CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2025-2026

YEAR 1

MARINE TECHNOLOGY

HYDRODYNAMICS FOR OCEAN ENGINEERING

PROGRAMME SUPERVISOR(S):
Lionel GENTAZ

YEAR 1 - Autumn Semester

CORE COURSES

Course code	Title	ECTS Credits
ALEMO	Algorithmics for Engineering Modeling	4
COMEC	Continuum Mechanics	5
CONF	Conferences	-
FLUM1	Fluid Mechanics 1	5
MARHY1	Marine Hydrodynamics 1	5
NUMME	Numerical Methods	5
TOME1	Tools and Methods for Research 1	4

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE1	Cultural and Communication English	2
ESP1	Spanish Language	2
FLE1	French Language	2

YEAR 1 - Spring Semester

CORE COURSES

Course code	Title	ECTS Credits
ENERG	Energetics	5
FLUII	Fluid Mechanics 2	5
MARHY2	Marine Hydrodynamics 2	5
PROPUL	Propulsion	5
STRME	Structural Mechanics	5
TOME2	Tools and Methods for Research 2	5

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE2	Cultural and Communication English	2
ESP2	Spanish Language	2
FLE2	French Language	2

Algorithmics for Engineering Modeling [ALEMO]

LEAD PROFESSOR(S): Domenico BORZACCHIELLO / Jose-Vicente AGUADO

Objectives

At the end of the course the students will be able to:

- Identify and properly apply numerical methods to different engineering problems
- Understand algorithmic aspects and handle practical implementation issues
- Program and optimize algorithms in Python
- Use standard libraries for scientific computing
- Produce reports and notebooks using Jupyter

Course contents

The course proposes a gentle introduction to numerical methods in scientific computing and their respective algorithms through practical problems that are often encountered in engineering applications. It will cover five fundamental topics : interpolation and differentiation, numerical quadrature, time-stepping integration techniques for ordinary differential equations, iterative solvers and nonlinear solvers.

Each topic will be presented through a practical application, that will serve as a basis to review implementation aspects as well as theoretical principles of the numerical methods involved. Several exercises in Matlab/Octave are proposed.

Course material

- Slides and Course Notes
- Deepnote Labs
- An Introduction to Programming and Numerical Methods

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Partnership s for the goals

Sustainable Development and Social Responsibility Positioning

A Python course for engineering modeling supports sustainable development and CSR by equipping students to quantify, compare, and optimize technical choices. Programming is used to model systems, analyze data, and simulate scenarios (energy, materials, emissions, reliability), helping identify more resource-efficient solutions and make trade-offs between cost, performance, and impact explicit. Emphasis on reproducibility, code traceability, and data quality improves transparency, which is key to justifying responsible decisions. By building models and metrics, students learn how to monitor impact and support continuous improvement.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	10 hrs	20 hrs	0 hrs	0 hrs	2 hrs

Continuum Mechanics [COMEC]

LEAD PROFESSOR(S): Siddhartha Harsha OMMI

Requirements

This course is designed as a Masters level course for those who have graduated with an engineering or corresponding applied mathematics degree.
The students are expected to have familiarity with,
- statics
- elementary stress analysis
- applied math for engineering
- basic notions of vector algebra (a recall is done at the beginning of the course)

Objectives

This course introduces Continuum Mechanics and more generally modeling in mechanics. It covers the fundamental concepts required for more advanced fluid/solid mechanics courses, while providing basic tools for engineering design.

A brief recall to vector algebra, followed by an introduction to tensor algebra and analysis, are performed at the very beginning to provide the mathematical tools needed for the rest of the course. Afterwards, the course focuses on the various balance laws, thermodynamic restrictions and the study of equilibrium of deformable solids in linear elasticity under the hypothesis of infinitesimal transformations by analyzing suitable Boundary Value Problems (BVPs).

The concepts developed here support first-semester courses of fluid mechanics (concepts that the students need to assimilate by themselves) and numerical methods (it provides models to be discretized with numerical methods). It forms the basis for second-semester structural mechanics for students of “solid” or “civil engineering” track and also provides useful tools for the course of “Mechanical design analysis"

At the end of the course, the students should at least be able to:

1) Describe the notions of Continuum mechanics and be at ease with the terminology
- Deformation and measures of deformation (stretch, strain, strain-rate)
- Stress and its measures
- Balance equations (Basic principles)
- Constitutive equations (material models)

2) Formulate and solve Boundary Value Problems (BVPs) within infinitesimal elasticity.
- Identifying the right set of equations and boundary conditions to solve engineering problems.
- Know the different possible approaches available for the solution of that BVP, and to solve it.

