



Introduction to Mechanical Engineering, CAE DYN 1

Introduction to CAE

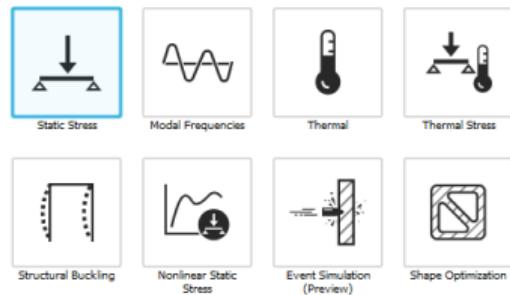
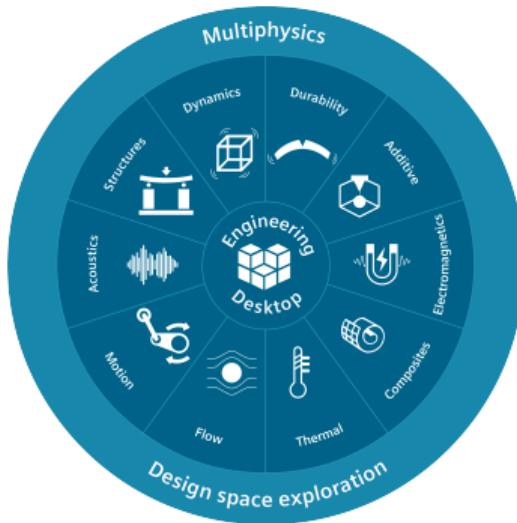
Animation Designer; Mechatronics Concept Designer; Motion Measure; Interference; Density; Assign Materials



Computer Aided Engineering (CAE)

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

- IC Engine (Fluent)
- Magnetostatic
- Modal
- Modal Acoustics
- Random Vibration
- Response Spectrum
- Rigid Dynamics
- Static Acoustics
- Static Structural
- Steady-State Thermal
- Thermal-Electric
- Topology Optimization
- Transient Structural
- Transient Thermal
- Turbomachinery Fluid Flow
- Coupled Field Static
- Coupled Field Transient
- Design Assessment
- Eigenvalue Buckling
- Electric
- Explicit Dynamics
- Fluid Flow - Blow Molding (Polyflow)
- Fluid Flow - Extrusion (Polyflow)
- Fluid Flow (CFX)
- Fluid Flow (Fluent)
- Fluid Flow (Polyflow)
- Harmonic Acoustics
- Harmonic Response
- Hydrodynamic Diffraction
- Hydrodynamic Response



CAE apps in ANSYS

CAE apps in Siemens NX

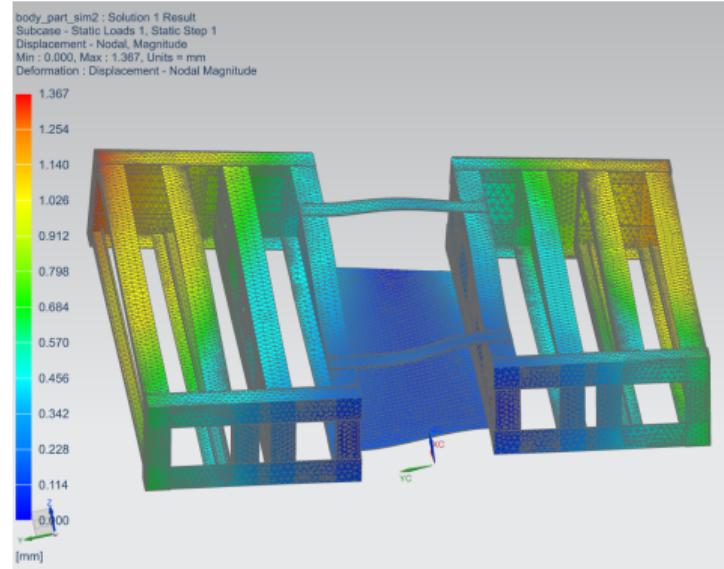
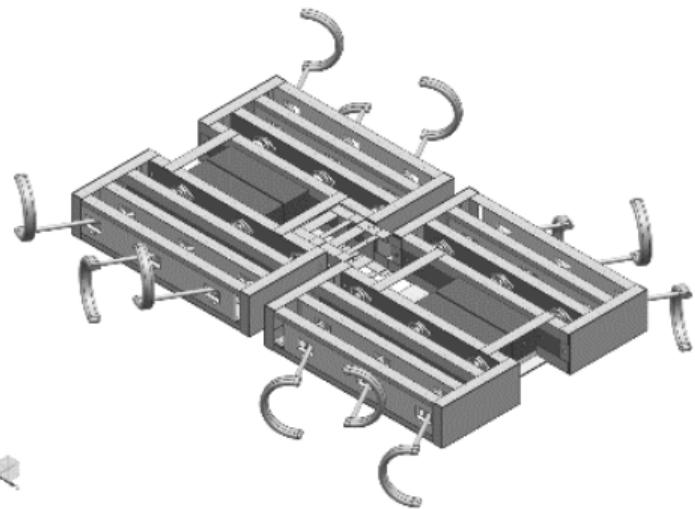
CAE apps in Fusion 360



Typical Engineering Tasks

Static Stress

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

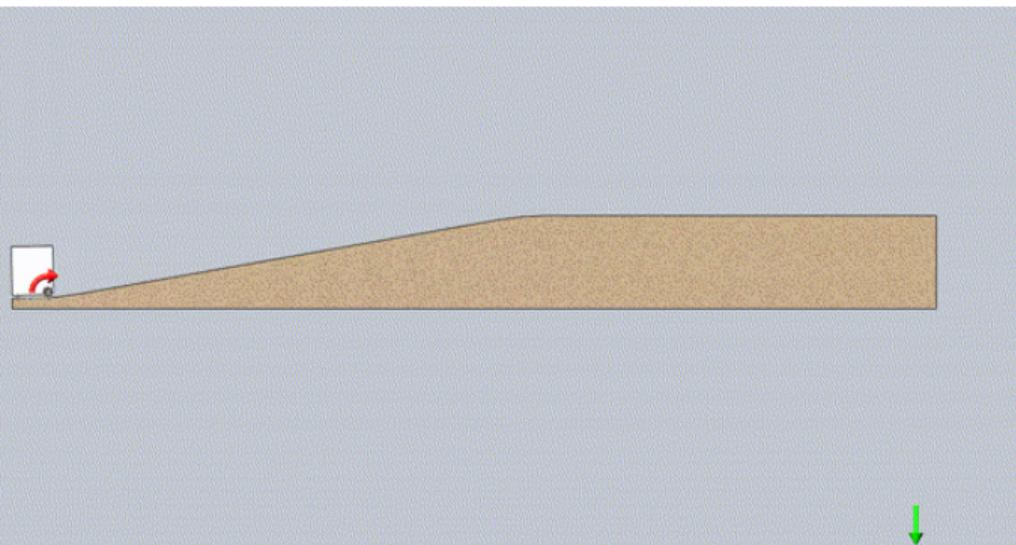
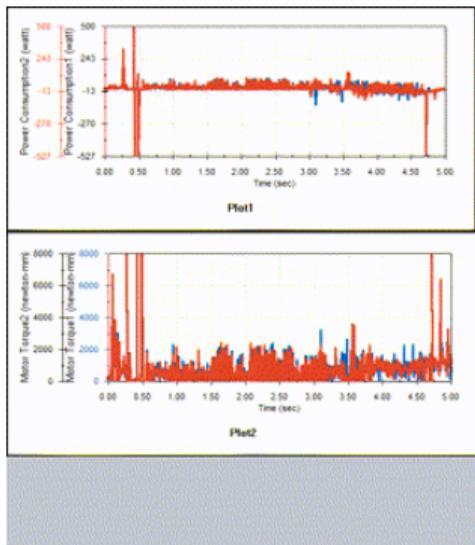




