SHAKE THE FUTURE.

CENTRALE NANTES

ENGINEERING PROGRAMME

SPECIALISATION

AERONAUTICS

AUTUMN SEMESTER

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

GROUPE **CENTRALE**

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AIRCRAFT STRUCTURE MODELLING

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Laurent GORNET

Objectives

- Description of linear and nonlinear behavior laws for metallic and composite materials.
- Homogenization methods are presented for material and structure (composite beams).
- Simulations of crack initiation and propagation for static and fatigue loadings.
- Finite Element prediction with Abaqus of aeronautic structures with beam, shell and continuum elements.

Course contents

- Composite material homogenization techniques
- Fracture mechanics: energetic theory, singularity, crack propagations, example of fracture mechanics with a Finite Element code.
- Plasticity and instabilities
- Plasticity and instabilities for beam and shell models.
- Damage mechanics: method of local state, fatigue, phenomenology, behavior laws (metal and composite materials).
- Regularization techniques for stress softening behavior laws.
- Finite Element prediction until ultimate failure of aeronautic structures.
- Interactions between experimental data and behavior laws for material and structures

Course material

Aircraft Structures, for Engineering students, THG Megson, Butterworth Heinemann
Généralités sur les matériaux composites, L. Gornet, hal.archives-ouvertes.fr
Mécanique des matériaux solides, J. Lemaitre - JL Chaboche
Mechanics of Aircraft structures, C.T. Sun, Wiley

Keywords

Damage and fracture of materials, optimization of structures

Links with other programmes

Continuum mechanics, First year course in Modelling approaches in mechanical engineering

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	24 hrs	8 hrs	0 hrs	0 hrs

GAS DYNAMICS

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Guy CAPDEVILLE

Objectives

A general introduction to the physics of compressible fluid flows with a bias towards aerodynamics.

Course contents

1. Fundamentals in aerodynamics
2. Equations for steady compressible fluid flow.
3. One-dimensional compressible fluid flow.
4. Waves in steady supersonic flows.
5. Jet Propulsion.
6. Practical exercices using STARCCM+.

Course material

[1] A.H. Shapiro, The dynamics and thermodynamics of compressible fluid flow, Vol. I, Ed. Ronald Press, (1953)
[2] M. J. Zucrow, J. D. Hoffman, Gas Dynamics, Vol. I, Ed. Wiley & Sons, (1976)
[3] J. D. Anderson, Modern compressible flows. With historical perspective, Ed. Mc GrawHill, (2003).

Keywords

Shock wave, rarefaction wave, Mach number, Rankine-Hugoniot, thermodynamics, supersonic regime, nozzle, diffuser, ramjet, rocket engine.

Links with other programmes

Flight dynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	26 hrs	6 hrs	0 hrs	0 hrs

INTRODUCTION TO NUMERICAL COMPUTATION

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Laurent GORNET

Objectives

To provide an introduction to numerical modelling techniques.

Course contents

PDE classification. Elliptic/ Parabolic/Hyperbolic equations
Main discretisation techniques: finite difference, finite volume, finite element
Aerodynamic and structure examples
Fluid and structure examples with the code CasT3M (CEA)

Course material

Résolution numérique des équations aux dérivés partielles, A. Le. Pourhiet, Cepadues
Introduction à la méthode des éléments finis en mécanique des fluides, S. Gounand, CEA
A first course in Finite Elements, J. Fish, T. Belytschko, Wiley
Cours éléments finis, Centrale Nantes, H Oudin

Keywords

Partial Differential Equations, finite difference method, finite volume elements method, finite element for fluids and structures

Links with other programmes

Continuum mechanics, First year course in Modelling approaches in mechanical engineering

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

FLIGHT DYNAMICS

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Laurent PERRET

Objectives

Based on the introductory course on aerodynamics, this course aims to describe and explain the flight characteristics and performance of planes through analysis of the lift and drag characteristics of airfoils, wings and the complete plane.

