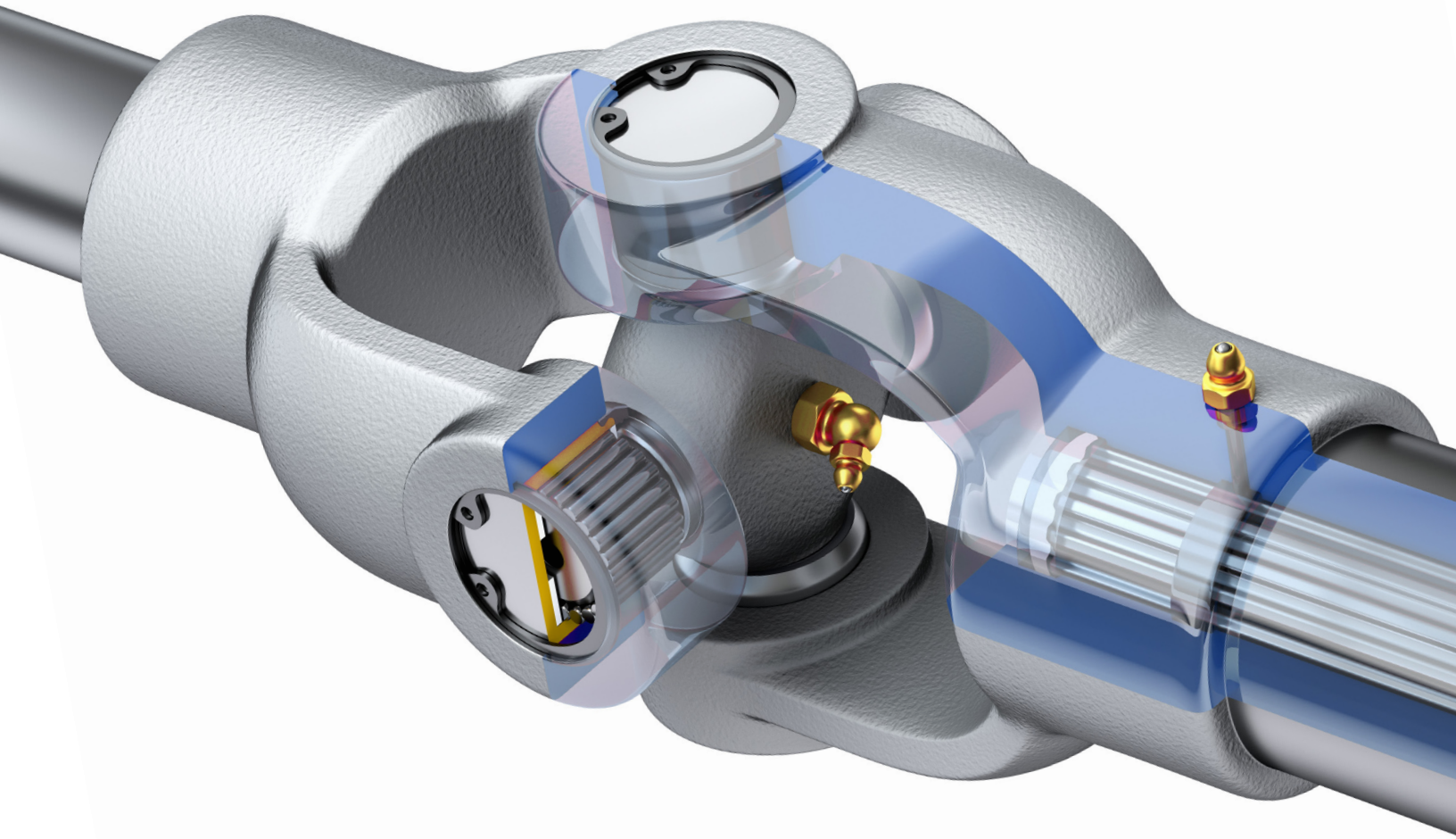
Nader G. Zamani

MECHANISM DESIGN ESSENTIALS IN 3DEXPERIENCE® 2016x

USING CATIA® APPLICATIONS



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Chapter
02

Block
Accelerating along a Path

Introduction

In this tutorial you will create a block which accelerates along a straight line according to a user prescribed formula. A prismatic joint is used to simulate this simple mechanism.

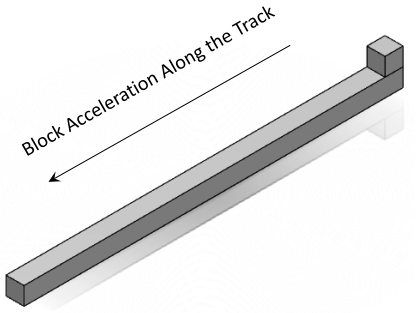
NOTE: It is assumed that you have basic familiarity with CAD modeling in 3DEXPERIENCE allowing you to create an assembly consisting of two blocks. If that is not the case, please consult the following tutorial book:

CAD Modeling Essentials in 3DEXPERIENCE, by Nader Zamani, SDC Publications, ISBN 978-1-63057-095-8.

