ME-331

Solid mechanics

Reis Pedro M.

Cursus	Sem.	Type
Mechanical engineering minor	E	Opt.
Mechanical engineering	BA6	Obl.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	3 weekly
Exercises	1 weekly
Number of positions	

Summary

Fundamental understanding and analysis of the mechanical behavior of engineering materials and their use in mechanical design based on the continuum mechanics of solids.

Content

The purpose of this course is to provide mechanical engineering students with a fundamental understanding of the physical mechanisms associated with design-limiting mechanical properties of engineering materials, including stiffness, strength, and toughness. Students will develop quantitative skills based on the continuum mechanics of solids to address materials-limited problems in engineering design, using continuum mechanics principles, while relating material microstructure to macroscopic mechanical response. Throughout, concrete examples will be provided across a wide range of engineering application scenarios, providing students with an introduction to the analytical tools necessary to select materials and predict their performance in real-world engineering applications. The course may cover, but not exclusively, the following topics: [1] 3D Continuum Mechanics: stress, strain, constitutive law (linear elasticity), stress concentration, limits of elasticity; [2] Rubber elasticity; [3] Viscoelasticity; [4] Plasticity; and [5] Fracture.

Keywords

Continuum mechanics, Mechanical properties, Stress analysis, Linear elasticity (Boundary-value problems), Stress concentration, Viscoelasticity, Rubber elasticity, Plasticity, Fracture mechanics, Material selection.

Learning Prerequisites

Required courses

- Materials: From chemistry to Properties (MSE-101a);
- Introduction to Structural Mechanics (ME-104);
- Mechanics of Structures II (ME-232);
- or equivalents from other institutions.

Important concepts to start the course

- Linear algebra
- Vectorial calculus
- Ordinary Differential Equations (ODEs) and some introductory concepts from Partial Differential Equations (ODEs).

Learning Outcomes

By the end of the course, the student must be able to:

- Model and analytically solve simple problems of statics and stress analysis.
- Analyze 3D stress and strain states in solids using tensor notation and coordinate transformations.
- Identify the constitutive behaviour of a material from the results of a mechanical test and choose a suitable test standard.
- Apply constitutive laws for different material classes (elastic, viscoelastic, plastic, hyperelastic) to solve engineering problems.
- Design against failure using appropriate yield criteria and safety factors for different loading conditions.
- Predict time-dependent material behavior using viscoelastic theory and long-term material performance.
- Model with analytical tools the nonlinear response of structures and materials.
- Assess / Evaluate stress intensity factors and apply fracture mechanics principles to evaluate structural integrity.
- Propose appropriate materials for specific engineering applications based on mechanical property requirements.

Transversal skills

- Use a work methodology appropriate to the task.
- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Set objectives and design an action plan to reach those objectives.
- Assess one's own level of skill acquisition, and plan their on-going learning goals.
- Access and evaluate appropriate sources of information.
- Manage priorities.
- Demonstrate the capacity for critical thinking
- Continue to work through difficulties or initial failure to find optimal solutions.

Teaching methods

Ex-cathedra

Expected student activities

Exercise sessions

Assessment methods

Final exam (100%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes
Others	"Office hours" on request, in between lectures, or at the end of the lecturers.

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

- L. Anand, K. Kamrin, and S. Govindjee, Introduction to Mechanics of Solids Materials, OUP (2022)
- J. Botsis and M. Deville, Mechanics of Continuous Media: an Introduction. PPUR (2018).
- A.F. Bower, Applied mechanics of solids. CRC press (2009).

• D. Gross, W. Hauger, J. Schröder, W.A. Wall, J. Bonet, Engineering Mechanics 2: Mechanics of Materials, Springer (2018).
• L. Anand and S. Govindjee, Continuum Mechanics of Solids, OUP (2020)
• S.H. Crandall, N.C. Dahl, T.J. Lardner, M.S. Sivakumar, An introduction to Mechanics of Solids, McGraw Hill (2012)

Ressources en bibliothèque

• Find the references at the Library

Notes/Handbook

Printed handouts of the lectures will be provided with material that enhances and complements the recommended books and/or provides the relevant content in a more syntetically and compactly.

Moodle Link

• https://go.epfl.ch/ME-331

Prerequisite for

• Computational Solid and Structural Dynamics (ME-473)
• Fracture mechanics (ME-432)
• Mechanics of composites (ME 430)