Institut d'Acoustique Graduate School
Le Mans Université

Faculté des Sciences & Techniques
Le Mans Université

International Master's Degree

in "Wave Physics and Acoustics" (WP&A)

Syllabus

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Contents

1 Syllabus guide

This document presents the complete syllabus (summary of the courses) of the International Mater Degree in Wave Physics and Acoustics (WP&A). The courses of both years of the Master program are given in the form of lectures (theoretical notions and some applications) and tutorials. You will note that semester 4 (2nd year) is entirely dedicated to an internship in a research laboratory. You will find for each course:

- ⋆ the name(s) of the lecturer(s) with their host structure (university, company, etc.).
- ⋆ the general theme of the course,
- ⋆ the hourly volume of the courses,
- ⋆ the credits of the European Credits Transfert System (ECTS) which stand for the coefficient of the course. As a reminder, the total number of ECTS (coefficients) is 30 per semester,
- ⋆ the objectives (skills and knowledge expected),
- ⋆ the content of the lectures in the form of an outline and key words,
- ⋆ the evaluation procedures,
- ⋆ the pre-requisites,
- ⋆ the educational ressources (if any).

The list of acronyms used in the following:

- ⋆ CNRS: Centre National de Recherche Scientifique ;
- ⋆ ECTS: European Credits Transfert System ;
- ⋆ LAUM: Laboratoire d'Acoustique de l'Université du Mans ;
- ⋆ LMU: Le Mans Université.

2 Year 1, semester 1

2.1 Physics of waves I

Year, semester: M1, S1
Lecturer(s): Simon Félix (coordinator, CNRS, LAUM), Vincent Tournat (CNRS, LAUM), Vassos Achilleos (CNRS, LAUM)
Hourly volume (lectures / tutorials): 32 / 12
ECTS credits: 8

Objectives (skills and knowledge expected)

This module is a broad introduction to the Physics of waves, intending to review the basics of wave propagation and wave processes, common to all types of waves. Fundamental equations and concepts will be introduced for mechanical waves in discrete systems, electromagnetic, acoustic, and matter (quantum) waves. The basic wave phenomena (interferences, dispersion, refraction, ...) will also be described. On successful completion of this course, students will have a broad knowledge and understanding of waves, and they will be able to solve most of the usual basic problems. Wave Physics can be seen as the core module of the Master's program.

Content

1. General introduction on waves, historical evolution of the concept of waves (2h VT)
2. Mechanical waves in discrete to continuous systems (4h + 2h VT)
3. Electromagnetic waves (4h + 2h VA)
4. Matter waves (6h + 2h VA)
5. Introduction/reminder about basic wave phenomena: attenuation, dissipation, interferences, dispersion, reflection, refraction, . . . (8h + 2h SF)
6. Scattering problems: 1D scattering, scattering matrix, multilayer system, . . . + project (8h + 4h SF)

Evaluation procedures

1 individual project with individual interview at the end of the semester. Students will be given the grade A (excellent, beyond expected), B (good, as expected), or C (in progress, insufficient).

Pre-requisites

Basic maths, differential equations. This course will at times refer to basic results and notions from the course Physical acoustics I.

Ressources

UMTICE link: https://umtice.univ-lemans.fr/course/view.php?id=6128

2.2 Physical acoustics I

Year, semester: M1, S1
Lecturer(s): Guillaume Penelet (coordinator, LMU, LAUM)
Hourly volume (lectures / tutorials): 20 / 12
ECTS credits: 6

Objectives (skills and knowledge expected)

This module is a general introduction to Acoustics, especially in fluids. The main scope of this module is to provide solid backgrounds in physical acoustics, starting from the conservation equations (mass, momentum, energy) and thermodynamic aspects of acoustics, continuing with the derivation of the wave equation, and next with the treatment of many classical problems of acoustics in fluids (e.g 1D waves in gas columns, reflexion/transmission phenomena, guided waves, etc...). Although some illustrations with practical applications in acoustics will be highlighted, this module will focus on fundamental aspects of acoustics including :

