Modeling parametric constraints

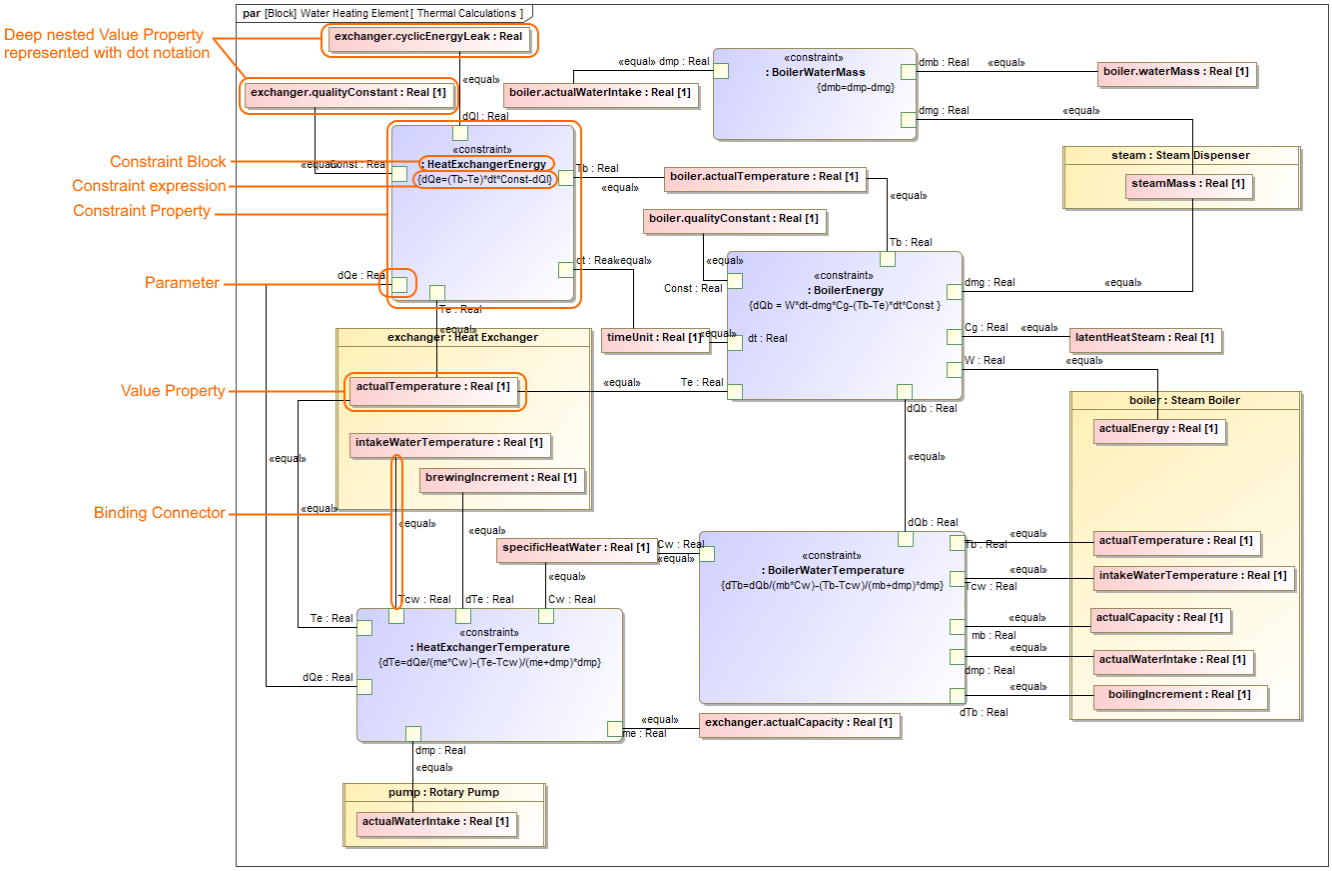
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Introduction

SysML Parametric Diagrams provide a way to integrate engineering analysis models described in mathematical equations and constraints, with design models describing the structural and behavioral aspects of systems. Parametric diagrams include usages of constraint blocks to constrain the properties of another block. A constraint property is a property of any block that is typed by a constraint block. To empower the constraint expression to perform calculations, you have to specify what system parameters should be consumed as variables of that constraint.

