

## Blended-Learning in Teaching Model-Based Design of Mechatronic Systems

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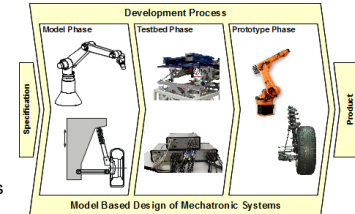
## Motivation

- **Aim:**  
Teaching model-based design  
of mechatronic systems

- **Development process:**  
beginning with the requirements  
the

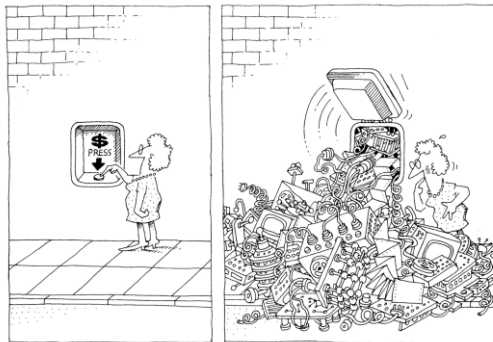
- model-
- testbed- and
- prototypephase

are run through; mostly with  
backspaces until the product status is  
reached



- **Every phase is characterized by a  
series of experiments and model  
refinements**

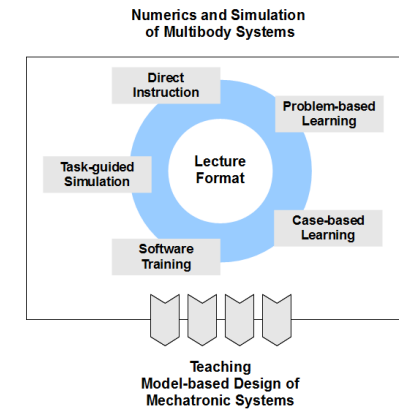
## The task in the development of complex systems



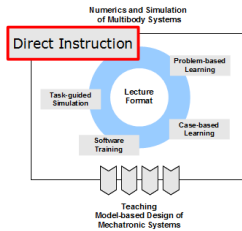
The task of the software development team is to engineer the illusion of simplicity.

Reference:  
G. Booch, Object-Oriented Software Design  
Addison Wesley, Menlo Park , 1994.

## Knowledge transfer in model-based design of mechatronic systems: The lecture format

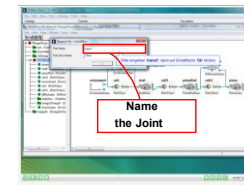
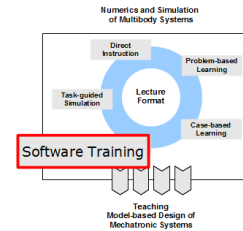


## Elements of the Lecture: Direct Instruction



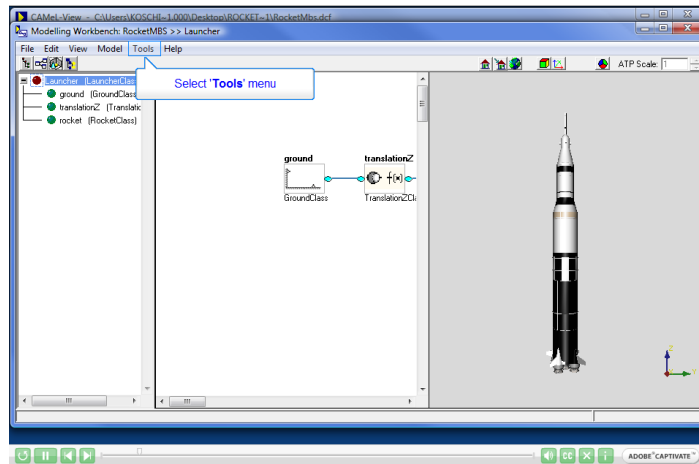
- **Presentation based frontal teaching imparting**
    - concepts and
    - methods
  - **Tablet-PC based frontal teaching for**
    - a step-by-step introduction
    - derivation and
    - working out
- of physical/mathematical facts of MBS dynamics**

## Elements of the Lecture: Software Training with Software Simulations

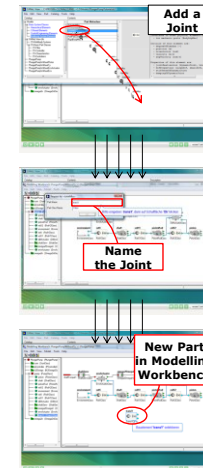


- **System design is increasingly computer-aided**
- **Teaching model-based design of mechatronic systems with CAE-Software is a basic**
- **Students should do model-based design on**
  - their own and
  - their own computer
- **Design environment supporting all 3 phases of the model-based design of mechatronic systems:**
  - CAMEL-View
- **Teaching units in the form of software simulations**

