SHAKE THE FUTURE.

CENTRALE NANTES

ENGINEERING PROGRAMME

SPECIALISATION

AERONAUTICS

SPRING SEMESTER

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

GROUPE **CENTRALE**

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COMPUTATIONAL AERODYNAMICS

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
SPRING SEMESTER

Professor: Isabelle CALMET

Objectives

- Computation of classical problem in aerodynamics using specific software.
- Use of theories and models developed in the other courses of the Aeronautics specialisation
- Comparisons between different numerical models.
- Comparisons of numerical results with theory and experience.

Course contents

- Technical methods for generating structured/unstructured meshes.
- Modelling of a supersonic jet in a converging-diverging nozzle.
- Turbulence modelling: turbulent boundary-layer, the backward facing step.
- Supersonic turbojet inlet - diffraction of a shock wave.
- Boundary-layer shock wave interaction.
- Noise generated by a fluid flow.
- Numerical simulation of a transsonic flow around a NACA airfoil.

Course material

Keywords

mesh generation, CFD, numerical methods, compressible flows, computational aerodynamics.

Links with other programmes

Gas dynamics, Flight dynamics, Turbulence modelling, Aeroacoustics

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

Aeroacoustics

Aeronautics, Engineering programme specialisation
Spring SEMESTER

Professor: Guy CAPDEVILLE

Objectives

Understanding and modelling the noise sources generated in a compressible turbulent flow.

Course contents

- Turbulence equations.
- Aeroacoustic analogies
- Specific numerical methods
- Examples: supersonic jets, cavities,...
- Computations using an aeroacoustic analogy

Course material

A. P. Dowling, J.E. Ffowcs-Williams, Sound and sources of sound, Ed. Wiley & Sons, (1982)

Keywords

aeroacoustic analogy, noise, Lighthill, sound source, numerical dispersion, numerical dissipation.

Links with other programmes

Turbulence modelling, Gas dynamics

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

STRUCTURAL DYNAMICS

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
SPRING SEMESTER

Professor: Pascal COSSON

Objectives

Context

Commissioning of aircraft depends on ensuring the safety of passengers. Among certification procedures, the control of natural frequencies and modes of the aircraft is one of the major issues. But we can also cite the issue of the design of some structural parts such as the landing gear for which it is important to know its kinematics and the efforts on the corresponding joints. This course is designed to provide the knowledge required to establish and solve (numerically) problems such as the movement of multibody systems or the vibration of systems.

Objectives

The course possesses two main aims: the first is related to the keys that are necessary to create elementary analytical models but sufficiently representative of the considered system in order to provide a quick overview of the solution. The second is to develop strong knowledge of numerical methods to solve the equations and to thus develop a critical mind as to the advantages/disadvantages of these methods.

- In the first part of the course (devoted to the equations of motion of rigid bodies), we recall the concepts of parametrisation, the joints and the fundamental principle of dynamics. We then propose the Lagrange Equation concepts. In this particular framework, we will mainly focus on the kinematically admissible parameters that are often used for vibrations studies even if some extension to non kinematically displacement fields will also be suggested.
- In the second part of course, we tackle an important aspect for the systems: vibration. We start by studying some systems composed of one degree of freedom and we extend the concepts to systems composed of several degrees of freedom. The natural frequencies, natural modes and eigenvectors are introduced as they correspond to a major aspect of vibration problems. Some specific cases such as rigid body modes, the multiplicity of the eigen frequencies will be handled.
- Finally, in the last part of course, the temporal integration schemes of different orders are discussed. Indeed, the equations of motions correspond to a system of second order differential equations. As the latter cannot be solved analytically, it is necessary to develop a strong grounding in numerical resolution. This will help the students to gain a great critical mind with regard to the utilisation of commercial software.

From the knowledge obtained through this course, the student will be able to not only propose a simple modeling and a numerical resolution of a given problem but will also have all the key points to criticize, confirm or refute the numerical results obtained from the software available on the market.