Typical Engineering Tasks

Rigid Dynamics

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

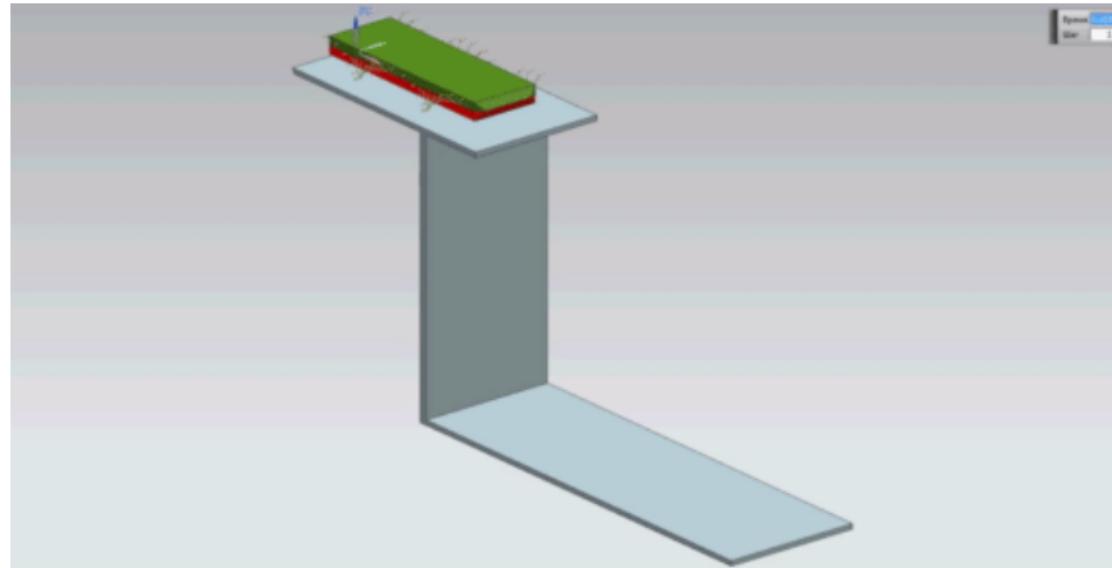




Typical Engineering Tasks

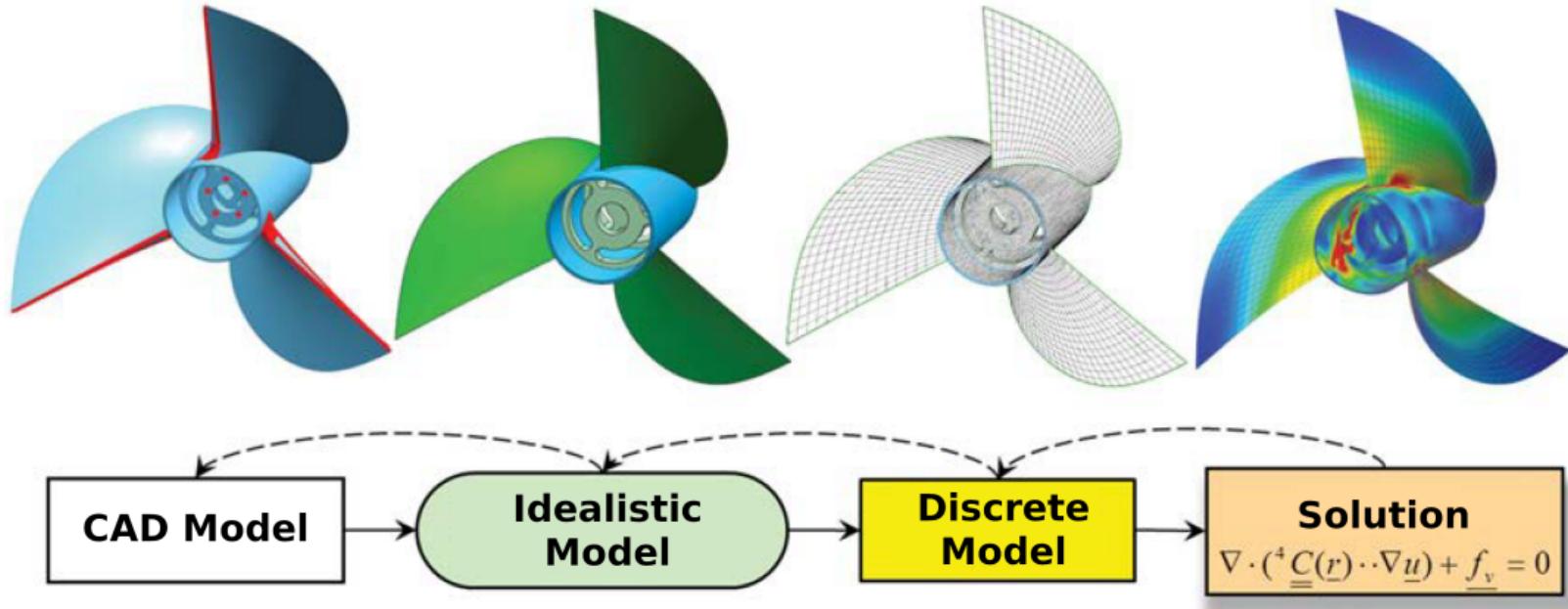
Motion Analysis

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



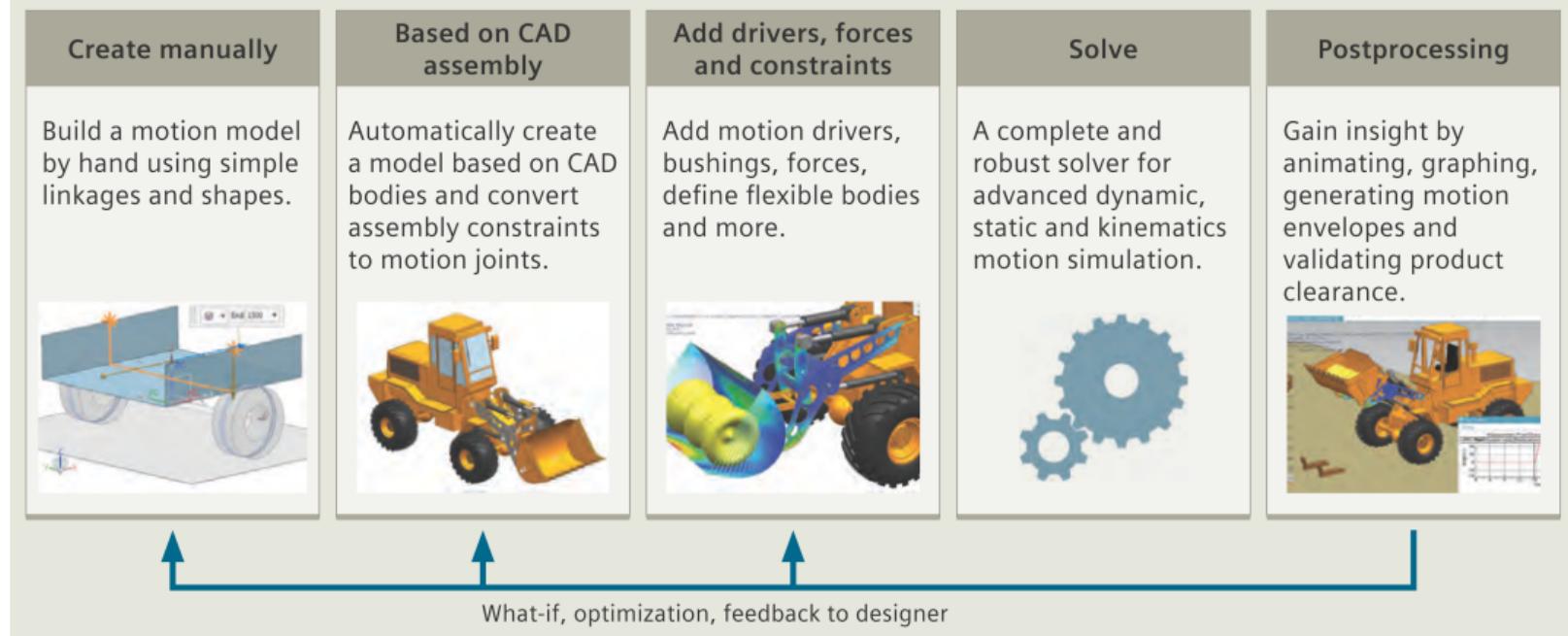


CAE General Workflow





CAE Motion Workflow





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.

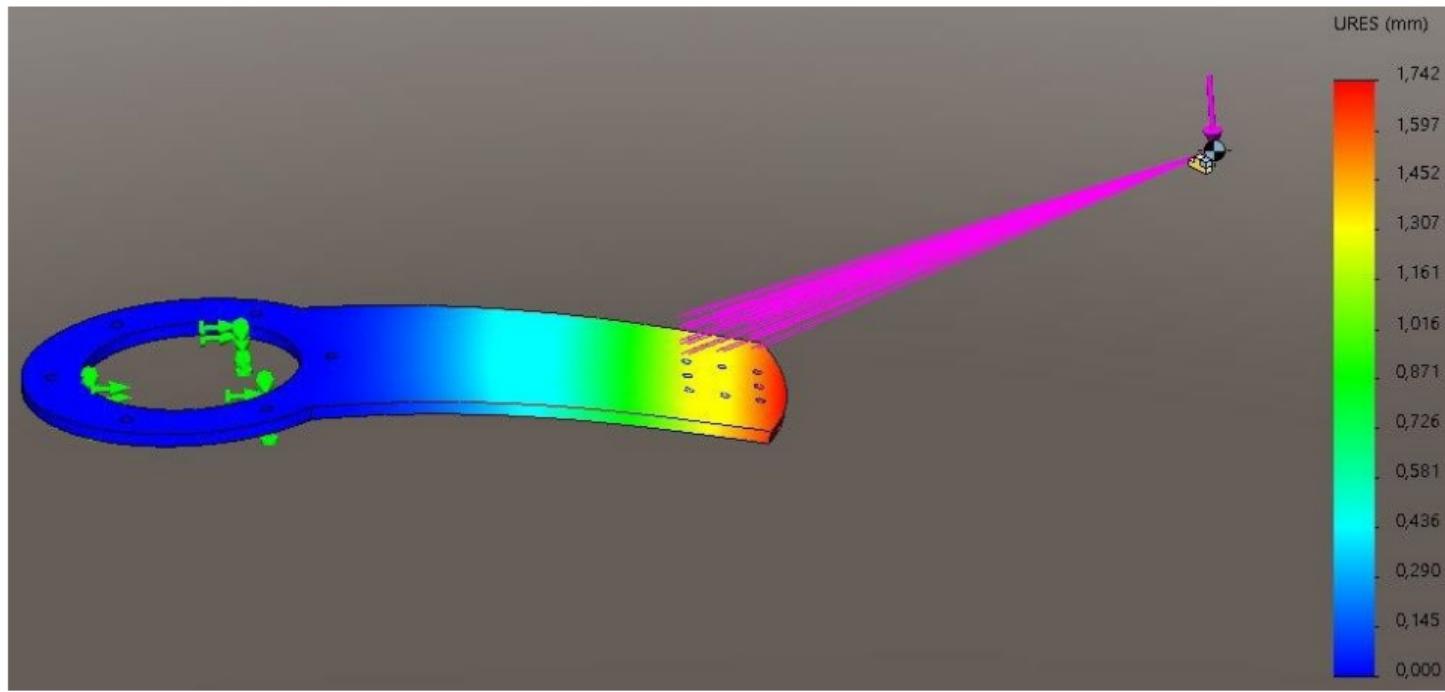
