Experience with International Students’ Project Work in Model Based Design

12th REM Kocaeli 2011

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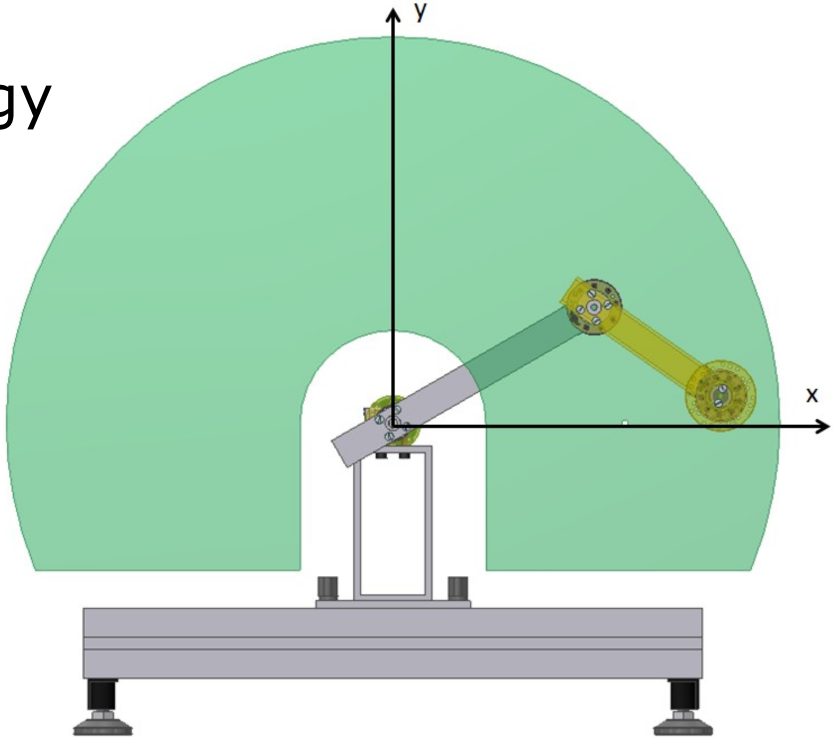


Merseburg University of Applied Sciences in Central Germany

BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING
HOME HOCHSCHULE MERSEBURG™ University of Applied Sciences
FACHBEREICH INGENIEUR- UND NATURWISSEN-SCHAFTEN

Merseburg University of Applied Sciences

Founded 1992

~3,000 Students in 4 Faculties

111 Professors and Lecturers

~200 Employees

Merseburg University of Applied Sciences
Faculty of Engineering and Natural Sciences

