

SEMESTER 4_2nd YEAR FAS CONSTRUCTION

Introducing

Description

Évaluation

L'évaluation des acquis d'apprentissage est réalisée en continu tout le long du semestre. En fonction des enseignements, elle peut prendre différentes formes : examen écrit, oral, compte-rendu, rapport écrit, évaluation par les pairs...

Practical info

Location(s)

 Toulouse

Mathematical tools 2

Introducing

Description

Linear Algebra

Eigen-elements: eigenvalues, eigenvectors, characteristic polynomial

Diagonalization

Applications

Euclidean Spaces

Scalar product: examples, properties

Orthogonality: Pythagoras theorem, orthogonal bases, orthogonal projection

Bilinear Algebra

Bilinearity

Symmetric positive definite matrices: definition, properties, characterization

Ordinary Differential Equations (ODEs) – Linear

Examples, general framework of affine ODEs

Special case of linear ODEs with constant coefficients

Multivariable Functions

Notion of differential for multivariable functions

First- and second-order optimality conditions

Multiple integrals

Numerical Analysis

Numerical resolution of ODEs

Interpolation

Numerical integration

Least squares method

Objectives

At the end of this module, the student should have understood and be able to explain the following key concepts:

Knowledge of the main results in matrix reduction

Understanding the concept of scalar product and orthogonality

Basic notions of bilinear algebra

The concept of the differential of a multivariable function and partial derivatives

Solving linear differential equations with or without a forcing term

Calculations of integrals of functions of several variables

Finding extrema of a function

The least squares method

Numerical interpolation

Numerical integration

Numerical resolution of differential equations

List of competencies:

Code Competency

1_1 Master mathematical concepts and computational tools relevant to engineering

1_2 Develop rigorous scientific reasoning and the capacity for abstraction

2_1 Master the fundamental tools of the mathematical engineer

(Competency matrix of CTI, 2019)

Necessary prerequisites

Linear algebra and first-year analysis, programming in Python.

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Practical info

Location(s)

 Toulouse

Dynamics

Introducing

Description

- Analyze the spatial mass distribution of a rigid body (inertia matrix, center of mass).

Newton's first law of motion for a system of rigid bodies:

- Determine the linear and angular momentum and their time derivatives using screw theory
- Determine a solving strategy to apply the first law (systems of interest, equations to be used)
- Determine mechanical actions or differential equations of motion by applying the first law

Work-energy theorem for a system of rigid bodies:

- Calculate the kinetic energy of a body in motion (rotation, translation, helical motion)
- Determine the power of external forces and contact forces
- Derive an equation of motion or determine a force using the work-energy theorem (WET)

Objectives

Rigid body dynamics

At the end of this course, you will be able to:

- Determine the motion of a mechanism over time given the forces acting on it,
- Determine the mechanical actions in the joints or

actuators required to produce the desired motion. Newton's first law of motion and the work-energy theorem (WET) will be used

Necessary prerequisites

Solid mechanics I course:

- Force and moment calculation
- Common forces modeling
- Calculation of velocity and acceleration
- Screw theory: modeling forces as wrenches and velocity fields as twists
- Solving a statics problem

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Practical info

Location(s)

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Energy Mix and Transition

Introducing

Description

The main concepts covered during the course are: conversion, transport, storage and usage efficiencies / power flux density / material resource intensity / load factor / stock and flow concepts / production and demand profiles / networking / energy mix / energy transition scenarios for 2050.

The course covers the following technologies: wind generation, electrolytic storage (H₂), photovoltaics, electrochemical batteries, hydroelectricity / WWTP, fossil-nuclear-biomass power stations, biogas production.

Objectives

To understand the stakes involved in supplying energy to our production system.

To be able to answer the following questions:

- How do we obtain our energy today (knowing the different means of conversion and storage, and the different mixes) ?
- What are the orders of magnitude for our individual and national energy consumption on a day-to-day basis ?
- Where are the dependencies, weaknesses and limits of our energy supply ?
- How can we build an energy mix that meets our demand profile up to 2050 and the challenge of

decarbonization ?

Necessary prerequisites

Be familiar with the concepts of electrical power and energy, as well as the general concepts of efficiency and density.

Have acquired the knowledge and skills of the first year at INSA, especially in electrokinetics, mechanics and thermodynamics.

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Practical info

Location(s)

 Toulouse

Digital culture and skills 1

Introducing

Description

Introductory course to AI: history, algorithms, issues.
"No code" discovery of neural networks on Vittascience;
notebook for building a small character recognition
network.
Presentation of PIX and study of a certain number of
themes independently with the objective of passing the
PIX certification at the end of the 3rd year.