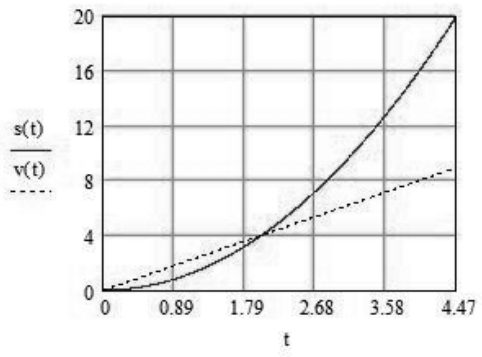
Problem Statement

The block shown below is starting from rest and moving along the base with a constant acceleration of 2 in/s^2. A simple integration of the acceleration term results in the expressions for position and velocity along the base. These expressions are given by $s(t) = t^2$ and $v(t) = 2t$ respectively.

The travel time from one end of the base to the other end is $t = \sqrt{20} \approx 4.47$ s.
In this tutorial, you will create the assembly and the needed joint. The problem under consideration involves a Prismatic Joint with the block sliding along the edge maintaining the surface contact.



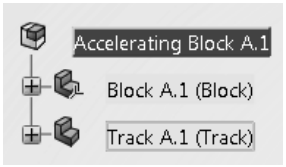
The graphical representation of the position and velocity vs time are provided below, where t is in seconds, s(t) is in inches, and v(t) is in inches per second.

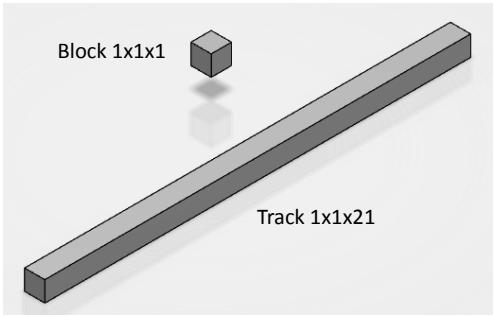


Creation of the Assembly Constraints in the Assembly Design App.

Using the Assembly Design App. 

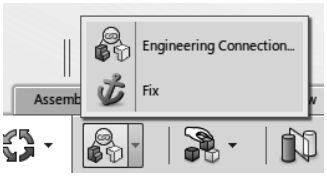
in 3DEXPERIENCE, model two parts named Block and Track as shown below with the dimensions being in inches.





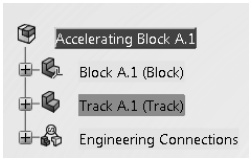
While in this App, you will be creating the appropriate constraints.
The first assembly constraint is to "Fix" the Track.

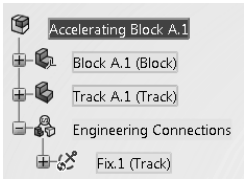
From the bottom row, select the "Assembly" tab. 

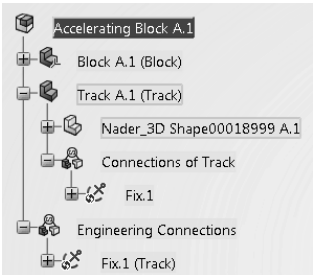
Next, select the "Engineering Connection" to see the choices. 

Finally, choose the "Fix" icon  .

Use the cursor to pick the Track part from the screen or the tree. Immediately, the tree acquires a new branch named "Engineering Connection" as shown below which upon expanding reveals that the Track has been fixed. Note that this information is also inherited by the Track A.1 (Track) as a part within the assembly.



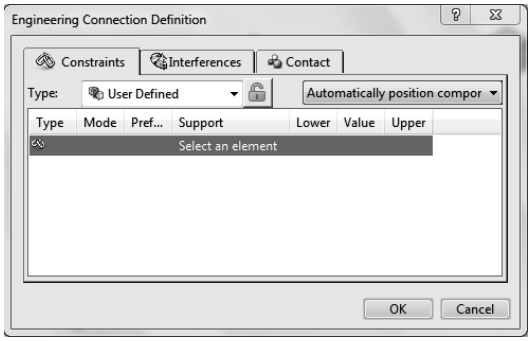




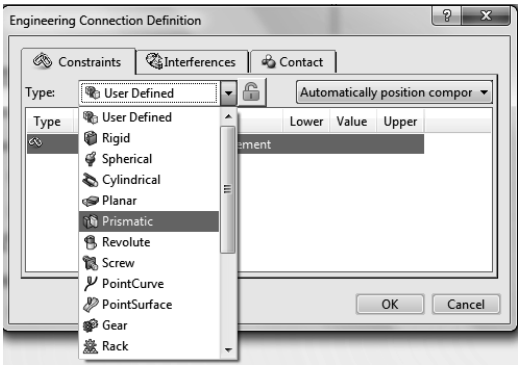
The marking indicates that the constraint needs to be updated. This can be achieved with the update icon  .

