Noise control

- Sound components
  - reflected (reverberated) $\rho$
  - absorbed $\alpha$
  - transmitted $\tau$

- Transmission loss TL
  $TL = 10 \log(1/\tau) = -10 \log \tau$
Mass law (Berger’s law)

- theory: doubling of surface density $\rho_S$ [kg/m$^2$] $\rightarrow$ - 6 dB
  i.e. $TL \propto 20 \log \rho_S$
- practice: - 5 dB
  i.e. $TL \propto 17 \log \rho_S$
Noise control

- Mass law (Berger’s law)
- Frequency law
  - doubling of frequency \( f \) [Hz] \( \rightarrow \) - 6 dB
    
    i.e. \( TL \propto 20 \log f \)

\[
TL \approx 20 \log (0.08 f \rho_s)
\]
Noise control

For low and high frequencies:
- resonance
- coincidence

Images by MIT OCW.
Noise control

Sound paths
1 - direct air transmission
2 - reverberation
3 - lateral transmission of airborne sound
4 - re-emission of impact sound
5 - transmission

Weakest path
Noise control

- Sound paths
- Weakest path

\[
TL = TL_0 - 10 \log \left[ 1 + \frac{S'}{S} \left( \frac{\Delta TL}{10} - 1 \right) \right]
\]
Noise control

Planning phase
- sensitivity to noise
- noise sources
- noise insulation requirements

Design phase
- acoustic criteria in positioning and orientation
- calm vs. noisy zones
- construction elements
- technical installations

→ e.g. cavities in walls, no connection between window layers
Noise control

- Environmental noise
Noise control

- Environmental noise
  - Anti-noise barriers
    - of "infinite" length

![Diagram showing attenuation vs. h/λ](image-url)
Noise control

- Environmental noise
  - Anti-noise barriers
    - of "infinite" length
    - of finite length L

![Graph showing attenuation vs. L/d](image)
Noise control

- Environmental noise
  - Anti-noise barriers
  - Acoustic urbanism
Noise control

- Environmental noise
  - Anti-noise barriers
  - Acoustic urbanism

- 66 db
- 69 db
- 72 db
- 74 db
- 78 db
- 50 db
Noise control

- Environmental noise
  - Anti-noise barriers
  - Acoustic urbanism

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**Noise source**
- Noisy factory
- Very loud radio
- Average workshop
- Lorry passing at 5 m
- Noisy restaurant or dance floor
- Average light factory
- Office: typewriters
- Living room, loud radio
- Quiet car passing at 5 m
- Conversation
- Moderate radio
- Average office
- Average home
- Quiet garden
- Subdued radio

**Requisite noise barrier**
- Special discontinuous construction
  - 300 mm concrete rendered
  - 240 mm brick or 150 mm concrete
  - 120 mm brick or 100 mm concrete
  - Double 3 mm glass, 100 mm space
  - 140 mm hollow block
  - 75 mm solid gypsum panel
  - Timber studs, 10 mm plasterboards
  - Timber floor plaster ceiling
  - Single 6 mm plate glass
  - 120 mm lightweight concrete block
  - Single 3 mm glass
  - 13 mm fibreboard
  - Badly fitting door
  - Open door or window

**Activity or situation**
- Threshold of audibility
- Recording studio
- Hospital ward, sleeping
- Studying
- Reading
- Houses
- Flats
- Hotels
- Quiet office
- Quiet restaurant
- Average office

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Image by MIT OCW.
Noise control

- Structure-borne noise
Noise control

- Structure-borne noise
Noise control

- Structure-borne noise
- Structure-borne noise
Noise control

- Structure-borne noise
Structure-borne noise

- Floating floor
- Flexible (soft) layer
Noise control

- Sound source in room

Image by MIT OCW.
Sound source in room

- $I_{abs} = I_{inc} \cdot \alpha_s$
- $P_{abs} = I_{\perp} \cdot A = I_{\perp} \cdot \alpha_s \cdot S$
- $I_{\perp} = \frac{1}{4} I_{stat}$
- $L_{stat} = 10 \log \frac{4P}{Io A}$

Image by MIT OCW.
Noise control

Sound absorbers

- Porous

Image by MIT OCW.
- **Sound absorbers**
  - Porous
  - Membrane

Image by MIT OCW.
Noise control

- Sound absorbers
  - Porous
  - Membrane
  - Cavity resonators

![Graph showing absorption coefficient vs frequency with minima at certain frequencies](Image by MIT OCW.)
Sound absorbers

- Porous
- Membrane
- Cavity resonators
Noise control

- Sound absorbers
  - Porous
  - Membrane
  - Cavity resonators
  - Perforated panels

![Absorption coefficient graph](Image by MIT OCW.)
Absorbent baffles

- Sound partially absorbed
- Sound transmitted fully
- Absorber

- Sound almost completely absorbed
- Sound partially absorbed
- Absorber

Bathroom flat 1
Bathroom flat 2

Ventilation duct

Minimum 1 m

(a) (b)

(c) (d)

Image by MIT OCW.
Noise Control

- Reading assignment from Textbook:
  - “Introduction to Architectural Science” by Szokolay: § 3.3

- Additional readings relevant to lecture topics:
  - "How Buildings Work" by Allen: p. 132 in Chap 14