Reformulated task: Check deformation displacement of the manipulator base.





Case Study

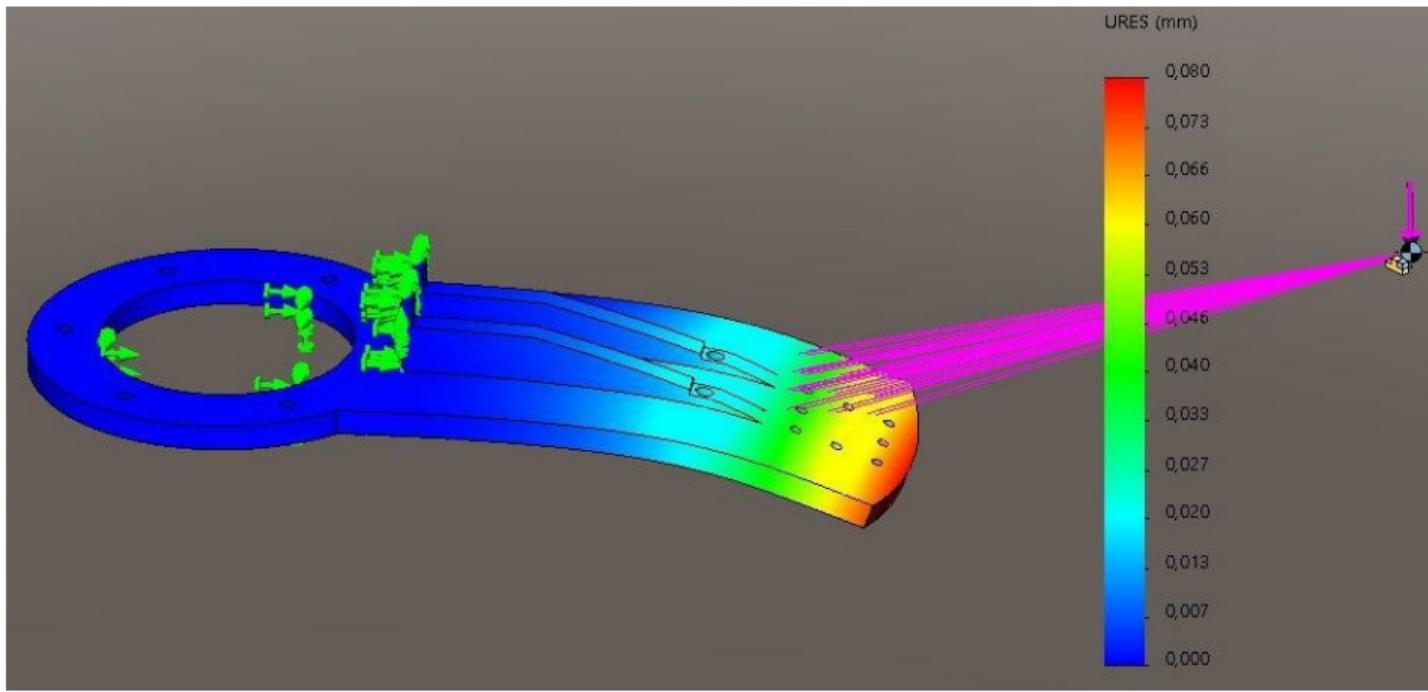
Implement and Interpret the result <<2-3>>





Case Study

Propose the solution <<4>>





Measure, Density, Interference

Video

7



Сборки в NX

NX 1957



Масса
сборки



Анализ
зазоров

масса сборки, анализ зазоров

Урок 7

Assembly

NX CAD



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**.

