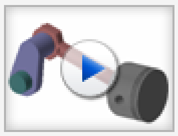
SimMechanics 3.2.2

Model and simulate mechanical systems

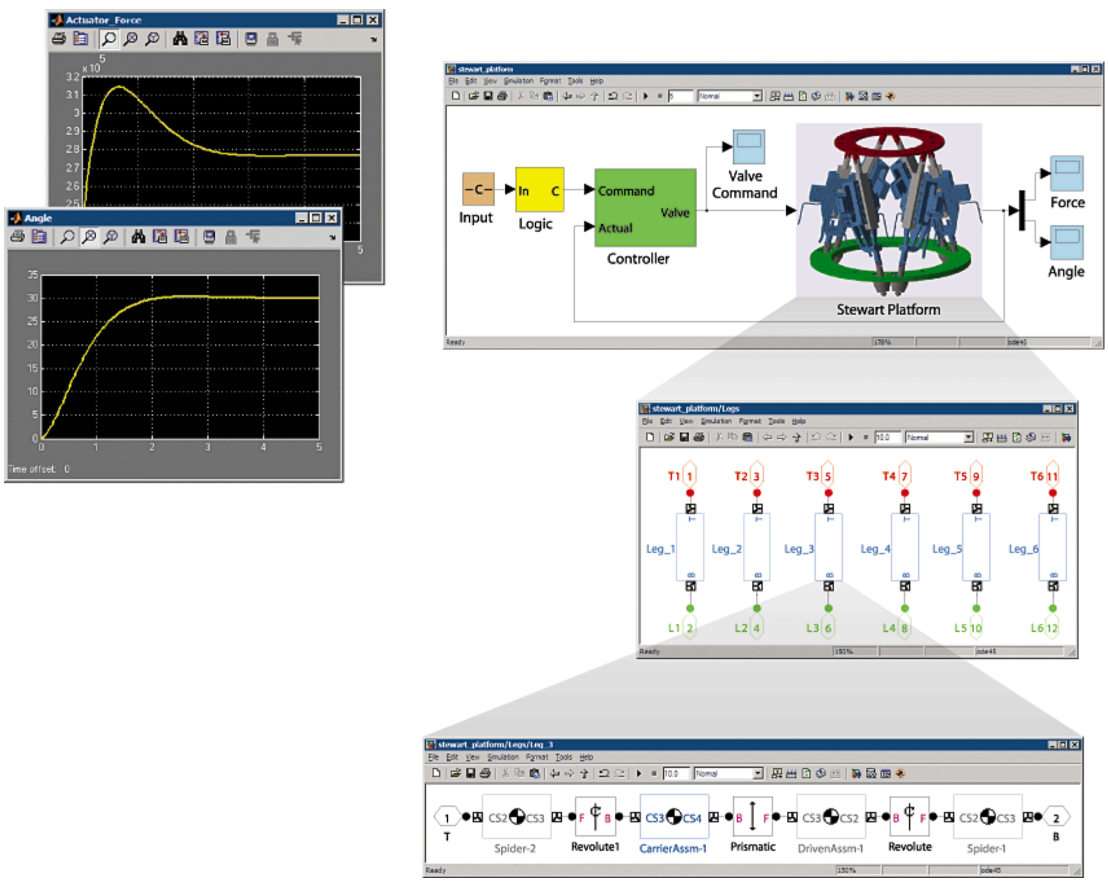
SimMechanics™ extends Simscape™ with tools for modeling three-dimensional mechanical systems within the Simulink® environment. Instead of deriving and programming equations, you can use this multibody simulation tool to build a model composed of bodies, joints, constraints, and force elements that reflects the structure of the system. An automatically generated 3-D animation lets you visualize the system dynamics. You can import models complete with mass, inertia, constraint, and 3-D geometry from several CAD systems.



Modeling a Piston *8:57*
Model a piston using multibody dynamics. Bodies, joints, and 3D visualization are defined and simulated.

SimMechanics models can be converted to C code with Simulink Coder™, enabling you to test embedded controllers using hardware-in-the-loop (HIL) tests instead of hardware prototypes.

SimMechanics can be used to develop active suspensions, robotics, surgical devices, landing gear, and a variety of other systems. You can combine SimMechanics with other MathWorks physical modeling products to model complex interactions in multidomain physical systems.



SimMechanics model of a robot arm. The colored blocks in the SimMechanics model (bottom) correspond to the colored parts in the 3-D visualization (top).

