

**Title:** Perturbation Methods for Nonlinear Dynamical Systems

**Aim:** The short-course aims at introducing analytical asymptotic methods for solving weakly nonlinear problems for finite-dimensional dynamical systems. Particular attention is devoted to the Multiple Scale Method, which is able to automatically reduce the dynamics of the system to a manifold of the original space-state.

**Duration:** 6 hours divided into 3 lectures.

**Arguments:** Perturbation methods; dimension reduction; bifurcations; internal, external and parametric resonances.

**Models:** Algebraic nonlinear equations; weakly nonlinear ordinary differential equations; Duffing oscillator; Multi d.o.f. nonlinear mechanical systems.

**Methods:** Perturbation methods: straightforward expansion, strained coordinate method, Multiple Scale Method

**Program:**

Lecture 1 - quasi-linear algebraic equation; Eigenvalue and eigenvector sensitivity analysis; Multiparameter systems; Initial Value Problems: straightforward expansions  
Lecture 2 - the Multiple Scale Method: basic aspects and advanced computational topics  
Lecture 3 - Duffing oscillator under external excitations: primary, super-harmonic and sub-harmonic resonances; Duffing oscillator under parametric excitation; Multi-d.o.f. quasi-Hamiltonian systems under external/parametric/internal resonances

**Bibliography:**

- [1] Ali H. Nayfeh, Dean T. Mook, Nonlinear oscillations, Wiley-VCH, 2004
- [2] Luongo, A., Di Egidio, A., Paolone, A., 'Multiple Scale Bifurcation Analysis for Finite-Dimensional Autonomous Systems' in Recent Research Developments in Sound & Vibration', Transworld Research Network, Kerala, India, ISBN:81-7895-031-6 161-201, 2002
- [3] Luongo, A., Paolone, A., Di Egidio, A., 'Multiple Time Scales Analysis for 1:2 and 1:3 Resonant Hopf Bifurcations', Nonlinear Dynamics, 34(3-4), 269-291, 2003
- [4] Luongo A., Paolone A., 'Multiple Scale Analysis for Divergence-Hopf Bifurcation of Imperfect Symmetric Systems', Journal Sound and Vibration, 218(3), 1998, 527-539.