equally distributed over the three 1/3-octave bands within this 500 Hz octave band. The next table shows the measurement results:

Source-nr.	500 Hz - octave band	2 kHz - 1/3 octave band
1	0 dB	6 dB
2	0 dB	6 dB
3	0 dB	6 dB
4	0 dB	0 dB
5	6 dB	0 dB
6	6 dB	0 dB
7	6 dB	0 dB

A: What is the total sound pressure level for the 500 Hz octave band?
B: What is the total sound pressure level for the 2 kHz octave band?
C: What is the total sound pressure level for the 500 Hz 1/3-octave band?
D: What is the total sound pressure level for the 2 kHz 1/3-octave band?
E: What is the total sound level L_A?

A: *(without calculator)* "0 + 0" = 3, "3 + 3" = 6, "6 + 6" = 9, "9 + 9" = 12, L_{p500} oct = **12 dB**
B: *(without calculator)* Within the 2 kHz-octave band only sound in the 2 kHz-1/3 octave band, thus: $L_{p\ 2k}$ oct = $L_{p\ 2k}$ 1/3 oct band. $L_{p\ 2k}$ oct = **12 dB**
C: Sound energy 500 Hz-octave band equally distributed over the 1/3 octave bands 400, 500 and 630 Hz. $L_{p\ 500}$ 1/3 oct = "12"/3 = 12 - 10lg3 = 12 – 4,8 = **7,2 dB**.
D: *(without calculator)* $L_{p\ 2k}$ 1/3 oct = **12 dB**.
E: $L_A = 10\lg(10^{(12 - 3,2)/10} + 10^{(12+1)/10})$ = **14,4 dB** (or dB(A))

Exercise 1 (outside)

The directivity factor of an omnidirectional sound source in a 2-surface corner is 4 (Q = 4). Suppose that this 2-surface-corner consists of a 100% reflective floor and wall that can be tilted (see figure).

A: Calculate the angle of the tilted wall to reach a directivity factor of Q = 3.
B: What happens to the sound pressure level at the listener position?
C: After tilting the wall the floor will be covered with a infinite high absorbing material. Discuss the directivity in that situation?

	Directivity	Inside angle	Gain (rel. direct field)
1 reflective floor only	Q = 2	360°/2 = 180°	10lg2 = 3,0 dB
2 asked angle	Q = 3	360°/3 = 120°	10lg3 = 4,8 dB
3 rectangular angle	Q = 4	360°/4 = 90°	10lg4 = 6,0 dB

A: 360°/3 = 120°. 30° backward tilting relative to vertical plane.
B: 1,2 dB less than rectangular 2-corner angle or 4,8 dB more than for omnisource in the free field or something like that…
C: Anyway, the directivity decreases strongly. A large part of the sound energy 'dissapears in the ground'. By all means Q will be smaller than 2 because of the fact that the source position is not in the middle of the reflective surface and that the surface is tilted. The directivity will be between 1 (omnisource in free field) and 2 (omnisource in front of a reflective surface).

Exercise 2 (concert hall)
The reverberation time in a concert hall is measured for the 1 kHz octave band using an interrupted noise source. The background noise (BGN) in this frequency band caused by the HVAC (airconditioning etc) is 30 dB. The sound pressure level of the sound source was 70 dB. After switching off the sound source the noise level decays and after 1.6 s the source level met the background level (at 30 dB).

What is the reverberation time RT for the 1kHz octave band (approx.)?

Decay of 40 dB in 1,6 s. Extrapolated to a decay of 60 dB: RT (T_{60}) = (60/40)*1,6 = 2,4 s.

FORMULAS (without explanation and without dimension)

$$c = \lambda f = 340$$

$$L_p = 10 \lg \frac{p_{eff}^2}{p_0^2}$$

$$L_W = 10 \lg \frac{W}{W_0}$$

$$L_I = 10 \lg \frac{I}{I_0}$$

$$L_{pdir} = L_W + 10 \lg \left(\frac{Q}{4\pi r^2} \right)$$

$$L_{pdiff} = L_W + 10 \lg \left(\frac{4}{A} \right)$$

$$L_p = L_W + 10 \lg \left(\frac{Q}{4\pi r^2} + \frac{4}{A} \right)$$

$$A = \sum (\alpha \cdot Opp)$$

$$T = \frac{V}{6A + 4mV}$$

$$r_k = \sqrt{\frac{QA}{16\pi}}$$

ref. values:
$p_0 = 2 \times 10^{-5}$
$W_0 = 10^{-12}$
$I_0 = 10^{-12}$