## Modelling and Simulation Prototype Technologies I

Code: MK3MOD1R06R117-EN

ECTS Credit Points: 6

Evaluation: mid-semester grade

Year, Semester: 3rd year, 1st semester

Its prerequisite(s): Applied Automatization I

Further courses are built on it: Yes/No

Number of teaching hours/week (lecture + practice): 2+4

**Topics**:

Multidomain simulation with Bond Graphs. Simulation of mechanical, electrical, thermal and flow processes. Derivation of differential equations from Bond Graphs. Linearization of differential equation at operational points. Numerical solution of differential equations with integration.

Sizing with simulation: derivation of parameters based on time and energy optimum. Performance measurement of simulated system using cost functions. Development of stability regions, using parameter disturbances (tolerances) and disturbance distribution.

Application of domain-specific simulation environments, solution of real-life challenges.

1. Application of building physics simulation software to model renewable energy utilization systems, and building management systems (BMS). (EnergyPlus form US DOE, NREL)

2. Complex, analog and digital electronics simulation system: static and transient analysis, parameter disturbance analysis, and effect of temperature change. (Multisim from National Instruments)

3. General purpose, multidomain, object oriented simulation environment. (Modelica and OpenModelica)

**Literature:**

*Compulsory:*


- Peter Fritzson "Object-Oriented Modeling and Simulation with Modelica 3.3", IEEE-Wiley, 2014, ISBN-13: 978-1118859124
- EnergyPlus, "Engineering Reference", ed. 8.7. US DOE, NREL
- "NI Multisim User Manual", National Instruments, 2009 January


**Schedule**

| **1st week Registration week** | |
|---|---|
| **2nd week:**<br>**Lecture:** Multi-domain simulation with Bond Graphs: Mechanical, Electrical, Thermal and Flow process simulation.<br>**Practice:** Multi domain computer simulation practice. | **3rd week:**<br>**Lecture:** Derivation of differential equation from BondGraph. Linearization of differential equations around operational point.<br>**Practice:** System linearization practice. |
| **4th week:**<br>**Lecture:** Numerical solution of differential equations.<br>**Practice:** Numerical solution practice. | **5th week:**<br>**Lecture:** Sizing with simulation: derivation of system parameters along time and energy constraints.<br>**Practice:** Sizing with simulation practice. |
| **6th week:**<br>**Lecture:** Simulated system performance measure with cost functions.<br>**Practice:** System performance measure | **7th week:**<br>**Lecture:** Derivation of operational stability range, against disturbance signals. |

| | |
|---|---|
| practice. | **Practice:** Operational stability practice. |
| **8th week: 1st drawing week** | |
| **9th week:** | **10th week:** |
| **Lecture:** Building physics simulation software introduction. | **Lecture:** Building simulation with renewable energy utilisation. |
| **Practice:** Building physics simulation practice. | **Practice:** Renewable energy utilisation practice. |
| **11th week:** | **12th week:** |
| **Lecture:** Mixed, analogue and digital electrical signal simulation introduction. | **Lecture:** Steady state and transient analysis, parameter variable analysis, heat generation and cooling. |
| **Practice:** Mixed electrical circuit simulation practice. | **Practice:** Multi analysis practice. |
| **13th week:** | **14th week:** |
| **Lecture:** General purpose multi-domain system theory. | **Lecture:** General purpose multi-domain system applications. |
| **Practice:** Multi-domain simulation practice. | **Practice:** Multi-domain simulation practice. |
| **15th week: 2nd drawing week** | |

**Requirements**

**A, for a signature:**

Attendance at **lectures** is recommended, but not compulsory.

Participation at **practice** is compulsory. Students must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Students can't make up a practice class with another group. Attendance at practice classes will be recorded by the practice leader. Being late is counted as an absence. In case of further absences, a medical certificate needs to be presented. Missed practices should be made up for at a later date, being discussed with the tutor. Students are required to bring the drawing tasks and drawing instruments to the course with them to each practice class. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

During the semester there are two tests, students have to sit for the tests.

**B, for grade:**

The course ends in a **mid-semester grade** based on the test results.

The minimum requirement for both mid-term and end-term tests is 50%. Based on the score of the tests separately, the grade for the tests is given according to the following table:

| Score | Grade |
|---|---|
| 0-39 | fail (1) |
| 40-52 | pass (2) |
| 52-63 | satisfactory (3) |
| 64-71 | good (4) |
| 72-80 | excellent (5) |

If the score of the sum of the two tests is below 40, the student once can take a retake test of the whole semester material.