1EL5000 – Continuum Mechanics

Instructors: Guillaume Puel
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: ANGLAIS, FRANCAIS
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 35,00

Description

The student should be convinced of the ubiquity of the concepts and tools of mechanics in any industrial project implying either basic or advanced technology. The basic concepts are introduced in a common unified framework for tridimensional deformable solids and slender structures. Problems involving mechanics at different scales illustrate the course, with some applications to civil engineering, transportation, biomechanics and nanotechnology typically.

Quarter number
SG1 and SG3

Prerequisites (in terms of CS courses)
None

Syllabus

1. Strains : Lagrangian description of movements, Green-Lagrange strain tensor, infinitesimal strain tensor
2. Stresses : global equilibrium equations for a material medium, Cauchy stress tensor, local equilibrium equation
3. Strength criteria: mechanical tests, brittle fracture criteria, Tresca and von Mises criteria, stress concentrations
4. Material behaviour : diversity, linear elastic isotropic behaviour, thermoelasticity
5. Elasticity : properties of the mechanical solution, exact and approximate solutions, simplifications of an elastic problem
6. Intermediary examination 1 (MCQ of 45 min) + numerical session : analysis of numerical solutions using the software Comsol Multiphysics
7. a) Intermediary examination 2 (analysis of numerical solutions : 30 min) / b) Beam approximation : demonstration of the assumptions of the beam model, definition of the internal loadings

8. Beam approximation : approximate kinematics, constitutive relations, connections
9. Beam approximation : solution methods, buckling phenomenon
10. Summary problem on beams
11. Summary session : design problem, with graded report
12. Final examination (2h)

Class components (lecture, labs, etc.)

Typical 1h30 lectures followed by 1h30 tutorial classes, except for sessions 6, 10 and 11 (3h-sessions of tutorial classes)
Occurrences 1.1 and 1.4 are in English ; occurrences 1.2 and 1.3 are in French.

Grading

Overall grade = 15% intermediary examination 1 grade + 15% intermediary examination 2 grade + 15% session-11 report grade + 55% final examination grade (written exam)
All documents are allowed, as well as non communicating calculators for the final examination

Course support, bibliography
Lecture notes

Resources
• Teaching staff (instructor(s) names): Andrea BARBARULO, Didier CLOUTEAU, Ann-Lenaig HAMON, Guillaume PUEL
• Maximum enrollment: 40 for each tutorial class
• Software, number of licenses required: Comsol Multiphysics (including the Structural mechanics module)
• Equipment-specific classrooms: none (numerical sessions with Comsol are taught in classical tutorial classes)

Learning outcomes covered on the course
Learning outcomes :
• Model the mechanical behaviour of a deformable solid

> Justify the relevant choice of model (2D or 3D, axisymmetry, slender structures, ...)
> Write the correct equations and boundary conditions corresponding to the loads and constraints applied to the domain and its boundaries
> Identify the mechanical properties of constitutive materials that are relevant to model the studied problem (e.g. rigidity, resistance, …)

• Determine the (stationary) mechanical response of a deformable solid

> Find the exact solution or an approximate solution (analytical or numerical) of the studied problem
> Deduce from the obtained solution the quantities allowing to make design choices
> Justify or criticize the validity of the obtained solution

Description of the skills acquired at the end of the course

The intermediate examination 2 allows the evaluation of the milestone 1 of the subskills **C1.2** "Modeling: use and develop appropriate models, choose the right modeling scale and the relevant simplifying hypotheses" and **C1.3** "Solving: solve a problem with the use of approximation, simulation and experimentation".

The report of session 11 allows the evaluation of milestone 1 of sub-skills **C1.1** "Analyzing: study a system as a whole, the situation as a whole. Identify, formulate and analyze a system within the framework of a trans-disciplinary approach with its scientific, economic and human dimensions" and **C1.4** "Designing: specify, realize and validate all or part of a complex system".

These two elements allow the validation of milestone 1 of skill **C1**, while the validation of milestone 1 of skill **C2** is directly related to the final mark for this course.