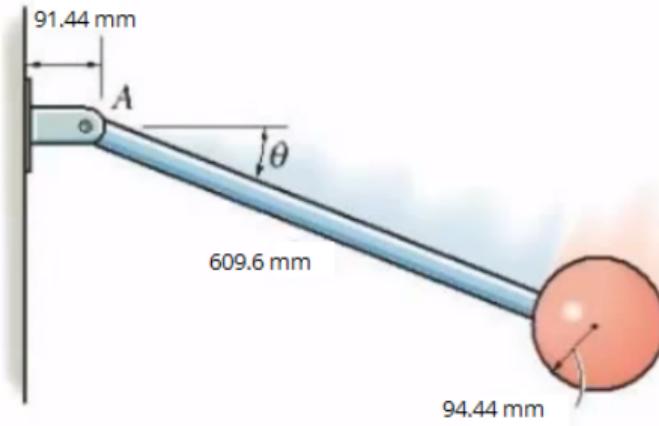


Task 1: solve it using 3 apps (Videos on next slides)

The pendulum consists of a 4.54 kg solid ball and 1.81 kg solid rod. If it released from rest, when the $\theta = 0^\circ$, 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: $\theta_2 = 39.8^\circ$

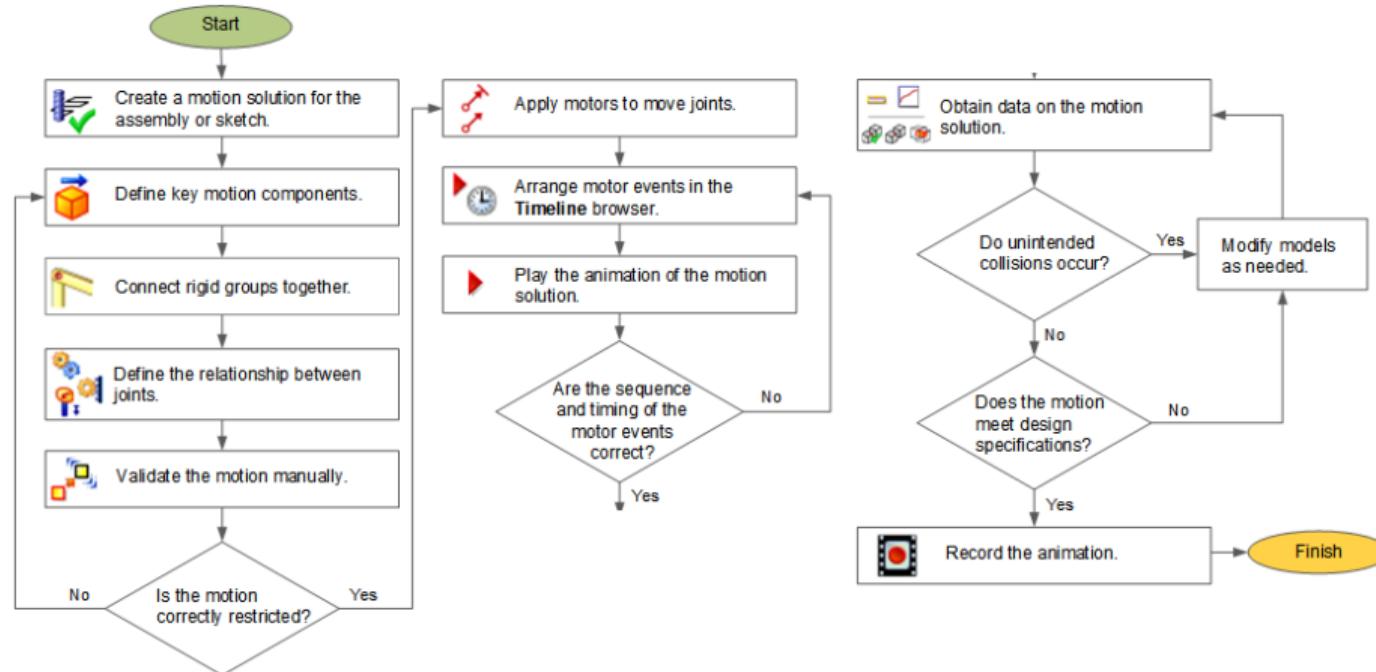
1. Make a CAD model of the mechanism (or take it from *labs/CAE_DYN1/task_data/pendulum.zip*)
2. Assign the mass of the objects (have a mass and volume → can find density → change the density of the detail)
3. Determine links, joints, collisions
4. Configure a solver and solve the task
5. Interpret the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





Animation Designer

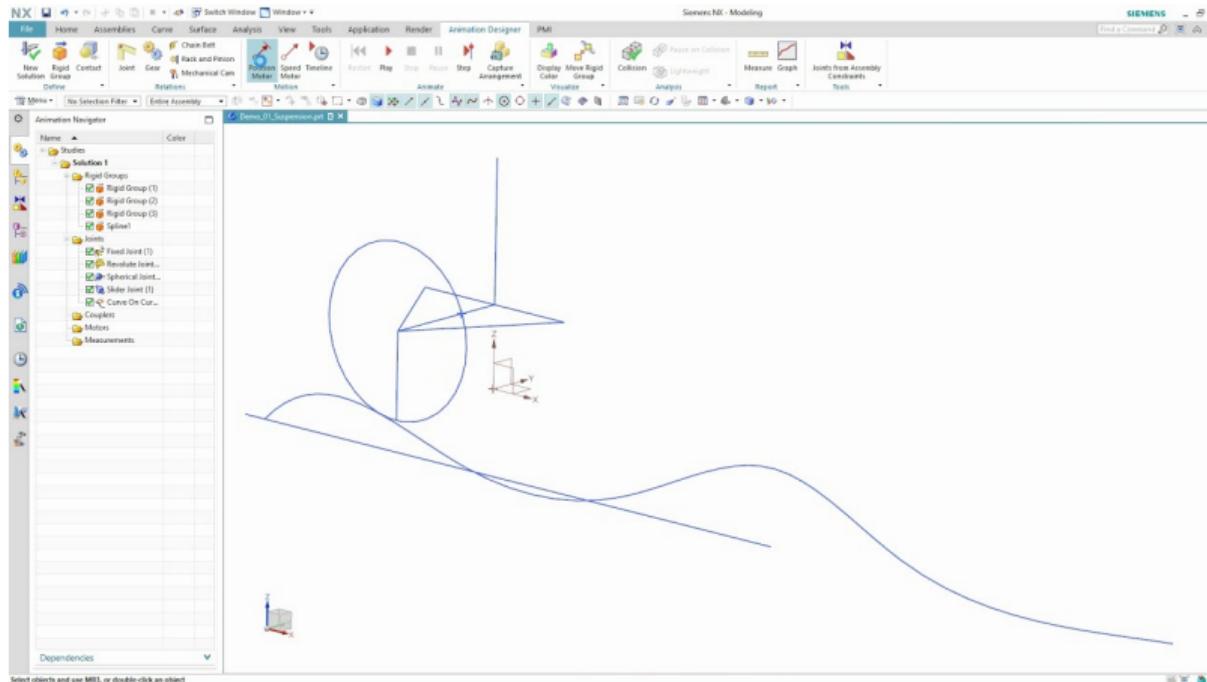
Workflow





Animation Designer: Possibilities (1)

