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CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

MECHANICAL ENGINEERING

ENERGETICS AND PROPULSION

YEAR 1
SPRING SEMESTER

PROGRAMME SUPERVISORS:
CHRISTIAN BURTIN, SEBASTIEN COMAS-CARDONA

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

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ENERGETICS

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Jean-Francois HETET, *jean-francois.hetet@ec-nantes.fr*

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

- Thermodynamique et énergétique, M. BOREL (Presses polytechniques Romandes)
- Thermodynamique générale et application, R. KLING (Technip)
- Thermodynamique, J.P. PEREZ (Masson)
- Energétique, M. FEIDT (Dunod)
- Introduction aux problèmes énergétiques globaux, R. GICQUEL (Presses des Mines)
- Fundamentals of thermodynamics, Sonntag, Borgnakke & Van Wylen (Wiley ed.)
- Internal combustion engines, Fergusson (Wiley)
- Introduction to ICE, Stone (MacMillan)

Keywords

Entropy, Enthalpy, Reversibility, Irreversibility, two-phase flow, nozzle, Compressor, gas turbine, steam turbine, Cogeneration, heat pump, Conduction, Convection, radiation

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

PROPULSION

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION
YEAR 1 - SPRING SEMESTER

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

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 engines: 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

Keywords

IC engines, performance, efficiency, energy conversion, gas exchange process, supercharging and turbocharging, fuel system, combustion, pollutant emission, powertrain, clutch, gearbox, gas turbine, turbojet, thermodynamic cycle

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

HYDRODYNAMICS

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Antoine Ducoin, antoine.ducoin@ec-nantes.fr

Objectives

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

Lifting profiles (AD):

- Design a blade for marine propellers and wind/tidal turbines applications
- Calculate performance using potential flow theory
- Determine which flow regime could occur around the lifting profile and be able to determine its direct effect on hydrodynamic performance

Wave theory (PF):

- Explain hypotheses leading to the derivation of the Airy wave model
- Use this model to estimate wave characteristics
- Understand the limits of the model and have a qualitative knowledge of the influence of higher order effects

Course contents

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 the blades occurring in the marine environment and of the resulting performance. The methods will focus on potential flow theory to calculate the flow around a lifting profile, and to calculate the performance.

- Basics and applications
- Flow physics – hydrodynamics: characterization of flow regimes, performance analysis, flow control
- Methods and theory: Conformal mapping, thin profiles theory, lifting line theory
- Tutorial: calculate the performance of a NACA section using the thin profile theory
- Lab sessions: code the lifting line theory using Matlab to analyze the effect of various blade geometries and of the aspect ratio on hydrodynamic performance

Wave theory:
The main objective of the course is to give students access to basic knowledge on the main characteristics of water waves. The derivation of the classical linearized Airy wave model through the method of separation of variables is detailed. The related important physical properties of water waves are then examined:

- Dispersion effects
- Phase velocity, group velocity
- Energy density
- Energy flux
- Asymptotic limits in shallow and deep water

- Notion of wave power spectrum
- Qualitative influence of higher order effects

In addition, a review of ongoing research related to ocean waves and their interaction with structures is given, addressing both numerical and experimental approaches.

As an applicative exercise, students are asked to build Matlab programmes based on Airy theory with targets such as particle trajectories, drift motion in waves, estimation of hydrodynamic loads based on simplified load models, etc. These exercises are prepared in groups of 2 students, who are asked to prepare a short report on which the evaluation is based.

Course material

- Abott, Theory of wing section, Dover publication, 1947
- Newman, Marine Hydrodynamics, The MIT Press, 1977
- Glauert H. Airplane propellers. In: Durand WF, editor. Aerodynamic theory. New York: Dover Publications; 1963
- Campbell Flake C. Manufacturing Processes for Advanced Composites. New York: Elsevier, 2004
- R.G. Dean, R.A. Dalrymple, Water Wave Mechanics for Engineers and Scientists: World Scientific, 1984

Keywords

Lifting profiles, hydrodynamic performance, potential flow theory, water waves, Airy theory, wave energy

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

FLUID MECHANICS 2

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Guillaume Ducrozet, *guillaume.ducrozet@ec-nantes.fr*

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 different 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.

Keywords

Fluid Mechanics, Potential flows, Integral balances, Head losses, Force, Viscosity, Pressure, Navier-Stokes, Hydraulic system

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

MECHANICAL DESIGN

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Stéphane CARO, *stephane.caro@ls2n.fr*

Objectives

This course presents an overview of the product design process:

- How to identify customer needs and to transform it into specifications
- Basic knowledge in product design development
- Functional analysis and value analysis
- Interviews and focus groups

Course contents

Design is an engineering activity that affects almost all areas of human life, using the laws and insights of science, building upon special experience, and providing the prerequisite for the physical realisation of solution ideas.
This course will deal with all the phases of the design process of a product, namely: task definition, conceptual design, embodiment, detailed design.

Particular attention will be paid to the conceptual design phase as it is a distinct phase of the design process and 75% of total product life-cycle cost is committed at that stage.

The course is evaluated with a final project that is conducted by groups of two students. Projects are suggested by the instructor. Project proposals are discussed during the first lecture to allow students an early start. A final report is due at the end of the course. The final project is also presented orally.

The instructions for the project are the following:

- a market study of the product (enterprises, patents, etc)
- a definition of the need and a system analysis of the product
- the search for innovative solutions according to the product requirements
- a comparison of the different technical solutions identified by the student

Course material

- French, M. J. Conceptual Design for Engineers, 3rd ed., 1999 (Springer)
- Pahl, G. and Beitz, W. Engineering Design: A Systematic Approach, 2nd ed. Wallace, K.M. (editor); Blessing, L., Bauert, F. and Wallace, K.M. (translators), 1996 (Springer-Verlag, London)
- Suh, N.P. The Principles of Design, 1990 (Oxford University Press, Oxford)
- Suh, N.P. Axiomatic Design. Advances and Applications, 2001 (Oxford University Press, Oxford)

Keywords

Design process, Optimization, Product, Innovative design, Conceptual design

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

CONFERENCES AND INITIATION TO RESEARCH

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Christian Burtin, christian.burtin@ec-nantes.fr

Objectives

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

- write a scientific and technical paper on a mechanical engineering topic
- Establish the reasoning behind a scientific paper
- Present orally and clearly scientific data in the context of mechanical engineering

Course contents

The goal is to prepare students for a PhD or any relative research activity (academic or industrial) in the context of mechanical engineering. The course is composed of three main parts:

Part A: Conferences (2 hours)
Part B: Scientific paper reading (4 hours)
Part C: Oral presentation (2 hours)

These parts represent how to organize and publish (Part B), how to communicate (Part C) and how to discuss scientific data (Part A). Applications are given for mechanical engineering work.

Course material

Keywords

Mechanical Engineering, Conference, Scientific Paper, Oral communication

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	2	2 hrs	0 hrs	6 hrs	0 hrs	0 hrs

MODERN LANGUAGES - FRENCH

MECHANICAL ENGINEERING – ENERGETICS AND PROPULSION

YEAR 1 - SPRING 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.

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

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

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 1 - SPRING SEMESTER

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

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).
Our own eZoomBook template for the Intercultural project.

Keywords

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

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	30 hrs	0 hrs	0 hrs	2 hrs