ME-426

Micro/Nanomechanical devices

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Cursus	Sem.	Type
Mechanical engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	3
Session	Winter
Semester	Fall
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

In this course we will see an overview of the exciting field of Micro and Nanomechanical systems. We will go over the dfferent scaling laws that dominate the critical parameters, how size affects material properties, how these devices are manufactured, designed and later used.

Content

The idea of this course is to give a full view of the field of MEMS/NEMS mostly from a mechanical engineering standpoint. The course will be divided into the following sections:

1. ***Introduction - Scaling laws:*** we will briefly see the where does the interest on this devices stems from. Reduction of dimensions not only to fit things into small places.

2. ***Fabrication:*** Briefly, we will study how these devices are manufactured and how this departs from the more typical (classical) way of machining.
3. ***Static deflection:*** due to forces, due to surface stress and/or temperature changes, and due to acceleration.
4. ***Normal modes calculation:*** normal modes calculation (frequencies and mode shapes), mechanical nonlinearities.
5. ***Material properties:*** We will analyze if and how material properties depend on the size of the fabricated device.
6. ***Quality factor:*** The fundamental damping sources for small mechanical resonators will be analyzed, including thermoelastic damping, anchor losses, and stress-based dissipation dilution.
7. ***Transduction:*** Since these devices are very small, the usual ways of detecting and creating motion cannot be applied anymore. We will briefly study the different options with their advantages and disadvantages.
8. ***Noise:*** A study of how noise appears in these systems will be performed.
9. ***Applications:*** The different applications of these devices will be briefly reviewed.

Keywords

- NEMS/MEMS
- Nanomechanics
- Quality factor
- Nonlinear dynamics

Learning Outcomes

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

- Explain the advantages of NEMS/MEMS in basis of scaling laws
- Analyze micro- and nano-mechanical systems

- Deduce behaviour of NEMS/MEMS both in static and dynamic mode
- Estimate nonlinear limits
- Estimate energy loss mechanisms
- Perform simulations to model these systems
- Recognize the different transduction mechanisms
- Apply the principle of statics and structural mechanics to analyse and design assemblies of simple mechanical elements in the framework of statics , buckling ; c ompute thermal str esses for simple cases, S2
- Carry out an experimental modal analysis to determine the dynamic characteristics of a real structure; assess the structural response from the obtained results and discuss, S4
- Apply the models for the behaviour of composite materials and laminates to compute the stiffness, the deformed shape and stresses of a simple composite structure. S7
- Assess / Evaluate the main measurement techniques in mechanics to characterize the steady - state or dynamic response of solids, fluids, structures and mechanisms ; e valuate the uncertainties and discuss the obtained experimental results , S11
- Describe in scientific terms and apply a numerical method for multiphysics simulations appropriate for a complex physics problem. Develop an idea lized model of dominant physical behaviours and of initial and boundary conditions, S16

Transversal skills

- Make an oral presentation.
- Summarize an article or a technical report.
- Write a scientific or technical report.
- Evaluate one's own performance in the team, receive and respond appropriately to feedback.
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.

Teaching methods

- Ex catedra
- Hands-on exercises
- Presentation from students on different reports/scientific works
- Presentation from students on their project

Assessment methods

- Evaluation during the semester based on the *group* project(s) that the students conduct (50%).
- In the exam period, an individual meeting will be held to establish the individual grade within each group (50%).

Supervision

Office hours	Yes
Assistants	No
Forum	No

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

http://www.springer.com/us/book/9783319286891
(Available for free from EPFL - electronic copy)

Ressources en bibliothèque

- Fundamentals of Nanomechanical Resonators / Villanueva