Note 1: The focus here will be BVPs in solid mechanics (fluid mechanics problems are treated in another course).
Note 2: We restrict ourselves to infinitesimal elasticity which suffices for a majority of engineering problems.

Course contents

The course consists of 30h of classes in presence, alternating between theory sessions (CMs) and tutorial sessions (TDs), each lasting 2h.

The outline of the course is as follows:
- Chp 0. Introduction
- Chp 1. Mathematical basics for Continuum Mechanics
- Chp 2. Kinematics of continuous media
- Chp 3. Stresses

- Chp 4. Balance Equations
- Chp 5. Constitutive Equations
- Chp 6. Linear Elasticity under Infinitesimal transformations

Course material

Books in english (available at ECN):
- Introduction to Continuum Mechanics, W. Michael Lai, David Rubin and Erhard Krempl, Elsevier, 2010.
- Continuum Mechanics, A.J.M. Spencer, Dover Publications, 2004.
- Nonlinear solid mechanics: a continuum approach for engineering, G.A. Holzapfel, Chichester, New York : Wiley , 2000.
- Nonlinear continuum mechanics for finit element analysis, J. Bonet, R.D. Wood, Cambridge University Press , 1997.

Books in french (available at ECN):
- Mécanique des Milieux Continus et discrets, Handbook of N. Moës, 2011,
- Mécanique, P. Germain, 1985, Ecole Polytechnique, volumes 1 & 2.
- Mécanique des milieux continus: cours et exercices corrigés, J. Coirier, C. Nadot-Martin, S. Liviu, 2013, Dunod. Available at the library of the school. (Good appendix on tensor algebra)
- Exercices corrigés de mécanique des milieux continus, H. Dumontet, F. Léné, P. Muller, N. Turbé, G. Duvaut. Paris, Dunod , 1998. (only available at the library of the university)

Other books:
- Introduction to the mechanics of a continuous medium, L.E. Malvern, Prentice-Hall, 1969.
- An introduction to continuum mechanics, M.E. Gurtin, Academic Press, 1981.

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Industry, innovation and infrastructure / Sustainable cities and communities

Sustainable Development and Social Responsibility Positioning

This course contributes to sustainable development by providing the mechanical modeling tools required to design safer, more durable, and resource-efficient structures and mechanical systems. By promoting rigorous analysis and responsible engineering practices, it supports the reduction of material waste through informed decision-making.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

Conferences [CONF]

LEAD PROFESSOR(S): Laurent GORNET

Objectives

how to write a report
how to make a technical presentation

Course contents

how to write a report
how to make a technical presentation
homework
oral defense

Sustainable Development Goals (SDGs) covered by this course

Quality education

Sustainable Development and Social Responsibility Positioning

A teaching program on scientific writing and presentation primarily contributes to (Quality Education) and (Innovation and Infrastructure), but it also indirectly touches SDGs like (Responsible Consumption), and (Strong Institutions), especially if the focus is on ethics and science accessibility. Skills targeted: rigor, critical thinking, information synthesis, clear communication. Skills targeted: summarizing results, science communication, oral and visual communication. Associated SDGs: Quality Education: Promotes skills in research, critical reading, and scientific communication. Industry, Innovation and Infrastructure: By facilitating the dissemination of reliable scientific results, it supports innovation and technological progress. Responsible Consumption and Production: Scientific writing encourages transparency, ethics, and responsible use of data.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	-	6 hrs	0 hrs	0 hrs	0 hrs	0 hrs

Fluid Mechanics 1 [FLUM1]

LEAD PROFESSOR(S): Guillaume DUCROZET

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Describe the main physical properties of a fluid.
- Identify the specificity of fluid mechanics in the continuum mechanics framework (i.e. compared to solid mechanics).
- Identify the non-dimensional numbers at play in any fluid mechanics problem and deduce how to perform experiments with appropriate similarity.
- Understand the notion of stresses and its representation through stress tensor.
- Describe the physical meaning of each term in the Navier-Stokes' equations
- Identify the different flow regimes.
- Evaluate the generalized force applied on any object in still water.
- Understand when the perfect fluid assumption is valid.

Course contents

This course aims to present the foundations and general principles of fluid mechanics. The lectures cover the following topics:

- Physics of fluids
- Dimensional analysis
- Stress tensors and fluids
- Navier Stokes' equations
- Flow regimes: introduction to turbulence
- Fluid statics
- Bernoulli's equation for a perfect fluid

In addition to those lectures, tutorials and lab sessions will allow the students to apply the theoretical knowledge to practical configurations.

