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CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

MECHANICAL ENGINEERING

COMPUTATIONAL MECHANICS

YEAR 1
AUTUMN 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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CONTINUUM MECHANICS

MECHANICAL ENGINEERING – COMPUTATIONAL MECHANICS
YEAR 1 - AUTUMN SEMESTER

LEAD PROFESSOR: THOMAS HEUZÉ - *thomas.heuze@ec-nantes.fr*

Objectives

At the end of the course (30 hours + personal work), the students will:

- understand strain and stress notions, and be able write their mathematical representation correctly.
- know that there are different kinds of equations with different purposes (balance equations, constitutive equations, boundary conditions).
- Be able to define the problem of the equilibrium of a deformable elastic solid body in infinitesimal strain by writing a Boundary Value Problem (BVP), and to choose the right set of boundary conditions.
- know the different possible approaches available to solve that BVP, and be able to solve it.

Course contents

This course is an introduction to continuum mechanics, and more generally to modelling in mechanics. The basic concepts required for more advanced fluid and solid mechanics courses are introduced here. The course then focuses on the study of the equilibrium of deformable solid bodies in linear elasticity and infinitesimal strain. This provides some basic tools required for engineers to design mechanical systems.

After some necessary lectures, the course is built on alternating the introduction of fundamental concepts and training examples, each lasting approximately 2hours.

The course outline is as follows:

- Mathematics for continuum mechanics
- Introduction
- Kinematics
- Stresses
- Equations of conservation
- Constitutive equations
- Equations of linear elasticity in infinitesimal strain

Course material

- Introduction to Continuum Mechanics, W. Michael Lai, David Rubin and Erhard Krempl, Elsevier, 2010.
- Continuum Mechanics, A.J.M. Spencer, Dover Publications, 2004.
- Mécanique des Milieux Continus et discrets, Handbook of N. Moës, 2011,
- Mécanique, P. Germain, 1985, Ecole Polytechnique, volumes 1 & 2.
- Introduction to the mechanics of a continuous medium, L.E. Malvern, Prentice-Hall, 1969.
- An introduction to continuum mechanics, M.E. Gurtin, Academic Press, 1981.

Keywords

Continua, linear elasticity, solid mechanics, modelling

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

FLUID MECHANICS

MECHANICAL ENGINEERING – COMPUTATIONAL MECHANICS
YEAR 1 - AUTUMN SEMESTER

LEAD PROFESSOR: Guillame DUCROZET - *guillaume.ducrozet@ec-nantes.fr*

Objectives

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

- Describe the main physical properties of a fluid.
- Identify the specificities of fluid mechanics in the continuum mechanics framework (i.e. compared to solid mechanics).
- Identify the non-dimensional numbers at play in any fluid mechanics problem and deduce how to perform experiments with appropriate similarity.
- Understand the notion of stresses and its representation through stress tensor.
- Describe the physical meaning of each term in the Navier-Stokes' equations
- Identify the different flow regimes.
- Evaluate the generalized force applied on any object in still water.
- Understand when the perfect fluid assumption is valid.

Course contents

This course aims to present the foundations and general principles of fluid mechanics. The lectures cover the following topics:

- Physics of fluids
- Dimensional analysis
- Stress tensors and fluids
- Navier Stokes' equations
- Flow regimes: introduction to turbulence
- Fluid statics
- Bernoulli's equation for a perfect fluid

In addition to those lectures, tutorials and 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, Viscosity, Pressure, Dimensional analysis, Reynolds number, Froude number, Mach number, Newtonian fluid, Navier-Stokes, Fluid static, Turbulent, Laminar, Perfect fluid.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	**5**	**14 hrs**	**12 hrs**	**4 hrs**	**0 hrs**	**2 hrs**

PROGRAMMING AND ALGORITHMICS

MECHANICAL ENGINEERING – COMPUTATIONAL MECHANICS
YEAR 1 - AUTUMN SEMESTER

LEAD PROFESSOR: Alexis Salzman – *alexis.salzman@ec-nantes.fr*

Objectives

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

- Handle creation and compilation of simple programs in C++ with basic algorithms (loop, function, computing with array, etc)
- Understand programs using all kind of variables (standard, pointer reference, array and enumeration)
- Understand programs using object-oriented paradigm (basic concept, Inheritance, Polymorphism) and associated algorithms (encapsulation, etc)
- Understand programs using template paradigm (template function, template class) and associated algorithms (generality, etc)
- Understand programs using STL library and associated algorithms (linked list, trees, hash function, etc)
- Acquire knowledge on development tools.

Course contents

Lectures present, step by step, all the programmatic and algorithmic components of a rich programming language: C++ [1]. This language first offers a way to learn the key concepts of structured programming and compilation which are rather common in other languages (C, Fortran, Basic etc). Some advanced aspects such as pointer and reference will also be studied in this first part of the course. Basic algorithmic concepts (bloc, scope, loop, function, etc) are given in this introduction.

Then, based on this knowledge, the students will learn other programming paradigms that are also available in this language:

- Object-oriented programming. Basic concept and design are presented first. Then two important aspects, Inheritance and Polymorphism, are explained to have a general idea of object-oriented strength.
- Template programming. Function and class template are briefly presented to understand the concept of genericity in a strongly typed language like C++.

