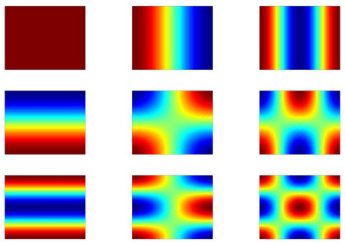
MF207
Acoustics in fluid media

Benjamin Cotté & Olivier Doaré

Nb of ECTS : 3



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Course description

Acoustics, or the science of sound, is a multi-disciplinary domain at the interface between Mechanics, Life and Earth Science, Material Science, Signal Processing and Cognitive Sciences. Application domains are numerous, from transportation systems (ground, air and maritime transportation), to environment (impact of noise on humans and animals), buildings, imaging (in geosciences and biology), or entertainment (home or professional audio, virtual reality, room acoustics).

The main course objective is to provide theoretical and practical knowledge needed to calculate acoustic fields in fluid media and to process acoustic signals. The presentation starts with the description of propagation in free space and is then extended to the description of acoustical phenomena in waveguides, rooms and cavities. Sound-structure interactions, electroacoustics and basic signal processing methods are also tackled during the course, with practical computer sessions. Finally, an introduction to sound perception by the human ear is given.

All along the course, these notions are illustrated by sound examples, visual documents and simple demonstrations from different acoustical domains: transportation noise, underwater acoustics, characterization of acoustic materials, industrial noise, musical acoustics, room acoustics, electroacoustics.

Course evaluation

The evaluation of the course will be done through one written exam (50%) and two homework projects (50%).

Course content

The course consists in 9 classes of 3h each

1. **Basics of linear acoustics and physiology of hearing**
   Introduction and fields of applications, assumptions and equations of linear acoustics, plane waves, intensity and acoustic power, sound level (decibel), physiology of hearing

Exercises: Reflection and transmission of plane waves at an interface, propagation through a rigid wall (mass law), hearing tests

2. **Acoustic waveguides** Pipes of rectangular or cylindrical cross-section , impedance concepts, discontinuities and derivations, lumped elements models and Helmholtz resonators
   Exercises: measurement of the reflection coefficient of a material using a standing wave tube, flute acoustics

3. **Solutions of the wave equation in free field**
   Solutions of the free field wave equation, spherical waves, notion of monopole and Green's function, levels in octave bands, equivalent sound pressure levels, musical intervals
   Exercises: Calculation of road noise level, radiation from a monopole, acoustics of a bell

4. **Extended sources / notions of vibroacoustics**
   Basic concepts of fluid-structure interactions on the pulsating sphere, Kirchhoff-Helmoltz integral equation, Rayleigh integral
   Exercises: Radiation of the plane piston / notions of near field and far field

5. **Room / cavity acoustics**
   Sound phenomena in a cavity or a room, impulse response and reverberation time, wave approach (room modes), statistical approach (Sabine law)
   Exercises: Calculation of decay curves and reverberation time for different room impulse responses, room response by convolution, engine noise in an industrial premises (DM with article reading)

6. **Introduction to acoustic instrumentation and electroacoustics. Application to room acoustics**
   Microphones, loudspeakers characteristics and their modelling
   Experimental session in class: acoustic measurements in a classroom, modal analysis, calculation of impulse responses, room response by convolution.
   Matlab/Octave project started in practical session and to finalize at home.

7. **Exam**

Benjamin Cotté (BC) is Assistant Professor at IMSIA / ENSTA Paris

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