Course material

- F. White, Fluid mechanics, McGraw-Hill, New York.
- B.R. Munson et al., Fundamentals of fluid mechanics, John Wiley, New York.

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Clean water and sanitation / Climate action / Goo health and well-being / Industry, innovation and infrastructure / Life below water / Life on land / Sustainable cities and communities

Sustainable Development and Social Responsibility Positioning

The Fluid Mechanics 1 course incorporates sustainable development considerations, notably through the application examples presented in the lectures and the topics addressed during tutorial sessions. Owing to its disciplinary nature, the knowledge and skills acquired may be applied across a wide range of fields related to sustainable development.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	14 hrs	12 hrs	4 hrs	0 hrs	2 hrs

Marine Hydrodynamics 1 [MARHY1]

LEAD PROFESSOR(S): Félicien BONNEFOY

Requirements

Fluid Mechanics 1

Objectives

The objectives of this course are to provide students with a general overview of the use of hydrodynamics in marine and ocean engineering, including the modeling and physics of free surface flows, hydrostatics, and the stability of floating structures. This broad overview will be further explored in subsequent courses of the Master's program.

Course contents

Lesson 1 - Industrial R&D and Research Activities in Free Surface Hydrodynamics and Ocean Engineering
A comprehensive overview of the engineering problems and applied research related to hydrodynamics is presented.

Lesson 2 - Introduction to the Experimental Approach in Hydrodynamics
Physical problems that can be addressed using experimental methods and related facilities (such as towing tanks and wave tanks) are introduced.

Lesson 3 - Introduction to Wave-Structure Interaction
The spectral description of water waves is introduced, along with key concepts in marine structure design, including natural periods, buoyancy, wave loads, moorings, extreme loads, and fatigue.

Lesson 4 - Hydrostatics and Stability of Ships and Marine Structures
The intact and damaged stability of floating structures is examined through both theoretical and practical perspectives. Computer lab work is conducted using state-of-the-art industry software.

Course material

- J.N. Newman, Marine Hydrodynamics, The MIT press, 1977
- O. Faltinsen, Sea Loads on Ships and Offshore Structures, Cambridge Ocean Technology Series, 1993
- V. Bertram, Practical Ship hydrodynamics, Elsevier, 2012 (2nd Edition)
- A.J. Hermans, Water Waves and Ship Hydrodynamics: An Introduction, Springer, 2010 (2nd Edition)
- Biran, Ship Hydrostatics and Stability, Butterworth-Heinemann, 2003
- J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer
- https://ittc.info/downloads/proceedings/ : proceedings of ITTC conferences

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Industry, innovation and infrastructure

Sustainable Development and Social Responsibility Positioning

Marine and ocean engineering plays a central role in addressing major societal and environmental challenges related to climate change, energy transition, coastal resilience, and the sustainable use of marine resources. This course, by providing fundamental knowledge in hydrodynamics, free-surface flows, hydrostatics, and the stability of floating structures, contributes directly to these objectives.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	12 hrs	6 hrs	12 hrs	0 hrs	2 hrs

Numerical Methods [NUMME]

LEAD PROFESSOR(S): Grégory LEGRAIN

Requirements

Mathematics for engineers
Programming basis

Objectives

At the end of the course (30 hours + personal work) the students will be able to:
- Classify standard second order PDEs (elliptic, parabolic, hyperbolic)
- Solve simple elliptic problems by means of finite differences or finite elements
- Determine the level accuracy of the schemes they use (convergence order)
- Program finite differences and finite elements in both 1D and 2D

Course contents

These lectures aim to present standard numerical methods, their features and limitations.

- Classification of PDEs
- Classification of boundary conditions, well-posed problems
- Introduction to finite differences (1D, 2D)
- Introduction to finite elements (1D, 2D)

Homework and lab sessions will provide an understanding of the programming and main features of the methods.