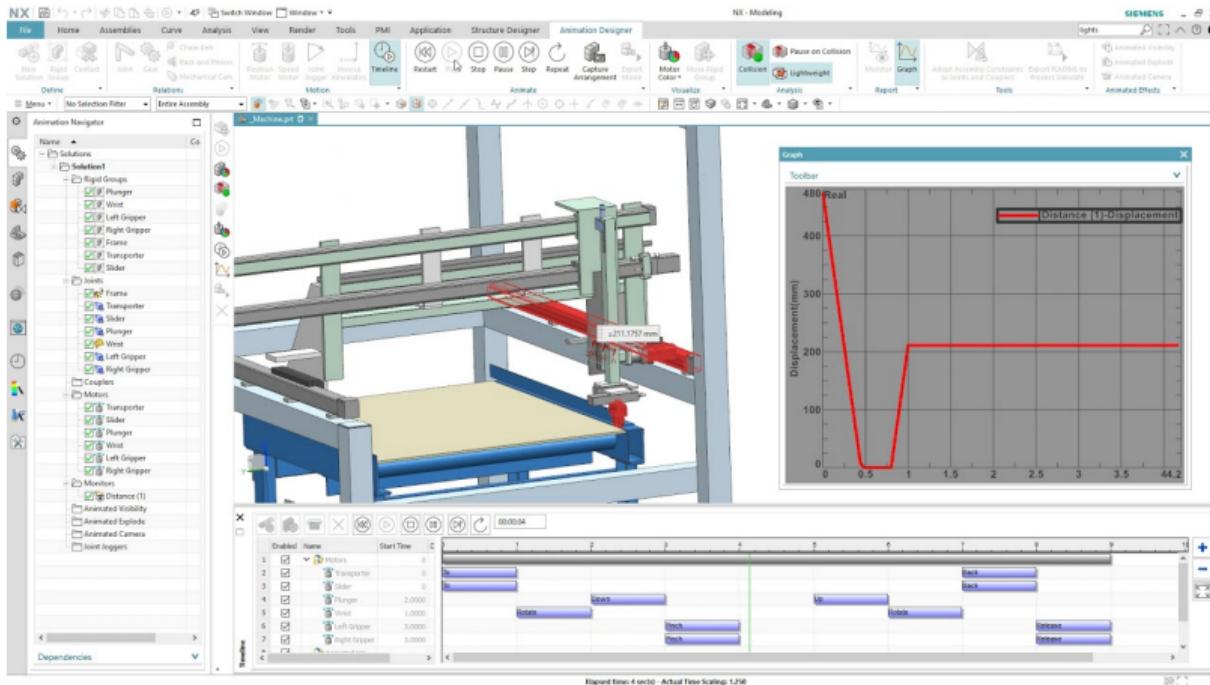
Video





Animation Designer: Possibilities (2)

