Architectural Acoustics

Exercises week 1 and 2

12-02-2020

Question 1

Consider a one-dimensional harmonic pressure signal at *t = 0 s* and *x = 0 m* as described by

*p = 0.1+j*0.2*

a) What is the amplitude of this pressure signal?

b) What is the phase angle φ of this pressure signal?

Question 2

Assume a washing machine exerts a harmonic force on a concrete floor, which causes noise in the room below. The force can be described by $F(t) = 5e^{j628{,}31t}$

a) What is the frequency of this harmonic force?

We describe the impedance of the floor for the frequency of the machine by
$Z(\omega) = 1.10^4\ e^{j\omega/800}$.

b) Compute the velocity of the floor due to the harmonic force of the washing machine.

c) Are the force and the velocity oscillating in the same phase for this frequency?

d) What is the power P_a injected into the floor by the washing machine for this frequency?

By putting the washing machine on springs, we could reduce the vibrational power input in the floor. Assume the washing machine has a mass of m = 50 kg and the spring has a compliance of n =2.10^{-7} s^2/kg. When we assume that the mass of the floor is much higher than that of the washing machine, the impedance of this mass-spring system can be described by

$$Z(\omega) = j\omega m + \frac{1}{j\omega n}$$

e) At what frequency is the system in resonance?

Question 3
An acoustic pulse is excited by a hand clap. In a simplified form, we describe the pressure function due to this hand clap by:

$$p(t) = \begin{cases} 1 & t = 0 \\ 0 & all\ other\ t \end{cases}$$

The spectrum of this signal can be obtained by applying a Fourier transform for a non-periodic signal to *p(t)*. If we denote the spectrum of this signal by *P(ω)*, show that *P(ω)* does not depend on ω.

Question 4
At some distance in free field, i.e. a space without any acoustic reflections, the spectrum of a male voice is described by the following effective pressure function

$$\tilde{p}(\omega) = 0.05e^{-10^{-8}(\omega-\omega_0)^2},$$

with $\omega_0 = 2\pi f = 2\pi 500$ rad, i.e. this pressure function has a maximum value at 500 Hz.

a) Compute the sound pressure level *L* of this voice at 1000 Hz.

The same voice is now recorded in a room. The transfer function of the room is
$G(\omega) = 3e^{-10^{-4}\omega}$

b) What is the sound pressure level L of the voice in this room at 1000 Hz.

Question 5
What type of sound wave(s) do we have when sound propagates in air?

Question 6
Assume a sound wave in air is described by

$$p(x,t) = \hat{p}e^{-j(\omega t - kx)}$$

a) For *f = 100* Hz, *c = 340* m/s, $\hat{p}$=1 Pa, compute *p(t=1,x=1)*.

b) From the 1D linear acoustic equations (Eqs. (3.15) and (3.16) in the book), compute the velocity $v_x(x,t)$, assuming that $v_x(x,t)$ has the same time dependence as *p(x,t).*