Syllabus Cursus Master's Degree in Engineering, Mechanics.

Sorbonne University CMI5

Acoustic (Acou)

List of Teaching Units

Semester 9

Core Units

- Technoscience, ethic and society
- Fundamentals for acoustic engineering
- Experimental methods and projects in acoustics
- Signal processing and numerical methods for acoustics
- Acoustic applications (choice of modules)

Acoustics Physical and Industrial Acoustics (AcPhy)

- Complements in physical acoustics

Architectural and Urban Acoustics Theme (AcAr)

- Complements in architectural acoustics

Semester 10

- Certification
- Deepening Project
- Graduation internship

Title Teaching Unit - Master Cycle – CMI5			Code	Lecture	Discussion session	Lab	SSA	Hours Attendance	Work Personal	ECTS
CMI 5 S9	Technoscience, ethic and society		MU5EEG03	16	8		24	24	40-60	6 *
	Acoustic (Acou)									
	Fundamentals for acoustic engineering		MU5MEAP1	56				56	70-90	6
	Experimental methods and projects in acoustics		MU5MEAP2			48	20	48	70-90	6
	Signal processing and numerical methods for acoustics		MU5MEAP3	36		28		64	70-90	6
	Acoustic applications (choice of modules)		MU5MEAP5		30	30		60	70-90	6
	Elective courses thematic	**Physical and Industrial (AcPhy)**								
		Complements in physical acoustics	MU5MEAP6	60				60	70-90	6
		Architectural and Urban Acoustics (AcAr)								
		Complements in architectural acoustics	MU5MEAA1	48			20	48	70-90	6
Total Common Core 24 +6* ECTS - Total Thematic 6 ECTS - Total CMI5 S9 Acou = 30 ECTS + 6 *										

Title Teaching Unit - Master Cycle – CMI5		Code	Lecture	Discussion session	Lab	SSA	Hours Attendance	Work Personal	ECTS
CMI5 S10	TOIC /TOEFL certification	MU4LVANT				30		30-40	3*
	Deepening Project	MU5EEG04				40		50-60	3*
	Graduation internship	MU5MES03					800	80-100	30
Total CMI5 - S10 30 ECTS + 6 *									

- Non-contractual units (not included in the calculation of the semester average (listed in the diploma supplement)

Updated 01/03/2020

Semester 9

Updated 01/03/2020

SCIENCES SORBONNE UNIVERSITÉ

Technosciences, Ethic and Society

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5EEG03 - Master's **mention**

Pedagogical presentation.
The objective of this course is to bring students to reflect on the social and ethical dimensions of the engineering profession. It focuses on the complex relations between society and technology, and in particular on the role of technology as a value carrier. Based on these analyses, the course then explores the ethical questions and dilemmas that engineers may encounter in the course of their work. Particular attention is paid to examining classic cases in engineering ethics, such as Three Mile Island and the Quebec Bridge. By the end of this course, students will be able to identify ethical issues raised by professional practices. They will also be reflective on their future profession. The course is taught in English.

Content of the Teaching Unit.

- Introduction
- Technical determinism and social construction. Read: T. Pinch and W. Bijker, The Social Construction of Facts and Artifacts? Presentation : (also) Robert Heilbroner, Do Machines Make History?
- Devices, systems, and their power of action on society. Read: B. Latour, Where are the Missing Masses? The Sociology of a Few Mundane Artifacts. Presentation: (also) T. Hughes, Technological Momentum.
- Techniques et valeurs. Lire : J. Wetmore, A. Technology : Reinforcing Values, Building Community. Exposé : (aussi) LangdonWinner, Do Artifacts Have Politics ? et R. Weber, Manufacturing Gender in Commercial and Military Cockpit Design.
- Complexity and uncertainty. Bring: Proposal for a dissertation Read: D. Vinck, Engineers in everyday life. Lecture : (also) JamesonWetmore, Engineering Uncertainty.
- Engineering and experimentation. Read, lecture: M. Martin and R. Schinzinger, Introduction to Engineering Ethics, pp. 77-103.
- Technical disasters. Reading and presentation : S.K.A. Pfaitteicher, Lessons amid the Rubble, pp. 36-61.
- Engineering and security. Reading and presentation : Mike Martin and Roland Schinzinger, Ethics in Engineering, pp. 117-145.
- Engineering and environment. Reading, presentation: Mike Martin and Roland Schinzinger, Ethics in Engineering, pp. 219-242.
- Nanotechnologies, génétique et robotique. Lire: Bill Joy, Why the Future Doesn't Need Us. Exposé : Interagency Working Group on Nanoscience, Engineering, and Technology, Nanotechnology : Shaping theWorld Atom by Atom.

