69713 - MECHANICS OF MACHINES M
Master course: **8611 - ELECTRICAL ENERGY ENGINEERING** - Cycle: 1 - CFU: 6
Faculty of Architecture and Engineering, Università di Bologna, **a.y. 2015-16**
Teacher: DdR. Ing. Alessandro Zanarini

Mechanics of Machines M - a course on structural dynamics for advanced machine design and diagnostics

I am pleased to announce for the academic year 2015-2016, 1st cycle, the new course of Mechanics of Machines M - a course on structural dynamics for advanced machine design and diagnostics, with particular emphasis on experimental approaches on real complex machines.

It is a course that can be chosen for the master students of Electrical Energy Engineering, to extend the basic knowledge on the Mechanics of Machines, already achieved at the bachelor, to the level needed to interact with design players in automotive, wind energy, aerospace and advanced product manufacturing or of modern high performance machines. Please find the skeleton of the course below or at the following link: http://www.engineeringarchitecture.unibo.it/en/programmes/course-unit-catalogue/course-unit/2015/401391

The course language is English.

Learning outcomes
The course strengths the knowledge of the students on the understanding and problem solving in dynamic behaviour of real machines and mechanisms, with particular attention to structural dynamics, experimental approaches, diagnostics and substructuring.

The main point is to give the students the instruments to dialogue with other experts in multidisciplinary groups that work on the constructions of complex machines, such as turbo-machines and wind-turbines in energy production and harvesting, but also on the emerging electrical vehicles and environmental friendly or vibro-acoustically comfortable machines, from an air conditioning system to a dish-washer. From this stand point, the course wishes to provide means to act on the machine concept and design, which are from aerospace origin but find more and more application in advanced common products; the master students will gain skills to better interact in a team of experts, being able to understand the language of designers and to rightly follow the evolution and behaviour of complex machines.

#	Lesson	Topics
1	22/09/2015	Brief introduction on the course perspectives and potential targets. Introduction to numerical kinematics. Survey on the student interest about the course.
2	23/09/2015	Numerical kinematics: equations of motion for free bodies; description of mechanical constraints from a mathematical point of view.
3	29/09/2015	Numerical kinematics: time and frequency domain analysis.
4	30/09/2015	Introduction to structural dynamics of multi degrees of freedom systems.
5	06/10/2015	Equations of motion and structural matrices representation for multi degrees of freedom systems.
6	07/10/2015	Modal base extraction, orthogonality of eigenshapes, modal transforms.
7	13/10/2015	Generalised damping in structural dynamics.
8	14/10/2015	Introduction to signal processing and measurements for structural dynamic characterization and diagnostics. The measurement chain.
9	20/10/2015	Sensors for vibro-acoustics. Sampling and transform theorems.
10	21/10/2015	Correlations, Spectra, Power Spectral Densities, Frequency Response Functions, Coherence Function.
11	27/10/2015	Introduction to the diagnostics of mechanical components and machines: cracks, superficial faults and fatigue life predictions due to dynamic loadings. Cumulative damage approaches in time and in frequency domain.
12	28/10/2015	Diagnostics of rolling bearings: the kinematical model, the dynamic signature & fault diagnosis.
13	03/11/2015	Diagnostics of gear mesh: problems in production and operation, the dynamic signature & fault diagnosis.
14	04/11/2015	Diagnostics of joints and couplings.
15	10/11/2015	Rotor dynamics and balancing for high speed spindles and axes, dynamic effects of fluid interaction in journal bearings.
16	17/11/2015	Introduction to Experimental Modal Analysis: principles of identification or inverse analysis of real vibro-acoustic problems, with many examples from industrial applications. Parallelism to direct modelling of many dof systems. Fundamental equations for EMA.
17	18/11/2015	Review of EMA approaches: single vs multi dof, local vs global, time- vs frequency- domain; comments.
18	24/11/2015	Examples of application of the EMA approaches in real test cases.
19	25/11/2015	An application of EMA results: structural model updating, tuning and optimisation. Examples.
20	01/12/2015	The concept of structural modifications in the framework of simulations from structural models. Some hints on vibro-acoustic similarities and applications for coupled-domain analysis.
21	02/12/2015	Introduction to the theme of substructuring in spatial and frequency domains.
22	09/12/2015	Substructuring in spatial and frequency domains: approaches for a consistent dynamic reduction versus partial reductions; comments on virtual vs experimental approaches.
23	15/12/2015	Coupling and assembly of reduced models in substructuring techniques. Hints on applications for flexible multi-body systems for general mechanisms.
24	16/12/2015	Examples of hybrid coupling for vibro-acoustics and experimental models.

References:

D.J. Ewins	Modal Testing, Theory, Practice and Application, ISBN-13: 978-0863802188
W. Heylen, S. Lammes, P. Sas	Modal Analysis Theory and Testing, KUL Press, Leuven, Belgium, 1997
J.S. Bendat, A.G. Piersol	Random data: analysis and measurement procedures, John Wiley & Sons, 2011
R.R. Craig	Structural dynamics: an introduction to computer methods,Wiley, 1981
A. Muszynska	Rotordynamics, 2005 by CRC Press, ISBN 9780824723996
E.J. Haug	Computer Aided Kinematics and Dynamics of Mechanical Systems, Volume I: Basic methods, Allyn & Bacon 1989