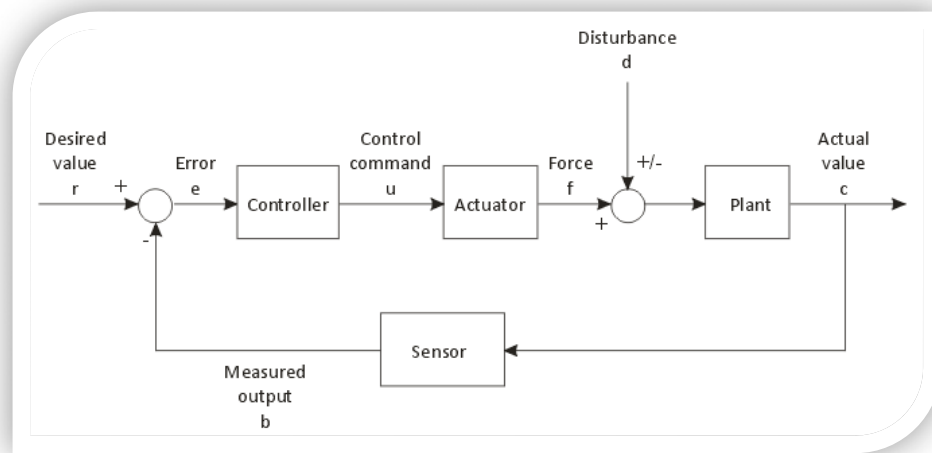# Mathematical Modelling Using SimScape
(Mechanical Systems)

Control Systems Laboratory
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1. <mark>**Translational Mechanical System**</mark>

In this example, you are going to model a simple mechanical system and observe its behavior under various conditions. This tutorial illustrates the essential steps to building a physical model and makes you familiar with using the basic Simscape blocks.

The figure 3.1 shows a simple model of a car suspension. It consists of a spring and damper connected to a body (represented as a mass), which is agitated by a force. You can vary the model parameters, such as the stiffness of the spring, the mass of the body, or the force profile, and view the resulting changes to the velocity and position of the body.
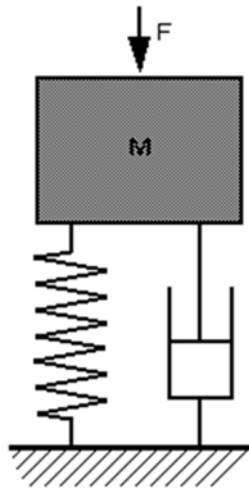

Figure 3.1: A model of Car Suspension

To create an equivalent Simscape diagram, follow these steps:

1. Open the Simulink® Library Browser, as described in Simscape Block Libraries.

2. Create a new model. To do this, from the top menu bar of the Library Browser, select **File > New > Model.** The software creates an empty model in memory and displays it in a new model editor window.

3. Open the **Simscape > Foundation Library > Mechanical > Translational Elements** library as shown in figure 3.2.

4. Drag the Mass, Translational Spring, Translational Damper, and two Mechanical Translational Reference blocks into the model window.

5. Orient the blocks as shown in the figure 3.3. To rotate a block, select it and press Ctrl+R.

6. Connect the Translational Spring, Translational Damper, and Mass blocks to one of the Mechanical Translational Reference blocks as shown in figure 3.4.

Figure 3.2: Mechanical Translational Elements, step 3
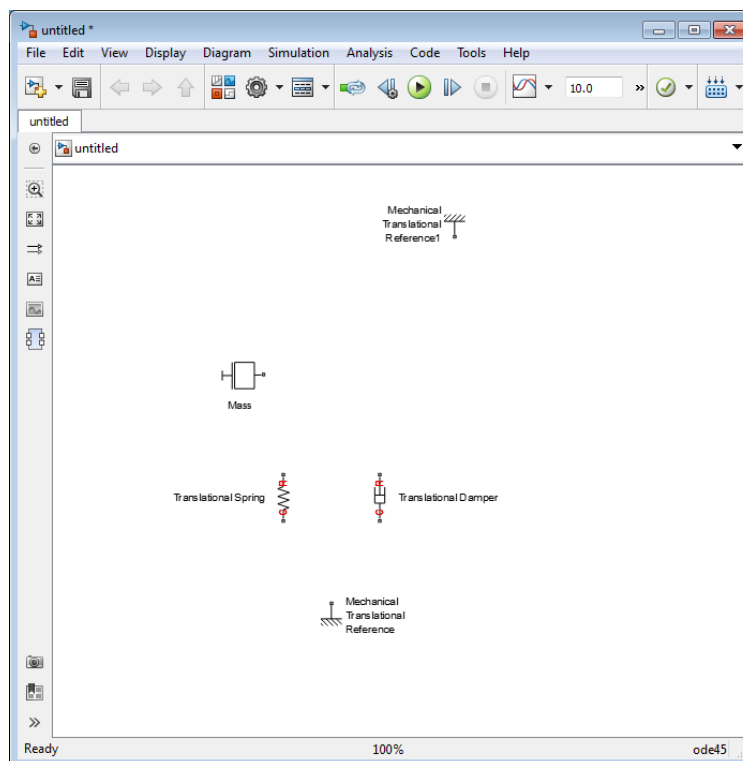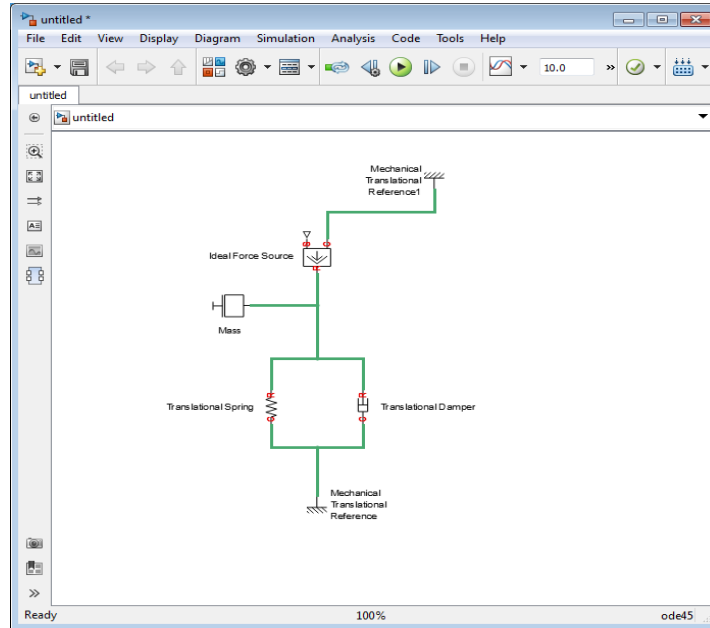

