CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2023-2024

YEAR 2

MECHANICAL ENGINEERING

ENERGETICS AND PROPULSION

PROGRAMME SUPERVISOR(S):

Xavier TAUZIA

YEAR 2 - Autumn Semester

CORE COURSES

Course code	Title	ECTS Credits
COMBU	Combustion	4
GDAHT	Gas Dynamics and Heat Transfer	4
HYBRID	Hybrid Powertrain and Energy Management	4
ICENG	Internal Combustion Engines	4
LABSIM	Practical and Simulation	4
PROJECT	Project	4
TUMAC	Turbomachinery	4

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE3	Cultural and Communication English	2
ESP3	Spanish Language	2
FLE3	French Language	2

YEAR 2 - Spring Semester

CORE COURSES

Course code	Title	ECTS Credits
THESIS	Master Thesis or Internship	30

Combustion [COMBU]

LEAD PROFESSOR(S): Alain MAIBOOM

Objectives

The main objectives are:

- To provide fundamental knowledge on combustion and pollutant emissions formation and reduction.
At the end of the course the students will be able to:
▪ Write combustion reactions in the case of stoichiometric or lean mixture
▪ Calculate the heating value from formation enthalpies
▪ Calculate the adiabatic temperature after combustion
▪ Evaluate auto ignition
▪ Calculate laminar flame velocity
▪ Use the mixing variable Z to describe diffusion flames

- To present some technical aspects of the combustion process in machines (internal combustion engine, gas turbines) and strategies to reduce pollutant emissions.

Course contents

The fundamental aspects of combustion are presented in the first part of the course. The main points presented in these lectures are:
▪ A brief introduction to combustion phenomena and the main applications
▪ Initial and final state: thermodynamics, equilibrium
▪ Chemical kinetics
▪ Reactive flow governing equations
▪ Auto-ignition
▪ Gaseous premixed flames
▪ Laminar diffusion flames
▪ Auto-ignition
▪ Gaseous premixed flames
▪ Laminar diffusion flames

The second part of the course deals with a study of combustion and the formation of pollutant emissions in the combustion chamber of some machines (piston engines and gas turbine). Strategies to reduce pollutant emissions are also covered. Practical class exercises are conducted and corrected as a part of the course.

Post-processing methods to reduce pollutant emissions are covered in a separate course.

Course material

▪ Poinsot & Veynante, Theoretical and Numerical Combustion
▪ http://elearning.cerfacs.fr/combustion/index.php

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

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

Gas Dynamics and Heat Transfer [GDAHT]

LEAD PROFESSOR(S): Xavier TAUZIA

Objectives

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

- Build a model with the simulation code (GT-Power)
- Run simulations and extract results
- Analyze and optimize the volumetric efficiency and performances of an engine
- Evaluate the main heat transfers (conduction, convection, radiation) under steady state and during transients
- Calculate heat-exchangers

Course contents

This course is composed of two independent parts:

Part I: Gas Dynamics
First, the students will learn to use the GT-Power software (practical sessions), a simulation tool used in order to study the behaviour of an engine. An application case is then proposed in order to study the influence of the intake characteristics and different technologies on the engine volumetric efficiency and performances..

Part 2: Heat Transfer
The main heat transfer processes are presented, as well as the governing equations. Specific methods used for heat-exchanger design are also provided. Tutorials present some thermal applications.

Course material

- Internal Combustion Engines, Giancarlo Ferrari, Societa editrice Esculapio
- Fundamentals of Heat Exchanger Design, Shah and Sekulic, John Wiley & Sons
- Fundamentals of thermodynamics, Borgnake and Sonntag, John Wiley & Sons

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	6 hrs	12 hrs	12 hrs	0 hrs	2 hrs

Hybrid Powertrain and Energy Management [HYBRID]

LEAD PROFESSOR(S): Xavier TAUZIA

Objectives

At the end of the course the students will be able to:
- Learn the fundamentals principle of fuel economy trough hybridization
- Distinguish between the different types of hybrid drivetrain and their interfaces with the vehicle
- Dimension a hybrid system (ICE, E-Motors, Energy Storage, Gear Ratio, etc)
- Evaluate the main energy fluxes in a vehicle
- Understand the advantages but also the imitations of hybrid drivetrains