Prerequisite. The corpus of societal and cultural opening lessons of the CMI course followed since the 1st year.

Références bibliographiques. Bowen R. 2012. Engineering Innovation in Health Care : Technology, Ethics and Persons. HRGE, pp. 204-221. Collins, Harry & Trevor Pinch. 2002. The Golem at Large : What You Should Know about Technology. Cambridge University Press. Didier. Ch. 2008. Penser l'éthique des ingénieurs. Paris, PUF. Didier, C.. 2008. Les ingénieurs et l'éthique : pour un regard sociologique. Hermes Science publications. Heilbroner, Robert. 1967. Do Machines Make History? Technology and Culture, pp. 335-345. Hughes, T. 1994. Technological Momentum, in Marx, Leo & Merritt Roe Smith, Does Technology Drive History? The Dilemma of Technological Determinism. Cambridge: MIT Press, pp. 101-113. Interagency Working Group on Nanoscience, Engineering, and Technology, Nanotechnology: Shaping the World Atom by Atom, in Johnson, Deborah et Jameson Wetmore. Technology and Society: Building Our Sociotechnical Future. MIT Press Johnson, D. & Jameson W.. 2008. STS and Ethics: Implications for Engineering Ethics, in Hackett, Edward, Olga Amsterdamska, M. Lynch et J. WajLecturean, The Handbook of Science and Technology Studies. Cambridge, MIT Press, pp. 567-582. Joy, Bill. Avril 2000. Why the Future Doesn't Need Us,Wired, pp. 238-262. Latour, B. 1992. Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts in Wiebe Bijker et John Law, Shaping Technology/Building Society: Studies in Socio-technical Change. Cambridge, MIT Press, pp. 225-258. Martin, Mike & Roland Schinzinger. 2005. Ethics in Engineering. McGraw-Hill. Martin, M. & Roland S.. 2010. Introduction to Engineering Ethics. New York : McGraw- Hill. Pfattaicher, S. K. A. 2010. Lessons Amid the Rubble. Johns Hopkins University Press. Pinch, Trevor & Wiebe Bijker. 1987. The Social Construction of Facts and Artifacts in Wiebe Bijker, Thomas H.,Trevor P., The Social

Construction of Technological Systems. Cambridge, MIT Press, pp. 17-50. Vinck, D. 1999. Ingénieurs au quotidien : ethnographie de l'activité de conception et d'innovation. Presses universitaires de Grenoble. Weber R.. 1997. Manufacturing Gender in Commercial and Military Cockpit Design, Science, Technology, & Human Values, pp. 235-253. Jameson. 2008. Engineering with Uncertainty: Monitoring Air Bag Performance, Science and Engineering Ethics, pp. 201-218. Jameson. 2009. Amish Technology: Reinforcing Values, Building Community in Johnson, D. et Jameson W.. Technology and Society: Building Our Sociotechnical Future. Cambridge: MIT Press. -Winner, Langdon. 1986. Do Artifacts Have Politics? The Whale and the Reactor: a Search for Limits in an Age of High Technology. University of Chicago Press, pp. 19-39.

Resources available to students. Lecture materials. List of books.

Scientific knowledge developed in the unit.

- Knowledge of the social and ethical dimensions of the engineering profession.

Skills developed in the unit.

- Improvement of the knowledge of English. Improvement of written expression.
- Forms of reasoning practiced in the social sciences.

Hourly volumes in and out of the classroom.

Total attendance hours: 24 hours divided into 16 hours of class, 8 hours of discussion sessions. Personal work 40-60 hours.

Evaluation. Attendance at sessions: 20%, Presentation: 20%, Essay: 40%, Essay defence: 20%.

Teacher. C. Lecuyer

Fundamentals for acoustic engineering

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5MEAP1 - Master's degree in Mechanics

Pedagogical presentation.
The objective of this teaching unit is to give the theoretical bases of acoustics (propagation of mechanical waves in fluids).

Content of the Teaching Unit.
The concepts covered in this course are:

- Introduction to the history of acoustics.
- Acoustic wave equation in perfect or dissipative fluids.
- Initial and boundary conditions, solutions of the propagation equations.
- Modelling of sound sources and radiated field: elementary sources, Green's functions, acoustic radiation of structures, diffraction theory.
- Reflection and transmission to the interfaces.
- Waveguides.
- Introduction to non-linear acoustics.
- Broadcasting.