Figure 3.3: Selected Elements, step 5

Figure 3.4: Connect the elements to each other, step 6

7. To add the representation of the force acting on the mass, open the **Simscape > Foundation Library > Mechanical > Mechanical Sources library** figure 3.5, and add the Ideal Force Source block to your diagram as figure 3.4.
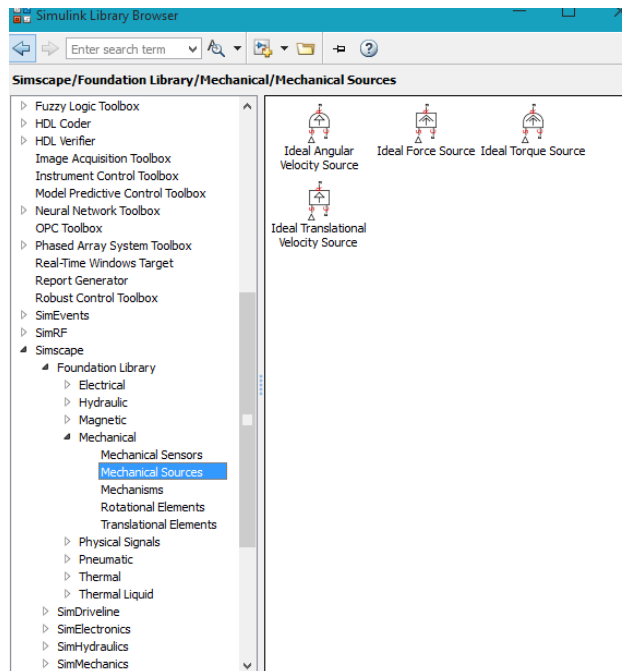