~600 Students

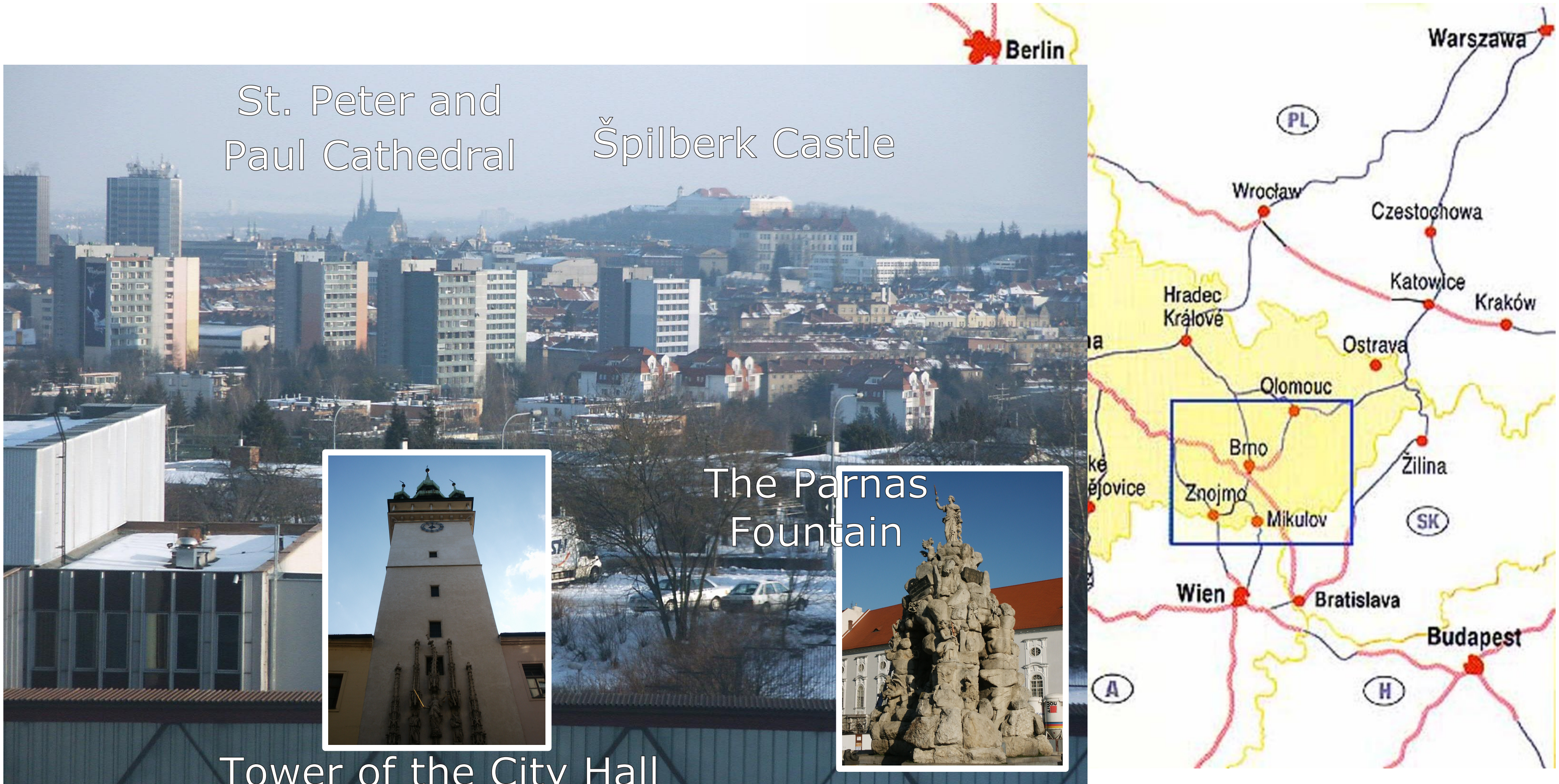
31 Professors and Lecturers

70 Employees

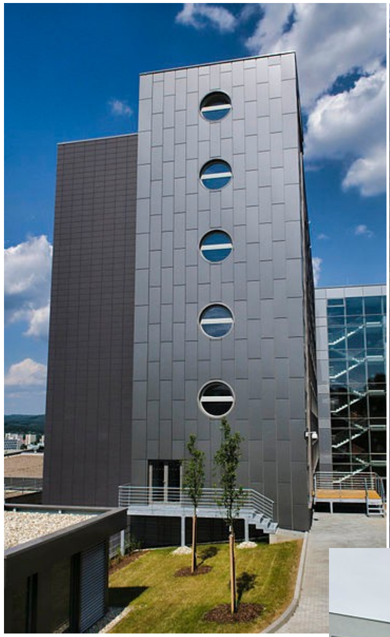
BRNO UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING

HOME HOCHSCHULE MERSEBURG University of Applied Sciences
FACHBEREICH INGENIEUR- UND NATURWISSEN-SCHAFTEN

Brno, the Capital City of Moravia, CR



BUT – Brno University of Technology



Founded 1899

~26,000 Students in

8 Faculties

1,272 Professors and Lecturers

1,481 Employees

BUT – Brno University of Technology
FSI/FME – Faculty of Mechanical Engineering

~5,000 Students in
15 Institutes
258 Professors and Lecturers
231 Employees

BRNO UNIVERSITY OF TECHNOLOGY
FSI
FACULTY OF MECHANICAL ENGINEERING

HOME HOCHSCHULE MERSEBURG University of Applied Sciences
FACHBEREICH INGENIEUR- UND NATURWISSENSCHAFTEN

International Collaboration

- Start with diploma thesis in 2004
- Annual exchange of lectures with TSM Teaching Staff Mobility Programme (ERASMUS)
- Exchange of students with Short Time Excursion starting 2010

Further goals:

- Development of a double diploma master study course in mechatronics
- PhD students from Merseburg in Brno
- Use of video conferences for defences of appropriate theses

