Mechanical Vibrations

Lecturers
Arnaud DERAEMAEKER (Coordinator) and Wout Weijtjens

Course mnemonic
MECA-H411

ECTS credits
5 credits

Language(s) of instruction
English

Course period
First term

Campus
Solbosch

Course content

The course studies the time dependent behavior of structures and systems excited by dynamic forces. The course starts with the analysis of systems with one, two and several degrees of freedom, with and without damping, and also deals with simple continuous structures (beams and bars) and more complex finite element models. The different sources of excitations for practical applications are described, together with a description of the effects and a discussion of possible design and remedial measures. Sensors, data acquisition and signal processing to measure vibrations experimentally are also presented.

Objectives (and/or specific learning outcomes)

The students will learn how to model time dependent dynamic behavior of structures. Emphasis is put on the ability to derive simple models from real complex structures and to compute their dynamic response due to different types of excitations.

The students will also develop a deep understanding of the sources and effects of vibrations on structures, as well as basics on instrumentation and methods to measure vibration levels, frequency response functions, and extract modal data on real structures.

When measured or predicted vibration levels are excessive, the students will learn what are the most relevant redesign and remedial measures and how to apply them, with a design oriented approach.

Teaching method and learning activities

The course is articulated around different case studies for which the students have to be able to describe the source of excitation, how to model the problem and predict vibration levels, as well as propose the most adequate design and remedial measures when these levels are excessive.

The course consists of 24h of lectures based on the principle of flipped classes. The students are asked to watch one or several short videos before the class, and the time in the class is dedicated to interactive activities such as wooclap sessions, group exercises and discussions about case studies to consolidate the theoretical knowledge.

The following topics are covered:

1. Introduction
2. One degree of freedom systems
3. Sources of vibrations
4. Multiple Degree of Freedom systems
5. Finite elements models
6. Continuous Systems
7. Equivalent SDOF systems
8. Flow induced vibrations
9. Vibrations problems
10. Dynamic response computation
11. Design and remedial measures
12. Damping
13. Tuned vibration absorbers
14. Vibration isolation
15. Vibration testing and modal analysis

In addition, 36h hours of exercise are organized. The exercises are aimed at illustrating the main steps involved in the description of the case studies: understanding of the excitation (based on Fourier analysis), modeling of the physical system (including reduction to a single degree of freedom system), computation of the response both in time and frequency domain, assessment of potential dynamic instabilities, and application of remedial measures, with a focus on practical engineering design. The exercise sessions are based on python language and jupyter notebooks.

The following topics are covered:

- One degree of freedom systems and general introduction
- Multiple degree of freedom systems and mode shapes
- Fourier Analysis and excitation sources
- Reduction to SDOF systems
- Vortex induced vibrations and flutter
- Dynamic response computation in time and frequency domain
- Damping and tuned mass dampers
- Vibration isolation

- Vibration measurements (FRF) and modal analysis

Contribution to the teaching profile

This teaching unit contributes to the following competences:

- In-depth knowledge and understanding of exact sciences with the specificity of their application to engineering
- Reformulate complex engineering problems in order to solve them (simplifying assumptions, reducing complexity)
- Correctly report on research or design results in the form of a technical report or in the form of a scientific paper
- Present and defend results in a scientifically sound way, using contemporary communication tools, for a national as well as for an international professional or lay audience

References, bibliography and recommended reading

Inman, D.J - Engineering vibrations. Prentice Hall, 3d Edition, 2007

Géradin M., Rixen D. Mechanical Vibrations - Theory and Application to Structural Dynamics. John Wiley & Sons, second edition, 1997

Course notes

Podcast and Syllabus

Other information

Place(s) of teaching

Solbosch

Contact(s)

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Evaluation method(s)

Project and Oral examination

Evaluation method(s) (additional information)

The evaluation is based on an oral examination, and evaluation of the exercise sessions. The oral examination is made of two parts, the first one is aimed at checking the general understanding of the theoretical concepts, while the second one consists in a presentation and discussion about one of the practical case studies presented in the course.

Determination of the mark (including the weighting of partial marks)

20% for the exercise sessions, 80% for the oral examination (40% for each part). The presence at the exercise sessions is compulsory. The professors may refuse participation to the oral examination in case of unjustified absence at the exercise sessions.

Main language(s) of evaluation

English

Programmes

Programmes proposing this course at the Brussels School of Engineering

MA-IRCB | Master of science in Biomedical Engineering | finalité Professional/unit 2 and MA-IREM | Master of science in Electromechanical Engineering | finalité Professional/unit 1 and finalité Operations engineering and management/unit 1