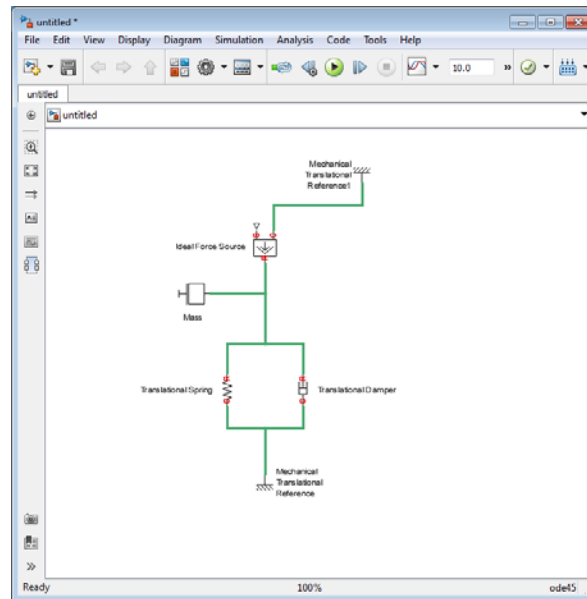**Figure 3.5**: Mechanical Force, step 7

Figure 3.6: The block diagram after add the Force, step 7

8. Add the sensor to measure speed and position of the mass. Place the Ideal Translational Motion Sensor block from the **Mechanical Sensors library** figure 3.7 into your diagram and connect it as shown in figure 3.8.
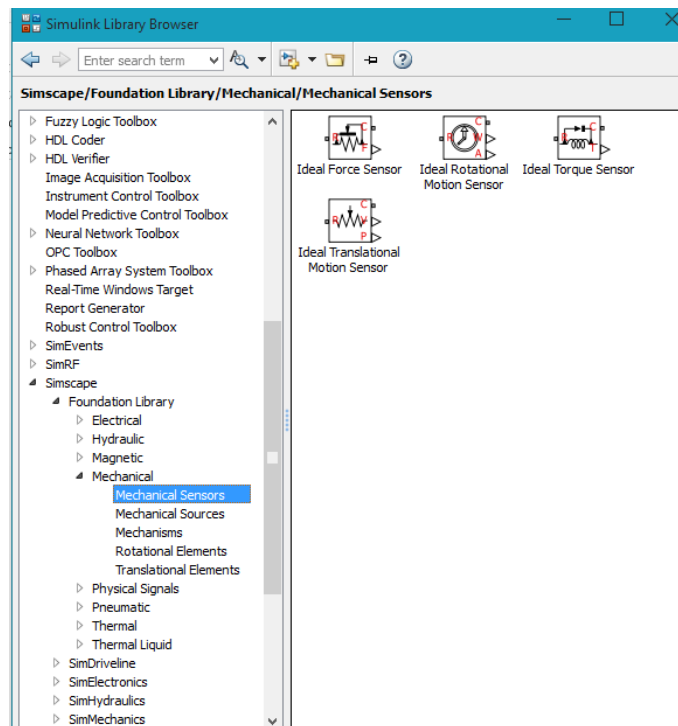

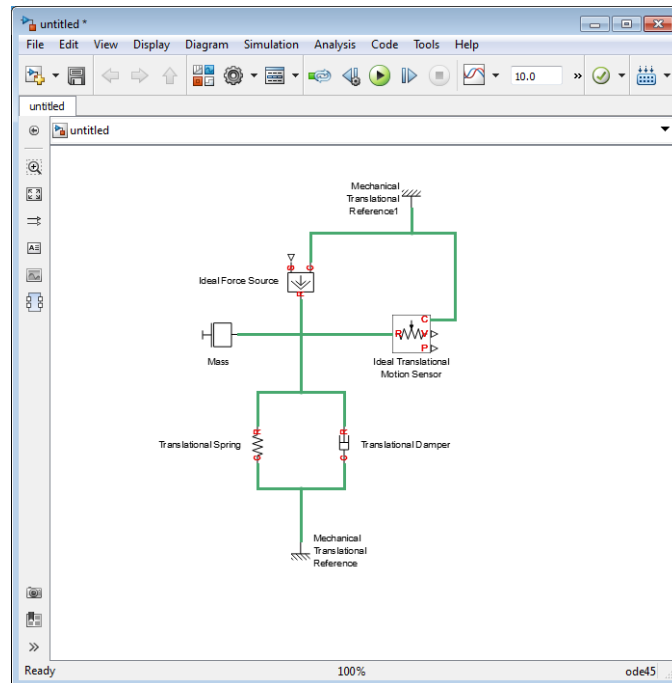**Figure 3.7**: Mechanical Sensors Library

Figure 3.8: Block Diagram

9. Now you need to add the sources and scopes. They are found in the regular Simulink libraries. Open the **Simulink > Sources library** and copy the Signal Builder block into the model. Then open the **Simulink > Sinks library** and copy two Scope blocks. Rename one of the Scope blocks to *Velocity* and the other to *Position*.

10. Every time you connect a Simulink source or scope to a Simscape diagram, you have to use an appropriate converter block, to convert Simulink signals into physical signals and vice versa. Open the **Simscape > Utilities library** figure 3.9 and copy a Simulink-PS Converter block and two PS-Simulink Converter blocks into the model. Connect the blocks as shown in figure 3.9.

