MAS601 Design, Modelling and Simulation of Mechatronic Systems
5 credits Grimstad autumn (2010 MRH, GH, HE)

Study program
PhD programme in mechatronics

Learning outcome
After the course, the students shall be able to understand the mechatronic design approach, where the different disciplines involved are developed using concurrent product development. Furthermore, the students will know about new directions in the mechatronics engineering development and new technologies.

The learning outcome of the modelling and simulation part of the course is an overview of the state-of-the-art within modelling of mechatronic systems. The successful candidate will know the governing equations for steady-state and dynamic modelling of the basic electronic, electrical, hydraulic, pneumatic and mechanical sub-systems of a mechatronic system. Also, the successful candidate will be capable of combining these equations into models of closed-loop controlled mechatronic systems.

Contents
The course consists of two parts: Design Methodology in Mechatronics (2 credits) and Modelling and Simulation of Mechatronic Systems (3 credits).

Design Methodology in Mechatronics
The following key elements of mechatronics are presented:
- physical systems modelling
- sensors and actuators
- signals and systems
- computers and logic systems
- software and data acquisition

Modelling and Simulation of Mechatronic Systems
The basic steady-state and dynamic modelling of
- electronic circuits
- power electronics
- hydraulic systems
- pneumatic systems
- mechanical systems

are presented. The governing equations as well as techniques for linearization and numerical solutions are discussed. Techniques for combining these fundamental models into models of closed-loop controlled mechatronic systems are presented and introduced via a number of applications derived from
- electrical and hydraulic servo drives
- wind turbine drive trains
- 3D robot milling
- offshore heave compensation
- mobile machinery propulsion and implement handling

Teaching
Design Methodology in Mechatronics: Lectures (3 days). Individual project
Modelling and Simulation of Mechatronic Systems: Lectures (5 days). Individual project

Examination requirement
Approved project report.

Examination
Oral examination. Pass/Fail.

Offered as a free-standing course
No

Responsible faculty
Faculty of Engineering and Science

MAS602 Advanced Control and Robotics
5 credits Grimstad spring (2010 GH, HRK, TAH)

Study program
PhD programme in mechatronics

Learning outcome
The learning outcome of the course is insight into current research topics within advanced control systems and robotics. The successful candidate will have knowledge of the state-of-the-art within a number of topics related to analysis and design of multivariable and nonlinear systems.

Contents
The course presents a number of selected topics within state-of-the-art in advanced control and robotics research. Emphasis is on multivariable, non-linear systems. The course will contain selected topics from the following list:

- Nonlinear dynamic modelling of robotic systems (Euler-Lagrange, Newton-Euler)
- Independent Joint Control and Multivariable Control of Robots
- Force Control
- Feedback Linearisation
- Variable Structure and Adaptive Control, Sliding Mode Control
- Model Predictive Control (MPC)
- Adaptive Backstepping Techniques
- Multivariable Robust Control (H-Infinity)
- Quantitative Feedback Theory (QFT)
- Linear Matrix Inequalities (LMI)

Teaching
Lectures (8 days). Exercises

Examination
Oral examination. Pass/Fail.

Offered as a free-standing course
No

Responsible faculty
Faculty of Engineering and Science

MAS701 Fluid Power Systems Design
5 credits Grimstad spring (2011 MRH)

Study program
PhD programme in mechatronics

Recommended previous knowledge
MAS601 or equivalent

Learning outcome
The learning outcome of the course is insight into current research topics within fluid power systems design. The successful candidate will have knowledge of the state-of-the-art within a number of topics related to analysis and design of hydraulically actuated mechatronic systems.

Contents
The course presents a number of selected topics within state-of-the-art in hydraulic system research. Emphasis is on model based design of closed loop controlled hydraulic systems.