See the figure below, as example of SysML Parametric Diagram wherein all elements are highlighted: Value Properties, Constraint Block, Constraint Property, Constraint expression, Constraint Parameter, Binding Connector.



The main elements used in the SysML Parametric Diagram.

Creating parametric constraints

This section explains how to model system constraints in the SysML Parametric Diagram. Parametric constraints are formulas, and parameters are variables that can be bound to value properties later. Variables can be inputs and outputs of the formula. In general, you must perform the following steps to model your system constraints. However, some actions may already be done in the model creation process, so you may skip these steps and use existing model data. The following procedure provides the main workflow of modeling parametric constraints manually and automatically.

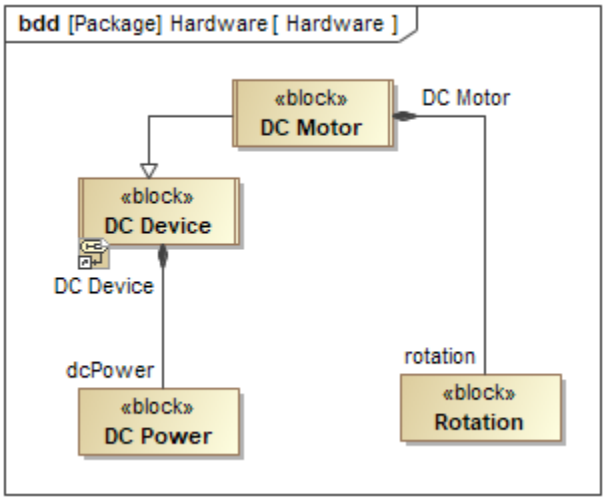
There are two ways to model parametric constraints:

- Manually by creating elements and binding them.
- Automatically by using the Parametric Equation Wizard.

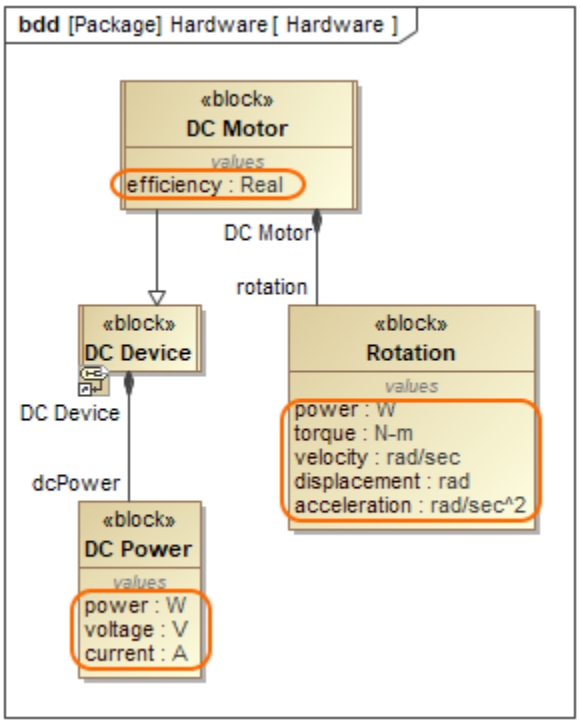
Creating parametric constraints manually

To create parametric constraints manually

1. Open existing project or create new.
2. Create a Block or it's structure in Block Definition Diagram. As shown in the figure, The *DC Motor* Block is decomposed into *Rotation* part and inherited *DC Power* part from *DC Device* Block. Learn more how to decompose Blocks >

