Università degli Studi della Basilicata
Scuola di Ingegneria

COURSE: Advanced Method for Mechanical System Modeling	
ACADEMIC YEAR: 2019-2020	
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: 62 n. of hours in laboratory: 19	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 vehicle dynamics;
- Methods to realize a complete experimental modal analysis;

Main competences:

- Numerical analysis to study the dynamics of a mechanical system, especially for vehicle dynamics;
- 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. (6 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. (6 hours of theoretical lessons)

VIBRATIONS OF CONTINUOUS SYSTEMS

Free longitudinal vibrations of string and beams: modes and natural frequencies. Transversal vibrations of beams. (6 hours of theoretical lessons)

EXPERIMENTAL MODAL ANLYSIS

Signal classification, analogic and digital. Aliasing, leakage e windowing. Discrete Fourier Transform (DFT). 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). (8 hours of theoretical lessons, 4 hours of laboratory tutorials)

VEHICLE DYNAMICS

Tires: dynamics and components. Forces exchanged with the external environment. Directional behavior of the vehicle. Resistance to motion: rolling resistance, aerodynamic resistance. Straight line performance: choice of gear ratios, speed and maximum incline. Curved motions: kinematic steering, single-track 3 gdl model, travel stability study. Steering stroke. Vehicle suspensions: classification and kinematics. (20 hours of theoretical lessons)

NUMERICAL METHOD AND MONTE CARLO TECHNIQUE

Linear and non linear numerical solutions of systems of ordinary differential equation with the MATLAB toolbox ODE. 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. (12 hours of theoretical lessons, 15 hours of laboratory tutorials).

TEACHING METHODS

The course is organized as follows:

- Theoretical lessons (62 hours);
- Laboratory tutorials to study the experimental modal analysis (4 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 focused on vehicle dynamics. 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 (3/5 of the total score) and at the project evaluation (2/5 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.
- G. Genta, Meccanica dell'autoveicolo, Levrotto & Bella.
- M. Guiggiani, Dinamica del Veicolo, Città Studi Edizioni.
- 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] 07/02/20, 06/03/20, 17/04/20, 05/06/20, 17/07/20, 18/09/20, 23/10/20, 27/11/20
SEMINARS BY EXTERNAL EXPERTS YES
FURTHER INFORMATION

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