ME-411

Mechanics of slender structures

Reis Pedro M.

Cursus	Sem.	Type
Mechanical engineering minor	H	Opt.
Mechanical engineering	MA1, MA3	Opt.
Mechanics		Opt.

Language of teaching	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**5 weekly**
Courses	3 weekly
TP	2 weekly
Number of positions	

Summary

Analysis of the mechanical response and deformation of slender structural elements

Content

Through this course, students will learn how to rationalize, analyze, and predict the mechanics of deformation of slender structural elements. The acquired knowledge will build upon, and further specialize material from, previous SGM courses in solids and structures (Introduction to structural mechanics, Structural mechanics, Continuum mechanics, Solid mechanics). The focus will be given to fundamental problems in mechanical systems comprising beams, rods, plates, and shells, primarily in their elastic regime. Methods of analysis will cover both scalings and analytical modeling. Students will recognize the specificities of slender structures, e.g., geometric nonlinearities, buckling, and the possibility of large deformations (albeit under linear material strains). Throughout, concrete examples of slender structures will be provided across a wide range of modern application scenarios and from the recent literature, including biological structures, micro-nano mechanical systems, robotics, and large engineering structures.
The course may contain, but not exclusively, the following elements: [1] Elasticity and dimensional reduction of elastic bodies; [2] Dimensional analysis and scalings; [3] Euler's *Elastica*; [4] Strings and Rods; [5] Plates; [6] Thin films, Multilayers and Coatings; [7] Shells; [8] Buckling of slender structures.

Keywords

Thin structures, Mechanics, Elastic deformation, Buckling, Geometric nonlinearities.

Learning Prerequisites

Required courses

ME-232 (Structural Mechanics), ME-201 (Continuum Mechanics), and ME-331 (Solid Mechanics), or equivalent from other institutions.

Recommended courses

ME-202 (Mechanical Systems); ME-373 (Finite element modeling and simulation). It will be beneficial for students to have taken ME-437 (Advanced Solid Mechanics), or to be taking it in parallel to this course, even if this is not required.

Important concepts to start the course

Familiarity with structural analysis of elastic systems (bars, trusses, beams, trusses, frames, and mechanisms) and boundary value problems in elasticity. The emphasis of the course is primarily on analytical methods to rationalize and model the mechanics of slender structure, hence, an affinity to mathematical and theoretical approaches in problem solving is expected.

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, S1
- Analyze and design assemblies of simple mechanical elements in the framework of static and buckling, S2
- Model with analytical or numerical tools the nonlinear response of structures and materials, S12

Transversal skills

- 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.
- 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.

Teaching methods

Lectures, practical demonstrations, example problems, in-class exercises, and homework.

Assessment methods

The course concludes with a written exam.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

The following books are not required but may be useful and complement to the material provided during the course:
L.D. Landau and E.M. Lifshitz "Theory of Elasticity (3rd Edition)" Elsevier (1986).
O.M. O'Reilly "Modeling Nonlinear Problems in the Mechanics of Strings and Rods" Springer (2016).
S.P. Timoshenko and S. Woinowsky-Krieger "Theory of plates and shells" McGraw Hill (1956).
M. R. Begley and J. W. Hutchinson "The Mechanics and reliability of films, Multilayers, and Coatings" Cambridge University Press (2017).
B. Audoly and Y. Pomeau ¿Elasticity and Geometry: From hair curls to the non-linear response of shells¿ Oxford University Press (2010).
E. Ventsel and T. Krauthammer ¿Thin Plates and Shells: Theory, Analysis and Applications¿ Marcel Decker (2001).

Ressources en bibliothèque

- The Mechanics and reliability of films, Multilayers, and Coatings / Begley
- Theory of plates and shells / Timoshenko
- Theory of Elasticity / Landau
- Elasticity and Geometry: From hair curls to the non-linear response of shells / Audoly
- Thin Plates and Shells: Theory, Analysis and Applications / Ventsel
- Modeling Nonlinear Problems in the Mechanics of Strings and Rods / O'Reilly

Notes/Handbook

Printed handouts of the lectures will be provided with material that enhances and complements recommended books.

Moodle Link

- https://moodle.epfl.ch

Prerequisite for

None