## Software simulations: An example ...



## Advantages of Software Simulations



- **A well designed storyboard allows the perfect combination of theory, practice, and application**
- **Release the lecturer**
- **Allows to concentrate**
  - on the aspects that show the interdependencies between the individual steps
  - the mathematical/physical background
- **The base quality of a software simulation based lecture is always the same**
- **Allows to step back in the lecture**
- **Allows the students after the lecture to replay the software simulation and learn themselves**
- **Internationalization is easy possible**

- Information provided by courtesy of the Kennedy Space Center ATX Team :-)) :
- It's made up of 3 rings and a cage where the participant is sitting
- The outside ring is stationary and anchored to the floor. It is 3 inches wide, 8 inches thick and measures 9 feet 2 inches from outside edge to outside edge
- The second ring is attached to a motor via a belt and turns at about 60 rpm. This ring is 3 inches wide, 8 inches thick and measures 8 feet 2 inches from outside edge to outside edge
- The third ring moves freely. This ring is 3 inches wide, 8 inches thick and measures 7 feet 2 inches from outside edge to outside edge
- The cage also moves freely and measures 5 feet 6 inches from top to bottom and 6 feet 8 3/4 inches from pivot point to pivot point

CV Evidenz Lab: QuarterVehicle

File View Help

stat 0.0 step 0.0 -1.0g 0.01 -1.1g 0.005 RungeKutta 4 Time 0.0 Status On

### Aktive-Passive Federung

aktive Federung

### Statische Radlast [N]

2000.0

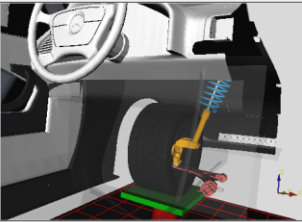
### Aufgabenstellung

- Bestimmen Sie die statische Radlast aus den Fedungskennwerten.
- Tragen Sie die statische Radlast in Feld über der Aufgabenstellung ein.
- Bestimmen Sie nun die maximale dynamische Radlastschwankung für die aktive und die passive Federungsvarianten.
- Bestimmen Sie die maximal Aufbauschwankung für den aktiven und den passiven Fall.
- Nehmen Sie eine Bewertung bzgl. Fahrverhalten und Fahrkomfort der beiden Varianten vor.

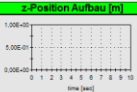
### Weitere Fragestellungen

- Versuchen Sie im Trial- und Erre-Verfahren das Fahrverhalten sowohl des passiven als auch des aktiven Radabschlüßung zu verbessern.
- Erarbeiten Sie mit Hilfe von Literatur und Internet systematische Vorgehens zur Fahrwerksauslegung.

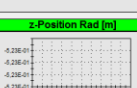
### Dynamik der McPherson-Radaufhängung



#### z-Position Aufbau [m]

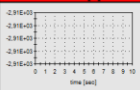


#### z-Position Rad [m]

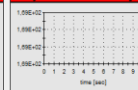


### Bewertungsgrößen

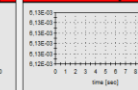
#### Radlast [N]



#### Dyn. Radlastschw. Ff (%)



#### Beschl. Aufbau [m/s^2]



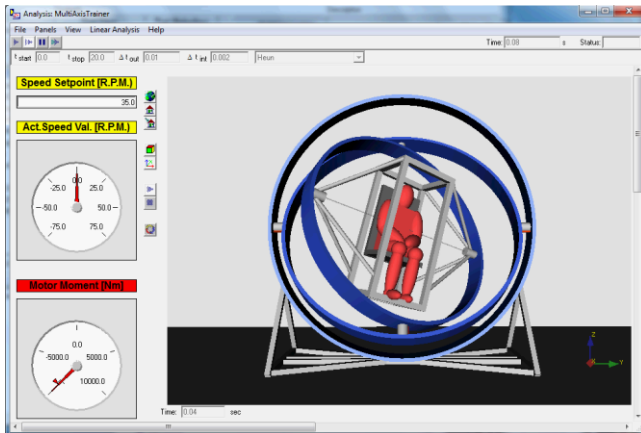
The screenshot displays the MATLAB/Simulink workspace. On the left, a 3D visualization shows a red mobile robot with two wheels and a sensor, positioned on a blue circular track. The robot's orientation is indicated by a yellow arrow. The track is surrounded by a blue barrier. A coordinate system (X, Y, Z) is visible in the bottom right corner of the 3D view.

