Architectural Acoustics

Exercises week 3: answers

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Figure 1. An 'omni-directional' sound source (www.bksv.com).

Question 1

At a distance of 10 m from the source, above what frequency is equation (1) valid?

We compute the frequency for which *kr = 1*. This implies that the frequency should be above $f = \frac{c}{2\pi r} = \frac{340}{2\pi * 10} = 5.4$ Hz.

Question 2

Compute the level difference ΔL between the sound pressure level at *r* = 100 m and at *r* = 200 m due to the sound source.

We compute the level difference from $\Delta L = 20log_{10}\left(\frac{\tilde{p}(r=100m)}{\tilde{p}(r=200m)}\right)$ (equation 3.35 in the book). Now, the root-mean-square value can be written as $\tilde{p} = \frac{\hat{p}}{\sqrt{2}}$ (p.10 of the book). We then find $\Delta L = 6$ dB.

Question 3

Compute the level difference ΔL between the sound pressure level at r = 100 m and at r = 200 m including air attenuation at 1000 Hz.

We first write $\hat{p}(r, \omega, m)$=$\frac{A(\omega)}{r} e^{-\frac{m}{2}r}$. Using the same equations as in Question 2 to compute ΔL, we find $\Delta L = 6.4$ dB.

Question 4
Compute the radiated power P_r in W of this sound source for *f* = 10 Hz and *f* = 1000 Hz. Can you explain the differences between the computed results?

We find $Re(Z_r)$ from equation (5.28) in the book: $e(Z_r) = 4\pi a^2 Z_0 \frac{(ka)^2}{1+(ka)^2}$. We then find: P_r=0.12 W for *f* = 100 Hz and P_r=0.96 W for *f* = 1000 Hz. For *f* = 100 Hz, *ka* = 0.37, and the radiated output power is low. The source is not an efficient radiator for this frequency as it has difficulties to compress the air for these frequencies.

Question 5
Compute the sound pressure level *L* at 100 m from this source in dB for 100 Hz and 1000 Hz.

From equation (4) and the results of Question 4, we can now compute $\tilde{p}$ at 100 m from the source. Then, using equation (3.34) in the book, we find L_p = 60.0 dB for 100 Hz and L_p = 68.9 dB for 1000 Hz.