Rak-43.3415 Building Physics Design 2 – Acoustical Design
EXAM 25.10.2016

Permissible equipment: writing accessories, calculator.

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

You can give your answers in *English* or *Finnish*.

1.

Define the following concepts. Give an example of how they are used in acoustical design.

a) panel absorber

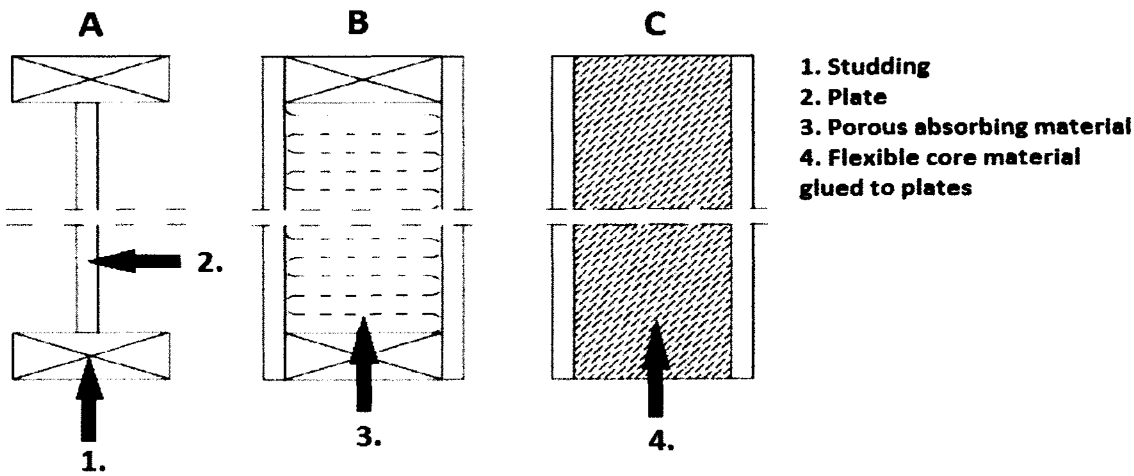
b) resonance frequency of floating floor

c) reverberation time

d) $L'_{n,w}$

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.

Your architect friend is designing a multi-storey dwelling situated near a highway. She asks for your acoustical consultancy concerning a requirement stated in the detail plan (asemakaava): *the sound level difference ΔL_A at the façade facing the highway must be at least 35 dB.* Advice the architect and explain:

- What does the requirement mean, i.e. how is the sound level difference defined?
- What factors affect the sound level difference? Give an example of how these can affect architectural design.

4.

Your assignment as an acoustician is to choose the most silent compressor of three models. You are given the following acoustic data from the manufacturers. Do the necessary calculations to answer which compressor you would choose.

- Compressor A: "Sound level measured in an anechoic room at a distance of 5 m from the source is 79 dB."
- Compressor B: "Sound level measured at a distance of 10 m from the source is 80 dB. Measurement conducted outside."
- Compressor C: "Sound level is 85 dB measured in a 250 m^3 room with a reverberation time of 1,6 s. Measurement conducted in the diffuse field."

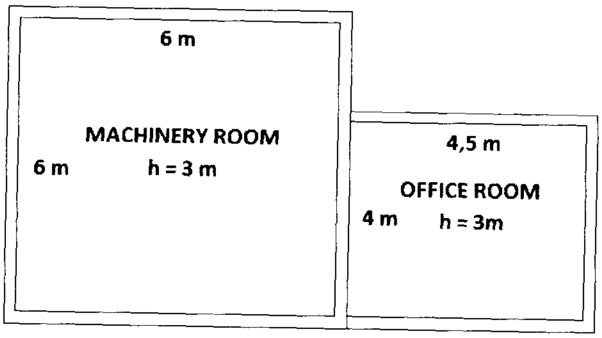
5.

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. From the Finnish Building Regulations D2-2012 you know 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 machinery rooms contains 3 ventilation units with sound power levels given below.

Do the calculations in octave bands 125-4000 Hz. Use 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



$\frac{1}{n} \sum \log(10^{\frac{L}{10}}$

$10 \cdot \log(10^{\frac{L}{10}}$

$10 \cdot \log(\sum_{i=1}^{n} 10^{\frac{L_i}{10}})$

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

$$T = 0.161 \frac{V}{A}$$

$$L_p = L_w + 10 \cdot \log \left[\frac{Q}{\Omega r^2} + \frac{4}{A} \right]$$

Cone C

$A = 25{,}5$

$L_W = 85 + 10 \cdot \log\left(\frac{25{,}15}{\ldots}\right) = 93\,dB$

$T_{60} = 0{,}161$

$$A = 0.161 \cdot \frac{250 m^3}{1.6 s} = 25{,}15$$

$L_w = 85 + 10 \cdot \log\left(\frac{4}{25{,}5}\right) = 77{,}0$

$L_w = 85 - 10 \cdot \log\left(\frac{1}{\ldots}\right.$

$L_w = 79 + 10 \cdot \log\left(\frac{1}{4\pi \cdot 25}\right) = 54\,dB$

$L_p = 54\,dB - 10 \cdot \log\left(\frac{1}{4\pi \ldots}\right.$