Course contents

These introductory lectures aim to present the different hybrid powertrains and the key points of a hybrid vehicle

Lectures:
- General knowledge on hybrid powertrain: ICE use at its best efficiency, Energy regeneration,
- Drivetrain architecture: Parallel, Serie, Serie-Parallel
- Hybrid levels : Micro-hybrid, Mild-hybrid, Full-hybrid, Plug-in hybrid, Range-extanders
- Electric motors general knowledge: Operation, Losses, Efficiency analysis
- General knowledge on Batteries: Main chemistry used, thermal behavior and thermal management, risks and materials extraction
- Other energy storages
- Other knowledge on hybrid vehicles: Weight reduction, aerodynamic optimization, market analysis and public mindset evolution

Lab sessions:
Analysis of Series-Parallel Transmission and Atkinson cycle gasoline engine of a Toyota Yaris Powertrain. Comparison with a 508 HY Powertrain, in order to visualize the components and their usage in different applications

Project:
Development of a hybrid parallel powertrain on Simcenter AMESim software, organised in small groups (2 students):
- Analysis of the hybrid powertrain control strategy
- Optimization of the hybrid vehicle control unit strategy (Torque of the ICE, Transmission gearing)
- Modification of the hybrid parallel vehicle to maximize fuel economy (ICE change, weight and aerodynamic impact analysis, Plug-in system implementation) with development costs taken into account

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	12 hrs	2 hrs	0 hrs	2 hrs

Internal Combustion Engines [ICENG]

LEAD PROFESSOR(S): Xavier TAUZIA

Objectives

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

- Know the main parts of a reciprocating piston engine
- Know the main types of engines and their applications
- Calculate engine performance and efficiency using theoretical thermodynamic cycles
- Evaluate the engine and/or vehicle performance and efficiency using measured maps and/or data
- Calculate air and fuel flow rates using simplified assumptions
- Calculate a turbocharger / supercharger
- Calculate a thermodynamic energy recovery device

Course contents

The main points presented in these lectures are:

- Some technological aspects of reciprocating piston engines
- Geometrical parameters; performance and efficiency indicators
- Main engine applications
- Design and control strategies to improve efficiency
- Engine hybridization and energy recovery devices
- Intake and exhaust systems
- Air charging systems
- Fuel induction systems, new clean fuels
- Combustion and emission production
- Emissions reduction techniques and after-treatment devices

Course material

- J.B. Heywood, Internal Combustion Engine Fundamentals, McGrawHill
- W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, Pearson

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

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

Practical and Simulation [LABSIM]

LEAD PROFESSOR(S): Xavier TAUZIA

Objectives

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

- Simulate an internal combustion engine using 0D/1D commercial simulation software (AMESim)
- Optimize some engine design or engine control parameters using simulation
- Perform basic studies on an experimental test-rig
- Analyse experimental data

Course contents

This course is broken down into two separate parts.

Part I: Engine Simulation with AMESim:
- How to build a model using elements from various scientific libraries (multi-physics approach)
- How to run a model and analyse results
- How to use simulation to modify engine design and calibration in order to optimize performance / efficiency / emission reduction

Part II: Practical work
- Engine test bench
- Engine assembly
- Fan & Air turbine test rigs
- Heat exhanger test rig
- Combustion test rig

Course material

AMESim user manual and tutorials

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	4 hrs	12 hrs	16 hrs	0 hrs	0 hrs

Project [PROJECT]

LEAD PROFESSOR(S): Xavier TAUZIA

Objectives

The goal in this project course is for students to face a real world problem. They will need to apply both their technical skills and their project management skills to solve it - as would a design office team responding to a tender process for instance.

Course contents

Once the design brief is understood, each subgroup will have to split the workload in an efficient manner.