Prerequisite. Mechanics of continuous media (level CMI3), Vector analysis, Function of several variables, Partial differential equation. It is recommended to have already taken a course on CMI3 or CMI4 level waves.

Bibliographical references.

- Blackstock, D. T., Fundamentals of physical acoustics, Wiley 2000.
- Pierce, A, An Introduction to Its Physical Principles and Applications, Springer 2019.

Resources available to students. Course handout and slides presented by the teacher.

Skills developed in the unit.

- Know the basic vocabulary in acoustics.
- Know how to model the linear propagation of acoustic waves
- Know how to model the dissipation of acoustic waves
- To know the basic solutions of the wave equation (progressive and retrograde waves, plane, cylindrical or spherical waves) and to know how to formally pose an acoustic problem.
- Know how to model the effect on propagation of the presence of interfaces or obstacles
- Know how to model the radiation from sources (monopole and dipole, any vibrating surface).
- Know how to model waveguide propagation: propagation mode, dispersion and cut-off frequency concept

Hourly volumes in and out of the classroom.
Total classroom hours: 56 hours of classes and integrated discussion sessions. Expected personal work: 70 - 90 h

Evaluation. A 3-hour written exam.

Teacher. Mr Q. Grimal

Experimental methods and projects in acoustics

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5MEAP2 - Master's degree in Mechanics

Pedagogical presentation.
The aim of this teaching unit is to present the most commonly used experimental methods in acoustics.

Content of the Teaching Unit.
Three themes to be explored in greater depth among:

- Aerial imaging use of microphone antennas to form acoustic images
- Building Acoustics, Acoustic characterization methods for buildings: insulation, source radiation, reverberation time, numerical modelling.
- Vibro-acoustics instrumentation, identification of the modal characteristics of a structure
- Project in Architectural Acoustics (AA), this theme is intended to provide students with the ability to integrate acoustic constraints and architectural objectives in a project approach that facilitates future engineering-architect dialogue.
- Ultrasonic acoustics: instrumentation associated with ultrasound, characterization of linear and non-linear acoustic fields, highlighting diffraction and scattering.
- Non-destructive testing. Introduction in the form of courses, practical work and conferences on the problems of non-destructive testing.

Prerequisites. Fundamentals of Acoustics (CMI5), Sensors for Acoustics (CMI4)

Bibliographical references.

- L. Hamayon, Réussir l'acoustique d'un bâtiment, Le Moniteur (2013)

Resources available to students. Practical work room with hardware, Acoustic simulation software.

Skills developed in the unit.

- Use sound recording equipment,
- Use equipment for building acoustics measurements
- Use equipment for the characterization of the vibro-acoustic behaviour of structures
- Use basic ultrasound equipment,
- Use antenna with a large number of microphones,
- Reflectively perform acoustic measurements, interpret experimental results,
- Analyse measurement errors and uncertainties

Hourly volumes in and out of the classroom.
Presential hours: 48 hours in the form of Practical Work
Expected personal work: 70-90 hours

Evaluation.
LAB review and reporting

Teacher. Q. Grimal

Signal processing and numerical methods for acoustics

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5MEAP3 - Master's degree in Mechanics

Pedagogical presentation.
This teaching unit is structured around two themes: signal processing and numerical methods for acoustics.

Content of the Teaching Unit.
Signal Processing This course is designed to be taught to physicists and mechanics, and not, as is sometimes the case in this discipline, as a course in pure mathematics or computer techniques. It consists of DISCUSSION SESSIONS courses and practical work sessions.

- Fundamental recalls: spectral description of a continuous time, discrete time, time and frequency sampling signal, the various Fourier transforms. The Hilbert transform and the Kramers-Kronig relations: use in physics.
- Linear and invariant digital systems, synthesis of digital filters in the context of signal analysis in the laboratory.
- Random signal analysis: noise reduction techniques, detection, classical estimation, parametric estimation.

Numerical methods for acoustics The notions introduced during the course will be covered during the practical session by a Matlab program to be developed by the student.

- Introduction to finite differences in the transport equation.
- Notions introduced: scheme order, implicit/explicit scheme, stability, dispersion and numerical dissipation, some standard schemes.
- Application of finite differences to the 2D wave equation.
- Introduction to the finite element method.