Key Features

- Modeling environment for building 3-D rigid-body mechanical systems
- Simulation modes for analyzing motion and calculating forces
- Visualization and animation of mechanical system dynamics with 3-D body geometry
- SimMechanics Link utility, providing an interface to Pro/ENGINEER® and SolidWorks® CAD platforms and an API for linking to other CAD platforms
- Ability to convert models to C code (with Real-Time Workshop)
- Integration in Simulink, enabling development of high- fidelity, nonlinear plant models and control systems in a single environment

Modeling Mechanical Systems

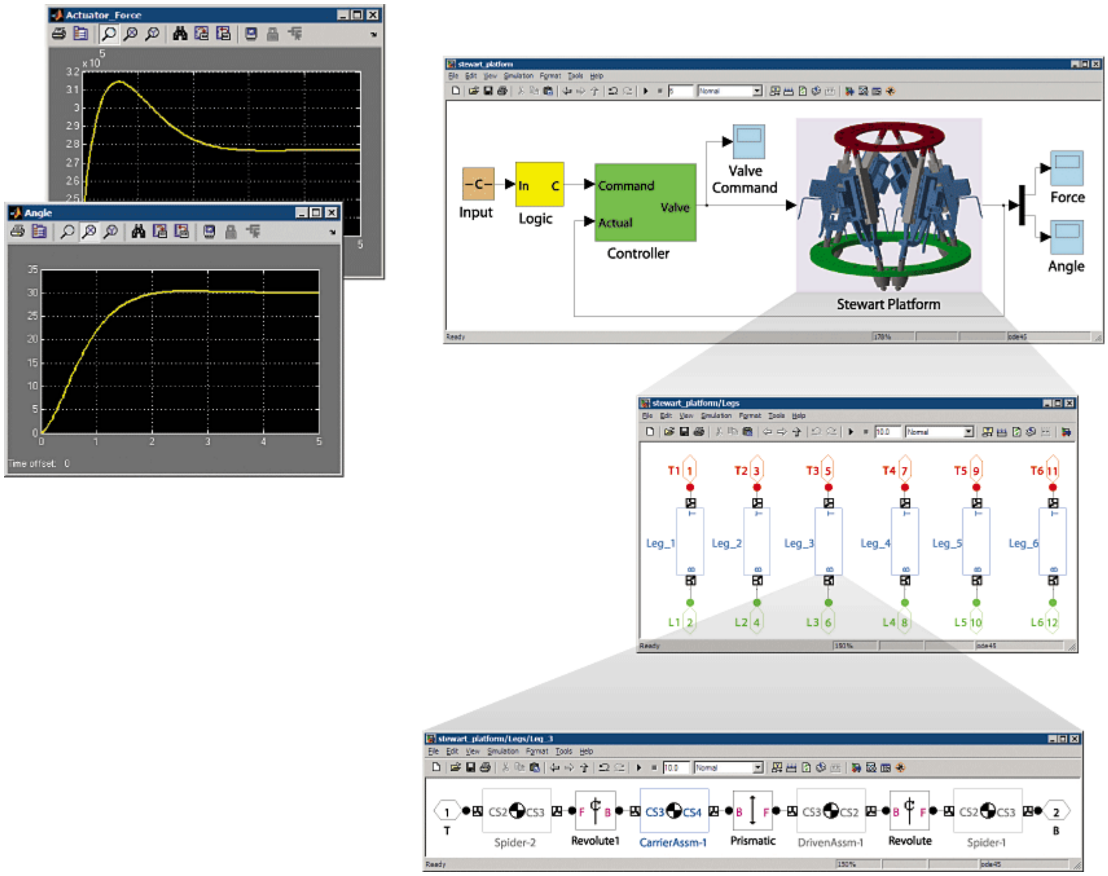
With SimMechanics you build a model of a three-dimensional mechanical system just as you would assemble a physical system. Using bodies, coordinate systems, joints, and force elements, you define a mechanical system that can be connected directly to other Simulink models. This approach lets you expand the capabilities of SimMechanics and reuse existing Simulink models. You can save models that combine Simulink and SimMechanics blocks as subsystems for reuse in many applications.

These subsystems can include:

- Nonlinear springs that use Simulink look-up tables
- Aerodynamic drag models that attach pressure distributions to aerospace components, such as ailerons and rudders
- Active vehicle suspension subsystems, such as stabilization mechanisms and controllers
- Tire models for aircraft and ground vehicles

Using the sensor blocks in SimMechanics, you can measure values for different physical quantities such as force, torque, and velocity, and then pass these signals into standard Simulink blocks. Actuator blocks enable Simulink signals to assign values to any of these variables and actuate your mechanical system. Sensor and actuator blocks let you connect a control algorithm developed in Simulink to a SimMechanics model.