Objectives

At the end of this module, the student will have
discovered the first dimensions of the field of AI:
history, examples of what AI allows, distinction between
supervised and unsupervised learning, rapid scope of
techniques and algorithms, ethical aspects, risks and
controversies. In a second part, the student will have
advanced his PIX course according to the defined
program.

Necessary prerequisites

Basics of Python Programming

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Practical info

Location(s)

 Toulouse

Strength of Materials II

Introducing

Description

Beam theory:

- Transition from the real system to the beam type model: average line and geometric properties of sections, connections, loading, linear elastic material;
- Static reminders – Balance – Linking actions – Isostaticity and hyperstaticity;
- Internal forces: normal force, bending, shear force, torsion;
- Stress/strain/displacement fields and potential energy of elastic deformation associated with the different internal forces;
- Methods for solving hyperstatic structures (by application of the superposition principle and Castigliano's theorem).

Objectives

The student will be able to assess:

The mechanical behavior of isostatic and hyperstatic “beam” type structures under static loading:

- Model a “beam” type structure (geometric characteristics, support and loading),
- Calculate the support actions and internal forces,
- Calculate the stress, deformation and displacement fields associated with each type of internal force,
- Calculate the potential energy of elastic deformation,
- Apply resolution methods for hyperstatic structure of

degree 1.

Necessary prerequisites

Mechanics
Materials science
Mathematical tools

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Practical info

Location(s)

 Toulouse

Materials science

Introducing

Description

Detailed programme for common materials:

6 CMs of 1.25h each

Crystallography of metals and ceramics - Amorphous structures

Thermodynamics of binary metal alloys: Gibbs free energy - Entropy - Enthalpy Binary iron-carbon metal alloy: Phase equilibrium diagram - Eutectoid transformation

Mechanical behaviour of construction materials at room temperature: Elasticity - Plasticity - Ductility - Fragility Mechanical properties of materials in use and mechanical tests at room temperature

Physical properties of construction materials and associated non-destructive testing

Chemical properties of construction materials and corrosion phenomena

Tutorial topics: 4 tutorials of 1.25 hours each

1/ Crystallography: Pattern - Atomic density - Miller indices

2/ Phase diagram: Iron-carbon diagram - Determination of the microstructure of a steel at room temperature

3/ Mechanical properties: Tensile strength curve and skimming - Strain energy

4/ Chemical properties: Corrosion

Practical work session: 2 TPs of 3 hours each

TP1 Mechanical tests: tensile test - Hardness test - Impact test

TP2 Chemical tests

Objectives

Make the link between the mechanical, physical and chemical properties of construction materials (metals, ceramics and polymers) and the characteristics of these materials on an atomic (crystallographic) and microstructural (binary phase diagram) scale.

Necessary prerequisites

For the common core of materials: Notion of Crystallography and Thermodynamics from 1A

Évaluation

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Practical info

Location(s)

 Toulouse

Building Environment and Materials

Introducing

Description

Materials for Civil Engineering: 18.75 hours

11.25 hours: Lectures on the portfolio of construction materials used in Civil Engineering.

2.5 hours: Tutorials on Life Cycle Assessment (LCA) approaches and quantitative methods.

5 hours: Laboratory sessions on materials and digital tools.

Project Design Component: 52 hours

7.5 hours: Lectures on design principles (Architecture and Structure).

8.75 hours: Tutorials on architectural analysis, load paths, and structural design linked to construction techniques.

2 hours: Construction site visit.

33.75 hours: Small-group project work, focusing on project selection and approach, architectural and structural design, justification of choices, numerical modeling, quantification, technical design details, defining and calculating load transfers, and assessing the environmental impact of construction materials.

Objectives

The student must be able to:

Understand and develop materials used in Civil Engineering.

Develop an interdisciplinary understanding of sustainable urban development.

Navigate the complexity of civil engineering design projects and apply multicriteria, multi-stakeholder, and multi-scale spatial and temporal decision-making frameworks.

Explore the concepts of eco-design.

Manage the design of architectural programs.

Define, select, and specify construction materials.

Justify and assess the environmental impact of prescribed solutions.

Design the load-bearing structure of buildings (limited to vertical loads).

Calculate and predict load transfers (restricted to gravitational and operational loads).

This course is designed to:

Facilitate the development of skills in civil engineering project methods.

Promote the use of digital tools.

Enhance practices in design projects.

Introduce architectural design principles.