11. Each topologically distinct physical network in a diagram requires exactly one Solver Configuration block, found in **the Simscape > Utilities library** figure 3.9. Copy this block into your model and connect it to the circuit by creating a branching point and connecting it to the only port of the Solver Configuration block. Your diagram now should look like figure 3.10.
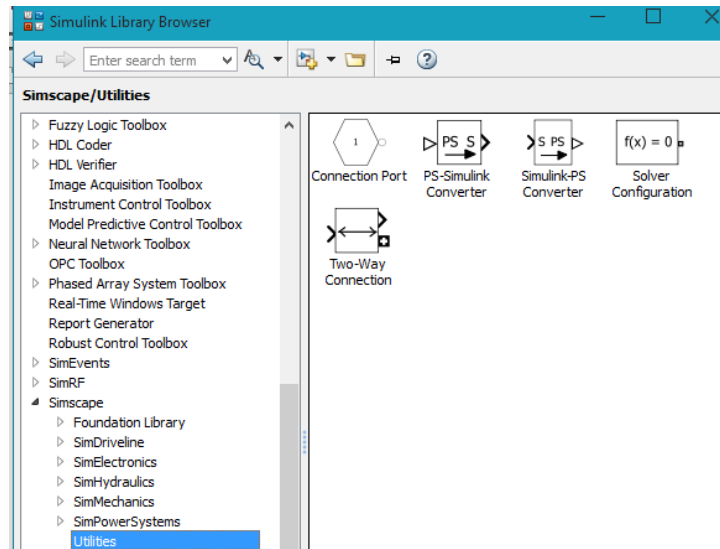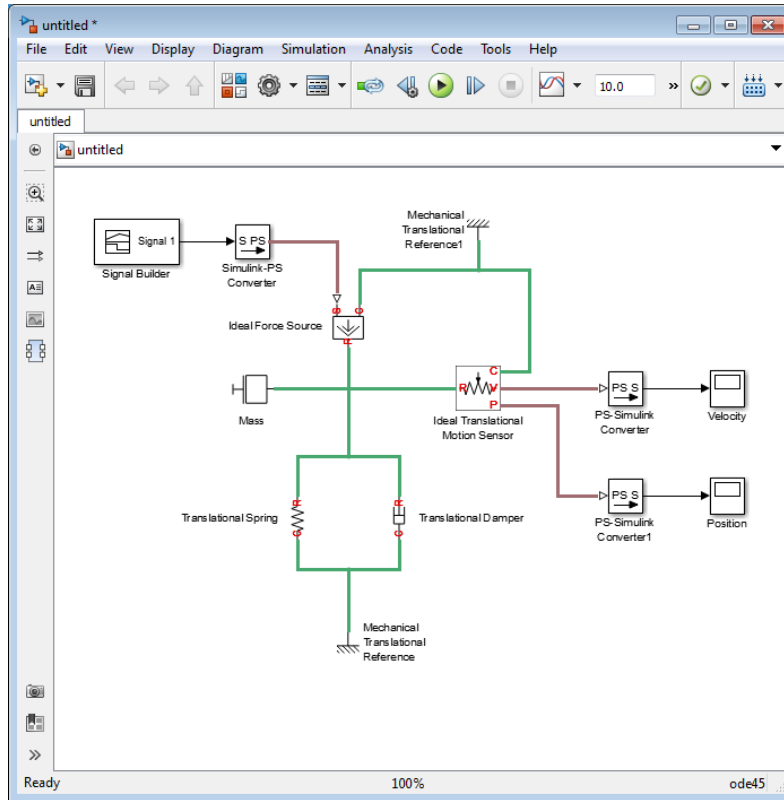
Figure 3.9: Simscape Utilities Library

Figure 3.1: Block Diagram of System

- ## **Modifying Initial Settings**

After you have put together a block diagram of your model, as described in the previous section, you need to select a solver and provide the correct values for configuration parameters.

To prepare for simulating the model, follow these steps:

1. Select a Simulink solver. On the top menu bar of the model window, select Simulation > Model Configuration Parameters. The Configuration Parameters dialog box opens, showing the Solver node.

Under Solver options, set Solver to ***ode23t (mod.stiff/Trapezoidal)*** and Max step size to 0.2.

Also note that Simulation time is specified to be between 0 and 10 seconds. You can adjust this setting later, if needed.
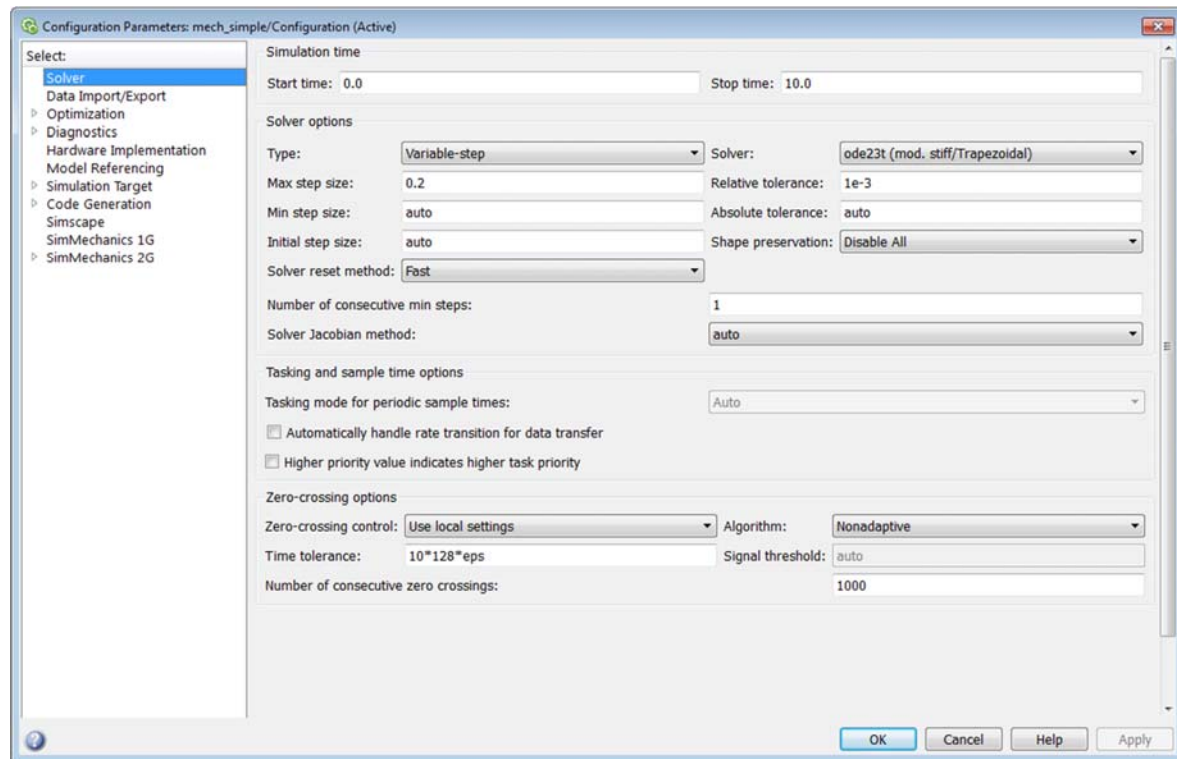

