Exercises week 3 – Room acoustics

1. Consider a noise with the following 1/3 octave spectrum:

f [Hz]	100	125	157	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
Lp [dB]	70	65	67	75	60	70	72	72	72	77	75	70	65	62	57	55	55	50

a. Give its spectrum by octave band
b. Determine the global noise pressure level (un-weighed)

2. Given the following data about three different rooms, answer the questions below:

Dimensions [m]	Average absorption coefficient
Room 1: 8×8×2.7	$\alpha_1 = 0.04$
Room 2: 5×5×2.7	$\alpha_2 = 0.04$
Room 3: 15×12×3	$\alpha_3 = 0.04$

a. Use Sabine's law to determine the reverberation time of the three rooms.
b. Instinctively, we associate large rooms with a long reverberation time. Is this correct?

3. An auditorium has the following dimensions: length (L=40 m), width (W=20 m) and height (H=5 m). All its walls and the floor have a constant acoustic absorption coefficient of α=0.25, whereas the ceiling has an unknown acoustic absorption coefficient α'. Measurements of the reverberation time in the room yield T_{60}=0.80 seconds (consider it constant for all frequencies)

a. Calculate α' by use of Sabine´s law.

The room contains a source emitting uniformly in all the directions with a sound power Π=0.10 W. In each point of the auditorium the global sound intensity I is the sum of two terms:

- Direct field intensity (originating directly from the source) $I_d = \Pi/(4\pi r^2)$ at a distance r from the source.
- Intensity of the reverberated field (originating from the reflections on the walls) $I_r = 4\Pi/A$ in any point of the room.

b. At which distance r_1 to the source do we have an equality $I_d = I_r$?
c. Calculate the global sound intensity I_1 and the corresponding sound intensity level at distance r_1.

<u>Reminder</u>: the sound intensity corresponding to the audition threshold is $I_0 = 10^{-12}$ W/m^2.

4. Determine and plot the absorption coefficients $\alpha_s(f)$ in 1/3 octave-bands for a glass wool panel by using the given measured reverberation times for 2 different configurations:

- Configuration 1: Empty reverberation room.
- Configuration 2: Reverberation room with the walls covered by a surface S_s of glass wool.

Use the following data: the volume of the reverberation room is V = 200 m^3, the surface of the walls in the reverberation room is S = 200 m^2, the surface of the sample is S_s = 12 m^2 and the reverberation times for both configurations are given in the table below.

f (Hz)	100	125	160	200	250	315	400	500	630
T_1	13.7	10.9	6.5	6.2	6.3	6.1	6	6.5	7.1
T_2	12.3	8.6	5	4.6	4.3	3.5	3.0	2.6	2.5
f (Hz)	800	1000	1250	1600	2000	2500	3150	4000	5000
T_1	7.1	6.4	6.2	5.6	4.5	3.9	3.2	2.5	1.8
T_2	2.4	2.1	2.0	2.0	1.9	1.8	1.7	1.4	1.2

Answers:

1. a.

f	125	250	500	1000	2000	4000
L_p	72.6	76.3	76.8	79.6	67.2	58.6

b. L_p = 83.14 dB

2. a. $T_{60,1}$ = 3.2 s,
$T_{60,2}$ = 2.6 s,
$T_{60,3}$ = 4.1 s.
b. Theoretical.

3. a. α' = 0.56
b. r_1 = 3.98 ≈ 4 m,
I_1 = 10^{-3} W/m^2,
L_1 = 90 dB.

4. a.

f (Hz)	100	125	160	200	250	315	400	500	630
α_s	0.034	0.08	0.15	0.18	0.22	0.35	0.47	0.64	0.71
f (Hz)	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k
α_s	0.76	0.88	0.93	0.89	0.85	0.84	0.79	0.9	0.83

b. $\alpha_s = 0.16 \cdot V/S_s \cdot (1/T_1 - 1/T_0) + 0.16 \cdot V/ST_0$