Mechanics and Machines, CAE DYN 1

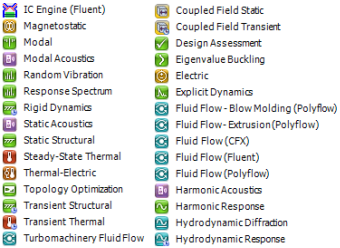
Introduction to CAE

Animation Designer; Mechatronics Concept Designer; Motion Measure; Interference; Density; Assign Materials

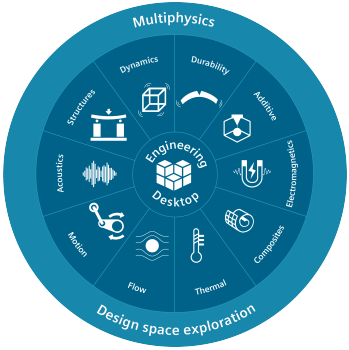
INNOPOLIS UNIVERSITY

Computer Aided Engineering (CAE)

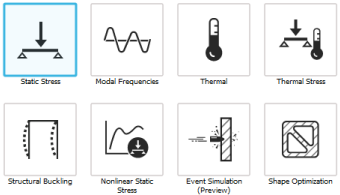
CAE — the broad usage of computer software to aid in engineering analysis tasks.



CAE apps in ANSYS



CAE apps in Siemens NX

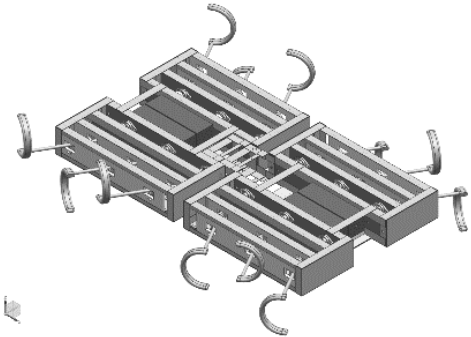


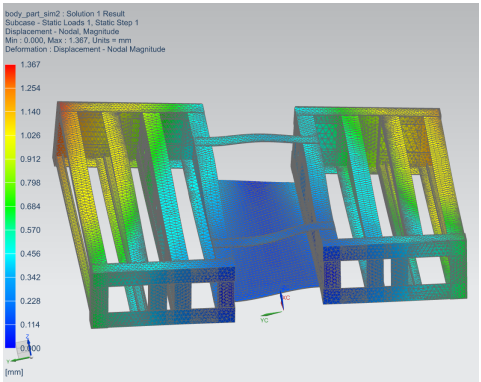
CAE apps in Fusion 360

Typical Engineering Tasks

Static Stress

Goal: Find *deformation displacement* after applied required forces and torques.

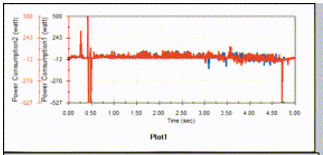


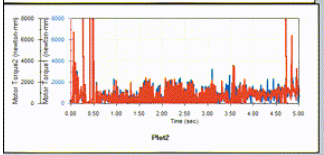


Typical Engineering Tasks

Rigid Dynamics

Goal: Find *max motor torque* when the robot with needed dimensions and weight are moving though expected terrain.