On the right, the Simulink block diagram illustrates the control system. The diagram includes the following blocks and connections:

- environment** (EnvironmentClass) block, which outputs  $x$  and  $y$  coordinates.
- jointE2ORing** (JointE2ORingClass) block, which receives  $x$  and  $y$  and outputs  $\theta$  (angle).
- outfiring** (OutfiringClass) block, which receives  $\theta$  and outputs  $\theta_d$  (desired angle).
- jointO2Mfiring** (JointO2MfiringClass) block, which receives  $\theta_d$  and outputs  $\theta_m$  (motor angle).
- middefiring** (MiddefiringClass) block, which receives  $\theta_m$  and outputs  $\theta_{mf}$  (motor firing angle).
- motor** (MotorClass) block, which receives  $\theta_{mf}$  and outputs  $\omega$  (motor speed).
- PI** (PIClass) block, which receives  $\theta_d$  and  $\theta_m$  and outputs  $u$  (control signal).
- deviation** (DeviationClass) block, which receives  $\theta_d$  and  $\theta_m$  and outputs  $e$  (deviation).
- seatedEspirion** (SeatedEspirionClass) block, which receives  $\theta_m$  and outputs  $\theta_{mf}$ .
- jointM2Rring** (JointM2RringClass) block, which receives  $\theta_m$  and outputs  $\theta_{mf}$ .
- jointZ5ring** (JointZ5ringClass) block, which receives  $\theta_m$  and outputs  $\theta_{mf}$ .
- inveffring** (InveffringClass) block, which receives  $\theta_m$  and outputs  $\theta_{mf}$ .

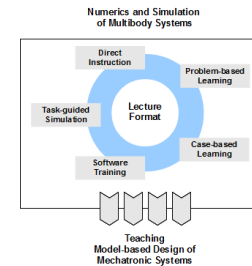
The diagram also shows a feedback loop where the motor speed  $\omega$  is integrated to produce the motor angle  $\theta_m$ . The control signal  $u$  is fed back to the PI block to adjust the desired angle  $\theta_d$  based on the deviation  $e$ .

## Example simulation model of the multi-axis trainer project task



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## Summary



- **Presentation of a modern lecture format teaching model-based design of**
  - mechatronic systems
  - especially Multibody Systems
- **Successful used elements**
  - direct instruction
  - software training with software simulations
  - task-guided simulations with MBS experiment environments
  - Problem-based Learning by course-accompanying project tasks
- **Teaching model-based design with CAMEL-View a modern, object-oriented design environment for the design of mechatronic systems**

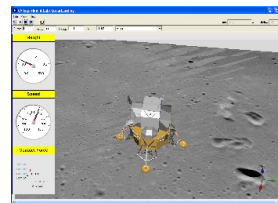
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## Outlook and further Information

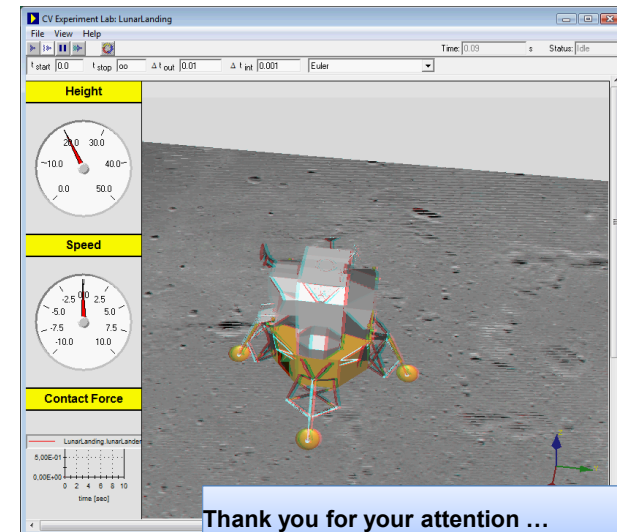
- **Extension to other courses**  
e.g. optimization of mechatronic systems
- **More examples and better integration into e-learning environments (e.g. Moodle)**
- **If you like more information about**
  - Software Simulations with Adobe Captivate
  - Modelling and Simulation of mechatronic systems with CAMEL-View
  - Creating Simulators and Experiment Environments using CVExperimentLab

please contact me ([martin@mhahn.name](mailto:martin@mhahn.name)),  
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([www.mhahn.name](http://www.mhahn.name)) and especially to

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