# Urban Acoustics

Week 4 Tutorial
Conceptual questions

prof.dr.ir. Maarten Hornikx
dr. Matthias Cosnefroy

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

# Conceptual questions

1. Scattering due to atmospheric turbulence leads to decorrelation of sound waves.

Answer

- Right. Turbulent scattering induces unsteady fluctuations in the amplitude and phase of the wave which reduces the auto-correlation of the wave in case of a single wave (and cross-correlation in case of the direct and reflected waves).

# Conceptual questions

2. The acoustic absorption coefficient α of a ground surface can be computed using the surface impedance $Z_n$.

Answer

- Right. The acoustic absorption coefficient can be calculated from the surface impedance with

$$\alpha(f,\theta) = 1 - \left|R(f,\theta)\right|^2$$

with the reflection factor

$$R(f,\theta) = \frac{Z_n(f)\cos(\theta) - \cos(\theta')}{Z_n(f)\cos(\theta) + \cos(\theta')}$$

# Conceptual questions

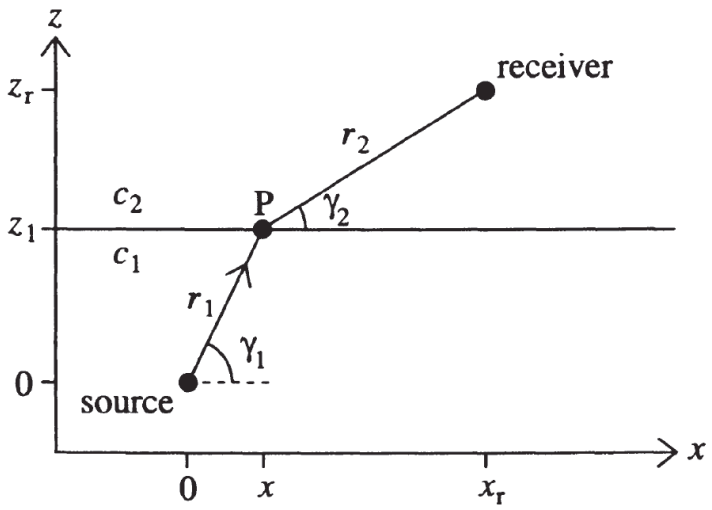
3. Sound waves are bent towards regions with lower sound speeds (assuming no influence of the wind on sound propagation).

Answer:

• Right. From Snell's law of refractive index (given below), sound waves are bent towards regions with lower sound speeds (here, $c_2 > c_1$).

$$\frac{\cos \gamma_1}{c_1} = \frac{\cos \gamma_2}{c_2}$$

$\gamma$ = Angle of elevation
$c$ = Speed of sound



# Conceptual questions

4. Diffraction at the edge of a barrier leads to acoustic energy in the area behind the barrier, where the sound source is not visible.

Answer

- Right. See figure 1.

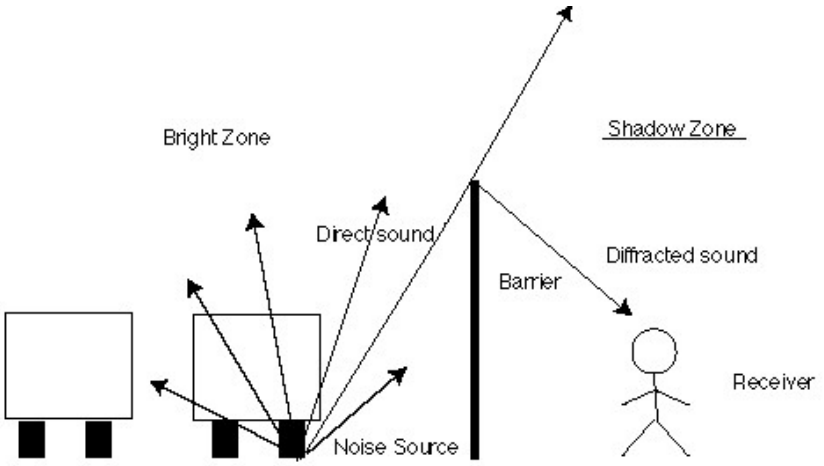



Figure 1: The barrier blocks the direct path from the noise source to the receiver. A shadow zone is created behind the barrier, in which listeners are protected from the noise. However, sound can still reach the receiver by sound diffraction at the top edge of the barrier.

