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# Mechanical vibrations A

## Finalità

The course gives the basics for the theoretical vibration analysis of lumped parameter systems and for the experimental study of vibration of mechanical systems.

## Programma

1. Vibrations of single-degree-of-freedom systems. Free and forced vibrations. Base excitation.
2. Linear systems, convolution integral and impulsive response. Integral transforms (Fourier and Laplace). Transfer function. Fourier series. Response of a damped single-degree-of-freedom system to generic excitation.
3. Discrete Fourier transform. Shannon theorem. Introduction to FFT. Aliasing, leakage and time windows.
4. Power spectral energy. Autopower spectrum and autocorrelation function. Cross-power spectrum and cross-correlation function. Averaging. Frequency response function (H1, H2 and HV). Coherence. Introduction to nonlinear systems: hardening and softening systems.
5. Condition monitoring of machines by vibration measurement. Application to rotating machines: imbalance, misalignment, runout, looseness, resonances. Damage of gearboxes and rolling-element bearings.
6. Vibrations of multi-degree-of-freedom systems. Equations of motion in matrix form. Free vibrations of conservative systems; reduction to a standard eigenvalue problem. Dynamic vibration absorber. Definite and semidefinite matrices. Properties of natural frequencies and modes. Normalization, orthogonality, expansion theorem. Linear transformation of coordinates; natural coordinates. Forced vibrations of conservative systems. Proportional damping. General damping and solution by transition matrix. Complex modes. Applications.
7. Experimental measurement of vibrations in laboratory. Measurement of time-varying signals, autopower spectrum, FRF, coherence. Experimental set-up. Instrumentations: accelerometers, force transducers, hammer for modal tests, electrodynamic exciter (shaker), power and charge amplifiers, front-end.

## Attività d'esercitazione

Guided experiences finalized to the use of equipment for vibration measurement.

## Modalità d'esame

Written exam on the program that can be integrated with assignments and reports of laboratory experiences.

## Propedeuticità

## Testi consigliati

- L. MEIROVITCH, 1986, Elements of Vibration Analysis, 2nd edition, McGraw Hill.  
P. SAS (editore), 1992, Course on Modal Analysis, Theory and Practice, Vol. 1 e 2, Katholieke Universiteit Leuven.  
R. GARZIERA 1998, Introduzione alla diagnostica dei sistemi meccanici, dispensa del corso.