SHAKE THE FUTURE.

CENTRALE NANTES

ENGINEERING PROGRAMME

SPECIALISATION

PROPULSION AND TRANSPORT

AUTUMN SEMESTER

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 74 74 06 | **www.ec-nantes.fr**

COMBUSTION AND POLLUTANT EMISSIONS

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Alain MAIBOOM

Objectives

This course has two main goals:

- Provide fundamental knowledge on combustion and pollutant emissions
- Present some technical aspects of the combustion process in machines (internal combustion engine, gas turbines) and strategies to reduce pollutant emissions.

Course contents

This course covers the main understanding of the processes linked to combustion, the formation of pollutant emissions and abatement techniques.

The fundamental aspects of combustion are presented in the first part of the course: chemistry, thermodynamics, initial and final states, enthalpy of formation, chemical kinetics, inflammation, laminar and turbulent combustion, physical and chemical mechanisms of pollutant formation during combustion.

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

Keywords

Chemical kinetics, pollutant emissions, combustion chamber, pollutant emission abatement

Links with other programmes

Applied Thermodynamics, Thermodynamic of engines, Gas dynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	12 hrs	18 hrs	0 hrs	0 hrs

TURBOMACHINERY

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Pascal CHESSE

Objectives

To understand how incompressible fluid (pump) and compressible fluid (turbine, compressor) turbomachines work.

Course contents

The course begins with a presentation of the general working principles of a turbomachine and a classification of turbomachines. The Euler theorem is then introduced followed by the layout and functioning of a centrifugal pump: wheel, pressure, diffuser. The course then deals with machine yield and cavitation.

An application for compressible fluid machines is then covered.

Following an explanation of how turbocompressors work, the focus turns to entropy charts, yield determination, other losses and shaft work. Then, typical turbomachine curves (compressor and turbine curves) are analysed.

Finally, the course examines turbomachine similarity and then concludes with a study of several practical exercises: powering up gas turbines, pressure-charging turbocompressors, jet turbopumps.

Course material

M. SEDILLE, Turbomachines hydrauliques et thermiques, Tomes 1,2,3, Masson Paris

M. PLUVIOSE, Turbomachines, Vuibert Ed.

Keywords

Pumps, turbines, typical curves, wheel, blades, diffuser, cavitation, compressor turbocharger

Links with other programmes

Gas dynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	8 hrs	14 hrs	0 hrs	8 hrs

APPLIED THERMODYNAMICS

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Jean-Francois HETET

Objectives

This course aims provide knowledge of the principal notions of fluid mechanics and energetics. These skills are necessary tools for any engineer who intends to pursue a career in the field of energetics and propulsion systems.

Course contents

The first part of the course presents simple compressible flow and how to model a flow, be it adiabatic or compressible etc.

Heat transfer basics are presented in the second part with application to real systems. Conduction and convection are introduced in this context. Then, a thermal analysis of a heat exchanger is undertaken to introduce the notion of logarithmic average value of temperature and the NUT number. This part of the course concludes with a case study on an exchanger and a full presentation of radiative heat transfer.

In the last part of the course the notion of exergy is introduced. Exergy leads to a better representation of the energy transfer in any system taking into account irreversibility (second law of thermodynamics). How to make an energy and exergy balance is the objective of this part with an application to some real systems (compressor, turbine, heat exchanger).

Course material

Michel FEIDT - Energétique: Concepts et Applications, Dunod Ed. (2006)
Lucien BOREL and Daniel FAVRAT - Thermodynamique et Energétique: de l'énergie à l'exergie, Presses polytechniques et universitaires romandes (2005)
Richard E. SONNTAG, Claus BORGNAKKE and Gordon J. VAN WYLEN - Fundamentals of thermodynamics, Ed. Wyley &Sons (1998)
Renaud GICQUEL - Systèmes énergétiques (3 volumes), Presses des Mines Paris Tech (2009)

Keywords

applied thermodynamics, heat exchanger, exergy balance

Links with other programmes

Gas dynamics, Turbomachinery, Energy management in automotive applications

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	8 hrs	22 hrs	0 hrs	0 hrs

INTERNAL COMBUSTION ENGINES

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Xavier TAUZIA

Objectives

The main goals are to provide:
1. the core elements on reciprocating internal combustion engines with a particular focus on thermodynamics;
2. a more detailed description of the main processes which take place in the engine, including technological aspects and strategies; interactions and trade-off are underlined;
3. an industrial point of view concerning mainly the calibration of automotive engines

Course contents

In the first part of the course the following points are presented: a historical perspective, the main characteristics, some technological aspects, the different types of engine, the characteristic dimensions, performance, and efficiency; intake and exhaust systems, supercharging and turbocharging, emission reduction, cooling, lubrication and friction.

In the second part, System engineering, V cycle, Powertrain objectives, control strategies, test facilities and calibration methods are described.

Some exercises on thermodynamic cycle calculation, performance and efficiency evaluation are solved during tutorial sessions.

Fuel systems and combustion are treated in the Combustion and Pollutant Emissions course. Fundamentals aspects of gas dynamics and turbomachinery are treated in Gas Dynamics and Turbomachinery courses.