Figure 3.2: Solver Configuration

2. <mark>Rotational Mechanical System</mark>

In this example, you are going to model a mechanical system and observe its behavior under various conditions. This tutorial illustrates the essential steps to building a physical model and makes you familiar with using the basic Simscape blocks.

The figure 3.12 shows a rotational mechanical system. It consists of a spring and damper connected to a body (represented as a inertia), which is agitated by a torque. You can vary the model parameters, such as the stiffness of the spring, the inertial of the body, or the torque profile, and view the resulting changes to the angular velocity and angular position of the body.
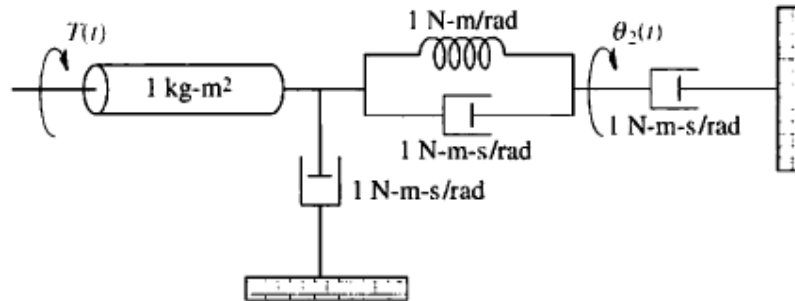

Figure 3.12 A Rotational Mechanical System

- **Modeling of System**

To create an equivalent Simscape diagram, follow these steps:

12. Open the Simulink® Library Browser, as described in Simscape Block Libraries.

13. Create a new model. To do this, from the top menu bar of the Library Browser, select **File > New > Model.** The software creates an empty model in memory and displays it in a new model editor window.

14. Open the **Simscape > Foundation Library > Mechanical > Rotaional Elements** library as shown in figure 3.13.

15. Drag the Inertial, Rotational Spring, Rotational Damper, and Mechanical Rotaional Reference blocks into the model window.

16. Orient the blocks as shown in the figure 3.14. To rotate a block, select it and press Ctrl+R.

17. Connect the Translational Spring, Translational Damper, and Mass blocks to one of the Mechanical Translational Reference blocks as shown in figure 3.15
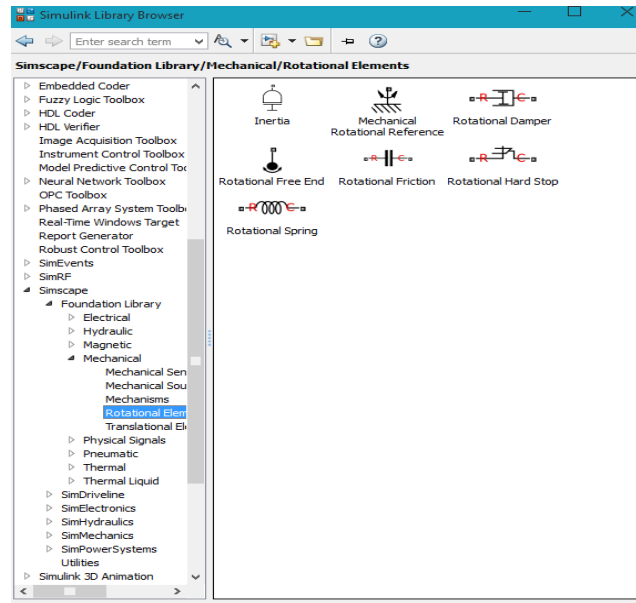
Figure 3.3: Mechanical Rotational Elements, step 3
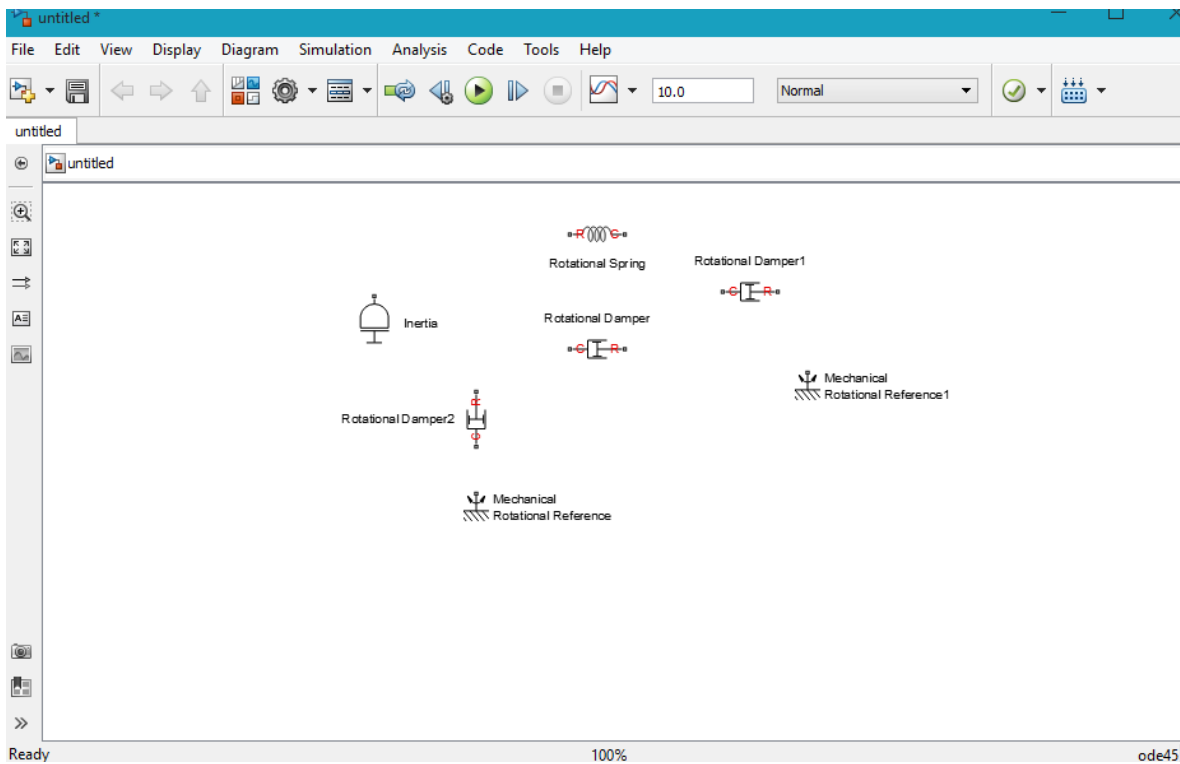
Figure 3.4: Selected Elements, step 5