International Collaboration

Students group from Merseburg in Brno

Module Description

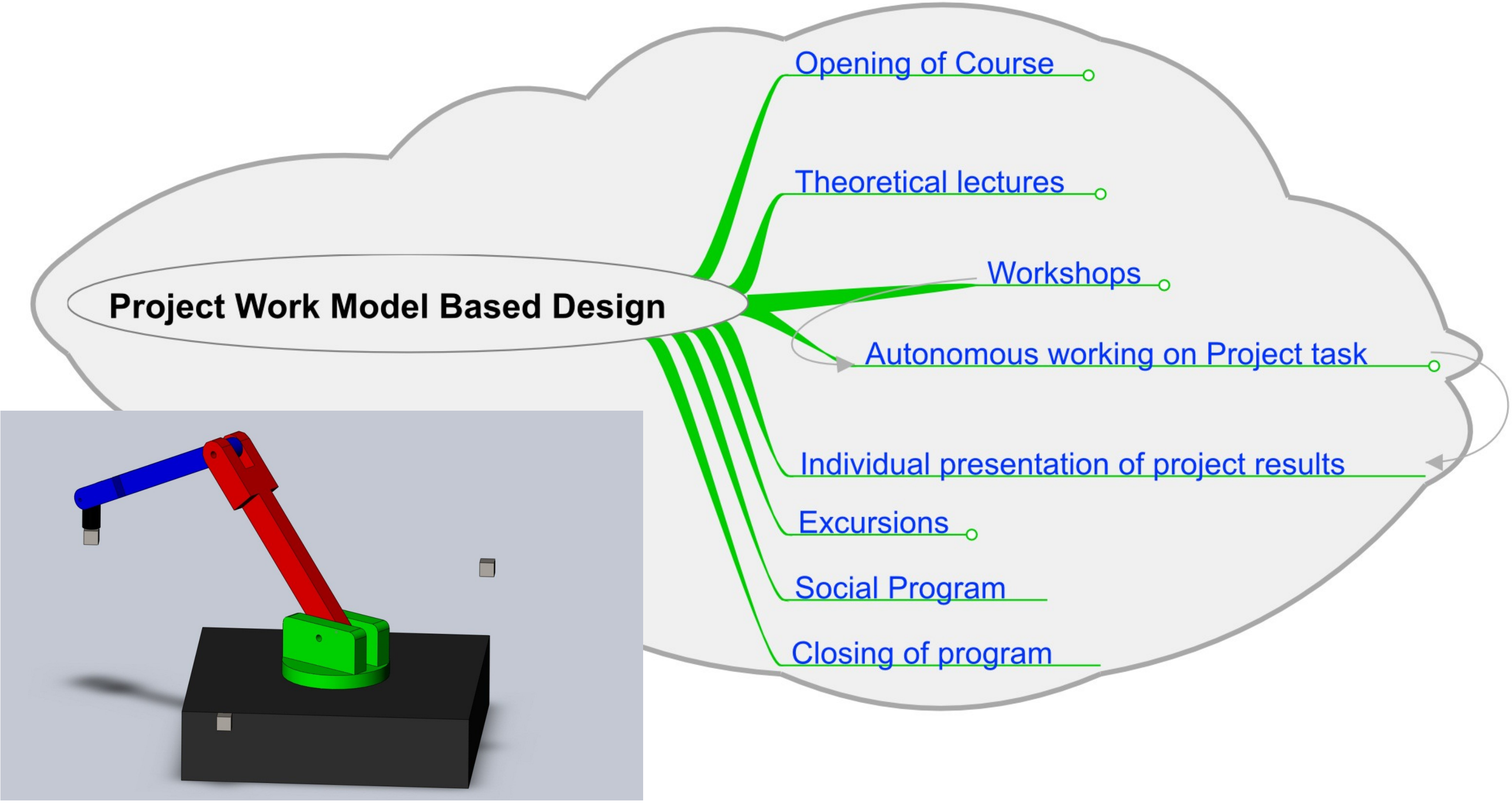
Study Course	Master "Mechatronics, Industrial and Physics Technology" (M.Eng.)
Module No / Module Name:	**M 06xx / Project Work Model Based Design**
Abbr.:	PME
Second Name:	
Module Form:	Technical compulsory optional subject, lectures and practical work
Semester:	3
Cycle:	Annually, on request
Person in Charge:	Prof. Dr. M. Lohöfener
Lecturer:	Prof. Dr. M. Lohöfener , Prof. Dr. T. Březina
Language:	German and English
Assignment to the Curriculum:	M.Eng. "Mechatronics, Industrial and Physics Technology", in 3rd semester, technical compulsory optional subject in study orientation "Mechatronics"
Teaching Methods / SWS (teaching hours per week)	1 SWS lectures, 3 SWS practical work with maximum 15 students