Course material

- The Finite Element Method: Linear Static and Dynamic Finite Element Analysis. T.J.R. Hughes
- Numerical Methods for Engineers and Scientists. J.D. Hoffman and S. Frankel

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Goo health and well-being / Industry, innovation and infrastructure

Sustainable Development and Social Responsibility Positioning

The course presents the use of mathematics and the numerical approaches necessary for the modelling of environmental phenomena. It also discusses their use for the optimization of industrial designs and processes.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	16 hrs	4 hrs	10 hrs	0 hrs	2 hrs

Tools and Methods for Research 1 [TOME1]

LEAD PROFESSOR(S): Christian BURTIN

Objectives

At the end of the course, the students will be able to:

- Write a scientific and technical paper on mechanical engineering area
- Establish the reasoning of scientific paper writing
- Present orally and clearly scientific data in the context of mechanical engineering
- Write the abstract on an article

Course contents

The goal is preparing undergraduate students to start a PhD or any relative research activity (academic or industrial) in the context of mechanical engineering. The course INITR is composed of four main parts :

Part A : lecture on IMRAD concept
Part B : Scientific paper reading and analysis based on IMRAD
Part C : Oral presentation and discussion
Part D: How to write the abstract of an article

These parts represent how to organize and publish (Part B and part D), how to communicate (Part C) and how to prepare and present a technical and scientific report (Part A). Applications are given for engineering works.

Sustainable Development Goals (SDGs) covered by this course

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	2 hrs	12 hrs	0 hrs	0 hrs	0 hrs

Cultural and Communication English [CCE1]

LEAD PROFESSOR(S): David TROYA

Objectives

This course aims at improving your critical thinking and persuasion skills in English. Using documentaries, we will explore, discuss and debate a range of cultural, political, social, and environmental issues relevant to current world events.

Speaking and understanding English as a second or third language is a great achievement, but does it mean you are an effective communicator? The next step involves, among other things, critical thinking and persuasive skills, both of crucial importance in the modern professional environment. We will address these issues by analyzing documentaries that will lead to formal debates.

Several competencies will be developed through class exercises. Oral presentations will be an opportunity put your verbal as well as your non-verbal communication skills into practice. During debate, you will be able to sharpen your analytical skills, provide constructive feedback, defend an argument, and prove a point.

Course objectives

- Improving your communication skills

- Becoming an active listener

- Enhancing your non-verbal communication skills

- Developing critical thinking toward media

- Boosting leadership skills through moderating

- Organizing evidence and arguments

Course contents

Each session will be dedicated to a particular cultural, political, social or environmental topic of relevance in the wider anglophone world. Each topic will include multimedia material in the form of a short documentary or documentary excerpt. During class, students will lead a primer presentation, a moderated discussion and a formal debate.

Primer Presentation:

In pairs, you will hold a short talk to prime us on the topic of that week's documentary: you will introduce us to the topic by setting it in a wider context and establishing what's at stake.

Moderated Discussion :

In pairs, you will moderate a discussion related to the themes explored by the documentary. Moderators will come prepared with open-ended questions pertaining to the strengths and weakness of the documentary. They will distinguish between content and form and encourage critical, constructive opinions.

Formal Debate:

What's the difference between an opinion and an argument? You will soon find out. After the moderated discussion, we will brainstorm potential topics for debate, and follow the British Parliamentary model to sharpen your research, critical thinking, and persuasive skills.

During the debate, each speaker will be assigned an audience member who evaluates their individual performance and provides a short debrief. A panel of two judges will determine which side wins.

Course material

Written and televised press, information and digital tools, general documents, business environment and company strategies. Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).

Sustainable Development Goals (SDGs) covered by this course

Climate action / Industry, innovation and infrastructure / Partnership s for the goals / Quality education / Reduced inequalities

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Spanish Language [ESP1]

LEAD PROFESSOR(S): Marta HERRERA

Objectives

For beginners:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of vocabulary and linguistic structures
Be able to talk about yourself and those around you
Be able to express oneself during daily activities
Know how to give your opinion

For advanced students:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of specialised vocabulary
Be able to understand the essential content of concrete or abstract subjects including a technical discussion
Be able to communicate spontaneously and fluently
Be able to express oneself in a clear and detailed manner, to express an opinion on a topical subject

Course contents

For beginners:
Personal environment (introduce yourself, express yourself, your tastes, your character, your hobbies, etc.), your surroundings (friends, family, location, climate), your interests (sports, leisure)
Present tense (regular and irregular)
Language patterns to express habit, obligation, "gustar" and its equivalents,
Possessive adjectives
Differences between "es", "está", "hay"
Use of "por" and "para"
Adverbs and frequency patterns
Numeral adjectives

For advanced students:
Knowledge of the Hispanic world (economic, technical, cultural and social environment)
Present tense (regular and irregular)
Imperative
Past tenses
Direct / indirect style
Future tense
Conditional tense
Present and past subjunctive moods