Prerequisite. Digital signal processing (M1), Digital methods (M1)

Bibliographical references.

- Papoulis, Signal Analysis (Papoulis), McGraw-Hill, 1977
- Max and Lacoume, Methods and techniques of signal processing, 2 volumes, Dunod, 2004.
- F. Cottet, Signal Processing and Data Acquisition, Dunod, 1997.
- Leveque, Numerical methods for conservation laws, Birkhäuser Verlag, 1992.
- Euvrard, Numerical solution of partial differential equations, Masson 1993.
- Dhatt and Touzot, A presentation of the finite element method, Maloine 1984.
- G. Cohen, Higher-Order Numerical Methods for Transient Wave Equations, Springer, 2002.

Resources available to students. Course handout.

Skills developed in the unit.

- Autonomy in the face of the numerical solution of a scientific problem
- Practice the principles of scientific programming and data processing.
- Understanding the constraints of sampling
- Know how to calculate and interpret a spectrum. Know how to choose a filter. Know how to synthesize a filter
- Know how to implement numerical methods and assess them in terms of stability, precision, convergence, ...
- Know how to present numerical methods and results.

Hourly volumes in and out of the classroom.
Hours of attendance: 36h course/ discussion sessions and 28h Lab.
Expected personal work: 70 - 90 hours

Evaluation.
For each theme, a written exam, a lab exam
Teacher. A. Derode, F. Coulouvrat

Applications in acoustics

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5MEAP5 - Master's degree in Mechanics

Pedagogical presentation.
The aim of this teaching unit is to present different applications of acoustics. The students who must choose 4 credits from the list presented in the content follow not all the proposed modules.

Contents of the Teaching Unit.
Waves in complex media II (1 credit): further study of the part Waves in complex media in the EU "Complementary physical acoustics". Prerequisite: Waves in complex media I.

Non-linear Acoustics II (1 credit): further development of the EU Non-linear Acoustics section "Complements in Physical Acoustics". Prerequisite: Non-linear acoustics I.

Infrasounds and Geoscience *(2 credits)*: Instrumentation and Monitoring of Natural Systems: "Infrasounds: Acquisition Techniques and Application to Geoscience". This UE proposes to present to students the modern methods of studying infrasound, from signal acquisition, processing and analysis methods, as well as their applications to different geosciences themes. Teaching will be provided by engineers and researchers from the CEA, an organisation that has been working on this technology for more than 40 years. It is divided into two main parts: the first describes the methods of signal processing, propagation simulation and signal interpretation, the second concerns a complete description of the measurement systems. The presentations will be illustrated by examples and practical work. To carry out this work, the teachers will provide the students with measurement equipment, recording bases, signal processing and simulation software. Targeted competences: to give students a global overview and a transverse vision of infrasound wave measurement and analysis techniques in the fields of environmental monitoring, earth and atmospheric sciences.
Evaluation : study projects in pairs proposed at the end of the training (signal processing and analysis / simulation / instrumentation). This theme is taught by members of the CEA (Commissariat à l'énergie atomique et aux énergies alternatives).

Aeroacoustics *(1 credit)*: study of the propagation and generation of sound waves in flows.
Model equations for acoustics in flowing media (convex wave equation, Lilley equation, linearized Euler equations) Phase velocity and group velocity in flows. Solutions in free or confined media. Introduction to geometric acoustics for long-distance propagation in heterogeneous media with flow. Kirchhoff's theorem. Notions of sources in aeroacoustics. Combustion Noise Generation of sound by flow. Lighthill analogy. Application to the reduction of turbojet engine noise.
Evaluation : final written exam

Medical Acoustics *(1 credit)*: Imaging and therapy using ultrasonic waves.
The objective is to provide students who follow a course in physical acoustics with an appropriate training based on the diagnostic and therapeutic medical applications of ultrasound. The course will be based on the theoretical concepts covered in the UE specialization and deepening in fluid and solid acoustics and on the student's knowledge of signal processing. The principles of ultrasound imaging, Doppler mode, biological effects and non-linear acoustics will be covered.
Topics covered: Principles of ultrasound imaging: ultrasound/biological tissue interactions, imaging modes (B, TM, 3D), sensors, major functions of the ultrasound scanner, focusing, speckle noise, image characteristics (resolution, contrast) Velocimetry and Doppler mode. Application of non-linear acoustics to imaging: harmonic imaging, contrast products. Biological effects of ultrasound: heating, cavitation, therapeutic applications (lithotripsy, hyperthermia), safety standards. Quantification and advanced methods: ultrasound bone densitometry, elastography.
Evaluation : Final written exam

Guided Waves *(2 credits)*: General notions about waveguides.
Eigenmodes of a linear waveguide, Homogeneous and time-invariant - Velocity of a wave group - Elementary guide - Elastoelectric field properties - Characteristic quantities - Field equations - Boundary conditions - Poynting's theorem - Energy balance - Laws of behaviour of an elastic and piezoelectric solid - Matrices of the elastic and piezoelectric components of the crystals - Elastic waves guided by one or two parallel planes - Decomposition of the propagation equations and boundary conditions Rayleigh waves - Propagation in a piezoelectric medium - Surface permittivity - Array coupler Generation by nested comb electrode transducer Detection - Piezoelectric - Optical - Lamb waves - Rayleigh-Lamb scattering equation - Mode classification and

mechanical displacement - Horizontal transverse waves (TH) - Non-piezoelectric medium (TH wave and Love waves) - Piezoelectric half-space (Bleustein-Gulyaev wave)

Psychoacoustics *(1 credit)*: study of human auditory perception
Basic knowledge of psychoacoustics: functional anatomy of the auditory system, perception of intensity (loudness), perception of pitch (and in both cases, existing models), auditory organization, localization of sound sources and timbre. Pathologies of the auditory system.
Methodological aspects of the experimental approach in psychoacoustics (unidimensional and multidimensional methods),

Insulation *(1 credit)*: study of the main sound insulation techniques. Topics covered : - Sources of noise and vibration - Modes of transmission of noise and vibration - Vibration reduction - Noise reduction
Acoustic insulation against (i) external noise: screens, facade insulation, window treatment and (ii) internal noise (airborne noise, impact noise, equipment noise). Integration of sound insulation issues into architectural and urban design. Vibroacoustic behaviour of walls in the building.

Bibliographical references. Depends on each module

Resources available to students. Depends on each module

Skills developed in the unit

- To know the technical vocabulary associated with a particular branch of acoustics.
- Implement the general tools seen in the theoretical units.

Hourly volumes in and out of the classroom.
Total Attendance Hours: 12 hours per credit in the form of integrated Courses and discussion sessions.
Expected personal work: 70 - 90 h.

Evaluation. One evaluation per module. The type of assessment varies according to the module.

Teacher. Q. Grimal

Physical and Industrial Acoustics

Updated 01/03/2020

SCIENCES SORBONNE UNIVERSITÉ

Complements in physical acoustics

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5MEAP6 - Master's degree in Mechanics

Pedagogical presentation.
The objective of this teaching unit is to give the complements in physical acoustics in three specific areas 1) waves in complex media, 2) non-linear acoustics and 3) propagation in isotropic and anisotropic solids.

Content of the Teaching Unit.
Waves in complex media I
Complex media" refers to heterogeneous media whose density and elasticity can be modelled by random functions. In this course, while keeping in mind the concern to be close to the experiments, we present to the students the fundamental concepts to describe the propagation of an electron in a metal containing impurities as well as a light wave in a turbid medium or an elastic wave for example in a grain steel (application to NDT) or in the earth's crust (applications to geophysics). We study speckle statistics (optical or acoustic) in single or multiple scattering regimes and introduce in particular the transport parameters (mean free path, scattering constant,...) and the different propagation regimes (coherent, incoherent, weak and strong localization).
Non-linear Acoustics I
The objective of this course is to study the non-linear propagation of acoustic waves in fluids, emphasizing its physical aspects. From the constitutive equations of acoustics, we establish the equation of nonlinear propagation in a thermo-viscous fluid. The plane wave solutions are then studied in detail: Burgers equation, shock waves, nonlinear interaction of two waves... The diffraction phenomena affecting nonlinear propagation are modelled using a perturbation solution in the low nonlinearity approximation, or numerically simulated from the KZ equation. At the end of the course, non-linear propagation in heterogeneous media is discussed through examples.
Propagation in isotropic and anisotropic (solids).
Boundary conditions. Energy transport (Acoustic Poynting theorem). Law of linear behaviour of an isotropic elastic solid. Longitudinal and transverse volume waves. Reflection and transmission at a liquid-solid, solid-solid interface. Waves guided by a free surface (Rayleigh waves). Waves guided by a plate (Lamb waves). Love waves. Representation of a physical quantity by a tensor. Tensor of deformations, stresses. Hooke's law for an elastic and piezoelectric solid. Tensors of elastic and piezoelectric constants. Reduction of the number of independent constants of crystals. Christoffel's propagation equation. Flat waves, polarization, phase velocity, energy velocity. Slow surface, wave surface. Propagation in a piezoelectric solid. Electromechanical coupling coefficient.