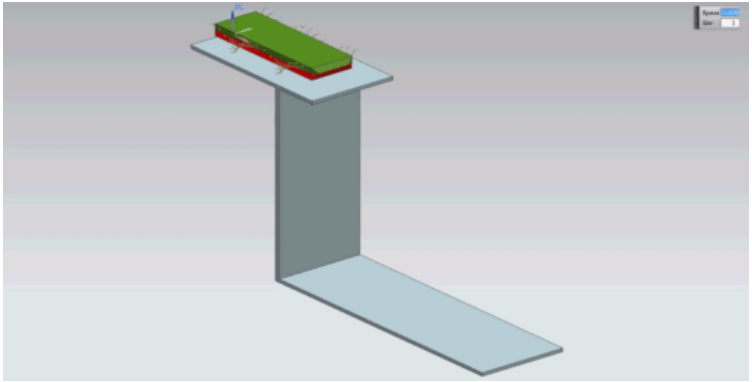




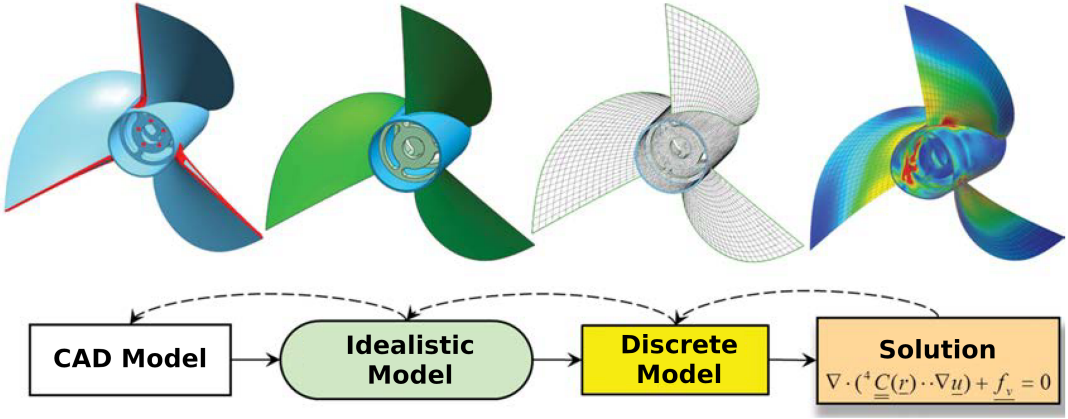
Typical Engineering Tasks

Motion Analysis

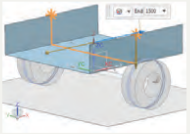
Goal: To understand the *kinematics and dynamics* of designed robot in some situation.



CAE General Workflow



CAE Motion Workflow

Create manually	Based on CAD assembly	Add drivers, forces and constraints	Solve	Postprocessing
Build a motion model by hand using simple linkages and shapes.	Automatically create a model based on CAD bodies and convert assembly constraints to motion joints.	Add motion drivers, bushings, forces, define flexible bodies and more.	A complete and robust solver for advanced dynamic, static and kinematics motion simulation.	Gain insight by animating, graphing, generating motion envelopes and validating product clearance.
				

What-if, optimization, feedback to designer

Solvers

Definition

Solver refers to a software tool that solves complex mathematical equations and models to simulate the behavior of physical systems.

The solver takes the **input data**, which includes the geometry of the system, the material properties, and boundary conditions, and then applies mathematical algorithms to calculate and solve the equations that describe the physical behavior of the system. The **output of the solver** is then used to evaluate the performance of the design and make necessary changes to improve it.

Algorithm examples for Motion Analysis: Euler-Lagrange, Newton-Euler, Kane's method

Popular solvers: NX Nastran (NX, Inventor, Fusion?), Abaqus (SolidWorks?), ANSYS (ANSYS)

Engineer's Guideline

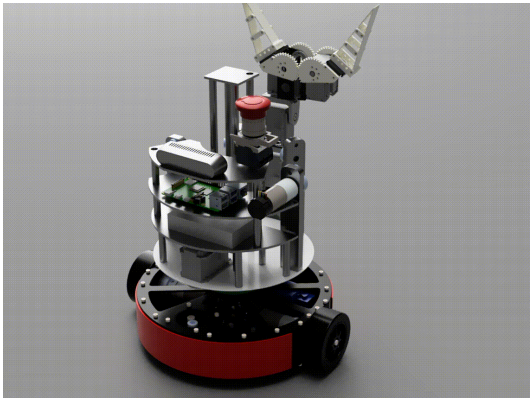
1. Formulate the task correctly (why and what we expect).
2. Implement the idea with the help of CAE or other tools.
3. Correctly interpret the obtained result.
4. Propose a solution based on knowledge from «3».
5. Check the result.