Effort:	Activity	Effort	Hours per semester
	Time of attendance (lectures, practical work)	4 SWS · 15 weeks	60 hours
	Private study and exam preparation		90 hours
	Effort for the module		150 hours

Module Description

Credit points:	5 CP
Requirements:	Mechatronic Systems (Module M 0101)
Educational Objective:	**“Knowledges”:** The students deal with the abstraction of technical systems to system models and their simulation. They know approaches and important software for modelling especially for mechanical systems. **“Skills”:** After finishing this module the students are able: • To describe functions in technical systems and • To simulate models of mechanical systems. **“Competencies”:** • Analysis of complex tasks and derivation of necessary steps to the solution • Choose of applicable solution methods • Choose of applicable computer software for the solution
Content:	✓ Building of models of systems ✓ Software tools ✓ Simulation with HiL (Hardware in the Loop) and SiL (Software in the Loop)
Exams:	Oral presentation 30 Minutes Prerequisites for admission to examination: Oral intermediate presentation and participation in study trip to Brno University of Technology BUT

Ideas for Module and Example



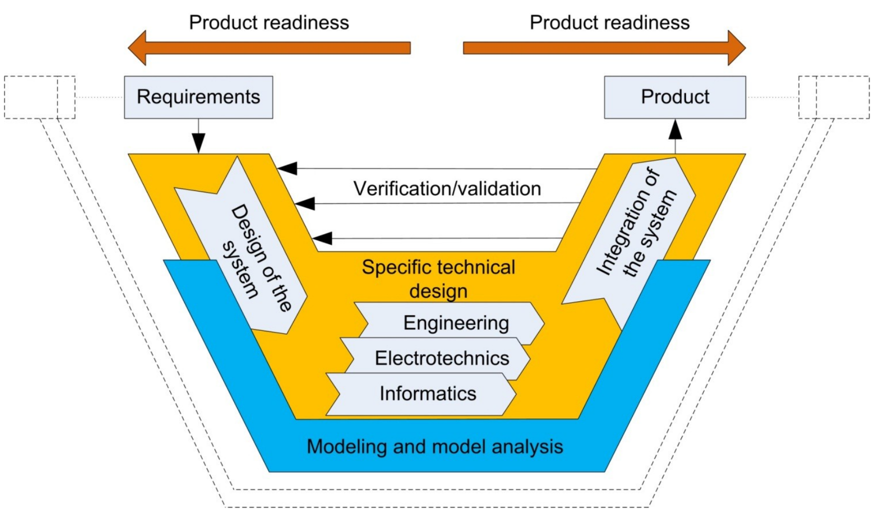
Detailed Programme

Day	Lesson
Monday	Opening
	Design of Mechatronic Systems
	TRIZ
	Project Task and Analysis Task
	Block of Theoretical Lectures
Tuesday	Workshop MATLAB / Simulink / SimMechanics
	Autonomous Working on Project Task
	Workshop CAD Solidworks
	Workshop ANSYS Workbench
	Workshop Actuators

Detailed Programme

Day	Lesson
Wednesday	Lecture on Quality in Development
	Workshop on Actuators and Sensors
	Workshop on Control
	Autonomous Working on Project Task
	Workshop on Co-Simulation
Thursday	Social Programme
Friday	Autonomous Working on Project Task
	Individual Presentation of Project Results
	Closing Programme