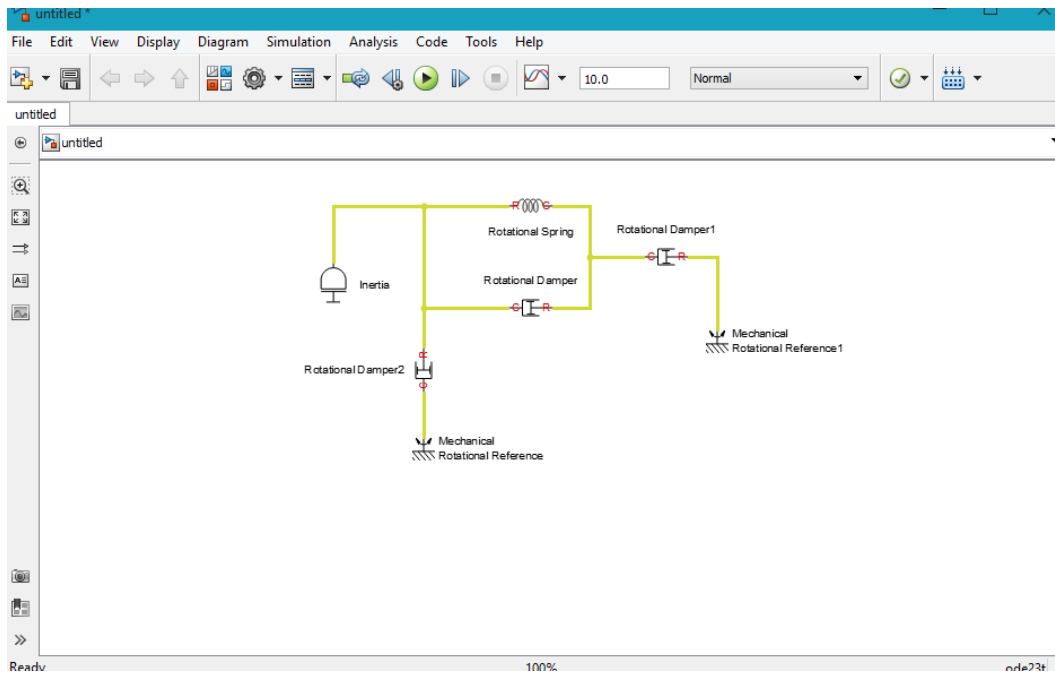**Figure 3.5**: Connect the elements to each other, step 6