Course material

J.B Heywood, Internal Combustion Engines Fundamentals, Mac Graw Hill, 2011
W.W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, Prentice Hall, 2003

Keywords

Performances & thermal efficiency, applied thermodynamics, system interactions, calibration

Links with other programmes

Applied Thermodynamics, Combustion and Pollutant Emissions, Gas Dynamics, Turbomachinery, Automotive propulsion, Energy management in automotive applications, Marine propulsion, Practical work in propulsion

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	**3**	**24 hrs**	**6 hrs**	**0 hrs**	**0 hrs**

GAS DYNAMICS

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: David CHALET

Objectives

The main goal is to study the compressible flow in different systems.

Course contents

In the first part of the course, gas dynamic equations are presented in steady state conditions.

Differents cases are studied:

- Quasi-monodimensional flows of a non-viscous compressible fluid-isentropic solution
- Laws of discontinuity associated with the conservative form of equations
- Quasi-monodimensional flows with shock: calculation techniques

Numerical aspects are also covered.

In the second part, non steady state equations are used and different techniques are studied (acoustic, 1D, transfer matrix, etc). The filling and emptying of internal combustion engines can be analyzed with these techniques.

Course material

Keywords

Gas dynamic, compressible flow, non-steady flow, steady flow, nozzle, internal combustion engine filling and emptying, acoustic

Links with other programmes

Applied Thermodynamics, Turbomachinery, Internal combustion engines, Aeronautical propulsion

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	22 hrs	0 hrs	0 hrs	8 hrs

PROJECT 1

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: David CHALET

Objectives

The objective of this project is to give students the possibility to learn GT-Suite software.

Course contents

Projects in Propulsion

Course material

Keywords

Links with other programmes

Applied thermodynamics, Combustion and pollutant emissions, Turbomachinery, Internal combustion engines, Gas dynamics, Energy management in automotive applications, Aeronautical propulsion, Automotive propulsion, Marine propulsion

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	1	0 hrs	0 hrs	0 hrs	32 hrs

ENERGY MANAGEMENT IN AUTOMOTIVE APPLICATIONS

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: David CHALET

Objectives

The aim is to identify the different energy flows in automotive propulsion in order to optimize the complete operation of the vehicle.

Course contents

First, an overview of the effects of the air flow in and around the vehicle will make it possible to study the vehicles relative movement with respect to the ambient air. This part focuses on the basic concepts of aerodynamics applied to automotive propulsion (consequence on the overall performance of the vehicle, and in particular its drag, which directly impacts fuel consumption).

The second part will identify vehicle cabin needs in term of cooling or heating but also to define the energy storage in battery.

The last part looks at engine thermal management. The topic will be introduced with a detailed explanation of the thermal balance of an engine, which will define the issues and the influential parameters. The specifics and principles of thermal management related to lubrication / cooling systems, admission and exhaust systems, engine under-cover and the electric motor / fuel cell will then be explained. The main existing or proposed technologies will be presented and discussed with particular attention to their impact on performance and engine emissions (low-performing technologies will also be discussed).

Course material

Keywords

Aerodynamics, energy flow, energy storage, thermal management

Links with other programmes

Applied thermodynamics, Internal combustion engines, Automotive propulsion

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	**3**	**30 hrs**	**0 hrs**	**0 hrs**	**0 hrs**

AICRAFT PROPULSION

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Vincent BERTHOME

Objectives

This is an advanced course on jet engines.

Course contents

This jet engine course cycle begins with the historical background of this technology.

Then the jet engine is studied, from its overall architecture to each and every element that composes the engine. Every aspect of engine design and construction is presented (thermal design, aerodynamics calculation, tests etc).

The final part of the course deals with helicopter engines.

Course material

Keywords

Aicraft engine, helicopter, jet engine

Links with other programmes

Applied Thermodynamics, Turbomachinery, Combustion and Pollutant Emissions, Gas dynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	30 hrs	0 hrs	0 hrs	0 hrs

AUTOMOTIVE PROPULSION

PROPULSION AND TRANSPORT, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: David CHALET

Objectives

The objective of this course is to study the different elements of an automotive propulsion system and to simulate this kind of system.

Course contents

In the first part, simulation software is used to implement the elements that have been studied in other courses. This leads in to studying the influence of factors related to vehicle (mass, Cx ...) or powertrain (engine, gear ratios, architecture, etc) on energy flow, fuel consumption and pollutant emissions reduction by post-treatment. It is thus possible to show the interest and limits of engine technologies (downsizing, cylinder deactivation, etc) or engine thermal management strategies.

The second part will identify vehicle needs (urban, road and motorway), vehicle effect parameters (mass, bearing losses, aerodynamics) on energy balance and environmental constraints. Following this, vehicle electrification will be considered (hybrid electric vehicles). This part concludes with an application.

Course material

Keywords

Automotive propulsion, powertrain, simulation

Links with other programmes

Applied thermodynamics, Internal combustion engines, Energy management in automotive applications

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	8 hrs	0 hrs	16 hrs	8 hrs