Prerequisites. Fundamentals in Acoustics (CMI5), Complementary Acoustics (CMI4), Mechanics of Continuous Fluid and Solid Media (CMI4).

Bibliographical references.

- M.F. Hamilton, D.T. Blackstock, « Nonlinear Acoustics”, Academic Press Inc, 1997.
- D. Royer and E. Dieulesaint, Ondes élastiques dans les solides : Propagation libre et guidée, tome 1, Masson, 1996.

Resources available to students. Course materials

Skills developed in the unit.
- Modelling elastic wave propagation in complex media
- Modelling the main non-linear effects in acoustics
- Modelling propagation in solids
- Implement Modelling strategies to provide an analytical description of complex phenomena.

Hourly volumes in and out of the classroom.
Total classroom hours: 60 hours of integrated classes/ discussion sessions. Expected personal work: 70 - 90 h

Evaluation. 3 written exams on each part.

Teacher. A. Derode (WTO), C. Barrier (ANL), F. Descremps (Solids)

Architectural and Urban Acoustics

Updated 01/03/2020

Complements in architectural and environmental acoustics

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5MEAA1 - Master's degree in Mechanics

Pedagogical presentation.
This teaching unit is intended to provide additional information on architectural and environmental acoustics.

Content of the Teaching Unit.

- *Room acoustics*

Basics of sound perception of space. Description of the acoustic phenomena of a room. Undulatory, statistical and geometric theories, impulse response. Objective parameters for describing a room and their measurement. Subjective parameters of room acoustics and their interpretation. Typology of listening places. Main materials used: reflection, absorption, sound diffusion. Use of computer simulation methods. The teaching will focus on showing that these technical aspects are integrated into a global architectural approach when designing rooms for speech and music.

- *Architectural acoustics*

Architectural conventions and representations: understanding the object and matter of architecture; learning to see, perceive and love architecture. Learning to read architecture and to anticipate the vision of space. Reading and manipulating architectural or urban plans. Understand the complexity of the project, its approach and objectives. Structuring and organizing the architectural project

- *Environmental acoustics*

To make students aware of the human and social science aspects of environmental acoustics: psychology, sociology, but also geography and economics. To present the basic hypotheses of sound mapping according to the European directive, as well as their limits. To insist on the importance of the inhabitants' sound experience for the expertise and its professions, and on the explanatory scope of the notion of territory to understand the diversity of the stakes related to projects concerning ambiences, architecture or urbanism. Perceptive assessment and effects of noise on humans: methods, results, notion of dose/response (psychophysics vs. psycholinguistics). Noise maps related to the implementation of the European directive. Urban sound atmospheres and landscapes, local conflicts in relation to noise and its expertise, territorial planning and urban development projects.

Prerequisites. Specialist teaching of the CMI4 level acoustic course and notions of building acoustics.

Bibliographical references.

- M. Barron "Auditorium Acoustics and Architectural Design" E & FN Spon, London, 1993.
- L. Cremer, H.A. Mueller"Principles and Applications of Room Acoustics" Vol. 1 et 2, Peninsula Publ. 2016.
- L.L. Beranek "Concert and Opera Halls: Music, Acoustics & Architecture" Springer, 2003.
- M. Forsyth "Architecture & Music" Pierre Mardaga, Liège, 1987.
- R. Murray Schafer "The soundscape" Ed. Wildproject, 2010.
- J.F Augoyard, H.Torgues "A l'écoute de l'environnement: Répertoire des effets sonores" Ed. Parenthèses, 1995.
- "Noise and the City" C.E.T.U.R. Publication, 1986.
- "Le guide du bruit" Ministry of the Environment publication, 1986.
- "Burden of disease from environmental noise", WHO, 2012.
- H.E. Rasmussen "Découvrir l'architecture" Ed. du Linteau, Paris, 2002.
- P. von Meiss, "De la forme au lieu, suivi de la tectonique : une introduction à l'étude de l'architecture", Presses polytechniques et universitaires romandes, 2014.
- Deplazes (ed.) "Building architecture: from raw material to building", Birkhäuser, 3rd ed., 2018.