18. To add the representation of the force acting on the mass, open the **Simscape > Foundation Library > Mechanical > Mechanical Sources library** figure 3.16, and add the Ideal Torque Source block to your diagram as figure 3.17.
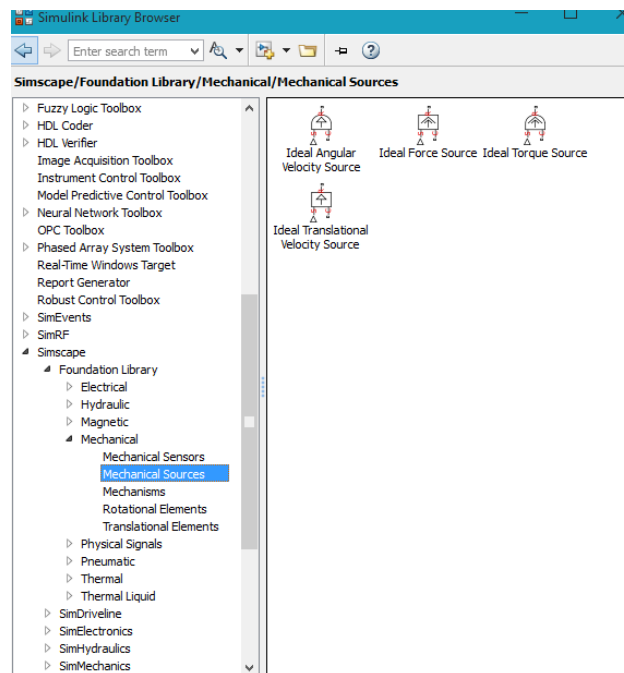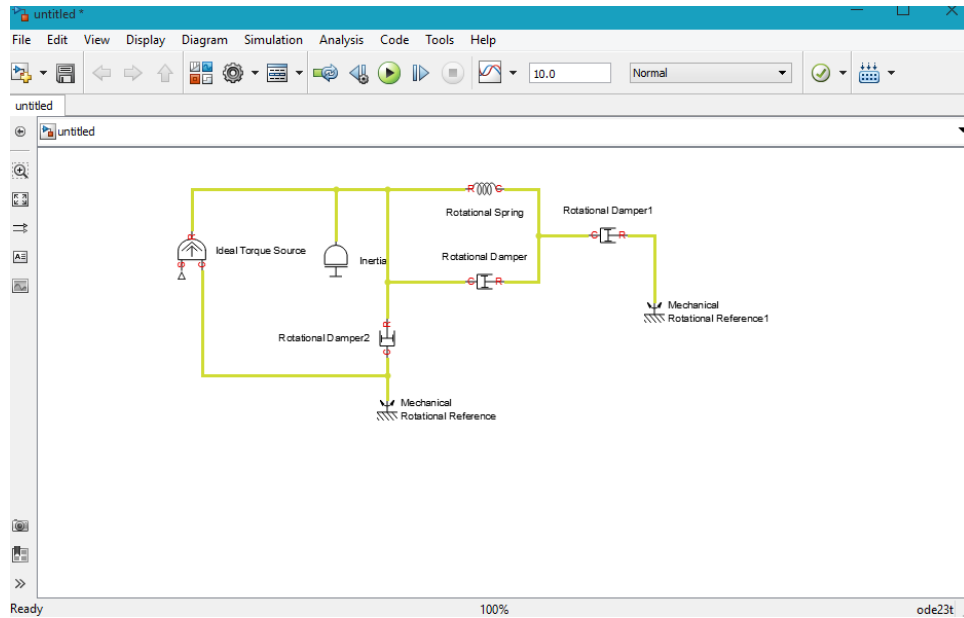

Figure 3.6: Mechanical Force, step 7

Figure 3.17: The block diagram after add the Force, step 7

19. Add the sensor to measure angular speed and angular position at $\theta_2(t)$. Place the Ideal Rotaional Motion Sensor block from the **Mechanical Sensors library** figure 3.18 into your diagram and connect it as shown in figure 3.19.
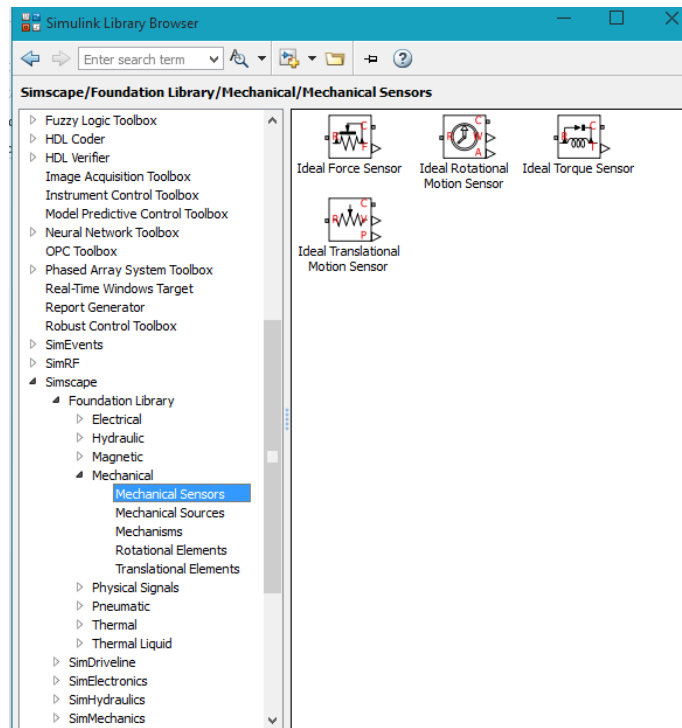

