Course Syllabus

1. Annotation

Course Description

Basic course for 1st year MSc students devoted to PLM as applied to product development. Lectures are devoted to an overview of current trends in industry digitalization, “digital twins” technology and modern implementation of computer-aided design, computer-aided engineering, computer-aided manufacturing, model-based systems engineering, product lifecycle management, multidisciplinary optimization, predictive and prescriptive maintenance. Practical classes are dedicated to the simulation-driven product development process in a particular case study. Students learn how to develop a high-level model of a complex system, split it into subsystems and connect it with the functional models of each subsystem and with preliminary 3D models (e.g. aerodynamics and structural analysis). Also, the optimization of the whole system plays an important role in the course. The case study is a challenging task like High-Altitude Pseudo Satellite or Truss-Braced wing aircraft) Thus, during the course students go through all the main stages of complex system development process.

Course Prerequisites / Recommendations

Basic knowledge of numerical methods, mechanics, aerodynamics, computer-aided design, computer-aided engineering

2. Structure and Content
### Course Academic Level
Master-level course suitable for PhD students

### Number of ECTS credits
6

<table>
<thead>
<tr>
<th>Topic</th>
<th>Summary of Topic</th>
<th>Lectures (# of hours)</th>
<th>Seminars (# of hours)</th>
<th>Labs (# of hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLM basics</td>
<td>PLM definition, PLM tools, market, vendors. PLM as a strategy. Business processes, introduction to Teamcenter PLM system</td>
<td>2</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>High-level design</td>
<td>Model-based systems engineering principles, V-diagram, high-level design, Truss-braced wing aircraft design assignment</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Functional modeling</td>
<td>Bondgraph method, introduction to Simcenter Amesim, multi-domain 1D simulation of aircraft systems.</td>
<td>3</td>
<td>4</td>
<td>10</td>
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<tr>
<td>Modern optimization techniques</td>
<td>Parametric optimization for simulation-driven product development, surrogate-assisted optimization, evolutionary optimization, global and local optimization, 3D and 1D models optimization</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Introduction to 3D-design</td>
<td>Computational Fluid Dynamics and Finite Element Analysis basics, 3D analysis of HAPS using Simcenter 3D and ANSYS</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
</tbody>
</table>

#### 3. Assignments

<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Analyze current trends in PLM tools</td>
</tr>
<tr>
<td>Homework</td>
<td>Overview of truss-braced wings aircrafts</td>
</tr>
<tr>
<td>Homework</td>
<td>System breakdown structure for truss-braced wing aircraft (TBW)</td>
</tr>
<tr>
<td>Homework</td>
<td>Design of experiments for the TBW optimization</td>
</tr>
<tr>
<td>Final Project</td>
<td>High-level design of a Truss-Braced Wing Aircraft</td>
</tr>
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</table>

#### 4. Grading

<table>
<thead>
<tr>
<th>Type of Assessment</th>
<th>Graded</th>
</tr>
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</table>
Grade Structure

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Activity weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td>30</td>
</tr>
<tr>
<td>Homework Assignments</td>
<td>15</td>
</tr>
<tr>
<td>Final Project</td>
<td>40</td>
</tr>
<tr>
<td>Final Exam</td>
<td>15</td>
</tr>
</tbody>
</table>

Grading Scale

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>86</td>
</tr>
<tr>
<td>B</td>
<td>76</td>
</tr>
<tr>
<td>C</td>
<td>66</td>
</tr>
<tr>
<td>D</td>
<td>56</td>
</tr>
<tr>
<td>E</td>
<td>46</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
</tr>
</tbody>
</table>

Attendance Requirements: Mandatory

5. Basic Information

Maximum Number of Students

<table>
<thead>
<tr>
<th></th>
<th>Maximum Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall:</td>
<td>18</td>
</tr>
<tr>
<td>Per Group:</td>
<td>18</td>
</tr>
</tbody>
</table>

Course Stream: Science, Technology and Engineering (STE)

Course Term (in context of Academic Year): Term 4

Course Delivery Frequency: Every year

Students of Which Programs do You Recommend to Consider this Course as an Elective?

<table>
<thead>
<tr>
<th>Masters Programs</th>
<th>PhD Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Manufacturing Technologies</td>
<td>Computational and Data Science and Engineering Engineering Systems</td>
</tr>
<tr>
<td>Information Science and Technology</td>
<td></td>
</tr>
<tr>
<td>Space and Engineering Systems</td>
<td></td>
</tr>
<tr>
<td>Computational and Data Science and Engineering Engineering Systems</td>
<td></td>
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<tr>
<td>Engineering Systems</td>
<td></td>
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</tbody>
</table>
6. Textbooks and Internet Resources

<table>
<thead>
<tr>
<th>Required Textbooks</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Grivers. Virtually Perfect: Driving Innovative and Lean Products through Product Lifecycle Management.</td>
<td>9780982138007</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Recommended Textbooks</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patrice Micouin. Model Based Systems Engineering: Fundamentals and Methods (Control, Systems and Industrial Engineering Series)</td>
<td>9781848214699</td>
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</table>

<table>
<thead>
<tr>
<th>Web-resources (links)</th>
<th>Description</th>
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<tbody>
<tr>
<td><a href="https://www.accenture.com/us-en/insight-digital-thread-digital-twin-strategies">https://www.accenture.com/us-en/insight-digital-thread-digital-twin-strategies</a></td>
<td>Comprehensive research among global high tech companies aimed to understand the industry’s readiness for, and adoption of, the Digital Thread</td>
</tr>
</tbody>
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7. Facilities

<table>
<thead>
<tr>
<th>Software</th>
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<tbody>
<tr>
<td>Siemens NX</td>
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<tr>
<td>Siemens Teamcenter</td>
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<tr>
<td>Simcenter 3D</td>
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<tr>
<td>ANSYS</td>
</tr>
<tr>
<td>Simcenter Amesim</td>
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<tr>
<td>pSeven</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Labs for Education</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Cyber-Physical Systems Lab (New Campus, E-B5-2007)</td>
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</table>
8. Learning Outcomes

<table>
<thead>
<tr>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-level design</td>
</tr>
<tr>
<td>Product Lifecycle Management basics</td>
</tr>
<tr>
<td>Business processes in development stage of product lifecycle</td>
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<tr>
<td>Modern optimization techniques</td>
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<table>
<thead>
<tr>
<th>Skill</th>
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<tbody>
<tr>
<td>Functional (bondgraph) modeling in Simcenter Amesim</td>
</tr>
<tr>
<td>Applied computational fluid dynamics in ANSYS FKUENT, STAR_CCM+</td>
</tr>
<tr>
<td>Structural analysis in Simcenter 3D</td>
</tr>
<tr>
<td>Computer-aided design in Siemens NX</td>
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<tr>
<td>Hands-on experience in pSeven</td>
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<table>
<thead>
<tr>
<th>Experience</th>
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<tbody>
<tr>
<td>Working on the development of complex system within PLM approach</td>
</tr>
<tr>
<td>Working on project in interdisciplinary team</td>
</tr>
</tbody>
</table>

9. Assessment Criteria

Input or Upload Example(s) of Assignment 1:

Select Assignment 1 Type Other

Input or Upload Example(s) of Assignment 2:

Input or Upload Example(s) of Assignment 3:

Input or Upload Example(s) of Assignment 4:

Input or Upload Example(s) of Assignment 5:

10. Additional Notes