V-Model in Mechatronic Design

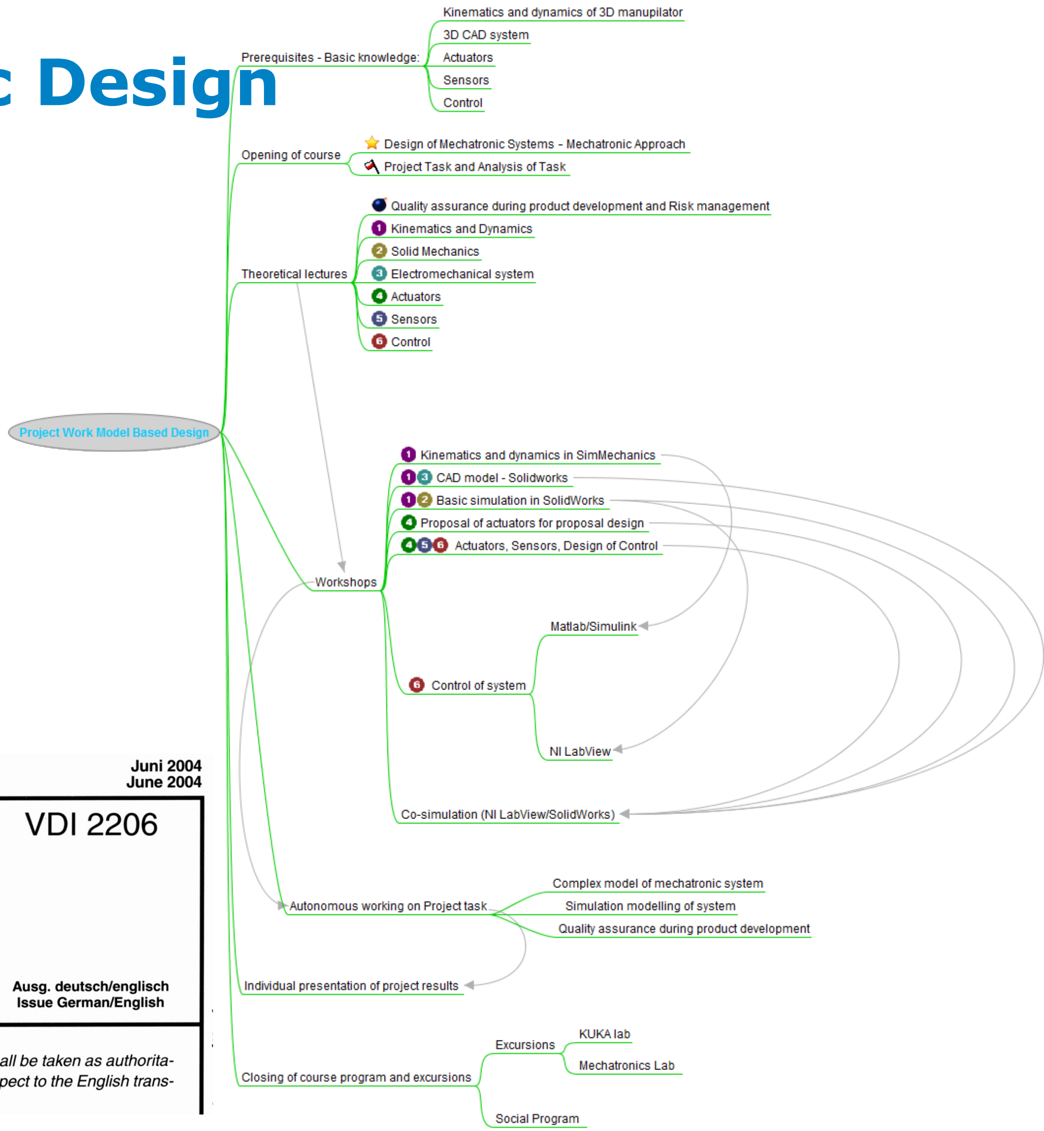


ICS 03.100.40; 31.220 — VDI-RICHTLINIEN — Juni 2004 / June 2004

VEREIN DEUTSCHER INGENIEURE	Entwicklungsmethodik für mechatronische Systeme Design methodology for mechatronic systems	VDI 2206 Ausg. deutsch/englisch Issue German/English

Die deutsche Version dieser Richtlinie ist verbindlich.

The German version of this guideline shall be taken as authoritative. No guarantee can be given with respect to the English translation.