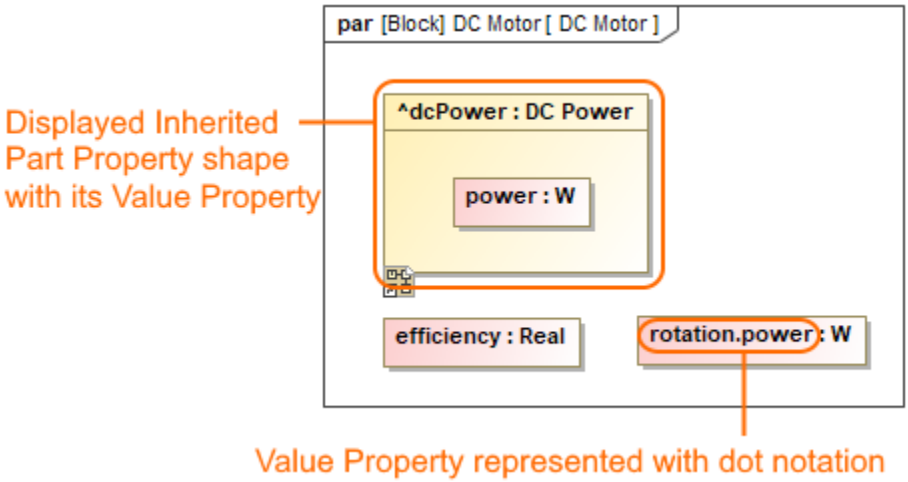


3. Create Value Properties for those Blocks. As shown in the figure below, the highlighted Value Properties created for the *DC Motor*, *Rotation* and *DC Power* Blocks. Specify their types.



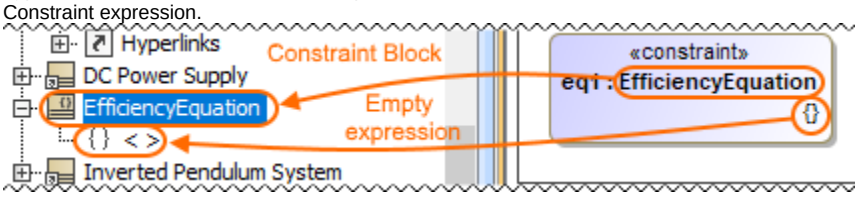
4. Right-click the Block and select **Create Diagram** > **SysML Parametric Diagram**. In the opened **Display Parameters/Properties** dialog, select either:
    - Part Properties with its Value Properties, if you have enough space on the diagram pane to display part shapes. As example, see the following figure where *power* Value Property is displayed inside inherited *dcPower* Part Property shape.

- Only Value Properties, if you need to save a space on the diagram pane. The dot notation is used in Value Property name instead of part shape. As example, see the following figure where dot notation (*rotation.power*) is used to express the path of *power* Value Property.

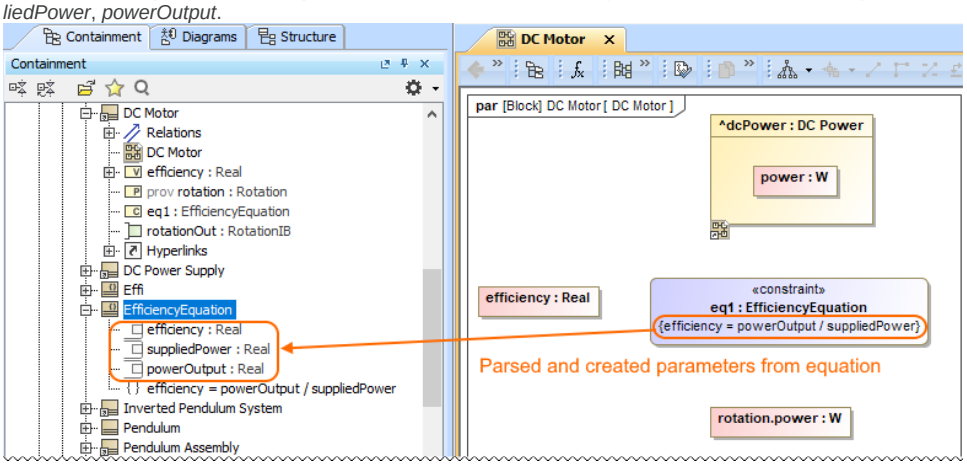


5. Click the **Constraint Property** button on the diagram palette and then click the empty place of that diagram pane. An unnamed Constraint Property is created. Type its name.

6. Specify Constraint property type by selecting the Constraint Property shape, from the smart manipulator toolbar, click and do either:
   - Type a name of a Constraint Block and press Enter. The new Constraint Block is created automatically in the model with an empty Constraint expression.



