MATHEMATICS AND MECHANICS 1 FIELD_12 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

Mathematics

Introducing

Description

Part: Mathematical Concepts (Lectures = 17.5h / Tutorials = 17.5h)
1.Generalized integrals and series (2 Lectures / 2 Tutorials)
2.Norms 1, 2, and infinity in finite and infinite dimensions (1.5 Lectures / 1 Tutorial)
3..Scalar product, Cauchy-Schwarz inequality, and Pythagoras (1.5 Lectures / 1 Tutorial)
4.Vector orthogonality, decomposition on orthogonal bases (1 Lecture / 2 Tutorials)
5.Special matrices: symmetric, projection, and isometries (1.5 Lectures / 2 Tutorials)
6.Continuity and differentiability of multivariable functions (2 Lectures / 3 Tutorials)
7.Multiple integration (3 Lectures / 3 Tutorials)
8.Hessian matrix and optimization (1.5 Lectures / 0 Tutorials)

Part: Numerical Analysis (Lectures = 7.5h / Tutorials = 7.5h / Lab Work = 17.5h)
0.Introduction to Python and numerical analysis (1 Lab Session)
1.Numerical integration (Rectangle, trapezoid, and Simpson methods) (1 Lecture / 1 Tutorial / 1 Lab Session)
2.Norms and conditioning (Induced norms and the impact of conditioning) (1 Lecture / 1 Tutorial / 1 Lab Session)
3.Direct resolution of linear systems (Gaussian elimination and LU decomposition) (1 Lecture / 1 Tutorial / 1 Lab Session)
4.Solving nonlinear equations (Bisection, Newton's method, and fixed-point iteration) (1 Lecture / 1 Tutorial / 1 Lab Session)
5.Polynomial interpolation (Vandermonde matrices and the Runge phenomenon) (1 Lecture / 1 Tutorial / 1 Lab Session)
6.Least squares method (Normal equations) (1 Lecture / 1 Tutorial / 1 Lab Session)

Part: Probability and Statistics (Lectures = 13.75h / Tutorials = 13.75h / Lab Work = 2.5h)
1.Events, probabilities, conditioning, independence
2.Random variables, probability distributions, discrete variables
3.Continuous random variables, random vectors
4.Statistical inference: point estimation, confidence intervals, and hypothesis testing

Objectives

This Teaching Unit (UE) aims to master the essential concepts and foundational knowledge in mathematics for engineers in Civil Engineering or Mechanical Engineering. The UE is divided into three components with complementary objectives:
1.Mathematical Concepts: Master essential mathematical tools for Civil or Mechanical Engineering.
2.Numerical Analysis: Implement efficient algorithms using Python and analyze their convergence.
3.Probability and Statistics: Understand and apply probabilistic and statistical modeling.

Necessary prerequisites

First-year Mathematics course. Note that the different sections are not independent, and tools introduced in one part may be used in others.

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Mechanics

Introducing

Description

Analyze structure equilibrium and apply Newton's second law to a system of rigid bodies:
- Model usual mechanical actions as wrenches using screw theory (kinematic joints and external forces)
- Model friction using Coulomb's Law of Friction
- Model the tilting of a plane joint using a mobile point of application for the normal force
- Identify a statically determinate/indeterminate system (number of static unknowns)
- Determine a solving strategy for the second law (systems of interest, external forces, free body diagram, equations to use, solid bodies subjected to only two external forces)
- Calculate the mechanical actions that need to be determined (joints or actuators)
- Validate the stability of a structure (sliding, tilting on a plane, loss of contact)

Determine the absolute or relative velocity and acceleration of a point on a rigid body:
- Interpret the kinematic parameterization of a mechanism
- Describe the velocity vector field that characterizes a body's motion as a twist using screw theory
- Apply velocity addition, velocity field analysis and time derivatives of vectors in rotating frames
- Determine the condition for rolling without slipping at the contact between two bodies
- Solve a 2D kinematics problem graphically (instantaneous axis of rotation, velocity field)

Objectives

Solid mechanics
At the end of this course, you will be able to:
- determine the mechanical loads exerted on rigid bodies (preliminary step to sizing),
- verify the stability conditions of a mechanism (friction, tilting, loss of contact),
- analyze velocities and accelerations in a mechanism (particularly in power transmissions).

Necessary prerequisites

- Reading a kinematic diagram
- Solving systems of algebraic equations
- Trigonometry and projections
- Vectors, scalar and vector products
- Derivatives of composite functions

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