Finally associated to C++ standard, the STL Library [2] is explained. Understanding of the two previous paradigms are mandatory to follow this last part. It is an introduction designed to help students to navigate in this vast library that offers really efficient tools and encapsulates complex algorithms.
To conclude the course, a lecture is dedicated to development tools that help programmers.

Homework and lab sessions will provide a way to assimilate lecture content.

Course material

- The C++ Programming Language (4th edition), Bjarne Stroustrup, Addison-Wesley Professional ISBN 978-0-321-56384-2
- The C++ Standard Library: a tutorial and reference (2nd edition), Nicolai M. Josuttis ISBN 978-0321623218

Keywords

C++, operator, loop, array, pointer, function, object-oriented programming, template programming, STL, development tool.

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

NUMERICAL METHODS

MECHANICAL ENGINEERING – COMPUTATIONAL MECHANICS
YEAR 1 - AUTUMN SEMESTER

LEAD PROFESSOR: Grégory Legrain – *gregory.legrain@ec-nantes.fr*

Objectives

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

- Classify standard PDEs (elliptic, parabolic, hyperbolic)
- Solve simple elliptic problems by means of finite differences or finite elements
- Solve simple parabolic problems, and assess their stability
- Assess the accuracy of the schemes they use
- Program finite differences and finite elements in both 1D and 2D

Course contents

These lectures aim to present classical numerical methods, their features and limitations.

- Classification of PDEs
- Classification of boundary conditions, well-posedness
- Introduction to finite differences
- Introduction to finite elements
- Parabolic problems

Homework and lab sessions will provide an understanding of the programming and main features of the methods.

Course material

- The Finite Element Method: Linear Static and Dynamic Finite Element Analysis. T.J.R. Hughes
- Numerical Methods for Engineers and Scientists. J.D. Hoffman and S. Frankel

Keywords

Partial Differential Equations, Finite elements, Finite differences, Collocation, Stability

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	14 hrs	6 hrs	10 hrs	0 hrs	2 hrs

VIBRATIONS AND DIFFERENTIAL EQUATIONS

MECHANICAL ENGINEERING – COMPUTATIONAL MECHANICS
YEAR 1 - AUTUMN SEMESTER

LEAD PROFESSOR: Panagiotis Kotronis - *Panagiotis.Kotronis @ec-nantes.fr*

Objectives

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

- Derive the dynamic equilibrium equation using variational principles
- Calculate the stiffness and mass matrices of discrete systems using the Lagrange equations
- Study linear vibrations about an equilibrium position
- Calculate the eigenmodes of discrete and continuum systems
- Apply the modal superposition technique
- Apply the Rayleigh-Ritz method

Course contents

These lectures aim to present the main aspects of the non-linear behaviour of steel, of concrete and of civil engineering structures. The main areas covered are:

- Discrete and continuum systems
- Hamilton principle
- Lagrange equations
- Linear vibrations about an equilibrium position
- Eigenmodal analysis
- Modal superposition technique
- Rayleigh-Ritz method

Course material

- M. Geradin and D. Rixen. Mechanical vibrations (second edition). Theory and application to structural dynamics. John Wiley and Sons Ltd, 1997.
- K. Chopra. Dynamics of Structures. Theory and Applications to Earthquake Engineering (second edition). Prentice-Hall, 2001.

Keywords

Vibrations, eigenmodes, Hamilton principle, Lagrange equation, modal superposition technique, Rayleigh-Ritz method

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

BUSINESS ENVIRONMENT

MECHANICAL ENGINEERING – COMPUTATIONAL MECHANICS
YEAR 1 - AUTUMN SEMESTER

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

Objectives

- Understand the general concepts of business English and marketing principles
- Understand the principles of given business models (for example: the collaborative economy)
- Build a professional project and explore international opportunities
- Develop strategies for inter-cultural practice
- Organize, lead and participate in discussions, interviews and meetings
- Strengthen self-confidence and level of conviction
- Develop active listening and understanding to reformulate, explain and argue
- Acquire notions of corporate culture and values
- Develop well-being at work and a sense of responsibility
- Enhance team work

Course contents

Business Environment: exercises to explore in practice the areas of business and marketing

Field-related or inter-cultural project:

- Field-based radio project: prepare, conduct and promote interviews for ECN's radio programme: L'Heure Centralienne (http://www.euradionantes.eu/emission/l-heure-centralienne), with the contribution of professors, doctorate students, industrial partners, industry players at fairs, etc.
- Inter-cultural project: construct a myplace4U eZoomBook, using the eZoomBook template. Devise a place branding strategy and analyse its impact on potential users of the myplace4U eZoomBook.

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

business model canvas, Dolan Framework, SWOT analysis, etc.

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

MODERN LANGUAGES - FRENCH

MECHANICAL ENGINEERING – COMPUTATIONAL MECHANICS
YEAR 1 - 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.

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. Gving 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 – COMPUTATIONAL MECHANICS
YEAR 1 - AUTUMN SEMESTER

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

Objectives

Introduction to Cultural and Communicational English:

- Understand the general concepts of communication English (different levels of language, etc.)
- Build a communicational project
- Develop strategies for enhanced interaction
- Organize, lead and participate in discussions, interviews and meetings
- Behavioral skills in an inter-cultural environment:
- Strengthen engagement and level of conviction
- Develop a capacity to explain and argue
- Acquire notions of corporate culture and values
- Enhance team work

Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication
Inter-cultural project (for example, documentary project, publishing project: construct a work of fiction or of educational value and experience the complete publishing process)

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