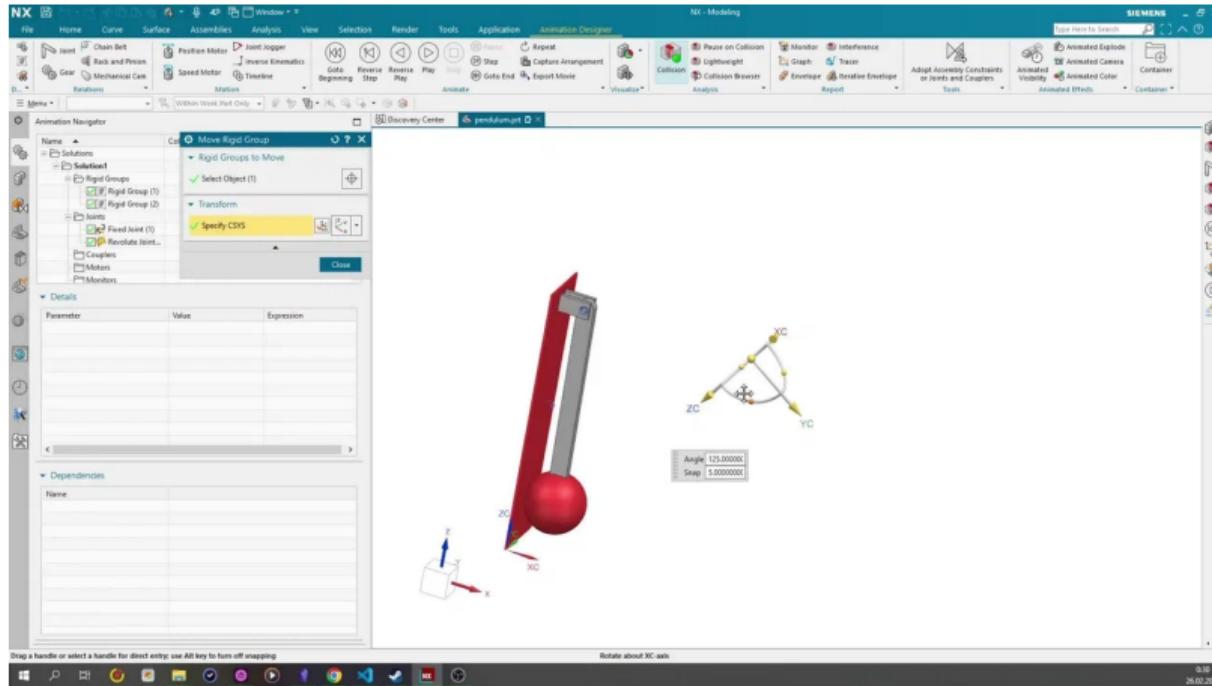
Video





Animation Designer

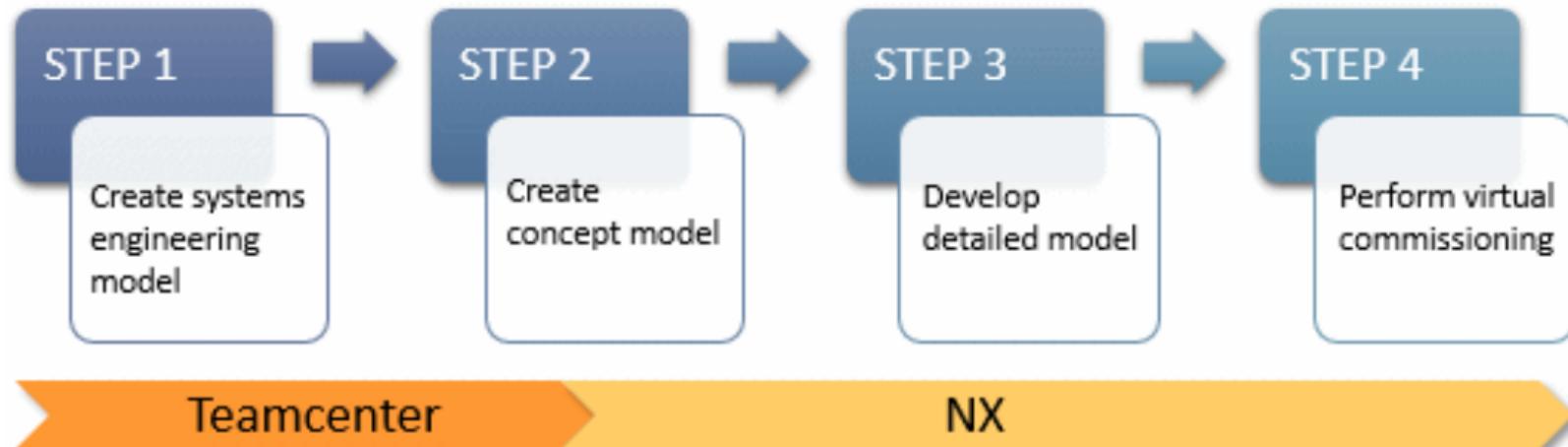
Task 1





Mechatronics Concept Designer

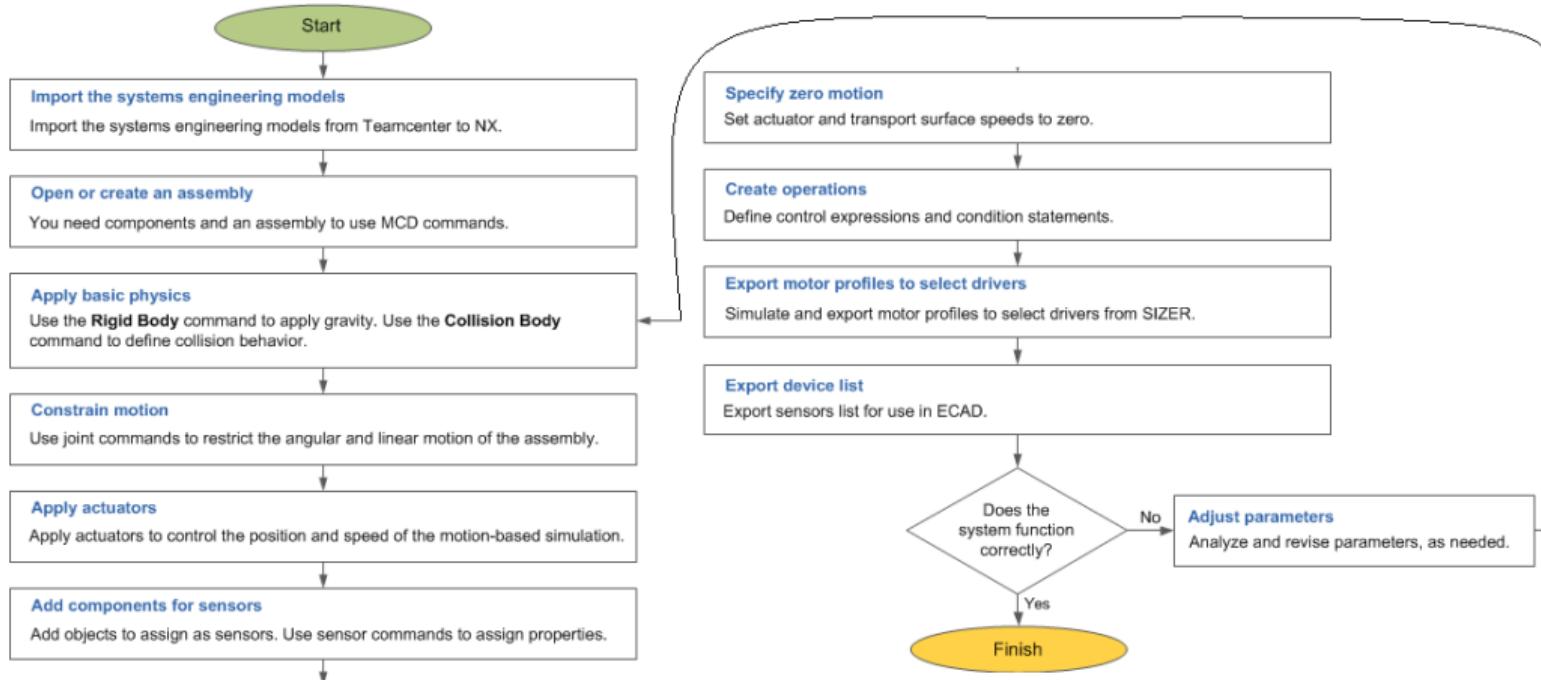
Global Workflow





Mechatronics Concept Designer

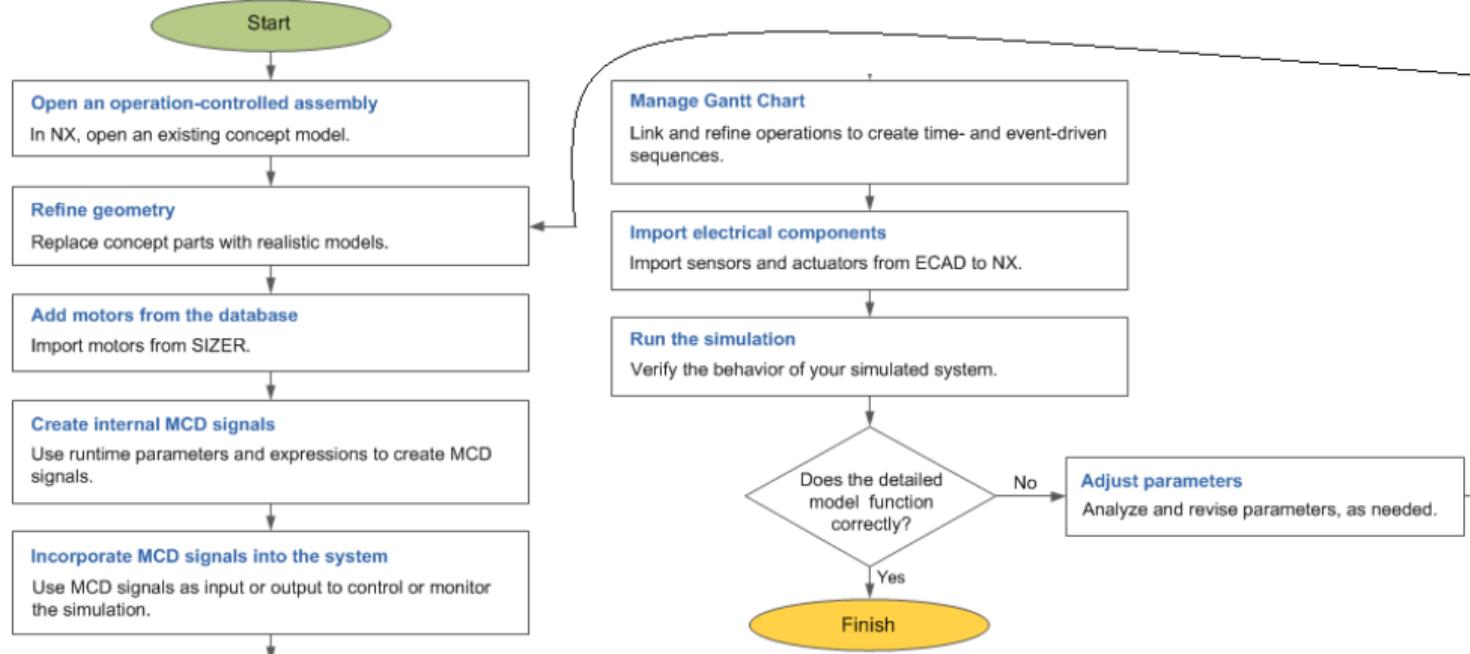