Case Study

Task formulation <<1>>

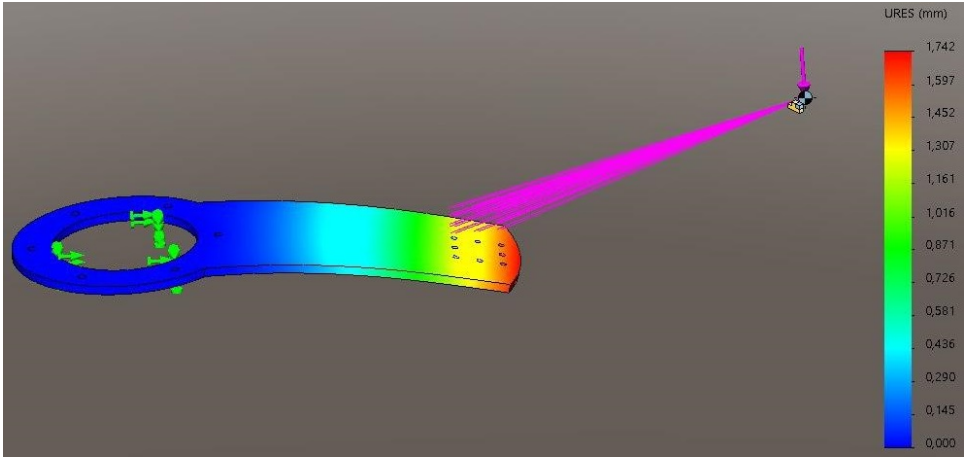
General task: Design the base for manipulator, which will not affects on the manipulator accuracy.

Reformulated task: Check deformation displacement of the manipulator base.



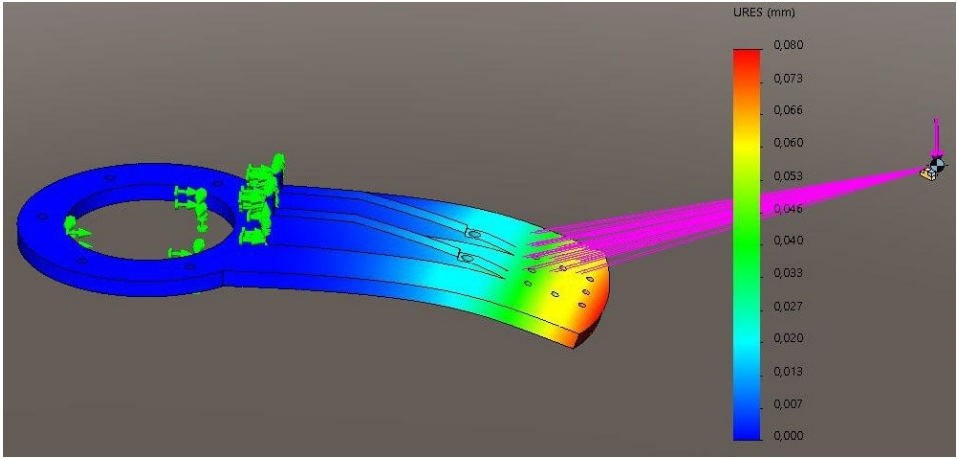
Case Study

Implement and Interpret the result <<2-3>>



Case Study

Propose the solution <<4>>



Measure, Density, Interference

Video

Motion Analysis Applications

Animation Designer

- Can solve only kinematics.
- Can animate sketches
- You can draw some simple plots
- Can add collisions

Motion Analysis

- Can solve complex rigid/flexible multibody dynamics, statics and kinematics with high accuracy.
- CAD and analytical collisions
- Can simulate bearings, springs gears and etc.
- Friction model is quite accurate

Mechatronics Concept Designer

- Can solve dynamics and kinematics with low accuracy.
- System-level Design: it allows you to design and model complex mechatronic systems at a system-level, considering the interactions between mechanical, electrical, and software components.
- Can add a complex sequence of control operations

Motion Analysis Applications

Summary

If I want to check my concept on kinematics part, without designing a mechanism — **Animation Designer**.

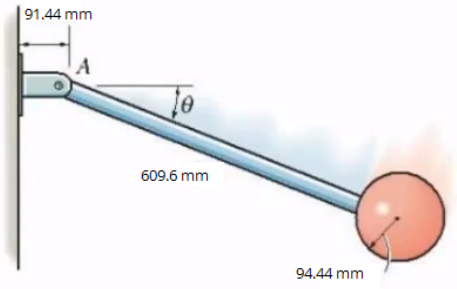
If I want to deeply simulate my mechanism, find all forces, reaction forces, torques etc — **Motion Analysis**.

If I want to simulate a whole robot with some control stuff or whole convenor — **Mechatronics Concept Designer**.

Task 1

The shown pendulum consists of a 4.54 *kg* solid ball and 1.81 *kg* solid rod.
If it released from rest, when the $\theta = 0°$, **determine the angle of rebound** after the ball strikes the wall and the pendulum swings up to the point of momentary rest. Take the restitution factor $e = 0.6$ between the ball and the wall.