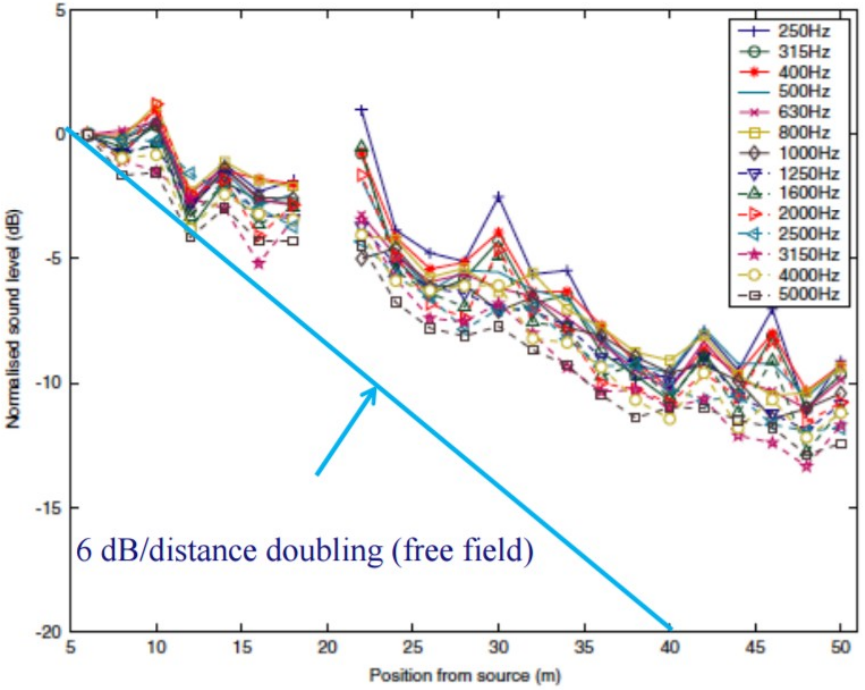
Penelope Menounou, Ilene J. Busch-Vishniac, David T. Blackstock; Jagged-edge Noise Barriers; ICA/ASA '98

# Conceptual questions

5. In narrow urban street canyons, the sound level does not decay with increasing distance from the source.

Answer

- Wrong. There is a decay, although it does not follow the 6dB / distance doubling as in free field. See figure below.



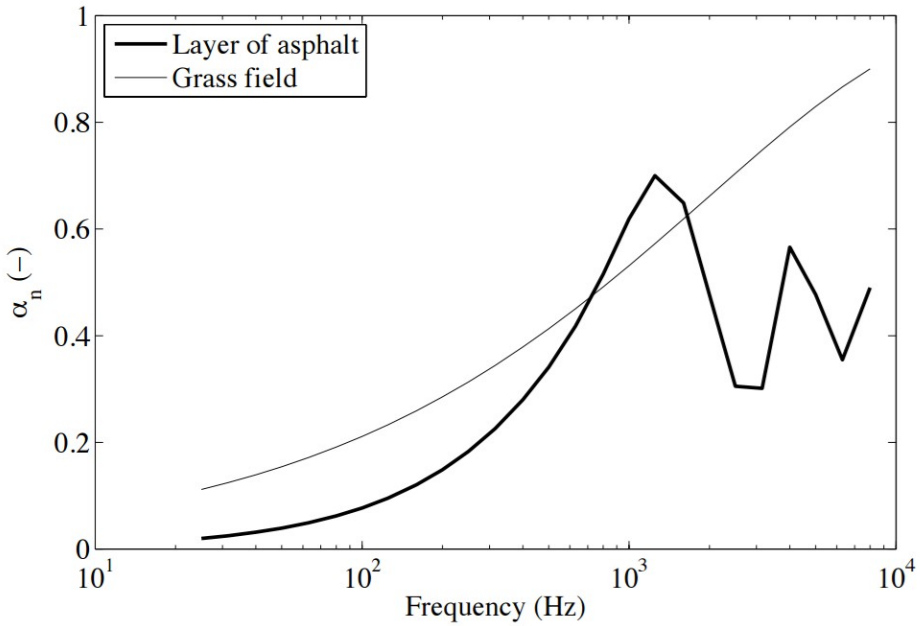

Picaut, J., Le Polles, T., L'Hermite, T., Gary, V. Experimental study of sound propagation in a street. App. Acoust. 66 (2005) 149–173