Concept Model





Mechatronics Concept Designer

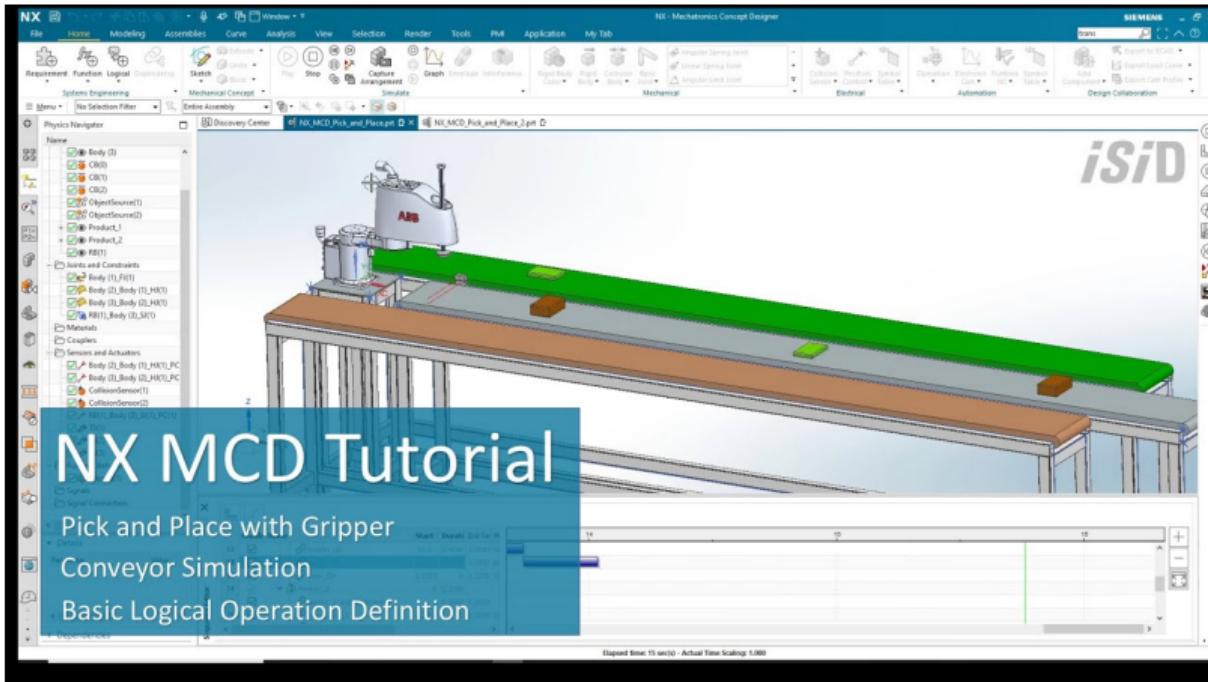
Detailed Model





Mechatronics Concept Designer: Possibilities (1)

Video





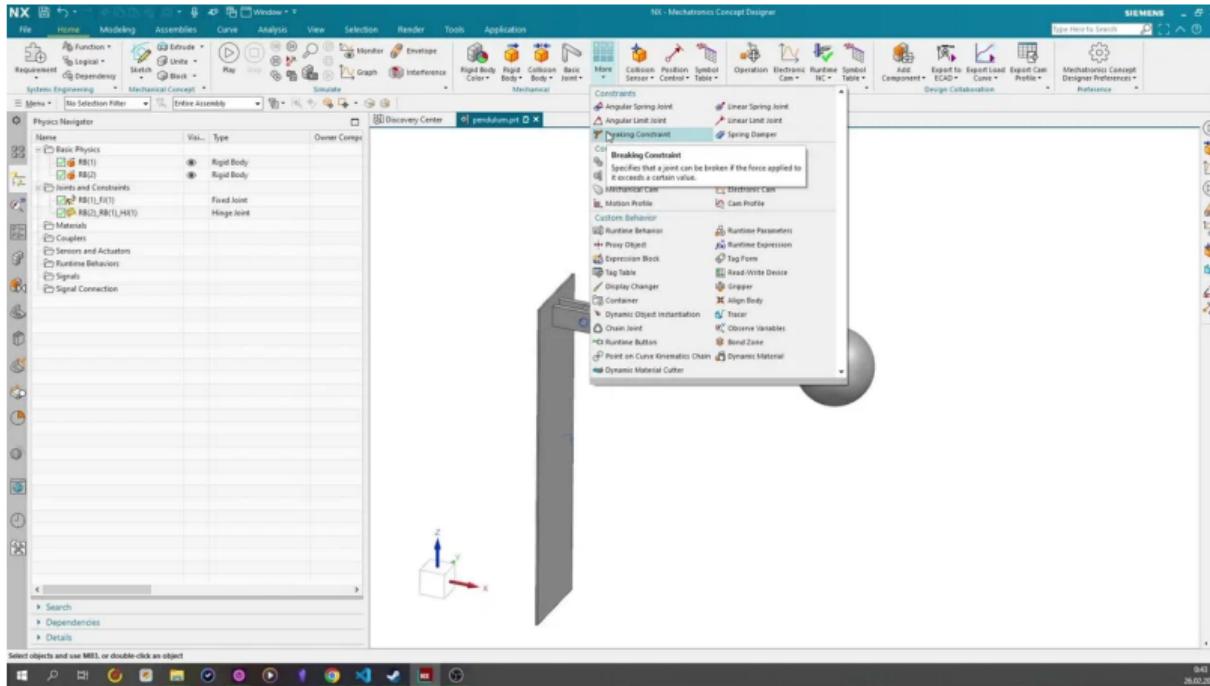
Mechatronics Concept Designer: Possibilities (2)