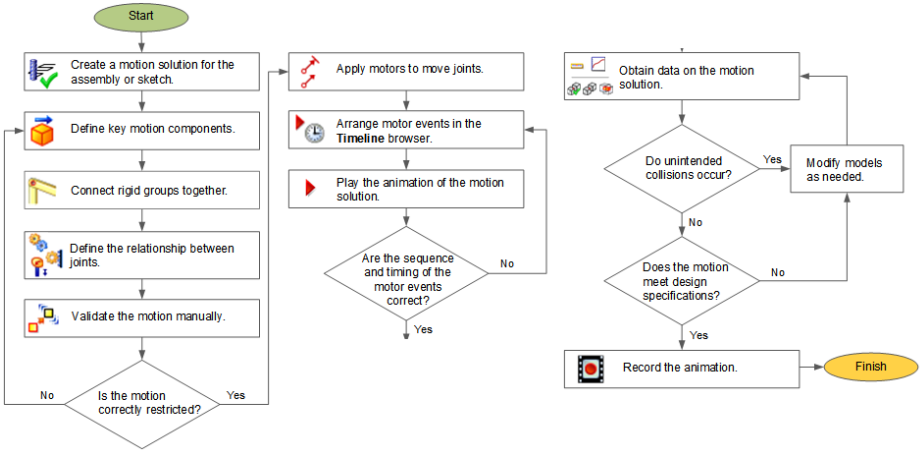
Answer: $\theta_2 = 39.8°$



1. Make a CAD model of the mechanism (or take it from *labs/CAE_DYN1/task_data/pendulum.zip*)
2. Assign the mass of the objects (have a mass and volume → can find density → change the density of the detail)
3. Determine links, joints, collisions
4. Configure a solver and solve the task
5. Interpret the answer

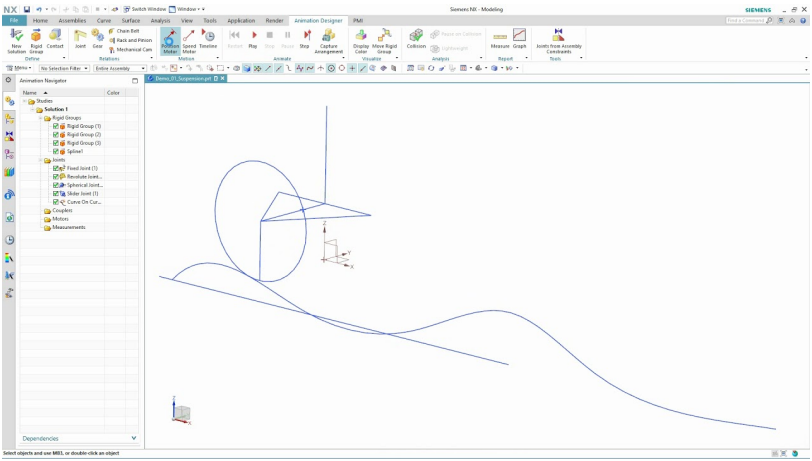
Animation Designer

Workflow



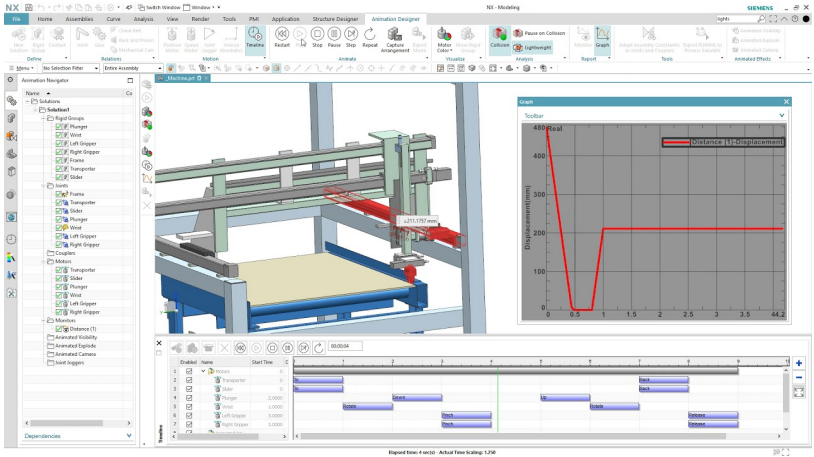
Animation Designer: Possibilites (1)

