Perturbation Methods for Nonlinear Continuous Dynamical Systems in Engineering I.

MSc/PhD course: 1 ECTS, 5 lectures of 3 hours each, 15 hours of self-study, practical work and home work.

Lecture 1: Introduction to the multiple time-scales perturbation method for ordinary differential equations. Mathematical justification of the method. Application of the method to linear and nonlinear ordinary differential equations. Raleigh and Van der Pol equation.

Lecture 2: Introduction to the multiple scales perturbation method for partial differential equations. Mathematical justification of the method. Application of the method to linear and nonlinear partial differential equations. Vibrations of a string-like structure on a nonlinear elastic foundation. Telegraph and Klein-Gordon equations.

Lecture 3: Application of the multiple scales perturbation method to beam-like structures. Weakly nonlinear vibrations of beams. Applicability of the Galerkin truncation method to string-like and beam-like problems. Resonance conditions and the small denominator problem.

Lecture 4: When Galerkin's truncation method is not applicable to string-like problems to obtain accurate approximations on long time-scales, it will be shown how the multiple time-scales perturbation method in combination with the method of characteristic coordinates can be used in some cases to obtain accurate results on long time-scales. The method is applied to conveyor belt problems and to elevator cable vibrations.

Lecture 5: Outline of the mathematical justification of the applied methods to wave and beam equations. Several examples in the field of linear and nonlinear vibrations of elastic structures (such as strings, beams, and plates) will be given to show the restrictions of the applicability of Galerkin's truncation method. It will be made clear how infinite dimensional systems of ordinary differential equations might be studied.

Home work: At the end of this one-week course (in study load), the student has to hand in the home work by email. This home work will be graded at the TU-Delft.