Environmental Acoustics

Answers to Exercises

Question 1

The normalized ground impedance Z can be written as $Z = Z'/Z_0$, with the specific impedance of the ground material and $Z_0 = \rho c$ the specific impedance of air.

a) Compute the plane wave reflection coefficient R_p, when Z =1 and $\theta = 0$ and $\theta = \frac{\pi}{2}$? Are these results as expected?

R_p ($\theta = 0$) = 0, R_p ($\theta = \frac{\pi}{2}$) = -1. If Z =1, the second medium has the same specific impedance as air, and we would expect R_p = 0 for all angles. The formula to compute R_p clearly is approximative (as it assumes a locally reacting ground surface).

b) Assume now $Z = 10 + j10$ and compute R_p for $\theta = \frac{\pi}{4}$. What does it mean that R_p is complex?

R_p = 0.8598 + 0.1228i. The phase of R_p is equal to atan(Im(Rp)/Re(Rp)) = 0.14. It means that the reflected ray has a phase lag of this value.

Question 2

A source and receiver are both located at a height of 1 m above a rigid ground surface, and are separated by 100 m. Compute the frequencies corresponding to the first 3 destructive interferences.

This can be computed by setting $k(R_1\text{-}R_2) = (1+2n)\pi$, with n = 0,1,2. This implies
$f_n = c(1/2+n)/(R_1\text{-}R_2)$ = *8.5 kHz, 25.5 kHz, 42.5 kHz.*

Question 3

a) Using a ray approach, what is the maximum height that a sound ray receiving at the receiver has reached in a downward refracting atmosphere wind logarithmic wind speed profile with b = 2, source-receiver distance = 200 m, c_0 = 340 m/s?

Eq. (4.9) from the CAA course material $h = r\sqrt{\frac{b}{2\pi c_0}}$=6.1 m

b) When the source and receiver are both located at a height of 1 m, what is approximately the level increase ΔL due to the meteorological conditions? What did you assume for the impedance of the ground surface?

Eq. (4.10) from the CAA course material $\Delta L = 10log_{10}N_{rays} = 10log_{10}\left(\frac{4h_1}{z_{sr}}\right) = 13.9$ dB

Question 4

Can you explain why the Fresnel number at p.738 of the course book depends on λ?

The Fresnel number is related to the detour of the sound path via the screen top relative to the direct sound path in the absence of the screen. When expressing a detour in the number of wavelengths, it means that a lower number will be found for lower frequencies.

Question 5
Compute the transmission loss TL of concrete wall with thickness d = 0.2 m and density ρ = 2500 kg/m^3 for the frequencies 100 and 200 Hz. What can we do to improve the sound insulation?

$TL = 10log_{10}\left(1 + \frac{\pi M f}{400}\right) - 5$= *21.0 dB (100 Hz)*

24.0 dB (200 Hz)

We can increase the mass or place another wall in front of this wall.