Practical application of the concepts will be achieved through a project concerning the behavior of an aeronautical structure.

Course contents

- Modelling a dynamic problem composed of rigid bodies
  - Parameterisation,
  - Joints,
  - Fundamental Principle of Dynamics,
  - Lagrange Equations,
  - Kinematic or non-admissible parameterisation.
- Vibration problem solving.
  - Systems of 1 degree of freedom,
  - Systems of n degree of freedom,
  - Eigenvalue problem,
  - Solving in the case of free or forced vibrations,
  - Modal analysis.
- Temporal integration schemes
  - Implicit or explicit Euler,
  - Runge Kutta,
  - Implicit or explicit Newmark,
  - Concepts of schemess stability and critical timestep.

Course material

- M. Géradin & A. Cardon Flexible Multibody Dynamics - A Finite Element Approach (JOHN WILEY & SONS 2001)
- D. LE HOUEDEC, Mécanique des Solides (372 pages), Editions GIN Nantes
- Software : Matlab / MotionView (Hyperworks)

Keywords

Rigid body, Vibrations, Motion equations, temporal integration schemes

Links with other programmes

First Year course in Modelling approaches in mechanical engineering, Aircraft structure modeling, Passive safety of aeronautic structures

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

Passive Safety of Aeronautic Structures

Aeronautics, Engineering programme specialisation
Spring SEMESTER

Professor: Laurent GORNET

Objectives

Industrial issues relating to safety, particularly in the area of transportation and thus in aeronautics, require increasingly precise knowledge of the behavior of materials and structures under rapid dynamic loading. This has become ever more important with the introduction of "new materials" such as composites.

The objective of this course is to examine current practices and future trends in this field, with regard to mechanical, numerical and experimental aspects. The main components of the course are: materials modelling under dynamic loading (behaviour laws, sensitivity to strain rate, experimental characterization methods), the design rules in crashes, numerical simulation (tools and integration schemes for a model) and experimental methods to characterise structure behaviour.

Through these concepts the engineering student will be able to connect the implementation of a model to the conditions of the experiment. He will be able to confront the different issues in each of these tools. This can only strengthen his critical sense and increase his/her capacity to propose the best numerical/experimental correlations.

To consolidate the learning process each student will undertake a project (which will serve as the evaluation for this course). This involves firstly carrying out a crushing test on a vertical drop shaft of a simple composite structure. The second step is to propose the numerical model referring thereto. The project concludes with a critique of the results, highlighting the various issues in each part.

Course contents

1. Overview of shocks
   a. Nature of shocks
   b. Type of shock
   c. Classification

2 Crash in the field of transportation
   a. Overview
   b. Safety
   c. Different approaches

3. Modelling
   a. Working on experimental data
   b. Behaviour laws
   c. Solving problems
   d. Different methods for time integration (implicit scheme, explicit scheme...)
   e. Nonlinearities

4. Experiment Means
   a. Description of the means at Centrale Nantes
   b. Different types of tests (front, side impact...)

5 Study of an analytical model for circular or square tubes

6 Simple case study

a. Experimental test of a simple structure
b. Numerical Simulation of the test and experimental/numerical correlations

Course material

N. Jones, Structural Crashworthiness, Cambridge University Press, 1997

W. Johnson, Crashworthiness of vehicles: An introduction to aspects of collision of motor cars, ships, aircraft and railway coaches, Mechanical Engineering Publications, 1978.

Keywords

Crash – Impact, numerical simulation, design, behaviour laws, experimental and numerical means

Links with other programmes

Introduction to numerical computation, Aircraft design and construction, Aircraft structure modelling, Structural dynamics

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

PROJECT 2

AERONAUTICS, ENGINEERING PROGRAMME SPECIALISATION
SPRING 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	2	0 hrs	0 hrs	0 hrs	48 hrs