FUNDAMENTALS OF MECHANICAL ENGINEERING FIELD_14 ECTS

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

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Partial Differential Equations and Numerical Analysis

Introducing

Description

Chapter 1 - Introduction to PDEs and classification -
Prerequisites in linear algebra, integration, resolution of ordinary differential equations, functions of several variables; Terminology and Examples of PDEs; Classification of linear PDEs of order 2.

Chapter 2 - Fourier Series -
Physical motivation; Space of periodic functions of square integrable; Trigonometric series; Fourier coefficient; Fourier series in L^1 (Dirichlet Thm) then in L^2 (Parseval Identity).

Chapter 3 - Fourier Transform -
Analysis and Synthesis of the Fourier transform on L^1, algebraic and derivation properties, inverse Tf and Plancherel Formula, Convolution; TF on L^2 and illustrative examples.

Chapter 4 - Sturm Liouville Problem -
Definition, examples and properties of the solutions.

Chapter 5 - Solving PDEs by Separation of Variables
Well-posed problem and Boundary conditions; Homogeneous 1D heat equation; Homogeneous 1D wave equation; Generalities on the method of separation of variables (homogeneous Eq, then with source term, then with non-homogeneous boundary conditions, and interest in knowing the associated Sturm Liouville problem)

Students will be provided with a course handout, TD statements (then their corrections) and TP. The TP will be carried out under Python

Objectives

This UE aims to master some basic mathematical concepts for the study of partial differential equations (PDE) by the future engineer in Civil Engineering or Mechanical Engineering. This UE is naturally composed of academic knowledge presented in lectures, and computational know-how (studied in tutorials) and numerical know-how (implemented in practical work). Students will learn to identify and classify PDEs according to their nature (elliptic, parabolic, hyperbolic). They will approach the basic concepts, properties and theorems concerning Fourier series and Fourier transforms, which are powerful tools for solving PDEs, particularly in areas related to periodic phenomena and vibrations. Finally, the separation of variables, a classic and effective technique for solving certain classes of PDEs, will be formalized and studied. This method will be illustrated through several concrete examples linked to wave-type equations (vibration phenomenon) or heat (diffusion phenomenon).

Necessary prerequisites

Mathematics UE for years 1 and 2.
More specifically:
- linear algebra (Diagonalization of matrices)
- integration (change of variable, Integrations by parts)
- resolution of ordinary differential equations (characteristic polynomial, solution of the homogeneous equation and particular solution...)

- functions with several variables (derivation)

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Solid mechanics

Introducing

Description

Theory of stresses, theory of strains, displacement-strain relationship, linear elasticity constitutive law, formulation of the elasticity problem, analytical methods for solving the general problem of linear elasticity. Applications in practical exercises using Python programming language.

Objectives

At the end of this module, the student should have a comprehensive understanding of solid deformation mechanics, stresses, linearized strains, displacement fields and the constitutive relationship in elasticity.
The student should be able to:
- Analyze the state of stress and strain of a solid under loading.
- Calculate the stress state based on the strain state and vice versa.
- Calculate the strain state based on the displacement field.
- Establish equations for the local equilibrium of the solid at every point.
- Propose a relevant modeling of a real problem, particularly in terms of boundary conditions.
- Calculate the stresses from the diagrams of internal solicitations obtained from beam theory.

Necessary prerequisites

Mathematics (analysis, linear algebra, numerical analysis), general mechanics (statics and kinematics), beam theory (internal solicitations, stresses in beams...), basics in Python programming.

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Practical info

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Fluid mechanics

Introducing

Description

Fluid Mechanics: Introductory definitions and general properties of a fluid, forces acting on a fluid particle. Fluid statics for incompressible and compressible fluids, manometry, buoyant force, forces and moments exerted by a fluid on flat and curved surfaces, and pressure distribution in rigid body motion. Fluid dynamics and kinematics, Euler's equation, Bernoulli's equation, mass conservation, control volume and Reynolds transport theorem, linear momentum equation.

Objectives

Fluid Mechanics:

At the end of this module, the student should have understood and be able to explain (main concepts):
- The concept of a fluid and the forces acting on a fluid particle.
- The distribution of static pressure within a fluid and the forces exerted by the fluid on a solid surface.
- The ideal fluid in motion: kinematics and dynamics.

The student should be able to:
- Calculate the forces exerted by a fluid on flat and curved solid surfaces.
- Use Bernoulli's equation (energy conservation) and Euler's theorem (momentum conservation) in a wide range of practical applications.

Necessary prerequisites

Basic thermodynamics concepts facilitate a better understanding of the fundamental principles.

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Dynamic Systems

Introducing

Description

Fundamentals of signals and systems. Transfer functions of linear time-invariant systems. Systems of 1st order, generalized 1st order, 2nd order, system delay. Frequency response in Bode diagram and its asymptotic plot. Introduction to state space representation.

Objectives

At the end of this module, the student should have understood the basics on signals and linear systems as well as the dynamical and frequency performances of the systems.

The student should be able to:
- Build in Matlab/Simulink a dynamic model of a system out of its algebro-differential equations;
- Determine and analyze the dynamic and frequency performances of a system of intermediate complexity (1st or 2nd order) based on its dynamic model;
- Carry out the preliminary sizing of a system of intermediate complexity (1st or 2nd order) to fulfill the dynamic specifications.

Necessary prerequisites

Laplace transform. Basic notions to model mechanical, electrical, thermal and hydraulic systems

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