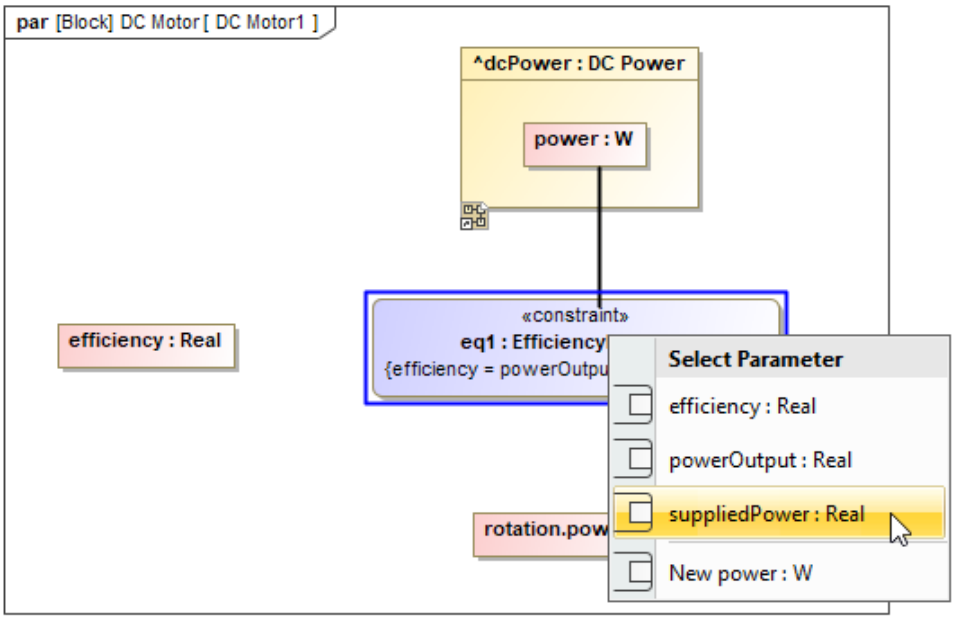
   Double-click {} and type an expression. To make a reusable Constraint Block, we highly recommend to use different value names than exist in particular model. E.g. *efficiency=powerOutput/suppliedPower*. Create parameters automatically from equation by clicking fro m Constraint Property smart manipulator toolbar. As shown in the figure below, three Constraint parameters are created: *efficiency*, *supp liedPower*, *powerOutput*.



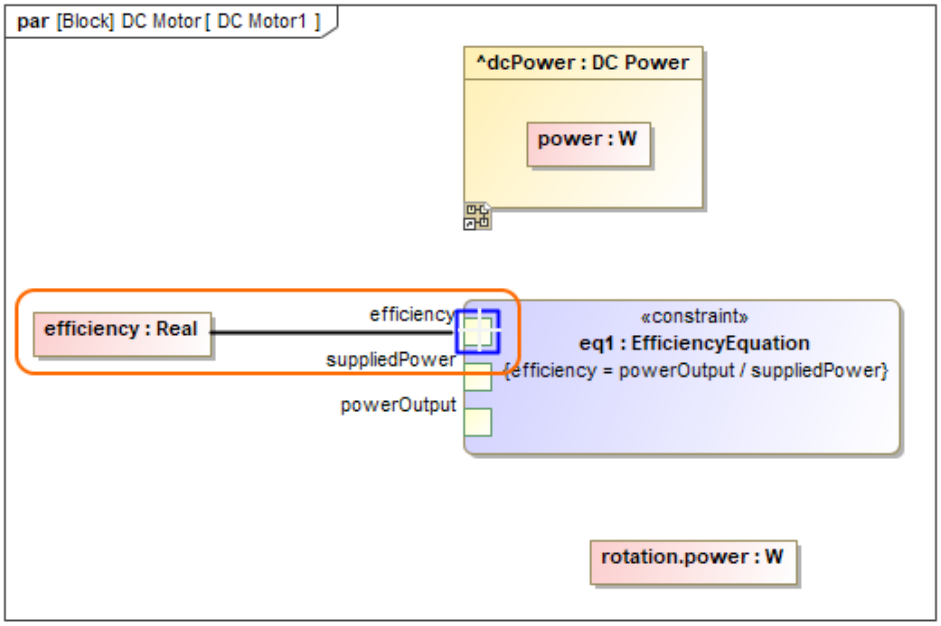
   - Select reusable Constraint Block from the library. The Constraint expression appears automatically.

7. Connect Value Properties with Constraint Parameters in one of the following way:

   - Select the Value Property shape, from smart manipulator toolbar click and connect it to a Constraint Property shape. From the **Select Parameter** menu list, select an appropriate parameter. As example, see the figure below where *power* Value Property is binding by selecting a *su pplierPower* parameter from the suggested list.