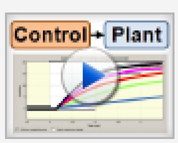
You can design the controller using the nonlinear plant model developed in SimMechanics. Alternatively, you can extract a linear plant model from the nonlinear model using Simulink Control Design™, enabling you to use linear control theory to design your controller.



SimMechanics model of a Stewart platform connected to a controller (top right). All six legs of the Stewart platform reuse the leg model (bottom). Plots (top left) show the angle of the platform and the force required of one actuator.

Simulating and Analyzing Mechanical Motion

By simulating your SimMechanics model, you can impose kinematic constraints, apply forces and torques, and measure the resulting motions and forces. You can also develop and test actuators, such as electric motors, ball screws, hydraulic cylinders, and engines.



Optimizing System Performance *6:08*
Automatically tune the performance of a hydromechanical pitch control system to meet system requirements using optimization algorithms.

SimMechanics adds to Simulink solver technology designed for simulating mechanical systems. It supports four motion analysis modes:

- **Forward Dynamics:** Assigns driving forces and torques to the motion-driving actuators and calculates the resulting motions of the entire system
- **Inverse Dynamics and Kinematics:** Determines the forces and torques that the actuators must exert to produce user-specified motions
- **Trimming:** Identifies the steady-state equilibrium points to be used for linearization and system analysis
- **Linearization:** Extracts a linear model that predicts the system's response to perturbations in driving forces, joint and constraint configurations, and initial conditions

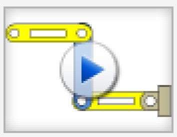
These modes of analysis enable you to test mechanical performance, select proper actuation systems, and develop optimal controls.

SimMechanics automatically creates a 3-D visualization of your mechanical model that can be animated during the simulation. The geometry in the visualization can be generated from the coordinate systems defined in your model, or you can attach realistic 3-D geometry to the bodies in your model. In addition, ellipses representing the mass and inertia of each part can be displayed to help you understand your system.

You can save the animation produced during simulation to a separate file so that you can view it independently of the simulation. You can enhance the visualization using all standard MATLAB® graphics functions.

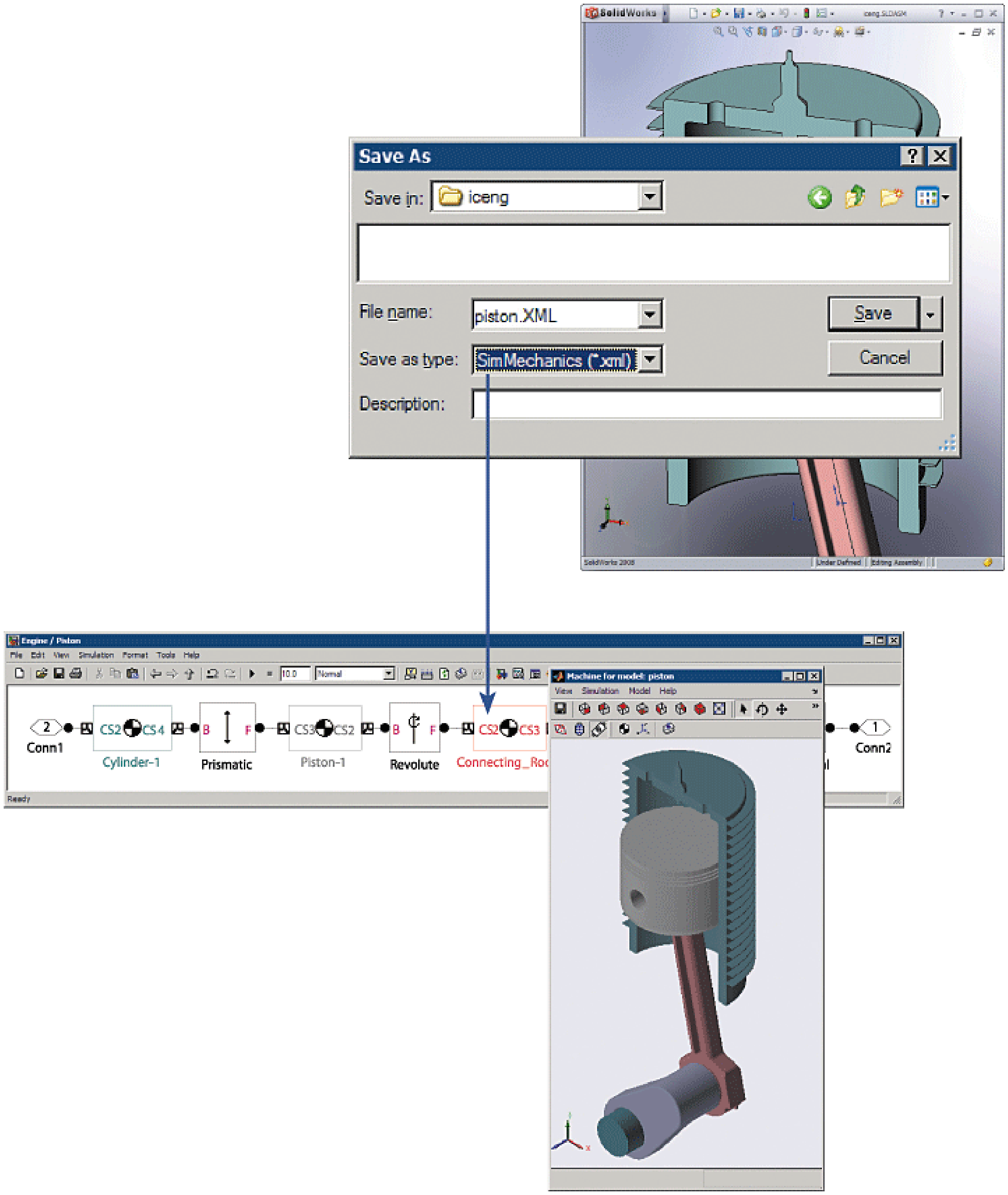
Exporting CAD Assemblies from a CAD System into SimMechanics