Video



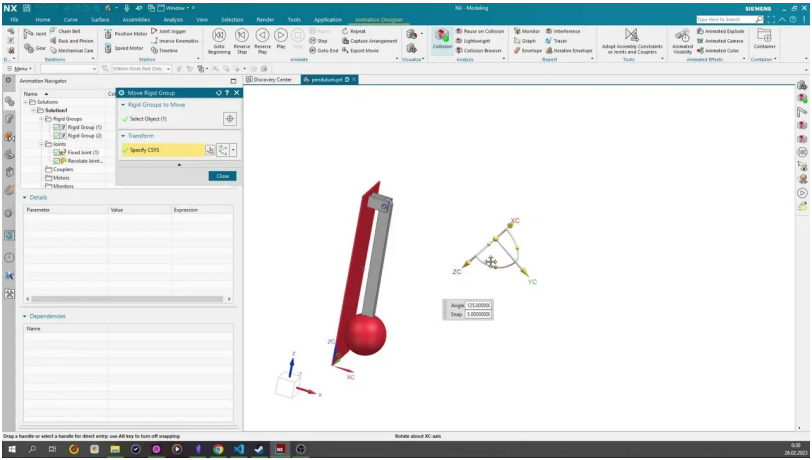
Animation Designer: Possibilites (2)