# Conceptual questions

6. The acoustic absorption coefficient α of porous ground surfaces (like grass) usually decreases with increasing frequency.

Answer

- Wrong. The absorption coefficient of porous ground surfaces increases or oscillates with increasing frequency. See figure below.



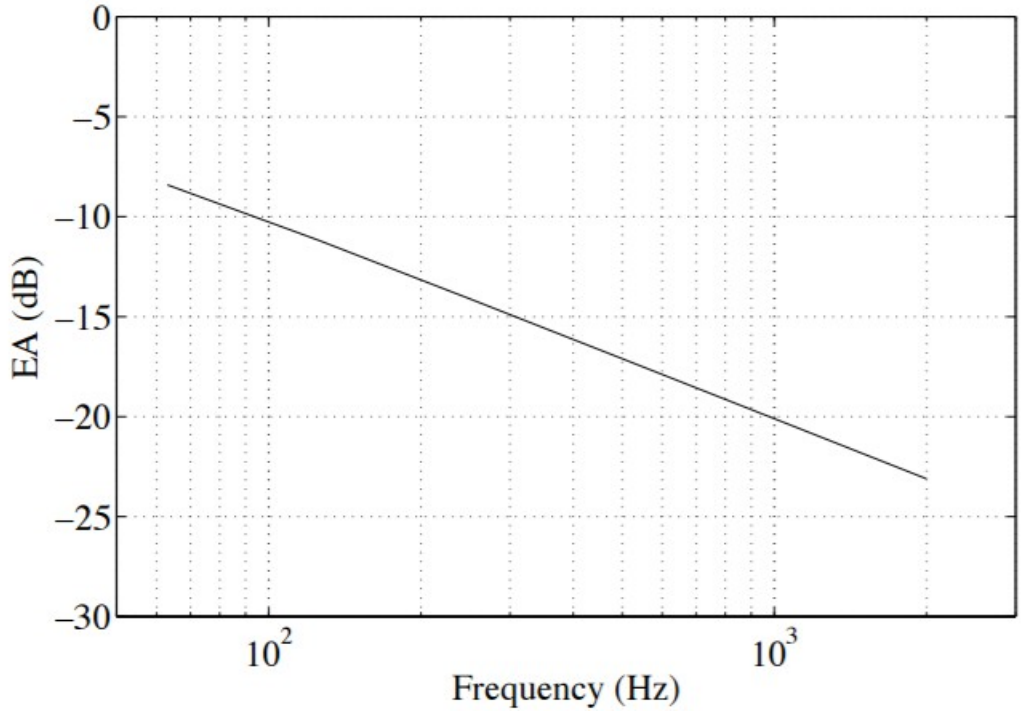

Calculation according to slit-pore model, Attenborough et al., J. Acoust. Soc. Am., **129**, 2806–2819

# Conceptual questions

7. Screening of sound by barriers reduces sound levels for all audible frequencies.

Answer

- Right. But the amount of attenuation depends on the frequency.



# Conceptual questions

8. The amount of air absorption in dB/m does depend on the wind velocity.

Answer

- Wrong. Air absorption depends on the frequency, temperature, humidity, and air pressure.

