

# Numerical methods for acoustics

34 hours: (9 lectures – 8 tutorials)

This course aims at providing the necessary knowledge to perform state-of-the-art numerical simulations in the various fields of acoustics. The main numerical methods employed in computational codes in the industry or in laboratories are presented. Several tutorials will allow to students to apply these various numerical methods on application cases. No preliminary knowledge in acoustics is required.

## SUMMARY:

- Finite differences
- Finite elements
- Boundary elements
- Rays
- Paraxial equations

Softwares: MATLAB, COMSOL

## DETAILED SUMMARY:

1. Introduction (session 1: 2 h) (lecturer: Didier Dagna)
  - brief review of acoustics, equations governing sound propagation, presentation of some recent and remarkable numerical simulations.
2. Finite difference methods (sessions 2 and 3: 2 \* 4 h) (lecturer: Vincent Clair)
  - 1st session (basics of FD methods): standard finite-difference schemes, time integration, order of accuracy, CFL number, numerical stability. Tutorial: 1-D wavepacket propagation.
  - 2nd session (advanced course): dispersion and dissipation errors. Tutorial: 1-D wavepacket propagation revisited
3. Boundary conditions (session 4: 4 h) (lecturer: Vincent Clair)
  - non-reflecting boundary conditions: sponge layers, PML. Tutorial: aeroacoustics.
4. Ray-tracing methods (session 5: 4 h) (lecturer: Didier Dagna)
  - formulation, ray tracing. Tutorial: infrasound propagation in the atmosphere
5. Paraxial equations (session 6: 4 h) (lecturer: Frédéric Sturm)
  - principle, application of numerical methods. Tutorial on underwater acoustics
6. Finite element methods (sessions 7 and 8: 2 \* 4 h) (lecturer: Sébastien Besset)
  - 1st session: weak formulation, discretization, elementary matrix and assembly.
  - 2nd session: multiphysics simulation. Tutorial using the commercial software COMSOL.
7. Integral formulation/Boundary element method (session 9: 4 h) (lecturer: Sébastien Besset)

## READING LIST:

Attala N., Sgard F., Finite Element and Boundary Methods in Structural Acoustics and Vibration, CRC Press, 2015.

Tam C. K. W., Computational Aeroacoustics: A Wave Number Approach, Cambridge University Press, 2012.

## SCHEDULE:

Session 1 (2 h): Introduction,	23 January 2020, 14 h – 16 h, I11, ECL
Session 2 (4 h): Finite difference 1,	24 January 2020, 14 h – 18 h, I11, ECL
Session 3 (4 h): Finite difference 2,	30 January 2020, 14 h – 18 h, I11, ECL
Session 4 (4 h): Boundary conditions,	31 January 2020, 14 h – 18 h, I11, ECL
Session 5 (4 h): Ray-tracing methods,	07 February 2020, 14 h – 18 h, I11, ECL
Session 6 (4 h): Paraxial equations,	13 February 2020, 14 h – 18 h, Micro4, H10, ECL
Session 7 (4 h): Finite element methods 1,	14 February 2020, 14 h – 18 h, Micro4, H10, ECL
Session 8 (4 h): Finite element methods 2,	21 February 2020, 14 h – 18 h, Micro4, H10, ECL
Session 9 (4 h): Boundary element method,	28 February 2020, 14 h – 18 h, Micro4, H10, ECL