- Display Constraint Parameters on Constraint Property shape by clicking smart manipulator toolbar. Select Value Property/Constraint Parameter shape, click and connect it to Constraint Parameter/Value Property. As shown in the figure elow, the *efficiency* Value Property is binding with an *efficiency* parameter.

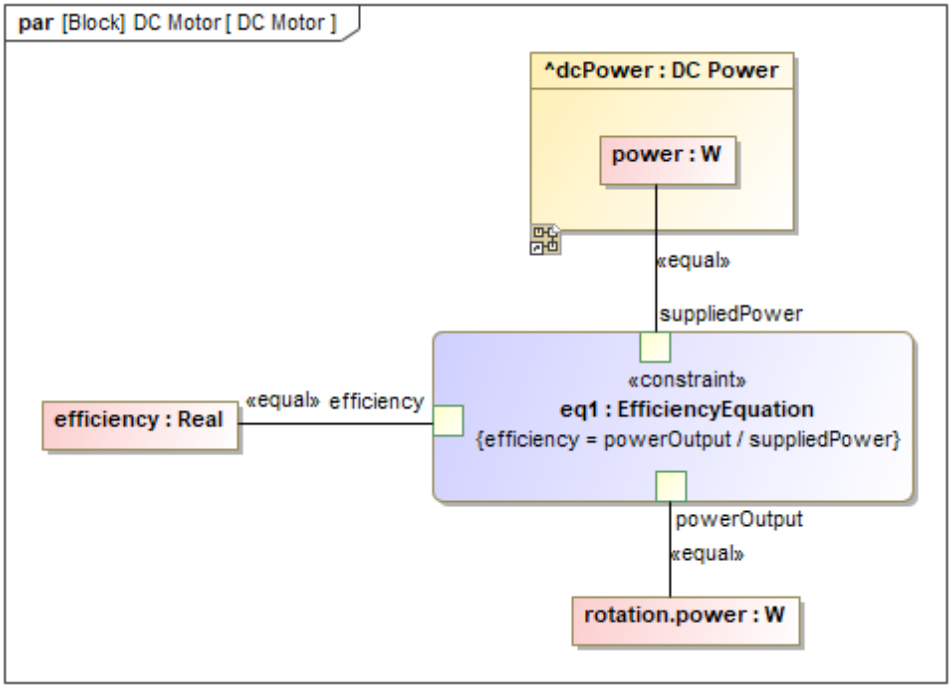


The Constraint Parameter are connected with Value Properties using Binding Connector. Now you can run the simulation of parametric data in one of the following way:

- Right-click the Block that owns the Parametric diagram and select **Simulation** > **Run**.

- From the Parametric Diagram toolbar, click .

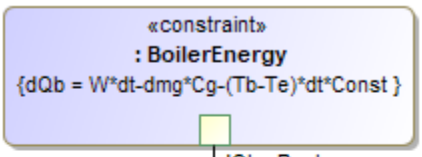
In the **Variables** tab, type values and click . Learn more about parameters simulation >



You can create an equation system by creating bindings between parameters between separate Constraint Properties. E.g. The *BoilerEnergy* and *BoilerWaterTemperature* Constraint Properties are connected through the *dQb* parameter because the *BoilerEnergy* constraint expression provides a value for the *BoilerWaterTemperature* constraint expression.