Video



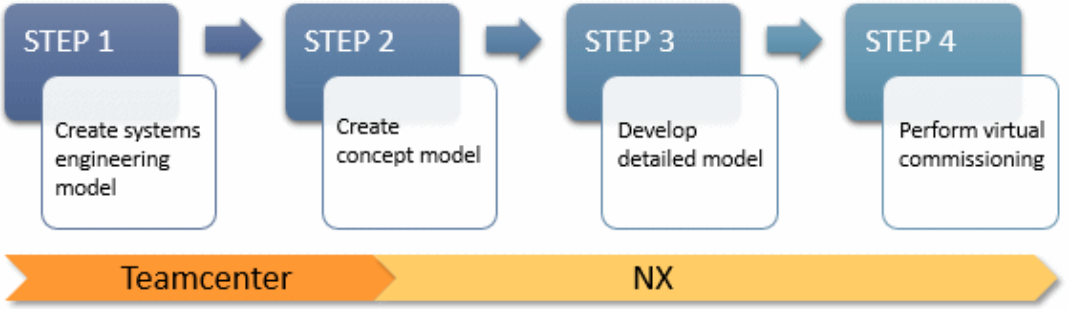
Animation Designer

Task 1



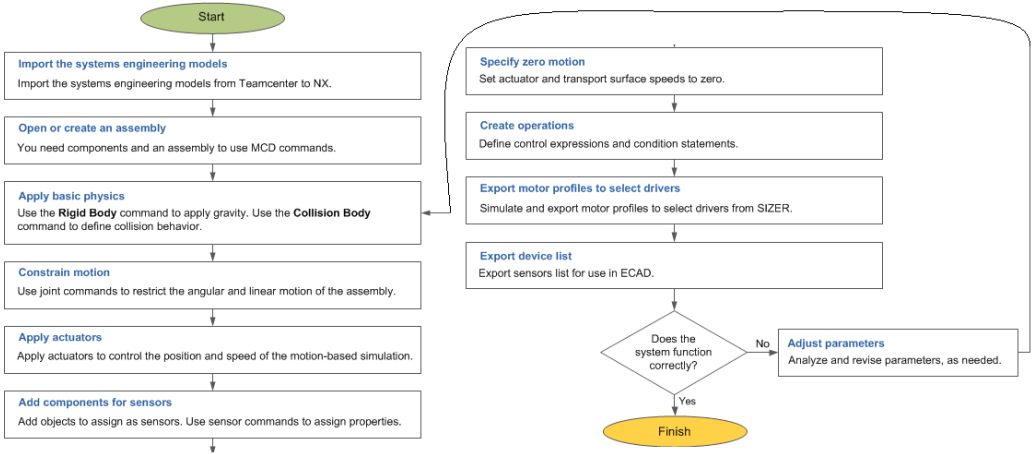
Mechatronics Concept Designer

Global Workflow



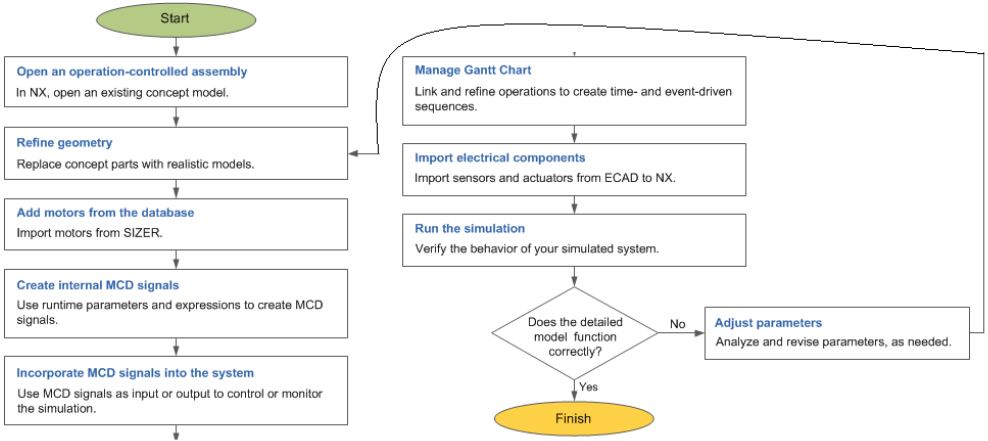
Mechatronics Concept Designer

Concept Model



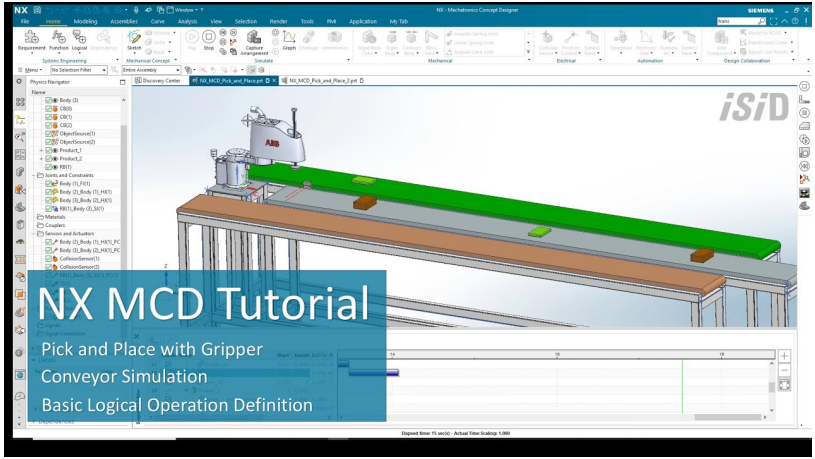
Mechatronics Concept Designer

Detailed Model



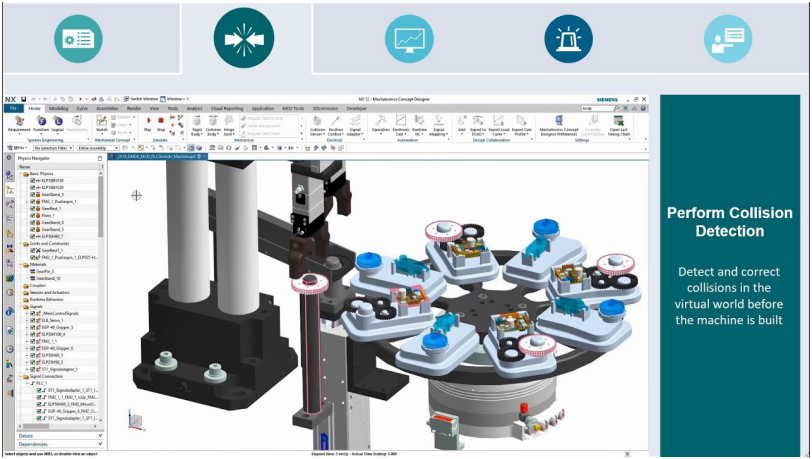
Mechatronics Concept Designer: Possibilites (1)