Resources available to students. Course notes/Basic software

Skills developed in the unit.

- Advanced knowledge in architectural and environmental acoustics
- Use of computer simulation methods.
- Reading and manipulation of architectural or urban plans, understanding projects
- Raising awareness of the human and social science aspects of environmental acoustics

Hourly volumes in and out of the classroom.
Total hours of attendance: 48 hours of attendance. Expected personal work: 70-90 h

Evaluation. 1 evaluation per module, in the form of a project.

Teacher. J.-D. Polack

Semester 10

Deepening Project

Level CMI5 - **Semester** S10 - **Credits** 3 ECTS - **Code** MU5EEG04 - Master's **degree in** Mechanics

Pedagogical presentation.
This deepening project is complementary to the specialization and can take different forms. It can represent the follow-up of an optional unit of additional specialization in semester S9 to broaden the knowledge base or to enhance a bibliographical part of the internship that would have been significant, or be associated with a scientific production for example in the context of the internship (presentation in a scientific conference, submission of a publication). It can also valorise an important associative investment or translate the validation of a teaching in the form of a MOOC (for example, a shared teaching on the European Virtual Exchange platform of the Sorbonne University Alliance 4eu+ network of partner universities: Charles University of Prague (Czech Republic), Heidelberg (Germany) and Warsaw (Poland), Universities of Milan (Italy) and Copenhagen (Denmark)). This project is usually carried out on an individual basis.

Content of the Teaching Unit.
Depending on the form of the project

Prerequisite miminum. Knowledge acquired in all teaching units since CMI1.

Bibliographical references. Function of the project subject.

Resources available to students. Function of the project subject and its environment.

Scientific knowledge developed in the unit
- Function of the project subject.

Skills developed in the unit.
- Take a step back from his training path.
- Knowing how to manage a personal project with commitment, defending it with conviction.

Hourly volumes in and out of the classroom.
Expected personal work: about 30 - 40 hours (and often more).

Evaluation. Evaluation usually in the form of a note of the written report, oral defence and involvement.

Teacher. Y. Berthaud, H. Dumontet.

SCIENCES SORBONNE UNIVERSITÉ

Graduation internship

Level CMI5 - **Semester** S10 - **Credits** 30 ECTS - **Code** MU5MES03 - **Mention** Master Mechanics

Pedagogical presentation.
This end-of-study internship takes place over 24 weeks at the end of the course. The objective is to enable the student to acquire an engineering attitude, in particular autonomy and the ability to work effectively in a team in the company, by relying on the knowledge acquired during the training and the skills developed in the simulation activities (projects, and previous internships). He consolidates the specialization and validates these acquired skills.

This internship can take place in France or abroad, in a company (generally in the R&D departments of large industrial groups) or research laboratory (provided that the student then has significant experience of an internship in a company). It leads to the writing of a report and a defence in French or English. The presentation is made in front of a mixed jury composed of members of the teaching team and external experts, including the supervisor in the case of an internship in a company.

Content of the Teaching Unit.
The course leaders validate the coherence of the subject, its adequacy with the speciality of the training, with the student's professional project and his/her academic results. This internship is the subject of an internship agreement signed by the company/laboratory, the university and the student.

Prerequisite miminum. All the knowledge and skills developed since the beginning of the course.

Resources available to students.

- List and description of previous internship topics. Internship offers.
- Validation procedures, drafting guidelines, internship agreements.
- Bibliographical resources according to the subject.

Scientific knowledge developed in the unit.

- Specific to each internship according to the subject area of the company / laboratory and the missions entrusted.

Skills developed in the unit.

- Knowing how to participate in teamwork, take initiatives, know how to situate oneself and acquire autonomy.
- Know how to apply one's knowledge and apply it to a new open subject.
- Be able to respect specifications and deadlines.
- Be Teacher for the quality of his work.
- Take a step back from his experience, gain confidence in professional integration.
- Know how to communicate about your work in writing and orally.

Hourly volumes in and out of the classroom. 24 weeks of full-time internship between March and the end of August.

Evaluation. Placement report (/35, about fifty pages excluding annexes), tutor evaluation (/30), oral defence (/35 , 25 minutes presentation, 25 minutes questions).

Teacher. Course managers, Mr Y. Berthaud and Mrs H. Dumontet.