Provide guidance on the selection of construction techniques and materials.

Develop quantitative and multicriteria approaches.

The module aims to:

Present the dual Architect-Engineer curriculum.

Foster analytical thinking and design methodologies for building projects integrated within an urban fabric.

Serve as a practical application of concepts from Strength of Materials 2 (covered in semester 4), specifically focusing on the understanding of beams, loads, and the concrete application of static principles.

Necessary prerequisites

"Civil Engineering Design with BIM: Utilizing a 3D modeling tool, focusing on the technical approach to parametric families and objects, and emphasizing collaborative workflows.

Strength of Materials 1 (SOM 1): Ability to apply the Fundamental Principle of Statics.

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Practical info

Location(s)

 Toulouse

Design and Materials Project

Introducing

Description

Detailed programme for common materials:

6 CMs of 1.25h each

Crystallography of metals and ceramics - Amorphous structures

Thermodynamics of binary metal alloys: Gibbs free energy - Entropy - Enthalpy Binary iron-carbon metal alloy: Phase equilibrium diagram - Eutectoid transformation

Mechanical behaviour of construction materials at room temperature: Elasticity - Plasticity - Ductility - Fragility Mechanical properties of materials in use and mechanical tests at room temperature

Physical properties of construction materials and associated non-destructive testing

Chemical properties of construction materials and corrosion phenomena

Tutorial topics: 4 tutorials of 1.25 hours each

1/ Crystallography: Pattern - Atomic density - Miller indices

2/ Phase diagram: Iron-carbon diagram - Determination of the microstructure of a steel at room temperature

3/ Mechanical properties: Tensile strength curve and skimming - Strain energy

4/ Chemical properties: Corrosion

Practical work session: 2 TPs of 3 hours each

TP1 Mechanical tests: tensile test - Hardness test - Impact test

TP2 Chemical tests

If the student chooses to approach the objectives with 'Mechanical Engineering' oriented materials

- 35.5 hours for a mechanical design project, through the study of a project in a small group, the students approach functional analysis, modelling (schematisation), the search for solutions, pre-dimensioning and the production of a 'digital mock-up' using CAD software. Students supplement the knowledge they need to develop the project with various documents at their disposal: resource documents on the 'moodle' platform, books, internet.

- 8 hours of practical work on bearing assembly,

- Using the elements made available to them (bearings, gear housing shafts, keys, elastic rings, locknuts, etc.), the students must analyse, design and produce bearing assemblies that comply with current regulations.

- 6 hours on the study and operation of different heat engines. Using visual aids, students discover the different cycles of internal combustion engines, the distribution and supply systems, and the principles of turbojet and turboprop engines. They identify the different functional elements of an engine from an overall drawing.

Materials for Mechanical Engineering - Lesson (7.5h)

- Phase transformations under equilibrium conditions: isothermal (eutectoid and eutectic) and non-isothermal transformations

- Diffusion: Fick's laws (unidirectional)

- Germination-growth mechanisms of a new phase (from a liquid or a solid phase)

- Mechanical properties of metal alloys: fatigue strength and behaviour in the presence of cracks

TD topics (5h)

1: Use of Fick's laws in steel carburising

2: Analysis of the microstructural evolution of steels

3: Work hardening - Introduction to residual stresses

4: Conventional fatigue limit and fatigue diagram (Haig)

Practical work (6h)

TP1 Mechanical test: Effect of cold rolling on tensile properties - Alloy Al20217

TP2 Microstructure: Microstructures of steels and white cast irons

If the student chooses to approach the objectives with 'Civil Engineering' oriented materials

Civil engineering materials: 18.75 h

- 11.25 h Portfolio lecture on construction materials used in civil engineering
- 2.5 h of tutorials on LCA and quantitative approaches
- 5 h of practical work on materials and numerics

Project design part: 52 h

- 7.5 h Lectures on project principles (architecture and structure)
- 8.75 h Tutorials: architectural analysis, load analysis and structural design in relation to construction techniques
- 2 h site visit
- 33.75 h project work in small groups based on project choices and approach, architectural and structural design, justification of choices, digital modelling, quantification, technical design details, definition and calculations of load transfers and environmental impact study of construction materials.

Objectives

- Make the link between the mechanical, physical and chemical properties of construction materials (metals, ceramics and polymers) and the characteristics of these materials on an atomic (crystallographic) and microstructural (binary phase diagram) scale.
- Make a reasoned selection of metallic materials for mechanical construction by making the link between the mechanical characteristics and the nature of the metallic alloy: chemical composition, microstructure, nature of the phases, heat treatment possibilities, etc;
- Implement a design procedure based on specifications and acquire a technological culture.