Video



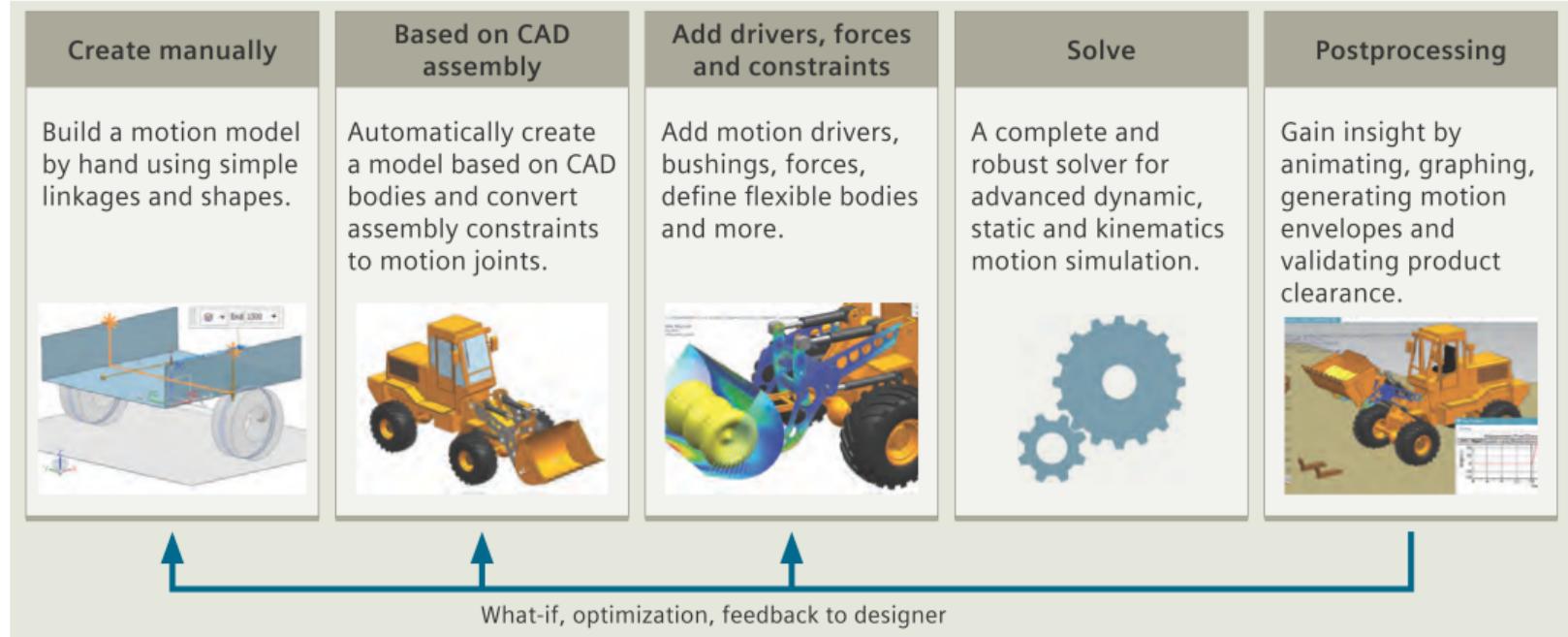
Mechatronics Concept Designer

Task 1





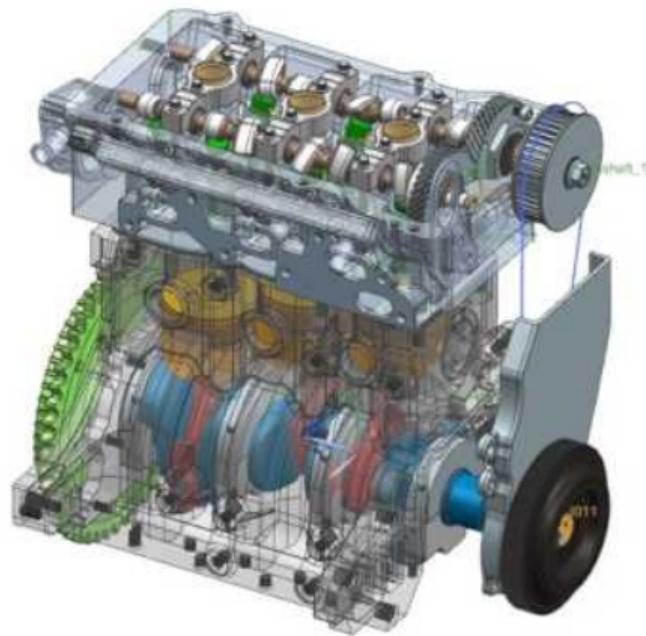
Motion Analysis: Workflow





Motion Analysis: Possibilities (1)

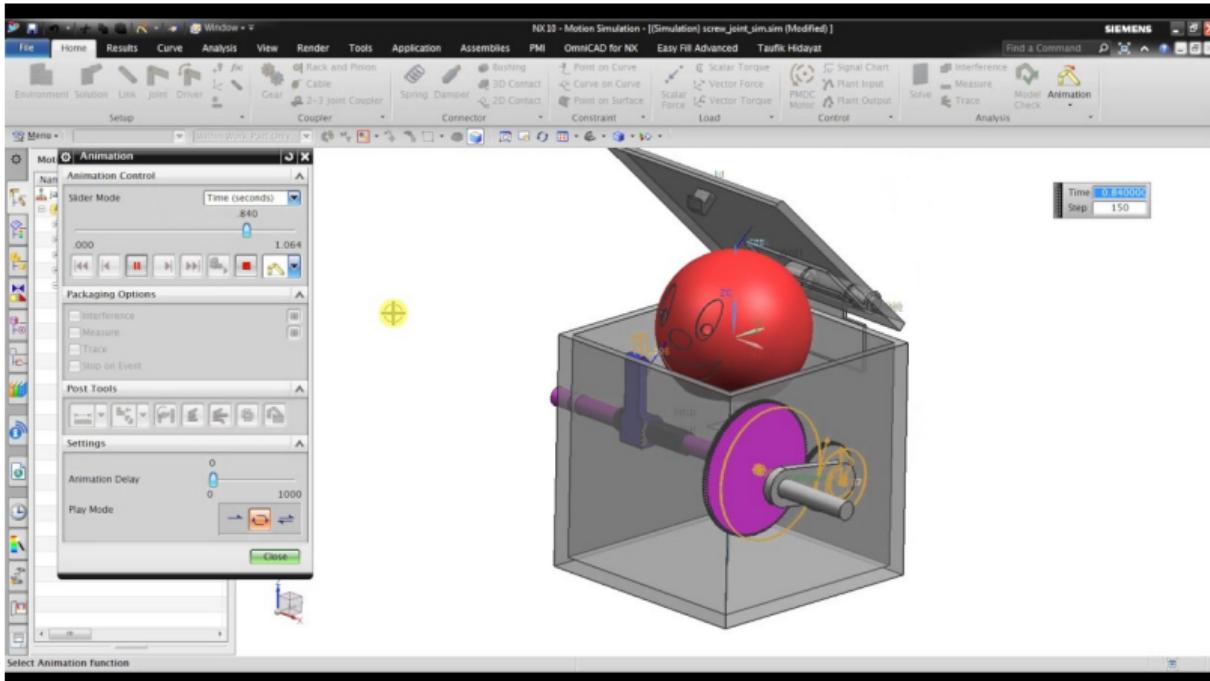
Video





Motion Analysis: Possibilities (2)

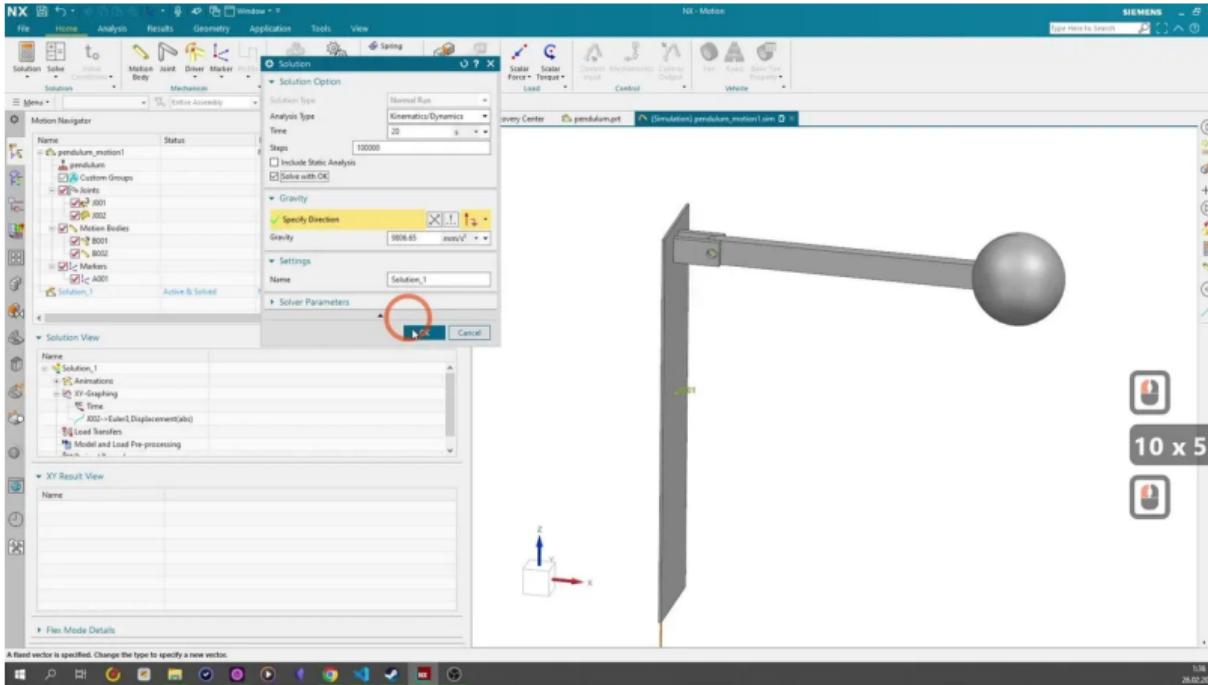
Video





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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↗ @Lupasic

🚪 Room 105 (Underground robotics lab)