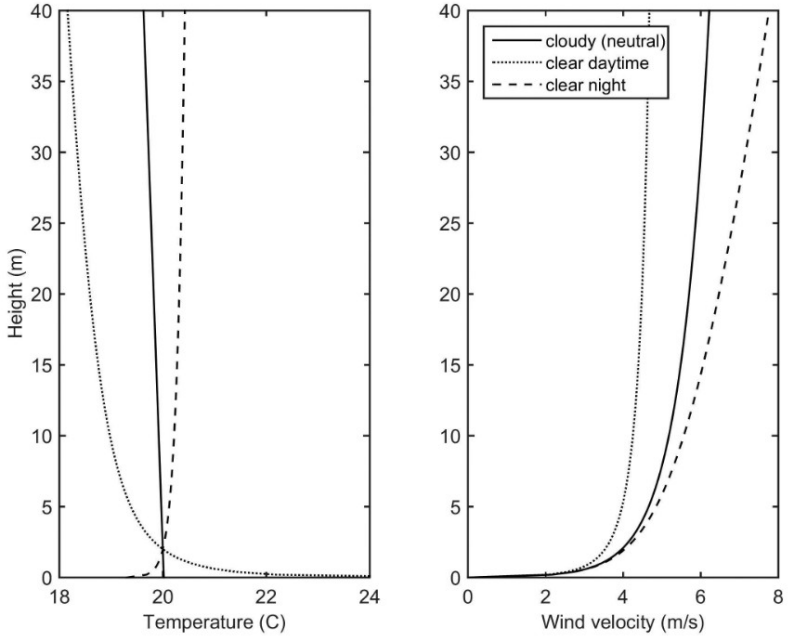
# Conceptual questions

9. The temperature in the atmospheric surface layer usually increases with height.

Answer

- Wrong. The temperature in the atmospheric surface layer increases with height at night, but not in clear daytime or neutral conditions. See figure.

Acoustics in Moving Inhomogeneous Media; Vladimir E.Ostashev, Keith D.Wilson; 2016



# Conceptual questions

10. Sound waves are refracted by high wind velocities.

Answer

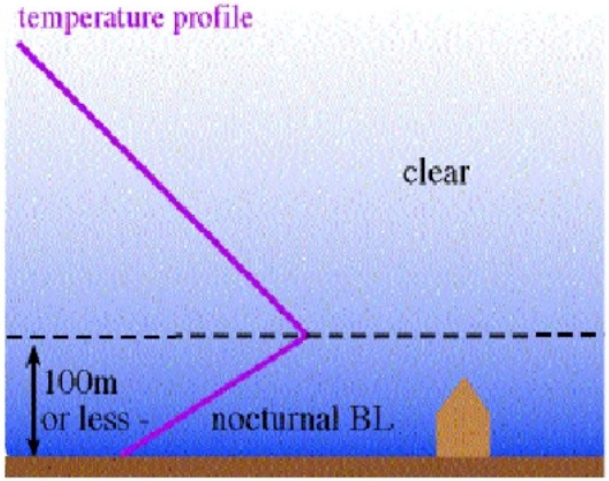
Wrong. Sound waves are refracted by varying wind velocities.

# Conceptual questions

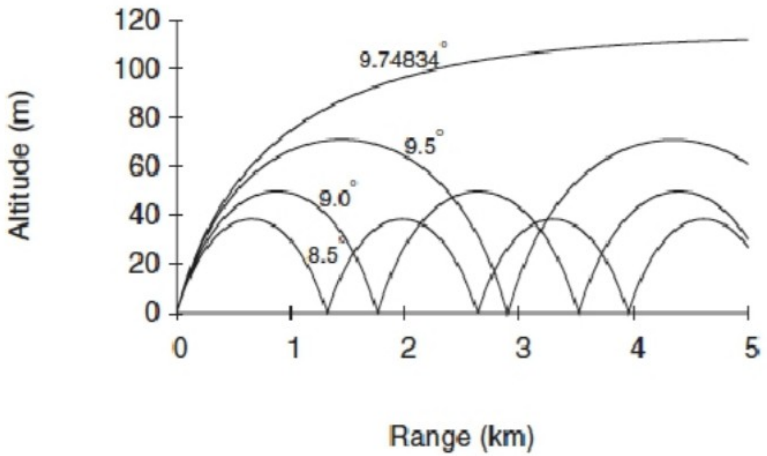
11. In the nocturnal boundary layer, sound waves are bent upwards

Answer

Wrong. The sound waves are bent downwards due to the temperature inversion at night (the temperature increases with height).




http://apollo.lsc.vsc.edu/classes/met130/notes/chapter9/bl_evol_6am.html




Waxler et al. J. Acoust. Soc. Am., 124(5), 2008.

