SHAKE THE FUTURE.

CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

MECHANICAL ENGINEERING

ENERGETICS AND PROPULSION

YEAR 2
AUTUMN SEMESTER

PROGRAMME SUPERVISORS:
XAVIER TAUZIA, SEBASTIEN COMAS-CARDONA

Établissement public sous tutelle du ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

GROUPE CENTRALE

École Centrale de Nantes | 1 rue de la Noë | BP 92101 | F 44321 Nantes Cedex 3
T +33 (0)2 40 37 16 00 | F +33 (0)2 40 37 16 97 | www.ec-nantes.fr

TURBOMACHINERY

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Georges Salameh, *georges.salameh@ec-nantes.fr*

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)

Keywords

Pumps, turbines, compressors, characteristic curve, wheel, impeller, blades, diffuser, distributor, volute, cavitation, surge, turbocharger

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	8 hrs	14 hrs	0 hrs	8 hrs	2 hrs

COMBUSTION

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Alain Maiboom, *alain.maiboom@ec-nantes.fr*

Objectives

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

Course contents

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

Course material

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

Keywords

Combustion, premixed flames, diffusion flames, auto-ignition, adiabatic flame temperature

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	20 hrs	10 hrs	0 hrs	0 hrs	2 hrs

GAS DYNAMICS AND HEAT TRANSFER

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: David Chalet, *david.chalet@ec-nantes.fr*

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 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 of the engine on volumetric efficiency.

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

- Fundamentals of Heat Exchanger Design, Shah and Sekulic, John Wiley & Sons
- Fundamentals of thermodynamics, Borgnake and Sonntag, John Wiley & Sons

Keywords

GT-Power, engine efficiency, Heat transfer, conduction, convection, radiation, heat-exchanger

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	6 hrs	8 hrs	12 hrs	4 hrs	2 hrs

INTERNAL COMBUSTION ENGINES

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Xavier Tauzia, *xavier.tauzia@ec-nantes.fr*

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
- 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

Keywords

Engine, thermodynamic cycles, energy conversion, combustion, intake and exhaust, air charging, pollutant emissions, hybridization, energy recovery devices, powertrain

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	20 hrs	10 hrs	0 hrs	0 hrs	2 hrs

HYBRID POWERTRAIN AND ENERGY MANAGEMENT

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Xavier TAUZIA, *Xavier.tauzia@ec-nantes.fr*

Objectives

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

- Distinguish between the different types of transmission (Manual, Automatic, DCT, CVT, etc)
- Distinguish between the different types of hybrid 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

Course contents

These introductory lectures aim to present the different hybrid powertrains and the key points of a hybrid vehicle, in order to allow discussion with specialists of each sub-system (ICE, E-Motors, Transmission etc).

Lectures:

- General knowledge on transmission:
  Mandatory representation and equation - Transmission landscape (types, particularity and market trends) - Drivetrain architecture: FWD, RWD, 4WD, Transaxle etc - MT - Automated MT (AMT) – DCT - AT: Basic knowledge - Transmission actuation device - CVT: Continuously Variable Transmission
- Hybrid transmission
- E-Drive
- Virtual All-Wheel-Drive
- Final Drive and Differential
- Energy storage

Lab sessions:
Analysis of Conventional Transmission, Toyota Yaris Powertrain and 508 HY Powertrain, in order to visualise the components and their usage in different applications

Project:
Development of a hybrid powertrain, organised in small teams (4 students) for each sub-system:

- ICE
- Energy storage
- E-Motors
- Transmission
- Hybrid supervisor (Torque, Speed, Efficiency)
- Vehicle simulation (Performance, Consumption) with Amesim-Drive (all)

Keywords

Hybrid, Transmission, ICE, Energy Storage, E-Motors

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	3	16 hrs	0 hrs	2 hrs	12 hrs	2 hrs

PRACTICAL AND SIMULATION

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Xavier Tauzia, *xavier.tauzia@ec-nantes.fr*

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 lecture is composed of two independent 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
- Fan test rig
- Air turbine test rig
- Combustion test rig

Course material

AMESim user manual and tutorials

Keywords

Multi-physics simulation, thermodynamic simulation, engine design, engine calibration, thermofluid experiments, energy balance, experimental uncertainties

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	3	0 hrs	0 hrs	16 hrs	16 hrs	2 hrs

MODERN LANGUAGES - FRENCH

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Silvia Ertl – *silvia.ertl@ec-nantes.fr*

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. 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.

Course material

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).

Keywords

reception (listening and reading), production (spoken and written), interaction (spoken and written), knowledge, skills, linguistic competence, sociolinguistic competence, pragmatic competence, register, cultural differences, non-verbal communication, business vocabulary

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
French	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

MODERN LANGUAGES – CULTURAL AND COMMUNICATIONAL ENGLISH

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Spencer Hawkridge- *spencer.hawkridge@ec-nantes.fr*

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 (for example, construct content for inter-cultural team-building activities; example WIOBOX website 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).

Keywords

Culture and communication, inter-cultural environment, team-building, digital tools, etc.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	14 hrs	16 hrs	0 hrs	0 hrs	2 hrs