- ⋆ backgrounds in fluid mechanics and thermodynamics ;
- ⋆ the derivation of the wave equation (mostly for the usual case of uniform fluids at rest, and for low amplitudes) ;
- ⋆ the acoustics of the gas column (resonance, free oscillations, coupling etc..) ;
- ⋆ reflection, transmission, and diffraction phenomena ;
- ⋆ guided waves and the modal theory ;
- ⋆ spherical and cylindrical waves (sound radiation, diffraction, guided waves in cylindrical ducts, etc...).

The objective is therefore to learn fundamentals of acoustics, which will be a useful background for other topics more focused on applications (e.g. room acoustics, duct acoustics, aeroacoustics, electroacoustics, thermoacoustics, etc...)

Content

1. Fundamental equations of acoustics (in fluids): reminder of thermodynamics and kinetic theory of gases, reminder of fluid dynamics, derivation of the wave equation, sound propagation in different kinds of fluids, practical consequences of the linear approximation, etc...
2. Plane waves: reflection phenomena and boundary conditions, duct acoustics (e.g. resonance in gas columns, coupling, propagation in ducts, horns, connection of ducts, Helmholtz resonator, etc...), plane waves in unbounded media (reflexion, transmission through an interface, refraction, transmission of sound through solids, etc...)
3. Cylindrical, Spherical waves, Guided waves: Applications of acoustics to problems with cylindrical or spherical symmetry (e.g. radiation by a pulsating cylinder or a pulsating sphere, resonance phenomena within a spherical cavity, sound propagation through ducts with circular cross-section, etc...)
4. Introduction to modal analysis: the concepts of orthogonality and eigen modes, and their applications to practical problems in acoustics (e.g. guided waves in ducts, forced oscillations by a point source in a 3D cavity, etc...)

Evaluation procedures

Evaluation through 1 individual project (with a topic selected among a few proposals) that starts at the end of the lecture sessions, for a duration of 4 weeks (a written report is required at the end of the project). A face to face meeting with the teacher will also be organised for giving a personal feedback on the project.

Pre-requisites

No pre-requisite explicitly needed. Having backgrounds in acoustics is obviously a good point, but it is not essential since we will re-start from scratch. Having solid backgrounds in mathematics is essential. This includes : trigonometry, integration/derivation, asymptotic expansions of usual functions, solving of O.D.E., functions of multiple variables, vector analysis and operators (in various systems of coordinates), linear algebra. . .

Ressources

The lecture notes are available on the following url `https://umtice.univ-lemans.fr/course/view.php?id=7451`.

2.3 Methods for waves I

Year, semester: M1, S1
Lecturer(s): Gwénaël Gabard (coordinator, LMU, LAUM), Laurent Simon (LMU, LAUM)
Hourly volume (lectures / tutorials): 32 / 12
ECTS credits: 8

Objectives (skills and knowledge expected)

This module provides the required tools to model and analyse wave phenomena. This includes mathematical fundamentals and basic computational techniques to model and simulate an acoustic system. In addition, signal processing techniques are also provided to use data in order to analyse a wave field and its source. The concepts and techniques presented in this module will be described and applied directly in the context of wave physics. They will form a toolbox required to tackle modelling and analysis problems encountered in the other modules of this master program.

Content

1. Linear algebra: Vector spaces, Euclidean spaces, Hilbert spaces, Matrix decompositions (eigenvectors, singular value decomposition, LU).
2. Partial differential equations: Classification & reduction of PDEs (parabolic, hyperbolic, elliptic...), Resolution methods in 1D, Transfer matrix, Matrix exponential.
3. Finite difference methods: Interpolation theory, Dispersion analysis of numerical schemes, Resolution of ODEs (Runge–Kutta), Time-domain finite-difference simulations.
4. Signal Processing for estimating sources and wave properties (signals and systems): overview of methods for estimating unknown quantities (rays, FRF, phase and group velocities...) from noisy data.

Evaluation procedures

Assessment will be based on an individual project combining and applying different techniques covered during the module. This project will be assessed through a report and a discussion with the lecturers.

Pre-requisites

- Algebra
- Differential and integral calculus
- Python programming for basic numerical computing

Resources

UMTICE page https://umtice.univ-lemans.fr/course/view.php?id=633

2.4 Introduction to research I

Year, semester: M1, S1
Lecturer(s): Samuel Raetz (coordinator, LMU, LAUM), Vassos Achilleos (CNRS, LAUM), LAUM director, Simon Félix (CNRS, LAUM), Manuel Melon (LMU, LAUM), Alann Renault (LMU, LAUM)
Hourly volume (lectures / tutorials): 0 / 16
ECTS credits: 6

Objectives (skills and knowledge expected)

This module is an introduction to the concepts and tools that are used on a daily basis by a researcher. The objectives are to give the students a good understanding of how research is conducted and shared among the scientific community and to discover the research topics in LAUM through presentation and, more importantly, their first individual scientific project. How important scientific communications are in a scientist life and and how to make one are discussed along 4 specific lectures. For the sake of the project success, 2 lectures deal with experimental aspects and the discovery of LAUM. The students are also encouraged to attend the maximum possible research seminars and PhD defenses to develop the taste of scientific culture. The Introduction to Research I module can be seen as the first contact of the student with research in an academic laboratory and their first realization.

Content

1. Written/Graphical scientific communication
   - ⋆ What is a scientific publication and deontology? (2h)
   - ⋆ Bibliography: method & tools (2h)
   - ⋆ LaTeX (2h)
   - ⋆ Scientific expression: how to think and make SciFi (Scientific Figures)? (2h)
2. Experimental tools
   - ⋆ Python/Matlab basics for instrumentation (4h)
   - ⋆ FabLab training (2h)
3. Laboratory discovery
   - ⋆ LAUM's tour with the lab's head (2h)
   - ⋆ Presentations of/Discussions with LAUM's Research Group
4. Scientific culture
   - ⋆ Attending research seminars in LAUM (at will)
   - ⋆ Attending PhD defenses in LAUM (at will)

Evaluation procedures

Using 3 grades A (excellent, beyond expected), B (good, as expected), C (in progress, insufficient). Evaluation through a report presenting an individual project conducted in the lab with the obligation to follow the rules of an imposed letter-format scientific journal (in the end of january).

Pre-requisites

None

Ressources

UMTICE link: https://umtice.univ-lemans.fr/course/view.php?id=6217

3 Year 1, semester 2

3.1 Physics of waves II

Year, semester: M1, S2
Lecturer(s): Vassos Achilleos (coordinator, CNRS, LAUM), Vincent Tournat (coordinator, CNRS, LAUM), Simon Félix (CNRS, LAUM), Vincent Romero-Garcia (CNRS, LAUM)
Hourly volume (lectures / tutorials): 24 / 12
ECTS credits: 6

Objectives (skills and knowledge expected)

This module is following module I and continues the broad introduction to the Physics of waves, intending to review the basics of wave propagation and wave processes, common to all types of waves. Advancing in the concepts related to wave physics, this second module reviews more advanced wave transport phenomena, usual approximations in higher dimensions, 2D, 3D, resolution methods of wave problems with a higher complexity (multiple scattering, beam diffraction, propagation in complex media, ...). Wave Physics can be seen as the core module of the Master's program.

Content

1. Green's function method for waves and resolution of related problems + project (6h + 4h SF)
2. Resonant 1D scattering (6h + 2h VRG)
3. Single scattering problems in 2D and 3D. Acoustic and elastic scattering, resonant scattering, Mie scattering, Rayleigh scattering. Scattering problems with Finite Element Method. Applications and introduction to multiple scattering in disordered media. (6h + 2h VT)
4. Model equations, transport equations, approximated problems (rays, parabolic equation, one-way, ...), perturbation methods for Schrödinger and other equations (6h + 4h VA)

Evaluation procedures

1 individual project with individual interview at the end of the semester. Students will be given the grade A (excellent, beyond expected), B (good, as expected), or C (in progress, insufficient).

Pre-requisites

Physics of Waves I course.

Ressources

UMTICE link: `https://umtice.univ-lemans.fr/course/view.php?id=6128`

3.2 Elastic waves, vibrations and introduction to nonlinear oscillators

Year, semester: M1, S2
Lecturer(s): Samuel Raetz (coordinator, LMU, LAUM), Frédéric Ablitzer (LMU, LAUM), Georgios Theocharis (CNRS, LAUM)
Hourly volume (lectures / tutorials): 36 / 12
ECTS credits: 8

Objectives (skills and knowledge expected)

This module is a general introduction to elastic waves in solids, vibrations and nonlinear oscillators. The main scope of this module is to provide backgrounds in elasticity, elastodynamics in unbounded and bounded solid media, vibrations and nonlinear oscillators.

Content

1. Elastic waves (SR, 12h + 4h)
   - ⋆ Continuous media, elasticity, Hooke's law, anisotropy
   - ⋆ Plane waves in isotropic solids - Christoffel's equation, slowness curves, Snell-Descartes laws
   - ⋆ Guided waves in isotropic solids (SH guided modes, Lamb modes, Rayleigh modes, ...)
2. Vibrations (FA, 12h + 4h)
   - ⋆ Vibrations of discrete systems: eigenmodes, free response, forced response
   - ⋆ Vibrations of continuous systems: strings, beams, membranes, plates
   - ⋆ State-space representation, complex modes
   - ⋆ Structural dynamic modification, component mode synthesis
3. Introduction to nonlinear oscillators (GT, 12h + 4h)
   - ⋆ Introduction to perturbation methods
   - ⋆ Phase Portrait method
   - ⋆ Duffing Oscillator
   - ⋆ Van de Pol Oscillator
   - ⋆ Driven Duffing Oscillator

Evaluation procedures

Using 3 grades A (excellent, beyond expected), B (good, as expected), C (in progress, insufficient). Evaluation through 3 individual projects with interviews during the semester.

Pre-requisites

- ⋆ Analytical methods for ordinary differential equations (ODEs)
- ⋆ Numerical integrations of ODEs
- ⋆ Linear algebra
- ⋆ Vibration of single degree of freedom (SDOF) oscillator

Ressources

UMTICE link: https://umtice.univ-lemans.fr/course/view.php?id=6603

3.3 Methods for waves II

Year, semester: M1, S2
Lecturer(s): Gwenaël Gabard (coordinator, LMU, LAUM), Laurent Simon (LMU, LAUM)
Hourly volume (lectures / tutorials): 24 / 12
ECTS credits: 6

Objectives (skills and knowledge expected)

The second semester of this module aims to further develop the range of modelling technique and signal processing methods available to the students. This includes more advanced mathematical concepts (complex analysis and Green's functions) as well as finite element methods for computational simulations. For signal processing, this will include advanced techniques to quantify and separate wave sources. The concepts and techniques presented in this module will be described and applied directly in the context of wave physics. They will form a toolbox required to tackle modelling and analysis problems encountered in the other modules of this master.

Content

1. Boundary-value problems: PDEs in 2D and 3D, Families of projection, Spectral methods of resolutions of simple PDEs.
2. Finite-element methods: Weak forms, Discretisation schemes, Mode calculations, Direct response calculations.
3. Digital filtering, non-stationary signal analysis, array signal processing.
4. Source separation, inverse problems (including regularization, sparsity, deconvolution).
5. Complex analysis: Contour integrals, Residue theorem, Integral transforms.

Evaluation procedures

Assessment will be based on an individual project combining and applying different techniques covered during the module. This project will be assessed through a report and a discussion with the lecturers.

Pre-requisites

- ⋆ Algebra
- ⋆ Differential and integral calculus
- ⋆ Python programming for basic numerical computing

Ressources

UMTICE page: https://umtice.univ-lemans.fr/course/view.php?id=633

3.4 Introduction to research II

Year, semester: M1, S2
Lecturer(s): G. Penelet (coordinator, LAUM)
Hourly volume (lectures / tutorials): 24 / 0
ECTS credits: 10

Objectives (skills and knowledge expected)

This module is a continuation of the Introduction to research I module, which closely related to the individual project made by the in the lab (in collaboration with his/her welcoming research team). A large part of the second semester will indeed be devoted to this individual project, and the student will be asked at the end of the semester to make an oral presentation of his work in front of a jury.
In addition to this individual project which will be the core of this module, some lectures will be provided within this module, including the so-called "advanced lectures" which are short lectures (typically 4 hours) given by a specialist of a given domain.

Content

1. Advanced lectures (up to 24h)
2. Scientific expression, how to prepare slides? (2h)
3. Research project in a LAUM's Research Group
4. Scientific culture
    - ⋆ Attending research seminars in LAUM
    - ⋆ Attending PhD defenses in LAUM

Evaluation procedures

Evaluation through an oral presentation of the individual project conducted in the lab in front of a jury (in May or June).

Pre-requisites

None

Ressources

UMTICE link: https://umtice.univ-lemans.fr/course/view.php?id=6217

4 Year 2, semester 3

4.1 Physics of waves III

Year, semester: M2, S3
Lecturer(s): Simon Félix (coordinator, CNRS, LAUM), Vincent Tournat (CNRS, LAUM)
Hourly volume (lectures / tutorials): 40 / 0
ECTS credits: 8

Objectives (skills and knowledge expected)

This module follows module I and II and continues the topic of Physics of waves to processes of guided, interface and surface waves. It provides tools for treating various problems of wave guiding, acoustics, electromagnetism, elastic, ... Theoretical concepts of modes, dispersion, coupling are analyzed. This course also provides tools for solving guided wave problems (analytical, semi-analytical, numerical).

Content

1. Guided waves (20h SF)
   - ⋆ Introduction to waveguides and guided waves through examples in various field of physics,
   - ⋆ One-dimensional waves,
   - ⋆ Modes in waveguides,
   - ⋆ Mode matching,
   - ⋆ Inhomogeneous waveguides.
2. Guided, interface and surface elastic waves (10h VT)
   - ⋆ Problems of dispersion in elastic waveguides,
   - ⋆ Lamb waves in plates,
   - ⋆ Rod waves,
   - ⋆ Rayleigh waves,
   - ⋆ Analytical and numerical (FEM) tools for elastic waves.

Evaluation procedures

1 individual project with individual interview at the end of the semester. Students will be given the grade A (excellent, beyond expected), B (good, as expected), or C (in progress, insufficient).

Pre-requisites

"Introduction to elastic waves" part of the Physics of waves I course, "elastic waves" part of the Elastic waves, vibrations and nonlinear oscillators course, Methods for waves I and II courses.

Ressources

UMTICE link: https://umtice.univ-lemans.fr/course/view.php?id=6128

4.2 Nonlinear waves

Year, semester: M2, S3
Lecturer(s): Vitali Goussev (coordinator, LMU, LAUM), Georgios Theocharis (CNRS, LAUM), Vassos Achilleos (CNRS, LAUM)
Hourly volume (lectures / tutorials): 40 / 0
ECTS credits: 8

Objectives (skills and knowledge expected)

To teach the students the physical principles and theoretical backgrounds of nonlinear acoustic phenomena, through the studies of theoretical equations describing transformation of temporal profiles and the frequency spectra of the acoustic waves, analysis of the typical experimental realizations and of the most important applications of the nonlinear acoustics in non-destructive testing, biomedical and fundamental research. Knowledge of physical principles of the nonlinear acoustic phenomena in general and such phenomena as harmonics generation, sub-harmonic emission, shock front and solitary waves formation, parametric emission and acoustic streaming in particular.