Using SimMechanics Link, you can automatically create a SimMechanics model from a CAD assembly. SimMechanics Link exports critical data and mate information to a file that can be imported by SimMechanics. The mass and inertia of each part in the assembly are converted to rigid bodies in SimMechanics. Geometry from the CAD assembly is automatically converted into geometry files and associated with the proper body in SimMechanics. The mate definitions in the CAD assembly are converted into the appropriate joints in the SimMechanics model.



Importing and Merging CAD Models into SimMechanics *7:14*
Import models from CAD systems to SimMechanics using SimMechanics Link. Separate changes made in the CAD system and SimMechanics are automatically merged in the final model.

For SolidWorks, ProEngineer, and Inventor models, you can install a plug-in to save the CAD assembly as an XML file that can be imported into SimMechanics. For other CAD systems, SimMechanics Link provides an API that you can connect to the API of your CAD system. Download SimMechanics Link.

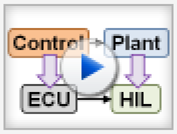


Piston model imported from CAD into SimMechanics. The CAD model of the piston (top) is saved as an XML file, and imported into SimMechanics. The visualization is generated from the STL files automatically exported from the CAD system (bottom).

Converting SimMechanics Models to C Code

With SimMechanics you can convert your models into C code, enabling you to use the accelerator modes of Simulink to reduce simulation time. You can also convert your SimMechanics models into C code using Simulink Coder, which lets you:

- Run your model in real time, enabling you to perform HIL testing
- Integrate your model into other simulation environments
- Compile your SimMechanics model for standalone simulations, accelerating analyses such as parameter studies and Monte Carlo simulations



Hardware-in-the-loop (HIL) Testing *5:21*
Use HIL testing instead of hardware prototypes to test control algorithms. A multidomain physical model is converted to C code and simulated on controller hardware.

Multidomain Physical Modeling in MATLAB and Simulink

SimMechanics provides expanded capabilities for simulating mechanical systems. You can create your physical plant model using physical connections and connect it directly to your control model with signal flows in Simulink. SimMechanics models can also be connected directly to other MathWorks application- and domain-specific physical modeling tools, enabling you to model complex interactions in multidomain physical systems. You can use MATLAB to parameterize your model, automate simulation tests, analyze output data, and optimize system performance. As a result, you can test your entire system (both the multidomain physical plant and the controller) within the MATLAB and Simulink environment.

Integrating Physical Systems and Controller *5:49*
Detect system integration issues in simulation. Mechanical, hydraulic, electrical, and control systems are gradually integrated into a full system model.

Resources

Product Details, Demos, and System Requirements
www.mathworks.com/products/simmechanics

Trial Software
www.mathworks.com/trialrequest

Sales
www.mathworks.com/contactsales

Technical Support
www.mathworks.com/support

Online User Community
www.mathworks.com/matlabcentral

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