SD2910 Spacecraft Dynamics 9.0 credits

Rymdfarkosters dynamik

This is a translation of the Swedish, legally binding, course syllabus.

If the course is discontinued, students may request to be examined during the following two academic years

Establishment

Course syllabus for SD2910 valid from Autumn 2014

Grading scale

A, B, C, D, E, FX, F

Education cycle

Second cycle

Main field of study

Mechanical Engineering

Specific prerequisites

Good knowledge in mathematics, mechanics and numerical methods from MSc education in Aerospace Engineering, Mechanical Engineering, Engineering Mechanics or Engineering Physics.

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

This course gives a deep understanding of modern spacecraft attitude dynamics and control. Rotational kinematics and dynamics of the spacecraft in orbit and different methods to passively or actively control the attitude are studied as well as implementation of nonlinear control laws for reaction wheels and variable speed control moment gyroscopes.

After the course you should be able to:

- Explain and use various parameterizations of rigid body kinematics in three dimensions: direction cosine matrix, Euler angles, principal rotation vector, Euler parameters (quaternions), classical Rodrigues parameters and modified Rodrigues parameters.
- Formulate and solve rotational torque-free dynamics problems in three dimensions.
- Formulate the attitude stability conditions for non-spinning and spinning spacecraft.
- Formulate constrained nonlinear modern attitude control laws based on Lyapunov stability functions, select suitable gain values, solve the problems numerically and evaluate the results.
- Implement nonlinear attitude control laws in reaction wheels and variable speed control moment gyroscopes, solve the problems numerically and evaluate the results.

Course contents

Part 1: Rigid body kinematics parameterizations in three dimensions: Direction cosine matrix, Euler angles, principal rotation vector, Euler parameters (quaternions), classical Rodrigues parameters and modified Rodrigues rarameters.

Part 2: Rigid body dynamics: angular momentum, kinetic energy and moment of inertia in three dimensions, Euler's rotational equations of motion, torque-free rigid body rotation, dual-spin spacecraft, momentum exchange devices and gravity gradient stabilization.

Part 3: Nonlinear spacecraft stability and control: stability definitions, Lyapunov stability, Lyapunov functions, nonlinear feedback control laws, Lyapunov optimal control laws and linear closed-loop dynamics.

Part 4: Nonlinear control law implementation in control devices: reaction wheels and variable speed control moment gyroscopes.

Disposition

The course is given together with the course SG2805 Spacecraft Dynamics on advanced level. The lectures briefly introduce the topics and methods used to solve the problems on the problem sheets. The workshops are tutored and the students are strongly encouraged to work in groups. The problem sheets cannot be finished during scheduled hours, so work on problem sheets during non-scheduled hours is required to meet the deadlines.

Course literature

Schaub, H. & Junkins, J. L. Analytical Mechanics of Space Systems, 2nd edition, AIAA Education Series, 2009.

Supplementary material in the form of research articles will be provided.

Equipment

The software Matlab is used throughout the course. Students are expected to use their own computers to solve the problems on the homeworks.

Examination

- PRO1 - Assignments with Oral Presentation, 4.0 credits, grading scale: A, B, C, D, E, FX, F
- TEN1 - Oral Examination, 5.0 credits, grading scale: A, B, C, D, E, FX, F

Based on recommendation from KTH’s coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

Other requirements for final grade

The participants are required to complete the following:

- Four problem sheets, related to the four parts of the course. The problem sheets are released at given dates and have to be submitted for correction before given deadlines.
- Oral presentation of selected problem sheet problems in front of class. The presenting students are randomly selected.
- Oral examination on all four parts of the course.

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.