

## Numerical Acoustics

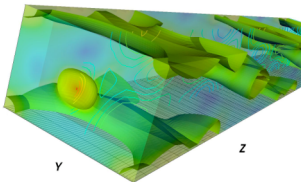
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The equations describing sound propagation are well developed but often difficult to solve in practical applications. This might be due to complex geometries, and changing sound speeds and fluid parameters over the domain of interest. Solving the equations numerically allows us to overcome such difficulties, and allows us to run numerical experiments at relatively low cost. This could be for predicting the sound propagation in a narrow fjord, the design of a concert hall, or optimizing the shape of a horn loudspeaker. One has therefore developed Finite Elements, Boundary Elements, Finite Differences and Ray Tracing techniques especially suited for acoustic calculations.

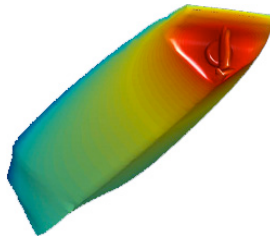
As computers develop we can attack larger problems with more exact techniques, but as the "general technique for solving all acoustic problems" is still far into the future, the numerical acoustician finds himself in the thrilling world of joining numerical models, experimental results and analytical techniques.

### Applications of Numerical Acoustics

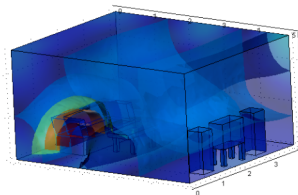
- Sound propagation in water and in the atmosphere.
- Design of concert halls
- Sound radiation from vibrating structures
- Interaction of sound and flowing fluids



Sound propagation in duct



Propeller radiation



Eigenmodes in a room



Olavshallen

### COURSES

#### Technical Acoustics - TTT4180

The course covers vibrations of mechanical systems as well as the generation, propagation and behavior of acoustic waves in different environments. Reflection and transmission of sound between different media, sound in waveguides and cavities, environmental acoustics, and architectural acoustics are important topics. Examples will be taken from common technical systems as well as musical instruments. The methods of analysis are mostly analytical, but an introduction will be given to numerical methods in acoustics.

#### Acoustics, Specialization - TTT4700

Includes a project as well as two smaller course modules. Elective modules include 3D sound, Music and perception, Effects of sound, Numerical acoustics, Building acoustics and others.

#### Theoretical Acoustics - TT8307

The subject contains acoustic waves in gas and fluid media - wave equations, reflection and transmission between two fluid media, from multi-layers and thin elastic plate. Furthermore the course deals with room acoustics, reverberation and statistic aspects and vibration from source and vibrating bodies; effects of viscosity and other dissipations; scattering and diffraction; ray acoustics and nonlinear effects in acoustic wave propagations.

#### Numerical Methods in Acoustics - TT8303

Numerical methods like the finite difference method, finite element method, and the integral equation technique for solution of relevant wave equations will be covered. It will also be given an introduction to geometrical methods and methods based on cellular automats. The most important applications are acoustic propagation in air and water and the interaction of sound and vibrating structures.

#### Marine Acoustics - TTT4175

The course covers reflection and transmission at interfaces, wave propagation methods such as ray tracing techniques and normal mode theory. The theories for echo formation of simple targets and reverberation from volume and surfaces are discussed and empirical values are presented and discussed. The course is problem-oriented with focus on applications for detection and localization of objects. In this his context the role and design considerations for the major system elements are discussed such as transmitter, receiver, antenna and transducer technology and signal processing algorithms.

#### Nordic courses on acoustics

The acoustics program cooperate with the International MSc programs on Sound and Vibration at Chalmers, Gothenburg and KTH, Stockholm. You can find a wide range of acoustics courses either for remote studies or by spending a semester abroad.

### RESEARCH PROGRAM

#### Sound Propagation in Littoral waters.

Sound propagation in fjords and straits is different from sound propagation in open waters. The effect of side walls to the propagating channel makes the sound more reverberant. A research program in cooperation with the Norwegian Defence Research Establishment has as aim to develop propagation models for such environments, as well as studying the sound radiation from ships operating in these. Both Ray Tracing, Finite Elements, and Boundary Elements are used.

#### The Discrete Huygens Method

Sound propagation is calculated using a simple technique of pulses moving along a regular network of transmission lines. Simple rules for reflection and transmission at the network joints on a microscopic scale, allows correct wave propagation phenomena to be observed on the macroscopic. The technique is stable and has promising applications in studies of sound propagation above ground, and in surroundings with strong scattering objects.

#### Interaction of Sound and Vibration

There is a strong coupling between vibrating systems and the sound they produce. In cooperation with the French Laboratoire de Mécanique et d'Acoustique, we look at methods to calculate such interaction numerically as well as analytically. Examples are sound transmission into rooms from flexible walls and noise in the transport industry, where the driving mechanism might be turbulent boundary layers on the surface of cars and trains.