Video



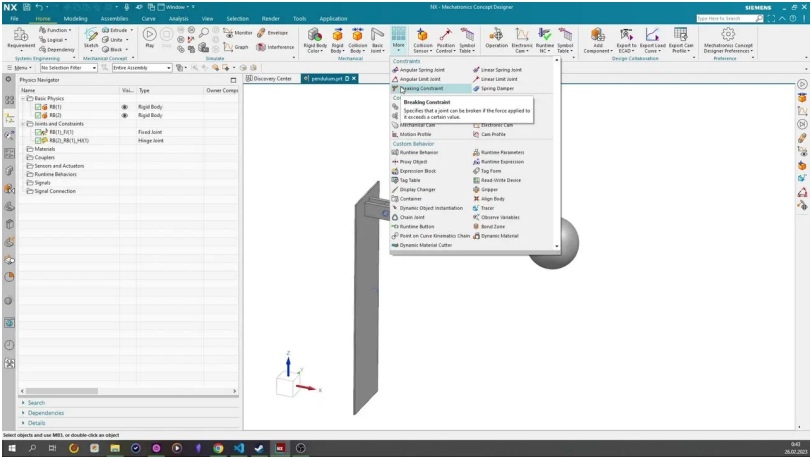
Mechatronics Concept Designer: Possibilites (2)

Video



Mechatronics Concept Designer

Task 1



Motion Analysis: Workflow

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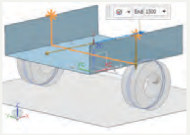
				

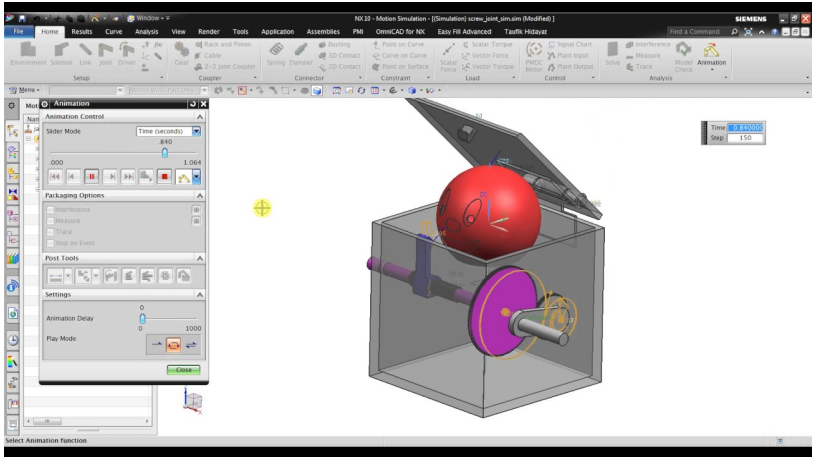
What-if, optimization, feedback to designer

Motion Analysis: Possibilites (1)

Video

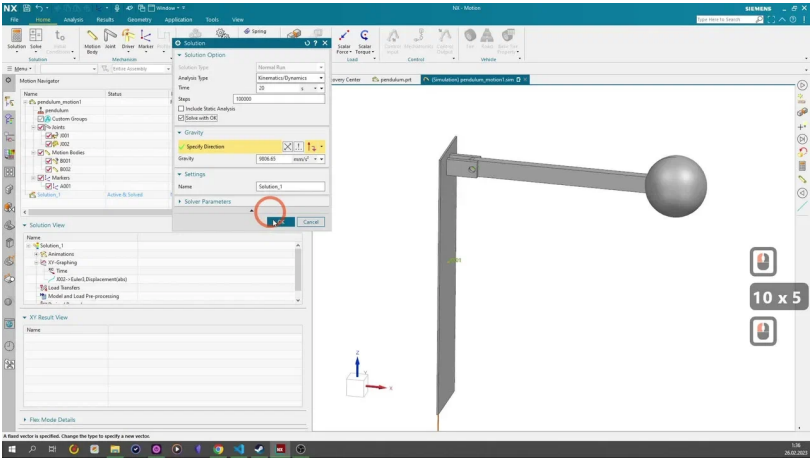
Motion Analysis: Possibilites (2)

Video



Motion Analysis

Task 1



Reference Material

1. Animation Designer documentation (official)
2. Mechatronics Concept Designer documentation (official)
3. Motion Simulation documentation (official)
4. Animation Designer Tutorials (video)
5. NX Motion Simulation Tutorials (video)
6. Mechatronics Concept Designer (video)
7. Mechatronics Concept Designer (book)
8. All Simcenter 3D modules explanation (book, rus)
9. All Simcenter 3D modules explanation (book, eng)

Deserve “A” grade!

– Oleg Bulichev

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