Course contents

1. Introduction
2. Fluid dynamics and aerodynamics
3. Lift
4. Drag
5. Mach number effect
6. Flight mechanics
7. Flight performance

Course material

- Aerodynamics, Aeronautics and Flight Mechanics, B.W. McCormick, Wiley;
- Introduction to Flight, J.D. Anderson, McGraw Hill;
- Flight Physics, E. Torenbeek & H. Wittenberg†, Springer;
- Boundary Layer Theory, H. Schlichting & K. Gersten, Springer;
- Polycopié de Mécanique des Fluides, Pr J.-F. Sini, ECN

Keywords

Aerodynamics, stability, performance

Links with other programmes

First year course in Physics and Fluid Dynamics, Turbulence Modelling

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	24 hrs	8 hrs	0 hrs	0 hrs

INVISCID AERODYNAMICS

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Guy CAPDEVILLE

Objectives

- Classical models for incompressible subsonic flow.
- Modelling techniques for classical problems in aerodynamics.
- Programming of a numerical model introduced in the course.

Course contents

- Introductory principles in aerodynamics
- Fundamentals of inviscid incompressible flow – Kutta-Joukowski Theorem.
- Incompressible flow around airfoils – Numerical method of vortex singularities.
- Incompressible flow around wings – PrandtIs Lifting line theory.
- Linear theory of thin airfoils – Prandtl-Glauerts correction.
- Computation of aerodynamic features of an airfoil by using the method of singularities.

Course material

- J.D. Anderson, Fundamentals of aerodynamics, Ed. Mc Graw-Hill, (1984)
- A. H. Shapiro, The dynamics and thermodynamics of compressible fluid flow, Vol. I, Ed. Ronald Press, (1953).

Keywords

Inviscid flow, lifting airfoil, vortex, Lifting line theory, Prandtl, Kutta-Joukowski, vortex singularity, linear theory, thin airfoil.

Links with other programmes

Flight dynamics, Gas Dynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	24 hrs	8 hrs	0 hrs	0 hrs

AIRCRAFT DESIGN AND CONSTRUCTION

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Philippe BLOT

Objectives

The first part of the course aims to provide fundamental knowledge on the principal types of airplane.
The second part presents the different and specific ways of producing and assembling metallic and composite components of an airframe.

Course contents

- Loads on airplanes.
- Airplane nomenclature.
- Methods for dimensioning the principle sub-sets of an airplane.
- Specific production techniques in aeronautics.
- Production techniques for metallic/composite materials.
- Assembling the parts of the airplane (with examples).
- Repair of composite material parts.
- Lectures and factory visits

Course material

- Résistance des Matériaux appliquée à l'aviation, P. Vallat.
- Calcul des structures d'avions - cours ECP, F. Delisée.
- Aérodynamique - cours ENSAE, P. Rebuffet.
- Le projet d'avion léger, L. de Goncourt.
- Les secrets de la construction des aéronefs légers, M. Fékété.

Keywords

composite materials, airframe loads, metallic materials.

Links with other programmes

Aircraft structure modelling

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	23 hrs	8 hrs	0 hrs	0 hrs

AICRAFT PROPULSION

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: François ROIGNANT

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

PROJECT 1

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Guy CAPDEVILLE

Objectives

Study and carry out a technical project dealing with aeronautics in order to consolidate knowledge acquired in the specialisation.

Course contents

Examples of previous projects undertaken:
- Modelling of winglets on the Onera-M6 wing
- Rocket simulation
- Study of the design of ultra-light aircraft
- Study of a ramjet engine
- Aero-elastic behaviour of airfoils and flaps
- Aerodynamic design of a drone
- Flight simulation of a hypersonic vehicle

Course material

Keywords

Links with other programmes

All courses within the aeronautics specialisation.

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

TURBULENCE MODELING

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Isabelle CALMET

Objectives

The main objective of this course is to provide an introduction to turbulent flows and their numerical modeling.
In addition to the course, statistical analysis of a wake flow and the study of several turbulence models are performed during tutorial and lab sessions.

Course contents

1. Introduction
2. Turbulence phenomenology
3. The turbulent boundary layer
4. Statistical modeling of turbulence
5. Large Eddy Simulation

Course material

- Boundary Layer Theory, H. Schlichting & K. Gersten, Springer;
- Turbulent Flows, S.B. Pope, Cambridge univ Press;
- Turbulence en mécanique des fluides, P. Chassaing, Cépaduès

Keywords

Turbulence, boundary layer, flows over obstacle, RANS modeling, Large Eddy Simulation

Links with other programmes

Flight Dynamics, First year course in Physics and Fluid Dynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	20 hrs	12 hrs	0 hrs	0 hrs