- A literature review will outline a set of technological solutions that could meet the requirements, as well as their pros and cons (readiness level, cost etc.)
- After making an educated choice amongst these technologies, a dimensioning of this solution will be necessary to propose a solution which meets the design brief's requirements
- A presentation defending the chosen solution alongside a written report will finish the job

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	0 hrs	0 hrs	0 hrs	48 hrs	0 hrs

Turbomachinery [TUMAC]

LEAD PROFESSOR(S): Georges SALAMEH

Objectives

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

- Understand the concept of a turbomachine and its different types: compressible and incompressible fluid turbomachines.
- Identify the different parts of a turbomachine and define the role of each.
- Calculate and draw the velocity triangles.
- Apply the similarity laws to different turbomachine applications.
- Describe the operating principle of a pump, a compressor and a turbine.
- Determine the required and the available net positive suction head of a pump.
- Understand the risk of cavitation and surge and identify their limits.
- Choose and dimension a turbomachine for a specific application (pump, gas turbine, turbocharger, turbojet etc).
- Define and calculate the different forms of efficiency (isentropic, polytropic, mechanical, volumetric, hydraulic etc) and determine their influence on the operating machine
- Use the performance maps of a turbomachine (turbine, compressor) with the similarity analysis.

Course contents

First, the general relationships describing the operation of a turbomachine and the classification of these machines will be presented. After presenting Euler's theorem, the layout and operation of a centrifugal pump will be detailed: wheel, pressure, and diffuser. The concept of efficiency of these machines will also be discussed and the phenomena of cavitation presented. An application for a compressible fluid machine will then be processed.

After detailing the operation of a turbocharger, the entropy diagram will be studied as well as the determination of efficiencies, various losses and work on the shaft. Thereafter, the characteristic curves of turbomachines (characteristic curves of compressors and turbines) will be analyzed. Finally, the relationships of similarity will be detailed. This course will end with the study of some application cases: start-up of a gas turbine, turbochargers, rocket turbopumps, etc.

Course material

- P. Chesse, Turbomachine à fluide compressible et incompressible (Ecole Centrale de Nantes)
- M. Pluviose, Machines à fluides, principes et fonctionnement (Edition ellipses 2010)
- M. Pluviose, Turbomachines hydrauliques et thermiques (Edition Eyrolles, 1988)
- M. Sedille, Turbomachines hydrauliques et thermiques, (Tomes 1,2,3, Masson Paris)
- D. Japiske and N.C. Baines, Introduction to turbomachinery (concepts ETI, Inc and Oxford Univ. Press)

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	12 hrs	18 hrs	0 hrs	0 hrs	2 hrs

Cultural and Communication English [CCE3]

LEAD PROFESSOR(S): David TROYA

Objectives

Team-building and Communicational English:
- Understand the general concepts of team-building
- Build a team-building project
- Understand and nurture the creative process
- Enhance self-belief and self-empowerment

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
Field-related or inter-cultural project.

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).

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 [ESP3]

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

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 [FLE3]

LEAD PROFESSOR(S): Silvia ERTL

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, 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. Those who already completed the first year of the French course will be prepared for working in a French business environment.

Course contents

Two different tracks are proposed: track 1 for students newly arrived at Centrale Nantes and track 2 for students who have completed the first year of the French course. Track 1:
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

Track 2:
This track follows on directly from the first-year French course, developing and completing the concepts studied thus far. The main themes are: housing, health and work. These topics will help prepare students for their future work environment. For example, housing is explored in the form of a search for accommodation upon arrival in a new city. Special workshops for CVs and cover letters, elevator pitches and job interviews.

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).

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

Master Thesis or Internship [THESIS]

LEAD PROFESSOR(S): Xavier TAUZIA

Objectives

- Be exposed to and adapt to an industrial or research environment
- Put in practice the scientific and technical skills acquired in the previous semesters
- Strengthen interpersonal and communication skills
- Be part of or manage a project
- Organize tasks, analyze results and build deliverables

Course contents

Students should be pro-active and career-oriented in the search for their thesis/internship. The topics are validated by the program supervisor to ensure an adequate Master level. The thesis/internship is evaluated through the submission of a written report and an oral defense.

Course material

- Turabian Kate Larimore, Booth Wayne Clayton, Colomb Gregory G., Williams Joseph M., & University of Chicago press. (2013). A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers (8th edition.). Chicago (Ill.) London: University of Chicago Press.
- Bui Yvonne N. How to Write a Master's Thesis. 2nd ed. Thousand Oaks, Calif: Sage, 2014.
- Evans David G., Gruba Paul, et Zobel Justin. How to Write a Better Thesis. 3rd edition. Carlton South, Vic: Melbourne University Press, 2011.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	30	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs