ME-331

Solid mechanics III

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

This course focuses on the fundamental understanding and analysis of the mechanical behavior of engineering materials and their application 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 and fatigue.

Keywords

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

- Analyze 3D stress and strain states in solids using tensor notation, coordinate transformations, and principal-value decompositions, and formulate the governing equations of equilibrium.
- Formulate and solve boundary-value problems in linear elasticity, including stress concentration analyses, by combining equilibrium, kinematics, constitutive relations, and boundary conditions.
- Identify the constitutive behavior of engineering materials from experimental data (e.g., mechanical testing) and relate macroscopic mechanical response to underlying physical micro-mechanisms.
- Apply constitutive laws for distinct material classes (elastic, hyperelastic, viscoelastic, and plastic) to model and solve engineering problems involving both linear and nonlinear material response.
- Design against failure by applying appropriate yield criteria, fracture mechanics principles (stress intensity factors, fracture toughness), and fatigue life predictions under both static and cyclic loading.
- Select appropriately appropriate materials for engineering applications by distinguishing between stiffness, strength, and toughness, and by evaluating trade-offs across material classes and loading conditions.

Transversal skills

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

Teaching methods

Ex-cathedra.

Expected student activities

Exercise sessions (Studios).
Note that, our of the 4 contact hours per week, some weeks may have 4 hours/periods of lectures and 0 of studios, whereas others will have 2 hours/periods of lectures and 2 hours/periods of studios. A detailed schedule will be provided at the start of the semester.

Assessment methods

Final exam (100%)

Supervision

Office hours	No
Assistant.e.s	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

- Anand, L., Kamrin, K., and Govindjee, S., Introduction to Mechanics of Solid Materials, Oxford University Press, Oxford, 2022.
- Bower, A. F., Applied Mechanics of Solids, CRC Press, 2009.

• Botsis, J., and Deville, M., Mechanics of Continuous Media: an Introduction, Presses Polytechniques et Universitaires Romandes (PPUR), 2018.

Ressources en bibliothèque

• Retrouver les références à la Bibliothèque

Notes/Handbook

Printed handouts of the lectures will be provided, along with material that enhances and complements the recommended books and/or presents the relevant content in a more concise, synthetic manner.

Websites

• http://moodle.epfl.ch

Moodle Link

• https://go.epfl.ch/ME-331

Prerequisite for

Mechanics of Slender Structures (ME-411)
Dynamic finite element analysis of structures (ME-473)
Modeling of soft and biological matters (ME-470)