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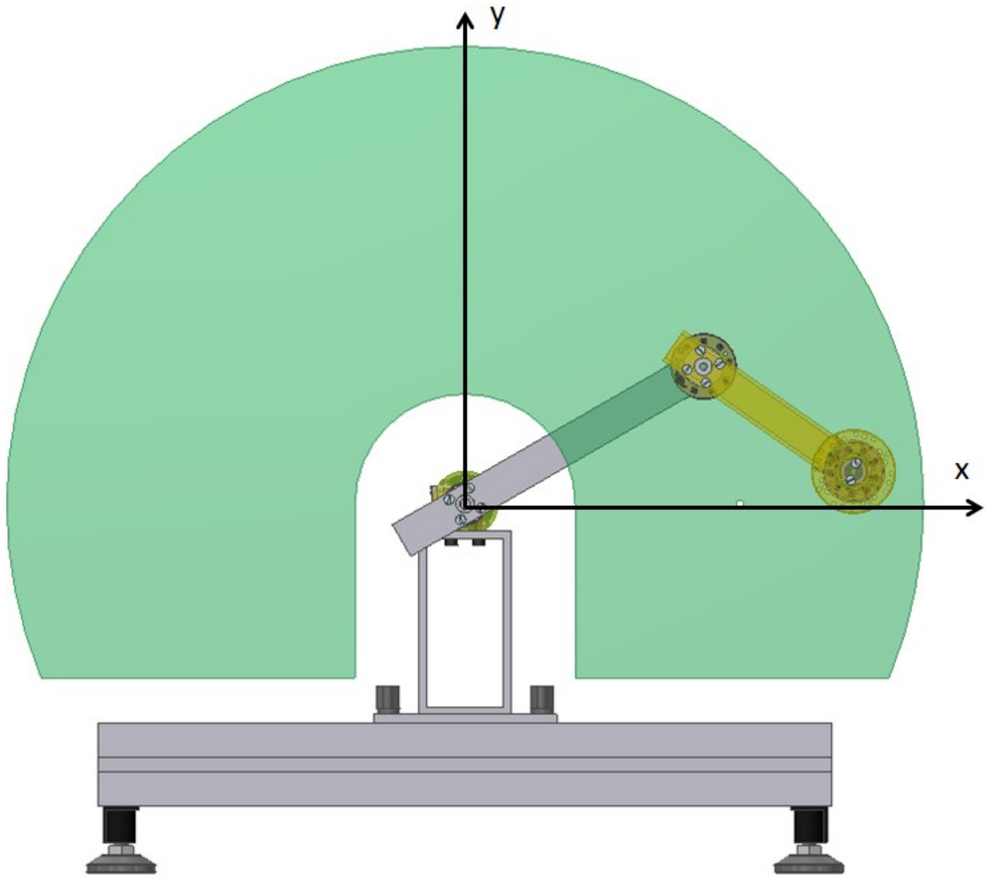
Example: Planar Manipulator with 2 DOF



Workspace: $0 \leq \varphi \leq \pi$
$150 \leq r \leq 500$ mm

Objects manipulated inside the workspace, trajectories not defined

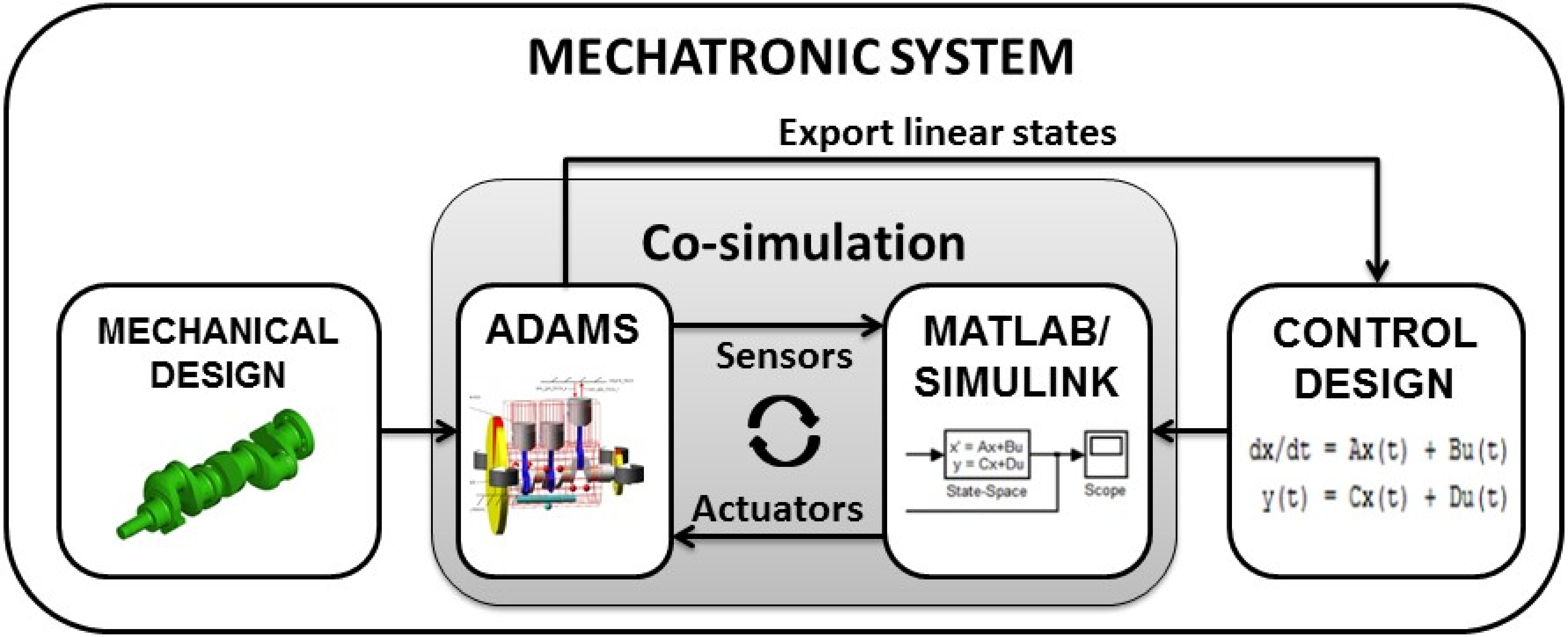
Geometry of the manipulated objects neglected