# Conceptual questions

12. Scattering due to atmospheric turbulence increases the air absorption of sound waves.

Answer

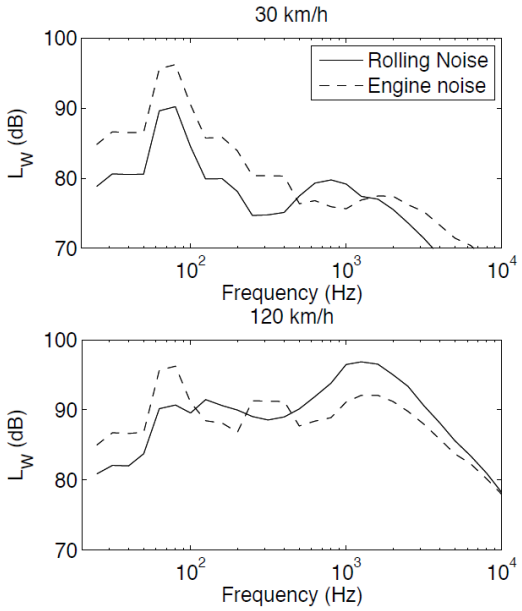
- Wrong. Turbulence effects have nothing to do with air absorption.

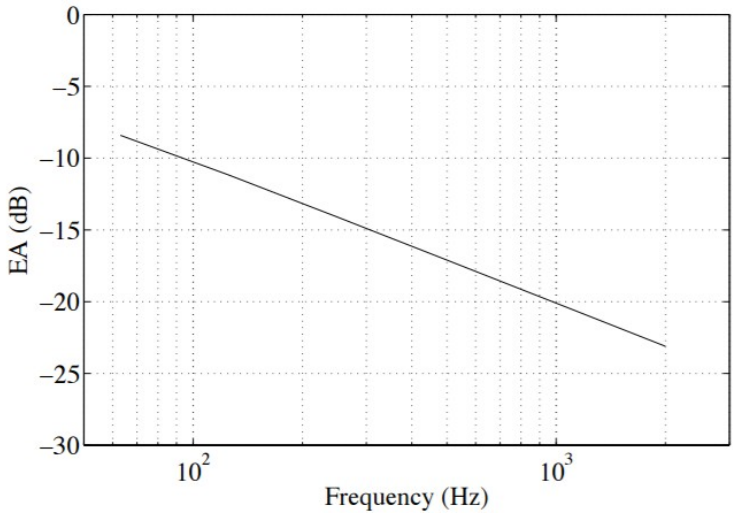
# Conceptual questions

13. Screening of sound by barriers is most efficient to reduce noise from road traffic vehicles at a low speed.

Answer

- Wrong. Higher speeds produce higher noise levels at higher frequencies (see figure). Attenuating capacity of barriers are better at higher frequencies.



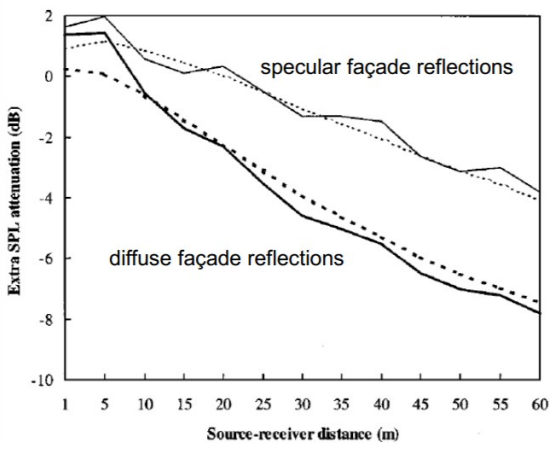



# Conceptual questions

14. In narrow urban street canyons, sound reduction over increasing source-receiver distance is larger when sound reflection from façades is specular (i.e., mirror-like) instead of diffuse.