- ⋆ Knowledge of the physically different types of sources of acoustic nonlinearity.
- ⋆ Knowledge of the classical equations of the nonlinear acoustics such as the simple-wave equation, Burgers equation, Korteweg de Vries equation and Khokhlov–Zabolotskaya equation.
- ⋆ Knowledge of the basic mathematical methods for the analysis of the nonlinear differential equations of nonlinear acoustics (both homogeneous and inhomogeneous).
- ⋆ Knowledge of the basic principles in application of nonlinear acoustics in non-destructive testing, in medicine, in design and construction of parametric emitters and receivers.

Mots clés : nonlinear acoustics, harmonics generation, subharmonic generation, frequency mixing, demodulation, parametric emission, simple-wave equation, Burgers equation, Korteweg de Vries equation, Khokhlov–Zabolotskaya equation, solitary waves, solitons, acoustic streaming, non-destructive testing

Content

1. Nonlinear acoustics (20h VG)
   - ⋆ physical and geometrical origins of the acoustic nonlinearity;
   - ⋆ basic nonlinear acoustic phenomena and their applications in non-destructive testing, in technology, industry, medicine and fundamental research:
   - ⋆ theoretical derivation of the basic equations of the nonlinear acoustic in fluids and solids;
   - ⋆ analysis of the harmonics generation and shock front formation in the frame of the simple-wave equation and of the Burgers equation;
   - ⋆ quadratic, cubic, hysteretic and other types of the acoustic nonlinearity and their typical manifestations;
   - ⋆ synchronous generation of the nonlinear acoustic waves by moving sources;
   - ⋆ nonlinear acoustics of the diffracting sound beams and parametric emitting antennas;
   - ⋆ nonlinear acoustics in media with dispersion and acoustic solitary waves.

2. Nonlinear dispersive waves

   (10h GT)

   ⋆ linear dispersive waves;
   ⋆ lattices dynamics: dispersion relation, basic properties, numerical methods;
   ⋆ nonlinear mechanical lattices: Fermi Pasta Ulam paradox and continuum limit (Boussinesq);
   ⋆ Boussinesq equation in physics and its soliton solutions;

   (10h VA)

   ⋆ numerical methods for nonlinear wave equation (finite difference and spectral methods);
   ⋆ nonlinear Schroedinger (NLS) equation in physics;
   ⋆ modulation instability;
   ⋆ soliton solutions of NLS.

Evaluation procedures

Using 3 grades A (excellent, beyond expected), B (good, as expected), C (in progress, insufficient). Evaluation through 1 individual projects and 1 written examination.

Pre-requisites

⋆ Knowledge of the backgrounds of fluid mechanics and of the elasticity theory,

⋆ Knowledge of the methods for the solution of ordinary differential equations (both homogeneous and inhomogeneous)

4.3 Physical acoustics II

Year, semester: M2, S3
Lecturer(s): Guillaume Penelet (coordinator, LMU, LAUM), Jean-Philippe Groby (CNRS, LAUM)
Hourly volume (lectures / tutorials): 40 / 0
ECTS credits: 8

Objectives (skills and knowledge expected)

1. Physical acoustics (viscothermal effects in acoustics)
   - ⋆ To derive the equations of acoustics for viscous and heat conducting fluids.
   - ⋆ To study various mechanisms of sound dissipation in unbounded media: viscosity, heat conduction, molecular relaxation ...
   - ⋆ To study the processes of dissipation involved within viscothermal boundary layers for a solid fluid interface, and next for problems of propagation of acoustic waves through ducts.
   - ⋆ To illustrate the aforementioned concepts by the study of various examples where viscosity and/or heat transfer processes play a key role: geometrical singularities and "vortex sound", acoustic streaming (Rayleigh/Eckhart), acoustic gyro, thermophones, thermoacoustic engines, combustion instabilities, ...
2. Waves in Periodic Media
   - ⋆ Calculate the dispersion relation for periodic media
   - ⋆ Highlight bandwidth and bandwidth restrictions
   - ⋆ Highlight the phenomena related to periodic interfaces