Weight of the objects: 0.5 kg

Change of the position: From 150 mm to 500,0 mm in 4 s

Positioning accuracy: ±5 mm

Design and Simulation



Steps of the Solution

1. **Solution analysis**
   - Choice of the lengths of the links
   - Creation of the conceptual model for the kinematics description
2. **Analysis of potential development risks**
3. **Analysis of the kinematics**
   - Velocities of the end-effector in the workspace
   - Requirements for the actuators velocities
   - Analytic / simulation modeling
   - ***Simulink / SimMechanics***

Steps of the Solution

4. **CAD model – *SolidWorks***
   – Creation of the conceptual model
   – Parametric model of the geometry
   – Inputs for the analytic model of dynamics
     • Masses
     • Inertia moments
   – Possibility of static, kinematic, dynamic and stress/strain analyses
   – Possibility of the connection with ***LabVIEW*** and implementation of the control
     • Co-simulations

Steps of the Solution

5. Simulation model *Simulink / SimMechanics*

- Creation of the simulation model
- Testing of the model
- Inputs for the model according to the CAD parameters
  - Masses
  - Inertia moments
- Analysis of dynamics

6. Design of the actuator based on the analysis of the dynamics

- Utilization of simulation model for the actuators design according to the velocity requirements
- Implementation of the actuators to dynamics model

Steps of the Solution

7. **Change of the geometry parameters (e.g. sections)**
   - There are changed parameters of the SolidWorks model according to the dynamics simulations. The changes will reflect in masses and inertia moments of the elements
   - Verification of the changed parameters in the model of dynamics
8. **Structural calculations (*SolidWorks - ANSYS*)**
   - Method of finite elements
   - Stress/strain verification based on the loads from the model of the dynamics
   - Modal analysis of the potentially elastic bodies

Steps of the Solution

9. **Design of a control (state-space *MATLAB*)**
   - Utilization of the dynamics ***SimMechanics*** model for the controller design
   - Simulation modeling of the control ***MATLAB / Simulink***
10. **Simulation experiment according to the assignment**
11. **Hardware – Sensors – Actuators**
   - Selection of the sensors
   - Implementation of the sensors and actuators
   - Realization of drivers in ***LabVIEW***

Steps of the Solution

12. Design of the control in *LabVIEW*

13. Possibility of a co-simulation *LabVIEW / SolidWorks*

- Basic control of the actuators (under development for the complete dynamics)
- Virtual prototype of the mechatronic system

14. Mechatronic approach

- Particular cycles of the development
- Increasing of the manipulator maturity

15. TRIZ utilization

- Heuristics for the selected physical conflicts
- (stiffness of the link vs. moment of inertia)

Presentation of the Results: Excellent!

Conclusions by our Students

- Repetition of important basics
- Basics in working with SolidWorks
- Further information about MATLAB and LabVIEW
- New interesting experience in using interfaces in modelling software
- International teamwork and improving English knowledge → Soft Skills

Conclusions

- The students are informed about the necessary simplifications and their possible consequences.
- Prepared functions and models allow quick demonstrations and comfortable experimenting with the control design.
- The students were able to develop and work with the models, to explain the graphs, to animate the behaviour of the models and to optimize the manipulator.
- They were very enthusiastic and appreciated the value of this module.

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Thank you for your attention