Answer

Wrong. Sound reduction is larger with diffuse reflections: more energy escapes the canyon since the waves are reflected in all directions.

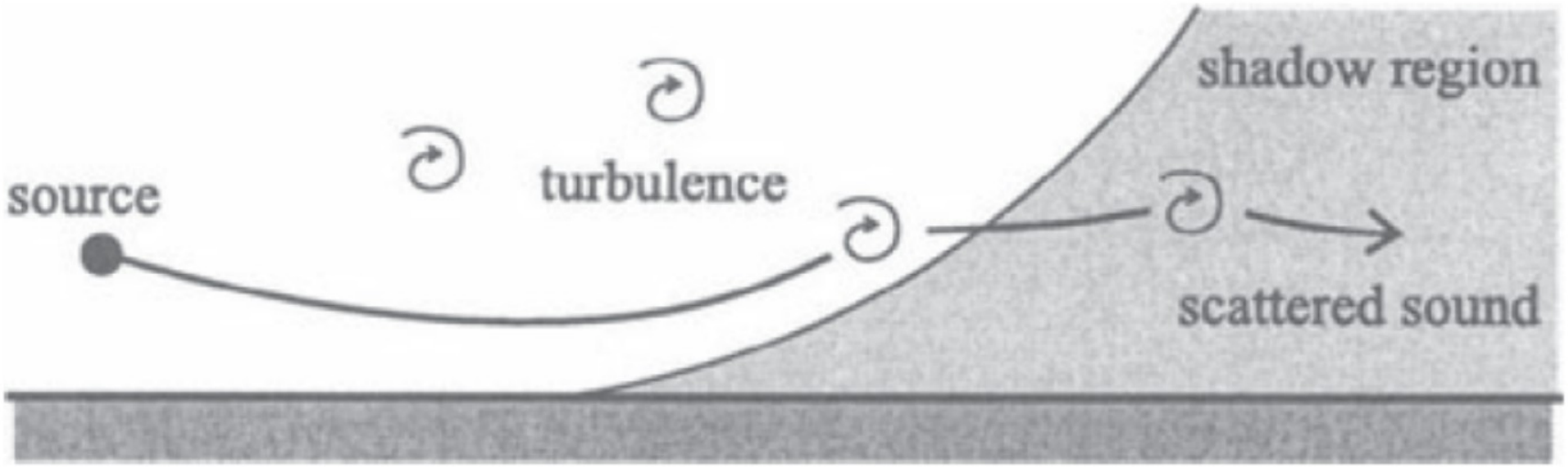


# Conceptual questions

15. Scattering due to atmospheric turbulence leads to higher sound levels in acoustic shadow zones.

Answer

- Right. In an upward refracting atmosphere, turbulent scattering makes the sound waves penetrate into the shadow region.

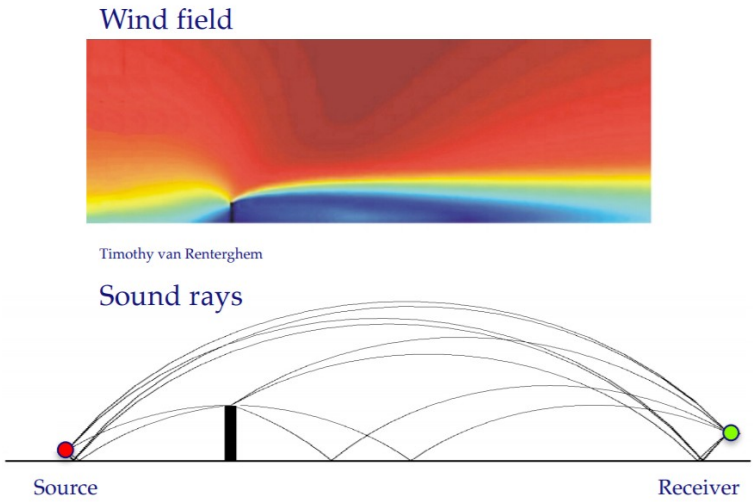


# Conceptual questions

16. If the wind blows from a source towards a receiver (downwind configuration), with a noise barrier in between, the performance of the barrier is worse than in the absence of wind.