Course material

Preparation manuals, our own tailor-made documents, written and internet press, general civilization documents, digital tools

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Decent work and economic growth / Gender equality / Goo health and well-being / Industry, innovation and infrastructure / No poverty / Partnership s for the goals / Peace, justice and strong institutions / Quality education / Reduced inequalities / Responsible consumption and production / Sustainable cities and communities / Zero hunger

Sustainable Development and Social Responsibility Positioning

Key competencies for sustainability Collaboration: the abilities to learn, to understand and respect others; to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving. Critical thinking: the ability to reflect on one's own values, perceptions and actions. Self-awareness: the ability to reflect on one's own role in a group; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
Spanish	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

French Language [FLE1]

LEAD PROFESSOR(S): Silvia ERTL

Requirements

N/A

Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources.
Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

Course contents

Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Gving and obtaining factual information:
- personal information (e.g. name, address, place of origin, date of birth, education, occupation)
- non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:
- meeting people and making acquaintances
- extending invitations and reacting to being invited
- proposing/arranging a course of action
- exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:
- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases
- ordering food and drink

Course material

Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

Sustainable Development Goals (SDGs) covered by this course

Quality education

Sustainable Development and Social Responsibility Positioning

Targeted competencies extracted from: Education for sustainable development goals, learning objectives (UNESCO) https: //unesdoc.unesco.org/ark:/48223/pf0000247507 https://www.coe.int/fr/web/common-european-framework-reference-languages/official-translations-of-the-cefr-global-scale

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	48 hrs	0 hrs	0 hrs	0 hrs

Energetics [ENERG]

LEAD PROFESSOR(S): Xavier TAUZIA

Requirements

basics of thermodynamics

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Understand a complex energetic system
- Make a comprehensive application of the laws of thermodynamics
- Determine the pertinent information to describe the system
- Identify the nature of the transformations
- Establish an equation of energy balance
- Calculate the characteristic parameters of a two-phase flow
- Calculate the power and efficiency of different thermal machines
- Calculate heat flux in processes involving conduction and convection

Course contents

The main objective of the course is for students to acquire the fundamental principles of thermodynamics and to apply them to the study of industrial processes involving energy transformation or transfer phenomena. The main elements covered in the course are:

- Principles of thermodynamics and selected elementary results: closed/open systems, perfect and real fluids.
- Energy transformations-compressors, nozzles, turbines, expander.
- Phase transitions: properties of mixtures, thermodynamic tables and diagrams.
- Thermodynamic cycles and thermal machines. Direct cycles: Carnot, Rankine, Hirn, reheating cycles, Joule's cycle, Otto and Diesel cycles.
- Introduction to turbocharging.
- Inverse compression cycles: Carnot and Joule's cycles, heat pump, refrigeration and air conditioning. Humid air. Steam absorption cycles.
- Thermodynamics of unbalanced systems - general principles. Heat transfer. Newton and Fourier's laws.
- Thermodynamic study of heat radiation. Black bodies, Planck, Stefan, and Kirchoff laws.

Course material

- Thermodynamics: An Engineering Approach, By Yunus Cengel, Michael Boles and Mehmet Kanoglu, Mc Graw Hill
- Fundamentals of thermodynamics, Sonntag, Borgnakke & Van Wylen (Wiley ed.)
- Fundamentals of Engineering Thermodynamics, 9th Edition, Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey
- Thermodynamique de l'ingénieur, Olivier Cleynen

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

This course addresses sustainable development during lectures and tutorials by introducing the fundamental principles of thermodynamics and providing concrete examples of applications that can: - improve the energy efficiency of a conversion system used, for example, for electricity, heat or cooling production, or for propulsion; - reduce heat losses in an energy system (e.g., a building); - reduce greenhouse gas emissions.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

Fluid Mechanics 2 [FLUII]

LEAD PROFESSOR(S): Guillaume DUCROZET

Requirements

Fluid Mechanics 1

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Apply the potential flow theory to simple configurations in fluid dynamics.
- Identify the limitations of the potential flow theory.
- Identify the sources of head loss in an internal flow.
- Evaluate the necessary power of a pump in a hydraulic system.
- Calculate the forces exerted on an object in a flow using Euler's theorem.
- Design experimental facilities for head loss identification and force measurements.

Course contents

This course is a follow-up to 'Fluid Mechanics 1', which presents the fundamentals and general principles of fluid mechanics. The aim is now to provide simple tools/formula to extract global information which is useful from an engineering point of view for fluid mechanics problems. The lectures cover the following topics:

- Potential flows
- Transport theorems and integral balances in fluid mechanics
- Head losses and the generalized Bernoulli's equation
- Momentum balance: Euler's theorem

In addition to those lectures, tutorials and lab sessions (4 3h-lab sessions) will allow the students to apply the theoretical knowledge to practical configurations.

Course material

- F. White, Fluid mechanics, McGraw-Hill, New York.
- B.R. Munson et al., Fundamentals of fluid mechanics, John Wiley, New York.

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Clean water and sanitation / Climate action / Goo health and well-being / Industry, innovation and infrastructure / Life below water / Life on land / Sustainable cities and communities

Sustainable Development and Social Responsibility Positioning

The Fluid Mechanics 2 course incorporates sustainable development considerations, notably through the application examples presented in the lectures and the topics addressed during tutorial sessions. Owing to its disciplinary nature, the knowledge and skills acquired may be applied across a wide range of fields related to sustainable development.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	8 hrs	10 hrs	12 hrs	0 hrs	2 hrs

Marine Hydrodynamics 2 [MARHY2]

LEAD PROFESSOR(S): Antoine DUCOIN

Objectives

Objectives
The objectives of this course are to give a general overview to students about:
- Classes of approximation in hydrodynamics for modelling of some typical problems
- numerical simulation in Hydrodynamics
- specificities of flows around lifting profiles and their application to naval engineering or Marine Renewable Energies
This global overview will be then detailed in other courses of the Master program.

After completing the course, students will be able to:
- Classes of approximation in hydrodynamics:
▪ Know which mathematical models are available in hydrodynamics for ocean engineering
▪ Select which mathematical models are adapted for different typical problems in ocean engineering
- Numerical simulation:
▪ Methodology for numerical simulation: how to go from modelling to analysis of results
▪ How is numerical simulation used in marine hydrodynamics at present time?
- Lifting profiles:
▪ Design a blade for marine propellers and wind/tidal turbines applications
▪ Calculate performance using potential flow theory
▪ Determine which flow regime could occurs around the lifting profile and be able to determine its direct effect on hydrodynamic performance

Course contents

Introduction to Numerical Simulation
▪ Following parts will be described:Methodology for numerical simulation of a physical problem
▪ Space and time discretization
▪ Discrete equations solving
▪ Convergence, verification and validation

Lifting profiles
The objective is to understand the fundamentals of lifting profiles, focusing on the specificity of marine applications. We will focus on the main operating principle, followed by an understanding of flow physics around marine profiles and their resulting performances. The theory focuses on potential flow theory to calculate the flow around a lifting profile, and to obtain the performances.
▪ Basics and applications
▪ Flow physics – hydrodynamics: characterization of flow regimes, performance analysis
▪ Methods and theory: thin profiles theory, lifting line theory
▪ Tutorial: calculate the performances of a NACA section using the thin profile theory
▪ Lab sessions: coding of lifting line theory using Matlab to analyse the effect of various blade geometries and aspect ratio on the hydrodynamic performances

Course material

Guyon, E., Hulin, J.P., Petit, L. Hydrodynamique physique, 3ème édition (in French), Editions du CNRS (available on internet)
Newman, J.N. Marine Hydrodynamics, The MIT press, 1977
Bertram, V. Practical Ship hydrodynamics, Elsevier, 2012 (2nd Edition)
Ferziger, J.H., Peric, M. Computational Methods for Fluid Dynamics, Springer, 2002 (available on internet)
Abott, I. H., Von Doenhoff, A.E. Theory of wing sections, Dover publication, 1949
Glauert, H. Airplane propellers. In: Durand WF, editor. Aerodynamic theory. New York: Dover Publications, 1963

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Industry, innovation and infrastructure

Sustainable Development and Social Responsibility Positioning

Contribution to Sustainable Development Challenges The teaching of numerical simulation applied to fluid mechanics and lifting surfaces directly contributes to sustainable development challenges by training future engineers in the modeling, analysis, and optimization of flows around lifting surfaces, with a focus on energy performance, hydrodynamic efficiency, and energy efficiency. Mastering numerical simulation tools enables students to: -optimize designs (propellers, wings, wind or tidal turbine blades) to reduce energy consumption and associated emissions, -limit costly experimental tests in terms of material and energy resources, thereby reducing the environmental footprint, -design safer and more sustainable flow-based systems adapted to the naval and marine renewable energy sectors. Societal Challenges and Engineers' Responsibility This course contributes to the education of responsible engineers who are aware of their societal role and are able to: -design lifting surfaces and marine systems that ensure the safety and reliability of installations, -integrate environmental and social impacts into technological choices (social acceptability, ecosystem protection, noise or vibration nuisances), -contribute to the development of technologies that promote more sustainable mobility and energy production.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	22 hrs	2 hrs	6 hrs	0 hrs	2 hrs

Propulsion [PROPUL]

LEAD PROFESSOR(S): Georges SALAMEH

Requirements

energetics

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Describe the main parts of a reciprocating piston engine and of an automotive powertrain
- Distinguish between various types of engine: 4 stroke/2 stroke; SI/CI; NA/supercharged/turbocharged
- Describe the main internal processes and their interactions
- Calculate theoretical cycles
- Evaluate engine performance and efficiency
- Describe the main parts of a gas turbine and a turbojet/turbofan

Course contents

These introductory lectures aim to present the main characteristics of IC engines, the main thermofluid processes involved and the main performance and energy conversion calculations.

This course also presents briefly gas turbine and aircraft engines. The contents are as follows:

- Main engine parts
- Theoretical cycles
- Geometrical characteristics
- Performance and efficiency indicators
- Intake and exhaust systems
- Supercharging and turbocharging - downsizing
- Types of fuel and fuel systems
- Combustion (SI and CI) and emissions – after-treatment
- Automotive powertrain: clutch, manual gearbox, automatic GB, CVT, power requirement, hybridization
- Gas turbines and aircraft engines

Course material

- JB Heywood, Internal Combustion Engine Fundamentals, Mc Graw Hill 1995
- W Pulkrabek Engineering Fundamentals of the Internal Combustion Engine, Pearson 2013

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Industry, innovation and infrastructure

Sustainable Development and Social Responsibility Positioning

The teaching trains students on the principles of thermodynamics and energy production cycles for propulsion.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

Structural Mechanics [STRME]

LEAD PROFESSOR(S): Patrice CARTRAUD

Requirements

Continuum mechanics, finite element method

Objectives

This course is an introduction to structural mechanics, focuses more particularly on the study of the equilibrium of linear elastic slender structures like beams, but also lattice trusses, undergoing infinitesimal strain and displacements in order to design them with respect to external loads. This will provide some of the basic tools for engineers to design simple mechanical systems with simplified approaches. The basic concepts required for this course will have already been introduced in the continuum mechanics course during the first semester. These concepts are here particularized for slender structures; the same methodology of analysis of a problem is also followed during this course.
The first part of the course focuses on theory and analytical methods. The last one is dedicated to the use of finite element method for trusses and beams.

At the end of the course (30 hours + personal work), the students will be able to:

- understand what are the key points in defining the kinematics of a beam.
- define the problem of the equilibrium of a beam or a lattice trusses in infinitesimal strain by writing a Boundary Value Problem (BVP), and choose the right set of boundary conditions.
- understand the different possible approaches available for the solution of that BVP, and solve it.

Course contents

The course outline is as follows:

- Study of 3D solutions of beams: torsion and pure bending
- Introduction to the Bernoulli beam theory:
- kinematics,
- modelling of internal forces,
- equilibrium and boundary conditions,
- writing of the Boundary Value Problem (BVP).
- Study of the in-plane bending subproblem.
- Force and displacement solution approaches
- Isostatic/hyperstatic beams, and strength criteria applied to beams
- Study of lattice trusses
- writing of the Boundary Value Problem (BVP); solution.
- Finite elements modeling
- case of trusses, beams and frames

Course material

- Beams, plates and shells. Donnell Lloyd Hamilton (1976). Mc Graw-Hill.
- Poutres et arcs élastiques. Patrick Ballard, (2009), Editions de l'Ecole Polytechnique.
- Handbook of Structural Mechanics. (2001) Patrice Cartraud.
- Poutre et plaques. Jean-Louis Batoz (1990). Editions Hermès.
- Théorie des poutres. Serge Laroze (1980). Paris Eyrolles.
- Mécanique des structures. Tome2: Poutres. Serge Laroze. Éditeur Toulouse Cépaduès-Éd. DL 2005.
- Mécanique des structures. Tome 5: Poutres exercices. Serge Laroze. Éditeur Toulouse Cépaduès-Éd. DL 2005,

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Quality education

Sustainable Development and Social Responsibility Positioning

This course aims in particular to provide students with the skills to design structures effectively, thereby contributing to more sustainable design.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	16 hrs	14 hrs	0 hrs	0 hrs	2 hrs

Tools and Methods for Research 2 [TOME2]

LEAD PROFESSOR(S): Guillaume DUCROZET

Objectives

This is the first introduction to laboratory research activities in view of testing the attitude of students to applied research and scientific development.

Course contents

The academic module consists of a project mostly within the domain of the research activities of the teaching staff.

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Industry, innovation and infrastructure / Sustainable cities and communities

Sustainable Development and Social Responsibility Positioning

This course incorporates sustainable development considerations into the selection of student projects. These projects demonstrate varying degrees of connection to this theme, depending on the opportunities available at the time the projects are undertaken.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	5	0 hrs	0 hrs	0 hrs	32 hrs	0 hrs

Cultural and Communication English [CCE2]

LEAD PROFESSOR(S): David TROYA

Objectives

Interview techniques and communicational English:

- Understand the general concepts of interactive communication
- Build a media project
- Acquire interview techniques
- Understand the process of sourcing and checking facts and figures
- Understand issues related to plagiarism
- Create a bibliography
- Behavioral skills in an inter-cultural environment:
- Strengthen self-confidence and capacity for interaction
- Develop active listening and reformulation skills
- Develop networking skills

Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication.
Media project (for example: prepare, conduct and promote interviews for a radio programme: L'Heure Centralienne (http: //www.euradionantes.eu/emission/l-heure-centralienne), with the contribution of professors, PhD students, industrial partners, industry players at fairs, etc.

Course material

Written and televised press, information and digital tools, general documents business environment and company strategies. Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).

Sustainable Development Goals (SDGs) covered by this course

Gender equality / Industry, innovation and infrastructure / Partnership s for the goals / Quality education / Reduced inequalities / Sustainable cities and communities

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Spanish Language [ESP2]

LEAD PROFESSOR(S): Marta HERRERA

Objectives

For beginners:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of vocabulary and linguistic structures
Be able to talk about yourself and those around you
Be able to express oneself during daily activities
Know how to give your opinion

For advanced students:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of specialised vocabulary
Be able to understand the essential content of concrete or abstract subjects including a technical discussion
Be able to communicate spontaneously and fluently
Be able to express oneself in a clear and detailed manner, to express an opinion on a topical subject

Course contents

For beginners:
Personal environment (introduce yourself, express yourself, your tastes, your character, your hobbies, etc.), your surroundings (friends, family, location, climate), your interests (sports, leisure)
Present tense (regular and irregular)
Language patterns to express habit, obligation, "gustar" and its equivalents,
Possessive adjectives
Differences between "es", "está", "hay"
Use of "por" and "para"
Adverbs and frequency patterns
Numeral adjectives

For advanced students:
Knowledge of the Hispanic world (economic, technical, cultural and social environment)
Present tense (regular and irregular)
Imperative
Past tenses
Direct / indirect style
Future tense
Conditional tense
Present and past subjunctive moods

Course material

Preparation manuals, our own tailor-made documents, written and internet press, general civilization documents, digital tools

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Decent work and economic growth / Gender equality / Goo health and well-being / Industry, innovation and infrastructure / Life on land / No poverty / Partnership s for the goals / Peace, justice and strong institutions / Quality education / Reduced inequalities / Responsible consumption and production / Sustainable cities and communities / Zero hunger

Sustainable Development and Social Responsibility Positioning

Key competencies for sustainability Collaboration: the abilities to learn, to understand and respect others; to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving. Critical thinking: the ability to reflect on one's own values, perceptions and actions. Self-awareness: the ability to reflect on one's own role in a group; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
Spanish	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

French Language [FLE2]

LEAD PROFESSOR(S): Silvia ERTL

Requirements

N/A

Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources.
Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

Course contents

Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Giving and obtaining factual information:
- personal information (e.g. name, address, place of origin, date of birth, education, occupation)
- non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:
- meeting people and making acquaintances
- extending invitations and reacting to being invited
- proposing/arranging a course of action
- exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:
- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases

- ordering food and drink

Course material

Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

Sustainable Development Goals (SDGs) covered by this course

Quality education

Sustainable Development and Social Responsibility Positioning

Targeted competencies extracted from: Education for sustainable development goals, learning objectives (UNESCO) https: //unesdoc.unesco.org/ark:/48223/pf0000247507 https://www.coe.int/fr/web/common-european-framework-reference-languages/official-translations-of-the-cefr-global-scale

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	48 hrs	0 hrs	0 hrs	0 hrs