Rak-43.3415 Building Physics Design 2 – Acoustical Design
EXAM 29.11.2014

Permissible equipment: writing accessories, calculator.

Write on each exam paper: course code and name, date, your name, student number and department.

Please write your answers *in English*.

1.

Explain the following concepts or phenomena and their significance to acoustical design:

a) panel absorber

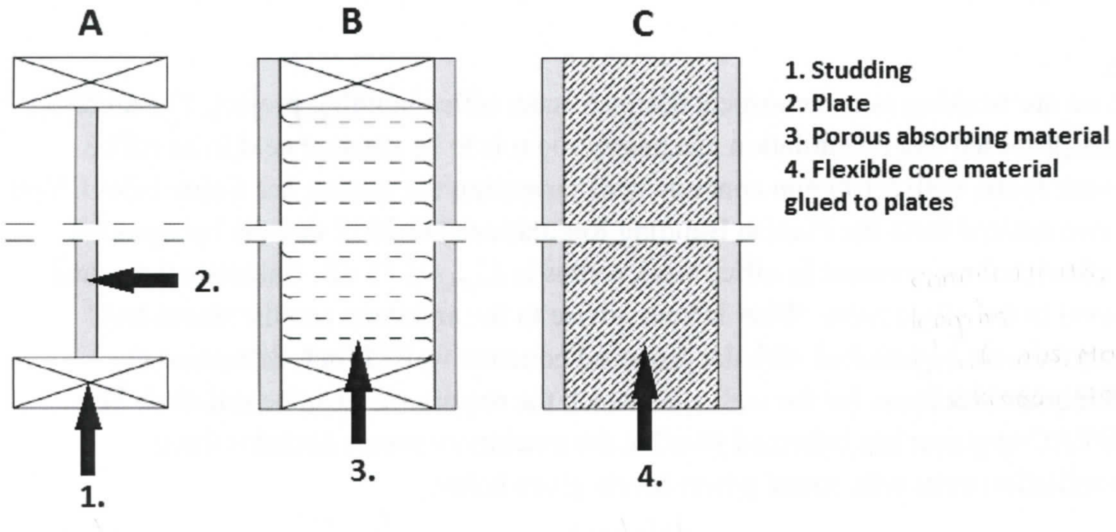
b) standardized tapping machine

c) lateral sound reflection

d) $R_w + C_{tr}$

2.

Below are depicted three structural types: A, B and C. Name the structures and explain what factors affect their sound insulation and how.



3.

a)

Derive an equation from the Sabine formula, with which you can calculate the absorption coefficient of a material from the reverberation times measured in a reverberation room. The reverberation time of the empty reverberation room is T_1, the reverberation time of the room containing the material sample is T_2 and the surface area of the sample is S. Calculate the absorption coefficient of a material with the following measurement results and present the result graphically in octave bands 125

– 4000 Hz. The volume of the reverberation room is 300 m^3 and the surface area of the material sample is 12 m^2.

[Hz]	125	250	500	1000	2000	4000
T_1 [s]	4,0	4,0	3,3	2,9	2,9	2,9
T_2 [s]	3,5	3,0	2,2	1,8	1,7	1,7

b)
What type of absorption material is it in 3a) and why? Give an example of a practical material of this type. How can the absorption coefficient of such a material be improved at low frequencies?

4.

a)
Define what *reverberation time* means. Explain what type of equipment is needed in order to measure the reverberation time of a room.

b)
The air conditioning of a concert hall with 1200 seats is organized so that supply air is distributed to the hall via supply air terminal units situated below the seats (one terminal unit under each seat). According to Finnish building regulations D2-2010 the equivalent noise level caused by HVAC-equipment in a concert hall must not exceed 25 dB(A). What is the highest permitted A-weighted sound power level for a single supply air terminal unit in order to satisfy the regulation? The volume of the hall is 8000 m^3 and the reverberation time at mid frequencies is 2,0 s.

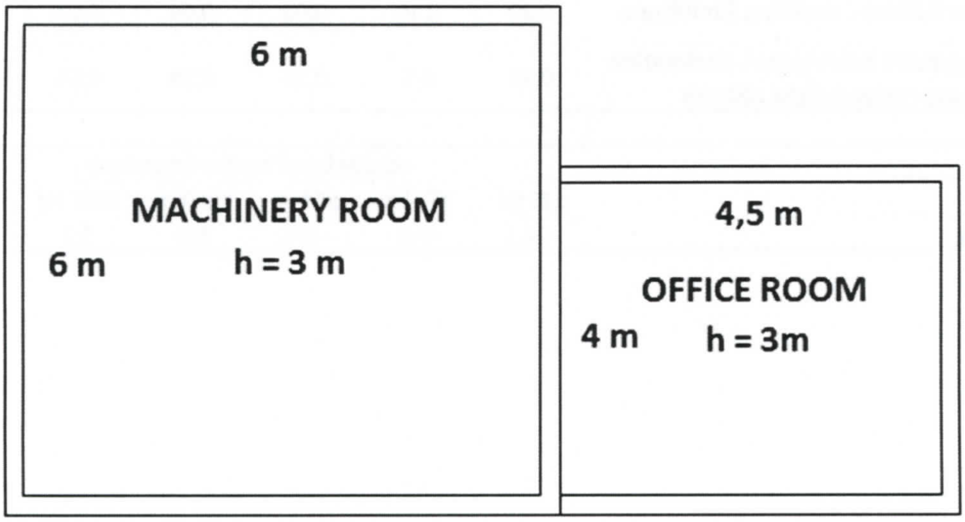
5.
You are working as an acoustical designer in an office building project. The architect has proposed that a ventilation machinery room is to be situated next to an office work room, with a 100 mm concrete wall separating the spaces; see figure below. You have noticed from the Finnish Building Regulations D2-2012 that the background noise level requirement in office work rooms is $L_{A,eq,T} \leq 33$ dB. Calculate the sound level in the office room. What is your advise to the architect: can the sound level requirement be satisfied with the proposed concrete wall? If not, determine the minimum thickness for the wall with which the requirement can be satisfied. The HVAC-engineer has informed you that the machinery rooms contains three ventilation units with sound power levels given below.

Do the calculations in octave bands 125-4000 Hz. Use the mass-law for calculating the sound insulation of the concrete wall. The density of concrete is 2500 kg/m^3. Flanking transmission can be neglected. The rooms have the following surface materials:

- machinery room / walls, floor and ceiling: concrete
- office room / walls: gypsum board 13 mm over studding, except for the concrete wall facing the machinery room
- office room / floor: concrete

- office room / ceiling: suspended ceiling with perforated gypsum board panels (17 % perforation ratio), suspension height 200 mm

Frequency [Hz]	125	250	500	1000	2000	4000
Ventilation unit 1, L_w linear [dB]	83	85	86	81	79	75
Ventilation unit 2, L_w linear [dB]	74	78	79	77	74	72
Ventilation unit 3, L_w linear [dB]	85	87	88	84	81	79



Appendix 1. Material data.

	sound absorption coefficient, α					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Concrete	0,01	0,01	0,02	0,02	0,02	0,02
Gypsum board 13 mm, studding 50x100 mm	0,29	0,10	0,05	0,04	0,07	0,09
Perforated gypsum board panel, perforation ratio 17 %, suspension height 200 mm	0,27	0,5	0,76	0,58	0,54	0,54

	octave band center frequency					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
A-weighting	-16,1	-8,6	-3,2	0,0	1,2	1,0