

# Numerical methods for acoustics

42 hours: (11 lectures – 10 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 the students to apply these various numerical methods on application cases.

## 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.
  - 2nd session (advanced course): dispersion and dissipation errors. Tutorial: 1-D wavepacket propagation
3. Finite element methods (sessions 4 and 5 : 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.
4. Boundary conditions (session 6: 4 h) (lecturer: Vincent Clair)
  - non-reflecting boundary conditions: sponge layers, PML. Tutorial on aeroacoustics.
5. Integral formulation/Boundary element method (session 7: 4 h) (lecturer: Sébastien Besset)
6. Paraxial equations (session 8) (lecturer: Frédéric Sturm)
  - principle, application of numerical methods. Tutorial on underwater acoustics
7. Ray-tracing methods (session 9) (lecturer: Didier Dagna)
  - formulation, ray tracing. Tutorial: infrasound propagation in the atmosphere
8. Nonlinear acoustics (session 10) (lecturer: Didier Dagna)
  - lecture and tutorial on nonlinear propagation

9. Acoustic analogies (session 11) (lecturer: Vincent Clair)  
- application to aeroacoustics

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,	16 November 2017, 13 h 30 – 15 h 30, INSA
Session 2 (4 h): Finite difference 1,	23 November 2017, 13 h 30 – 17 h 30, INSA
Session 3 (4 h): Finite difference 2,	07 December 2017, 13 h 30 – 17 h 30, INSA
Session 4 (4 h): Finite element methods 1,	14 December 2017, 13 h 30 – 17 h 30, INSA
Session 5 (4 h): Finite element methods 2,	20 December 2017, 13 h 30 – 17 h 30, ECL
Session 6 (4 h): Boundary conditions,	18 January 2018, 13 h 30 – 17 h 30, INSA
Session 7 (4 h): Boundary element method,	01 February 2018, 13 h 30 – 17 h 30, INSA
Session 8 (4 h): Paraxial equations,	08 February 2018, 13 h 30 – 17 h 30, INSA
Session 9 (4 h): Ray-tracing,	15 February 2018, 13 h 30 – 17 h 30, INSA
Session 10 (4 h): Nonlinear acoustics,	08 March 2018, 13 h 30 – 17 h 30, INSA
Session 11 (4 h): Acoustic analogies,	15 March 2018, 13 h 30 – 17 h 30, INSA