Answer

- Right. Because of downward refraction, acoustic waves travel above the barrier and are refracted towards the receiver.

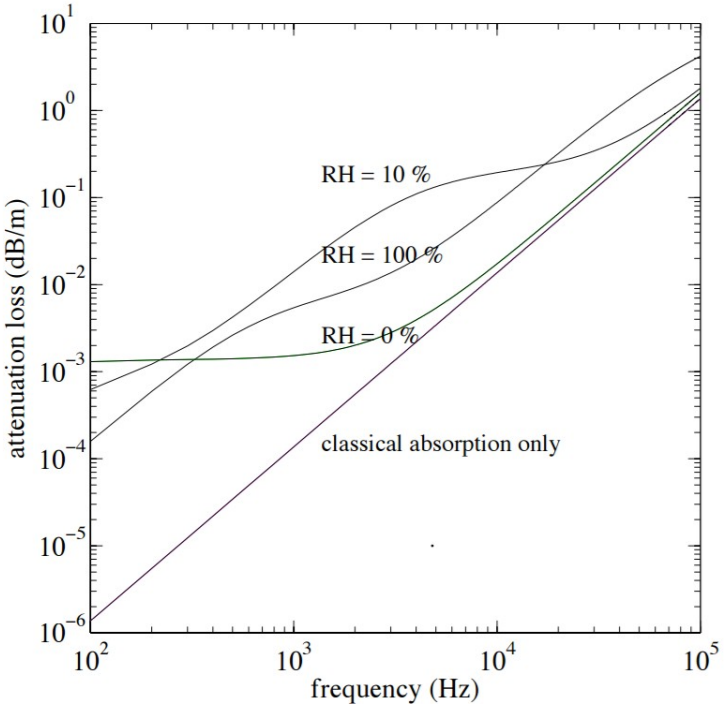


# Conceptual questions

17. The attenuation loss due to the molecular absorption in air is linearly proportional to the sound frequency.

Answer

- Wrong. The attenuation loss is non-linearly proportional to the frequency.



# Conceptual questions

18. Atmospheric turbulence leads to sound pressure levels behind noise barriers that are lower than in the absence of atmospheric turbulence.

Answer

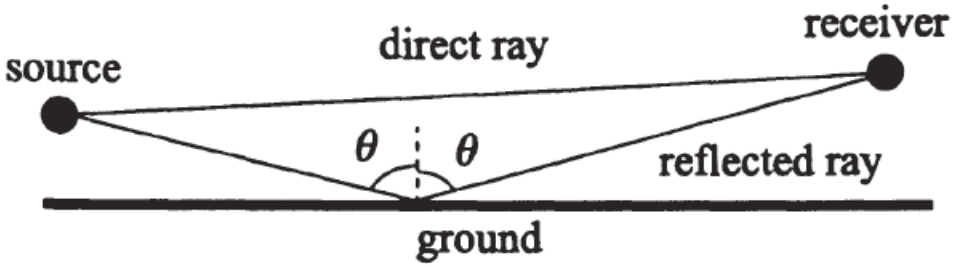
- Wrong. Similar to the refractive shadow region, turbulence scatters noise behind the barriers, thus increasing the sound levels.

# Conceptual questions

19. The sound field due to a direct sound wave (from the source) and its reflection on the ground can lead to a sound level smaller than the level of the direct wave alone.

Answer

- Right. Destructive interference between the direct and the reflected waves can occur depending on the frequency and on the position of the receiver.



# Conceptual questions

20. The refraction of acoustic waves by the wind does not depend on the frequency.

Answer

Right. The refraction of acoustic waves does not depend on the frequency because the sound speed does not depend on the frequency (i.e., air is not a dispersive medium).

However, a frequency dependence can be observed compared to a no-wind case due to a modification of the interference between the direct and ground-reflected waves.

# Conceptual questions

21. The amount of air absorption (in dB/m) depends on the molecular composition of air.

Answer

- Right. In addition to the viscous and thermal effects (i.e., the “classical absorption”), the air absorption also depends on the relaxation and compression of the molecules in air (e.g., nitrogen and oxygen).