Content

1. Physical acoustics (20h GP)
   - (a) Lossy propagation in unbounded media
     - ⋆ Fundamental equations for viscous and heat conducting fluids
     - ⋆ Lossy propagation in monoatomic gases
     - ⋆ Lossy propagation in polyatomic gases (molecular relaxation)
   - (b) Losses due to viscothermal effects near boundaries
     - ⋆ Diffusion of heat and vorticity next to boundaries
     - ⋆ Reflexion of a plane wave by a rigid boundary
     - ⋆ Propagation of plane waves in ducts
     - ⋆ Application to a few other problems
   - (c) Potpourri of viscous and thermal effects in acoustics
     - ⋆ Viscosity effects (acoustic gyrometer, minor losses, vortex sound, acoustic streaming...)
     - ⋆ Thermoacoustic effects (thermophones, rijke tubes and combustion instabilities ...)
     - ⋆ Thermoacoustic engines

2. Waves in Periodic Media (20h JPG)

   * Propagation and dispersion relation in a 1D periodic medium: from Transfer Matrix
   * Propagation and dispersion relation in a 2D periodic medium : Expansion in plane waves
   * Reflection by a 2D periodic surface grating
   * Multiple scattering by infinite and finite gratings
   * Introduction to acoustic metamaterials

Evaluation procedures

* Physical acoustics (GP):

  Evaluation through 1 project (either individual or with a binome partner) that starts at the end of the lecture sessions, for a duration of 4 weeks (a written report is required at the end of the project). A face to face meeting with the teacher will also be organised for giving a personal feedback on the project.

* Waves in Periodic Media (JPG):

  Evaluation through a written examination at the end of the semester.

Pre-requisites

* Physical acoustics (GP): Physical Acoustics 1 (M1)
* Waves in Periodic Media (JPG):

  Mastering of:

  * mathematical basis of acoustics
  * spatial Fourier transform
  * Poisson distribution

Ressources

* Physical acoustics (GP): A printed monograph will be provided to the students. The lecture notes and other useful documents are available on the following url https://umtice.univ-lemans.fr/course/view.php?id=7392

4.4 Introduction to research III

Year, semester: M2, S3
Lecturer(s): S. Raetz & G. Penelet (coordinator, LAUM)
Hourly volume (lectures / tutorials): 12 / 0
ECTS credits: 6

Objectives (skills and knowledge expected)

This module is a continuation of the Introduction to research modules of the first year, and again, it is closely related to the individual project made by the student in the lab (in collaboration with his/her welcoming research team).

Content

1. Advanced lectures (up to 12h)
2. Research project in a LAUM's Research Group
3. Scientific culture
   - ⋆ Attending research seminars in LAUM
   - ⋆ Attending PhD defenses in LAUM

Evaluation procedures

Evaluation through an oral presentation of the individual project conducted in the lab in front of a jury (in the end of january).

Pre-requisites

None

Ressources

UMTICE link: https://umtice.univ-lemans.fr/course/view.php?id=6217

5 Year 2, semester 4

5.1 Internship in a research laboratory

Year, semester: M2, S4
Hourly volume: 5 to 6 months
ECTS credits: 30

Objectives (skills and knowledge expected)

The objective of the internship is to participate in a scientific research in a research laboratory research laboratory (in the public or private sector). This internship allows students to further confront to the realities of the daily work of a researcher and to understand the different missions he/she has to perform. They will have to be able to carry out a bibliographic research, develop theoretical models and/or elaborate experiments allowing the demonstration of physical phenomena. This internship will also also lead to the writing of a scientific report as well as a presentation of the work done.

Evaluation procedures

- ⋆ 1 internship report,
- ⋆ 1 oral presentation of 15 minutes in front of a jury.