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# Applied acoustics

## Finalità

This course is aimed to develop a basic operational knowledge about all the topics being part of the Applied Acoustics field. The contents are tailored to the requirement of the Italian law n. 447/1995.

## Programma

Physical Acoustics: definition of the quantities, propagation of mechanical perturbations in an elastic medium: sound pressure, particle velocity, sound wave speed. Acoustical wave equation.

Energetic Acoustics: sound propagation view as energy transport. Definition of Acoustic Intensity, and Sound Energy Density. Active and reactive energy, traveling and stationary sound fields. The sound energy speed, the reactivity index.

Sound propagation: <plane waves, spherical waves, stationary waves. Reflection and absorption. Specular and diffuse reflection. Definition of the sound absorption coefficient, and of the sound scattering coefficient. Measurement of these coefficients.

Outdoor acoustics: ground absorption, effects of temperature gradient and wind, shielding due to obstacles. The Maekawa and Kurze-Anderson formulas for estimating the sound reduction obtained by a noise barrier.

Indoor acoustics: multiple reflections, stationary reverberant field. Equation of the reverberant and of the semi-reverberant field. Transient phenomena occurring when switching on or off the sound source: the sound tail, the impulse response of a room, Schroeder's backward integration. Definition of the reverberation time and of the other acoustical parameters related to time transients. Sabine's Eyring's and millington's formulas for estimating the reverberation time. Apparent acoustic absorption coefficient, and measurement of it inside a reverberant room.

Sound propagation through building's structures: sound insulation of walls, windows, sound impact insulation of floors. Measurement technique and Italian legislation.

Electroacoustics: transduction between electrical and acoustical signals, microphones, loudspeakers. Analog and digital processing of the acoustical signal: amplifiers, equalizers, reverb units, compressors, etc. . Applications to consumer electronics, telecommunication systems, broadcasting systems, recording and media industries, automotive industry, aeronautics and naval applications.

Numerical simulation of the sound propagation: models based on finite elements, boundary elements, ray tracing, beam tracing. Practical usage of simulation software. Auralization, virtual acoustics reality. Modern applications to entertainment industry and musical performances, future developments about real-time, "live" usage.

Instrumentation and equipment for acoustical measurements: sound level meter, spectrum analyzer, impulse response measurement system. Virtual instruments implemented on PC, software for acoustical measurements, with practical training in the lab.

Numerical acoustic signal processing: from general theory to practical applications running on the PC. The "plugins" employed for numerical acoustics effects, development of code for practical implementation of real-time processing algorithms exploiting the techniques already learned in previous courses: FIR and IIR filters, fast convolution by FFT processing, computation of numerical inverse filters, active sound cancellation, with practical training in the lab.

Acoustical imaging and applications for underwater sonar, medical imaging, acoustical tomography and holography.

## Attività d'esercitazione

Approximately 8 to 12 hours will be spent in the CEDI lab, where the students will make experiments employing personal computers equipped with real-time sound analysis software, and will develop their own "plugin" capable of real-time sound processing in VST format.

## Modalità d'esame

Oral examination, but students who took part to the lab training will present their own "plugin", which will be evaluated up to 10 points in addition to those already obtained during the oral examination. Furthermore, each student will have to present a small dissertation, produced expanding one of the topics presented above, selected by the teacher. Also this dissertation will be evaluated up to 10 points.

## Propedeuticità

No previous knowledge about acoustics and digital signal processing is required for following this course, which starts from a basic level. Further training can be obtained following the specific Master in Acoustics and Environmental Technical Physics.

## Testi consigliati

R. Spagnolo - Manuale di Acustica applicata, 2001, Anno ristampa 2005, pp.928 € 46.00 Editore: UTETLIBRERIA

S. Cingolani, R. Spagnolo - Acustica musicale e architettonica 2004, pp.992 € 45.00 Editore: UTETLIBRERIA