COURSE: Advanced Method for Mechanical System Modeling	
ACADEMIC YEAR: 2017-2018	
TYPE OF EDUCATIONAL ACTIVITY: Characteristic	
TEACHERS: Elena Pierro (6 CFU), Antonio D'Angola (3 CFU)	
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Language: ITALIAN	

ECTS: 9	n. of hours: 81 n. of hours of lessons: 60 n. of hours in laboratory: 21	Campus: POTENZA School: Scuola di Ingegneria Program: Ingegneria Meccanica	Semester: I

EDUCATIONAL GOALS AND EXPECTED LEARNING OUTCOMES

The course is strongly inter-disciplinary, with the aim to provide theoretical, numerical and experimental methods useful to investigate the dynamics of mechanical systems and their linear and non linear vibrations. The Monte Carlo method is shown mathematically and numerically. During the course, experimental aspects related to mechanical vibrations and some procedures useful to realize a numerical project are analyzed in laboratory.

The main concepts provided are:

- Fundamentals of mechanical vibrations of one/n d.o.f. systems;
- Vibrations of continuous systems;
- Numerical methods to study mechanical vibrations;
- Basic knowledge of signals, useful to study experimental frequency response functions;
- Methods to realize a complete experimental modal analysis;

Main competences:

- Numerical analysis to study the dynamics of a mechanical system;
- Experimental analysis to study the mechanical vibrations.

The course improves the abilities of the student in applying theoretical, experimental and numerical methods, to design and analyze complex mechanical systems. The judgment autonomy is improved by means of projects, experiments and applications. Communicative abilities are improved through practical applications and tests, learning abilities are encouraged by means of teaching methods, such as the analysis and the resolution of different complex problems.

PRE-REQUIREMENTS

Concepts of Physics and Mathematical Physics (Kinematics of a particle trajectory. Kinematics of rigid bodies. Dynamics of rigid bodies). Statistics.

SYLLABUS

INTRODUCTION TO MECHANICAL VIBRATIONS

Free vibrations. Harmonic oscillator. Damping mechanisms (proportional and non proportional). Example of vibration measurement (logarithmic decrement) and stability concepts. (4 hours of theoretical lessons)

1 d.o.f. SYSTEMS

Classical solutions of differential equations. Time and frequency domain analysis. Laplace and Fourier Transform. Definition of Frequency Response Function (FRF). Response to a random input, periodic and non periodic, and to an impulsive signal. (8 hours of theoretical lessons)

n d.o.f. SYSTEMS

Definition of mass, stiffness and damping matrices. Modal analysis, eigenvectors and eigenvalues, eigenvectors orthogonality, equations decoupling. Eigenvectors normalization. N d.o.f. systems with viscous (proportional) damping. Lagrange equations. Concepts of vibrations insulations. (8 hours of theoretical lessons)

VIBRATIONS OF CONTINUOUS SYSTEMS

Free longitudinal vibrations of string and beams: modes and natural frequencies. Transversal vibrations of beams; acoustic waves and definition of acoustic properties. Vibro-acoustical coupled systems. (8 hours of theoretical lessons)

FREQUENCY ANALYSIS AND RANDOM VIBRATIONS

Signal classification, analogic and digital. Aliasing, leakage e windowing. Discrete Fourier Transform (DFT). FRF estimation with random excitation. Probability distribution. Mean and expected value. Correlation. Power Spectral Density (PSD). Response of linear systems to random vibrations. (8 hours of theoretical lessons)

EXPERIMENTAL MODAL ANLYSIS

Measurement chain. Experimental modal analysis (EMA): set-up, data acquisition, post-processing. Eigenvalues and eigenvectors identification by means of experimental FRF. Practical applications, concepts of methods to extract the modal parameters (parametric modal analysis) and alternative experimental techniques (Operational Modal Analysis – OMA). (12 hours of theoretical lessons, 6 hours of laboratory tutorials)

MONTE CARLO METHOD

Probability and statistics. Expected values, variances, Cebicev inequality. Central limit theorem. Random number generation. Sample generation. Estimate of integrals and solution of integral equations. Statistical convergence of Monte Carlo. Importance sampling, biasing methods and convergence acceleration. Random nonlinear oscillations. (12 hours of theoretical lessons, 15 hours of laboratory tutorials).

TEACHING METHODS

The course is organized as follows:

- Theoretical lessons (60 hours);
- Laboratory tutorials to study the experimental modal analysis (6 hours).
- Laboratory tutorials to implement numerical algorithms (15 hours).

EVALUATION METHODS

The examination consists of an oral test and the mandatory compilation of a numerical project on the Monte Carlo method for mechanical systems. The project must be released at least one week before the oral examination.

The final score is the sum of the scores obtained at the oral examination (4/5 of the total score) and at the project evaluation (1/5 of the total score). In order to pass the exam, both scores must be at least 18/30. The student that obtains at least 18/30 at the project evaluation can access to the oral examination.

Oral examination and project can be repeated and it's possible to repeat the oral examination preserving the project evaluation.

TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL

Educational material available in the shared folder (contact the teacher to register) and exercises available at the web page of the course(http://www2.unibas.it/epierro/MAMSM.html).

Textbooks:

- D. J. Ewins, Modal Testing, Theory, Practice, and Application (Mechanical Engineering Research Studies: Engineering Dynamics Series).
- D. J. Inman, Engineering Vibrations, Prentice Hall.
- Meirovitch L.: Fundamentals of vibrations. McGraw-Hill, New York.
- Heylen W., Lammens S., Sas P.: "Modal Analysis Theory and Testing", Katholieke Universiteit Leuven– Departement Werktuigkunde.
- Norton M. P., Karczub D.G.: "Fundamentals of Noise and Vibration Analysis for Engineers", Cambridge University Press, Cambridge.
- J. Roberts, P. D. Spanos, Random Vibration and Statistical Linearization, Dover Pub.

INTERACTION WITH STUDENTS

During the first lessons, the teachers show the educational goals and expected learning outcomes, the syllabus and all the details of the course (evaluation methods …). Then, the teachers take the list of the students to share a folder where the lessons and further educational material will be uploaded.

PROFESSOR’S OFFICE HOUR: Thursday, 09.30 Floor V, room 75 (Elena Pierro); Thursday, 11.30 Floor V, room 69 (Antonio D’Angola)

EXAMINATION SESSIONS (FORECAST)[1]

02/02/18, 23/02/18, 18/05/18, 29/06/18, 20/07/18, 28/09/18, 26/10/18, 23/11/18

SEMINARS BY EXTERNAL EXPERTS NO

FURTHER INFORMATION

[1] Subject to possible changes: check the web site of the Teacher or the Department/School for updates.