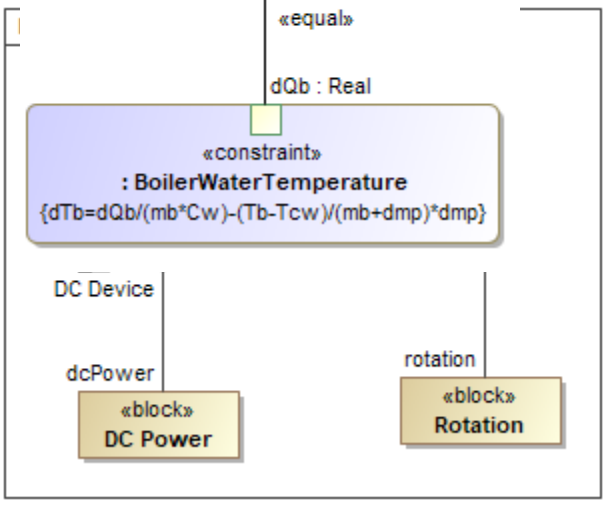
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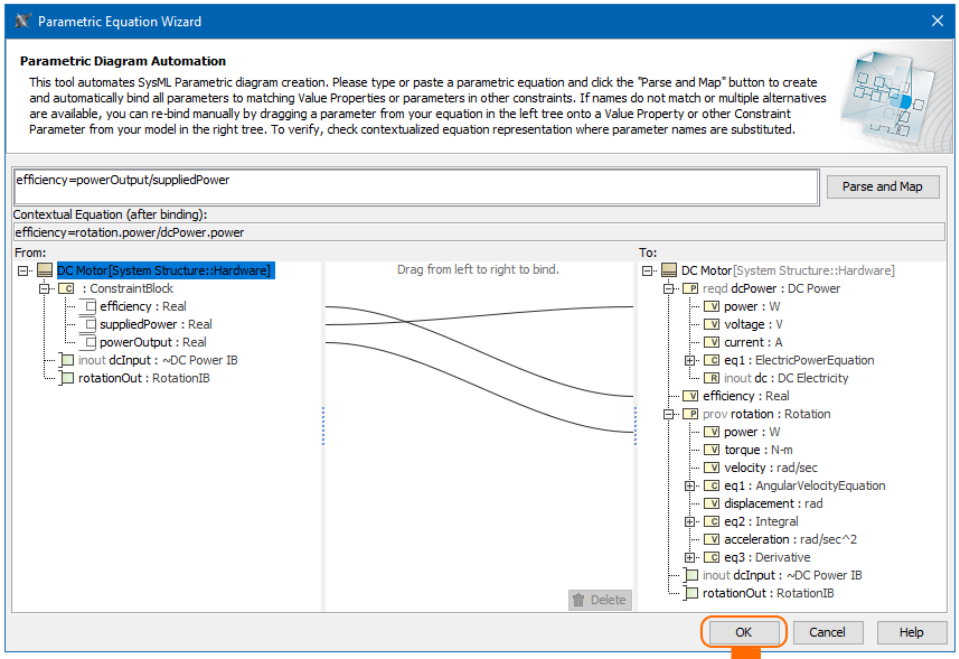
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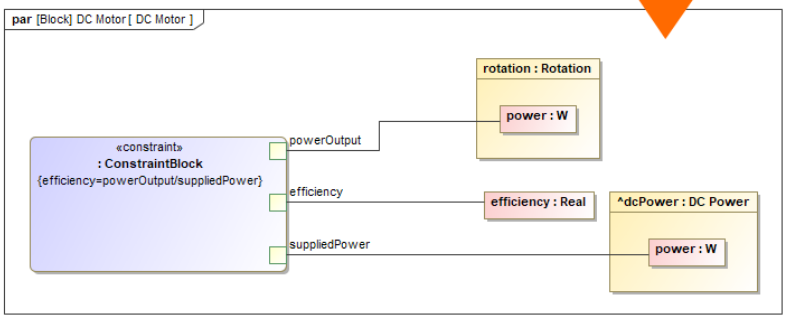
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e how to decompose Blocks >



3. Right-click the Block for which you want to create SysML Parametric Diagram, select **Tools** > **Parametric Equation Wizard**. Learn more about Parametric Equation Wizard >

4. Type equation and click the **Parse and Map** button. The Constraint Block with parameters are created automatically. If the names of Constraint Parameter and Value property are the same, they and mapped automatically. You can change bindings by dragging Constraint Parameters in the left tree onto properties in the right tree. Learn more about creating Parametric Diagram from an equation >





5. In the SysML Parametric Diagram toolbar, click  to remap or include additional Value Properties.

Related pages

- Defining Constraint Blocks
- SysML Parametric Diagram context
- Creating Constraint Parameters automatically
- Extracting Constraint from Requirement
- Parametric Equation Wizard
- Displaying parameters and properties
- Creating Binding Connector
- Creating reusable constraint libraries
- Wrapping MATLAB functions

Sample model

The model used in the figures of this page is the **InvertedPendulum** sa mple model that comes with SysML plugin. To open this sample do one of the following:

- Download *InvertedPendulum.mdzip*.
- Find in modeling tool *<modeling tool installation directory>\samples\sysml\Inverted Pendulum\InvertedPendulum .mdzip*.