- Advanced modelling concepts
- System design - criteria, design variables, optimization
- Stability in hydraulics systems
- Single actuator control schemes
- PLS controlled servohydraulics
- Digital displacement pumps
- Load sensing systems
- Separate meter-in separate meter-out valves
- Tool point control
- Offshore heave compensation systems

Teaching
Lectures (8 days). Individual project

Examination requirement
Approved project report.

Examination
Oral examination. Pass/Fail.

Offered as a free-standing course
No

Responsible faculty
Faculty of Engineering and Science

MAS702 Electromagnetic Modelling
5 credits Grimstad spring (2011 OMM)

Study program
PhD programme in mechatronics

Recommended previous knowledge
MAS601 or equivalent

Learning outcome
After completing the course, the successful student will have a sufficient understanding of generalized theory of AC electrical machines (dq-theory), enabling them to apply these principles in advanced control of induction motor drives; and have a sufficient understanding of mathematical formulations for static and quasistatic electromagnetic field problems, enabling them to apply these principles in analysis and design of certain mechatronic system components.

Contents
Part 1: Advanced modelling of electrical machines. Space vectors, dq-theory and vector control of induction motor drives.
Part 2: Short review of Maxwell's equations. Formulations and solutions for selected static and quasistatic electromagnetic field problems.

Teaching
Lectures, exercises and project work (individual or groups of 2-3 students).

Examination requirement
Approved project report.

Examination
Oral examination. Pass/Fail.

Offered as a free-standing course
No

Responsible faculty
Faculty of Engineering and Science

MAS703 Analysis of Dynamic Mechanical Systems
5 credits Grimstad spring (2011 MKE, KGR)

Study program
PhD programme in mechatronics

Recommended previous knowledge
MAS601 or equivalent

Learning outcome
The learning outcome of the course is insight into current research topics within modelling of dynamic multibody systems. The successful candidate will have knowledge of the state-of-the-art within a number of topics related to analysis of dynamic mechanical systems.

Contents
The course consists of two parts: Multibody Dynamics and Vibrations (3 credits) and Applied Fracture Mechanics and Reliability (2 credits).

Multibody Dynamics and Vibrations
The course presents a number of selected topics within state-of-the-art in modelling of dynamic multibody systems. Special emphasis is put on flexible systems and the associated vibrational phenomena.

- Advanced modelling concepts
- Choice of coordinates
- Rigid body dynamics
- Inverse versus forward dynamic analysis
- Vibrational aspects
    1. Lumped flexibility
    2. FE-models
    3. FE-beam models
    4. Mode shapes
- Vibration theory

Applied Fracture Mechanics and Reliability
Fatigue in machined and welded structures

- crack initiation and growth
- low, medium and high cycle fatigue
- post weld treatment

Finite element based fatigue analysis of welded structures

- hot spot method
- toe curvature approach

Reliability assessment of mechatronic systems

Teaching
Multibody Dynamics and Vibrations: Lectures (5 days). Exercises
Applied Fracture Mechanics and Reliability: Lectures (3 days). Exercises

Examination
Oral examination. Pass/Fail.

Offered as a free-standing course
No

Responsible faculty
Faculty of Engineering and Science

MAS704 Energy Conversion
5 credits Grimstad spring (2011 TOS)

Study program
PhD programme in mechatronics

Recommended previous knowledge
MAS601 or equivalent

Learning outcome
After the course is completed, the students will have an overview of the relevant types of energy conversion principles. Furthermore, the students will know about some of the current research topics and research methodology within this field.

Contents
The course will contain selected topics from the following list:

- Principal Fuels for Energy Conversion
- Production of Thermal Energy
- Fossil-Fuel Systems
- Nuclear Reactor Design and Operation
- Environmental Impact of Power Plant Operation
- Production of Mechanical Energy
- Production of Electrical Energy
- Energy Storage
- Solar and Wind Energy

Teaching
Lectures (8 days). Exercises

Examination
Oral examination. Pass/Fail.

Offered as a free-standing course
No

Responsible faculty
Faculty of Engineering and Science