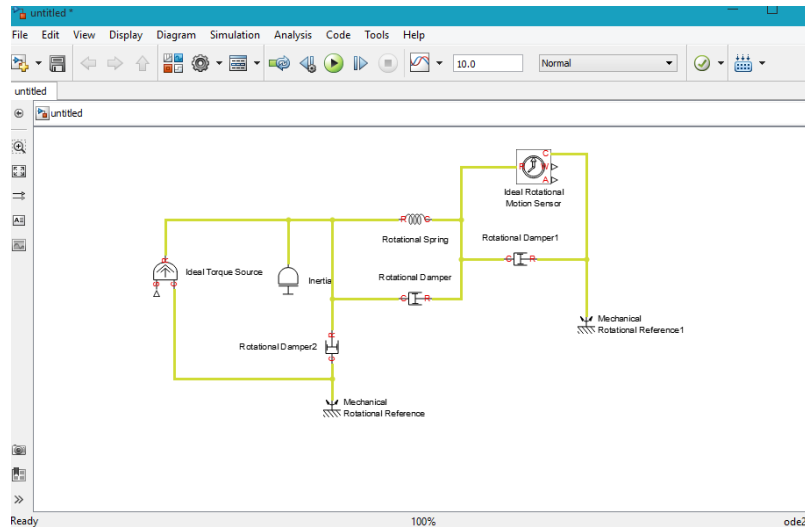**Figure 3.18:** Mechanical Sensors Library

Figure 3.19: Block Diagram

20. Now you need to add the sources and scopes. They are found in the regular Simulink libraries. Open the **Simulink > Sources library** and copy the Signal Builder block into the model. Then open the **Simulink > Sinks library** and copy two Scope blocks. Rename one of the Scope blocks to *Velocity* and the other to *Position*.

21. Every time you connect a Simulink source or scope to a Simscape diagram, you have to use an appropriate converter block, to convert Simulink signals into physical signals and vice versa. Open the **Simscape > Utilities library** figure 3.20 and copy a Simulink-PS Converter block and two PS-Simulink Converter blocks into the model. Connect the blocks as shown in figure 3.20.

22. Each topologically distinct physical network in a diagram requires exactly one Solver Configuration block, found in **the Simscape > Utilities library** figure 3.21. Copy this block into your model and connect it to the circuit by creating a branching point and connecting it to the only port of the Solver Configuration block. Your diagram now should look like figure 3.21.
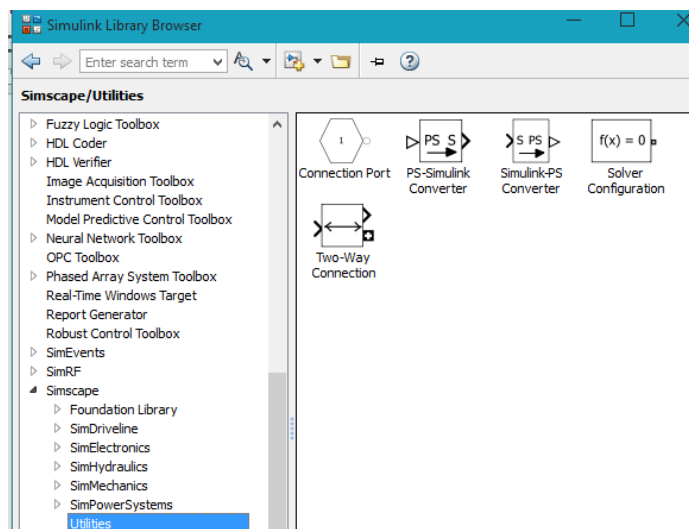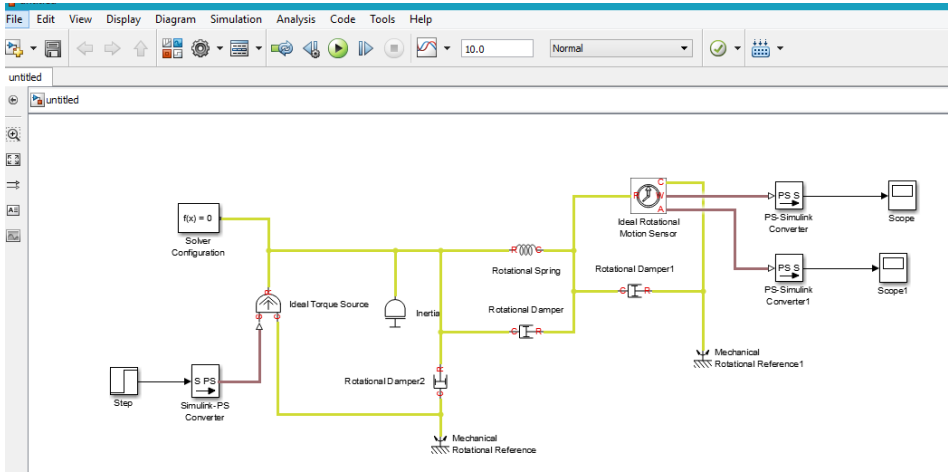

Figure 3.7: Simscape Utilities Library

Figure 3.8: Block Diagram of System