The student may choose to approach this general

objective with either a 'Mechanical Engineering' or a 'Civil Engineering' teaching aid.

If the student chooses to approach the objectives with 'Mechanical Engineering' oriented teaching aids, he/she must :

- Propose one or more solutions in the form of a kinematic diagram, based on a set of specifications.
- Calculate the powers involved and choose a motor.
- Design and size a simple gearbox.
- Design and size a radial contact ball bearing assembly.
- Calculate the isostatism of an assembly of fixed parts and a moving mechanism.
- Produce a digital model of the mechanism using CAD software.
- Give an oral and written presentation of the project.
- Participate and get involved in a work group.
- Identify the links to be implemented using real components for the bearings.
- Be familiar with 4-stroke and 2-stroke cycles.
- Be familiar with distribution and supply systems.
- Be familiar with the principles of turbojet and turboprop engines.
- Be able to identify the functional elements of an engine from a drawing.
- Be familiar with the secondary functions (cooling, lubrication, electrical generation, etc.).
- Be familiar with the terminology of the component parts.

If the student chooses to approach the objectives using 'Civil Engineering' oriented materials, he or she will be able to :

- Develop an interdisciplinary culture around sustainable urban development,
- To immerse themselves in the complexity of civil engineering design projects and in multi-criteria, multi-actor and multi-scale spatial and temporal decision-making.
- Discover the concepts of eco-design
- Design architectural programmes
- Define, select and specify construction materials
- Justify and assess the environmental impact of the solutions prescribed
- Design the load-bearing structure of buildings

(vertical loads only)

- Calculating and predicting load transfer (gravity and operational loads only)

This course is designed to be closely linked to the development of skills in civil engineering project methods, the use of digital tools, the development of design project practices, the discovery of architectural design, the choice of construction techniques and materials and the use and development of multi-criteria and quantitative approaches.

The module provides an introduction to the dual Architect/Engineer curriculum, and develops analytical skills and design methods for building projects within an urban fabric. The project also provides an opportunity to practise the concepts of Resistance of Materials 2 seen in S4, with an understanding of beams, loads and the practical application of the principles of statics.

Necessary prerequisites

For the common core of materials: Notion of Crystallography and Thermodynamics from 1A

If the student chooses to approach the objectives with 'Mechanical Engineering' oriented materials

- I2ICTI31 teaching in semester 3 (kinematic diagram, isostatism applied to the assembly of fixed parts, design of an assembly of radial contact ball bearings, knowledge of the rules of industrial drawing, knowing how to use the basic functions of CREO.
- Teaching I2ICME31 in semester 3 (knowing how to use the Fundamental Principle of Statics).

If the student chooses to approach the objectives with 'Civil Engineering' oriented materials

- I2ICTI31 teaching in semester 3 GC BIM design with tools linked to the use of a 3D modeller, technical approach to parametric families and objects, collaborative approach.
- I2ICME31 teaching in semester 3 (knowing how to use

the Fundamental Principle of Statics).

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Practical info

Location(s)

 Toulouse

Thermodynamics

Introducing

Description

Fundamental concepts (concept of systems, evolution of a system, mathematical tools in thermodynamics, ideal gas model). Work and heat. The first law of thermodynamics and the internal energy function. The enthalpy function and the steady-state systems. Thermodynamic functions changes during reactions. Thermodynamic machines (heat engines).

Objectives

At the end of this module, students should have understood and be able to explain:

- the inductive approach, specific to thermodynamics, which is to generalize, by defining them as laws, the conditions for energy conservation and evolution of systems;
- the significance, the relevance and the application areas of the main thermodynamic functions (internal energy, enthalpy, entropy and Gibbs function).

Students should be able to:

- identify the system under study and to establish, for this system, routinely and systematically, the material balance, the energy balance and the balance of entropy;
 - explain the operation of thermodynamic machines, based on the two laws of thermodynamics and on phases equilibria.
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Necessary prerequisites

Math: Concept of function of several variables and partial derivatives.

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Practical info

Location(s)

 Toulouse

Foreign language 1

Introducing

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Practical info

Location(s)

 Toulouse

Foreign language 2

Introducing

Description

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Practical info

Location(s)

 Toulouse

Professional Path Initiative 2nd Year

Introducing

Description

Évaluation

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Practical info

Location(s)

 Toulouse

Physical Activities and Sports

Introducing

Description

Évaluation

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Practical info

Location(s)

 Toulouse