The next step is to create the constraints between the Track and the Block which eventually leads to a "Prismatic" joint.

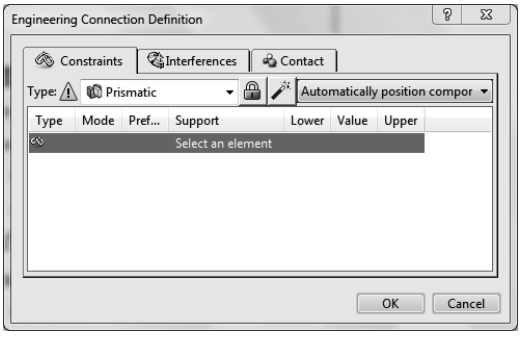
Click on the Engineering Connection icon  .
The dialogue box shown on the right opens up.



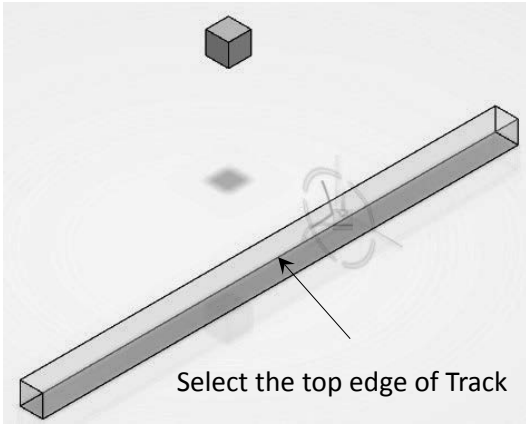
Using the pulldown menu, display the list of the joints that can be created.

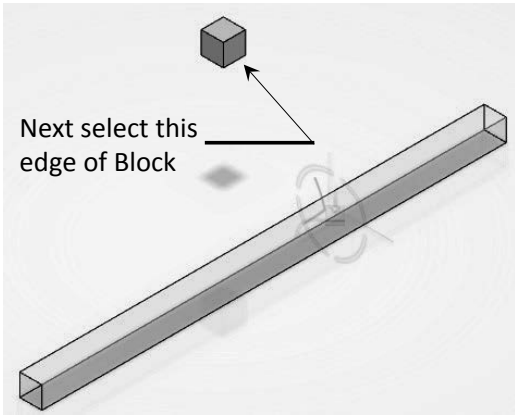


Select the "Prismatic" joint as shown.

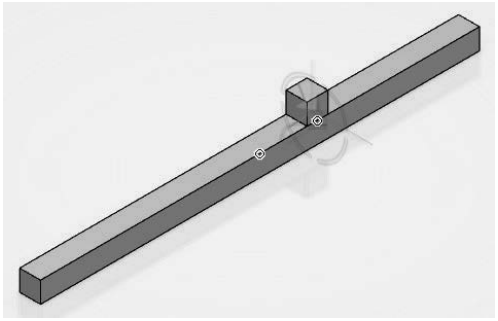


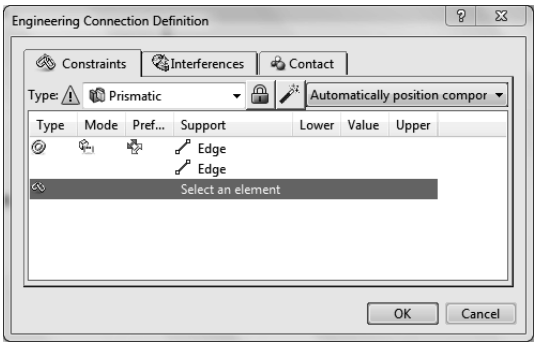
From the screen, select the top edge of the Track and the bottom edge of the Block.



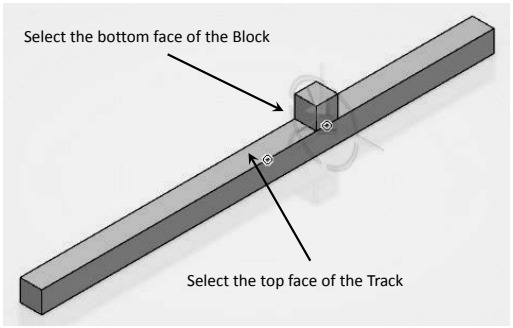


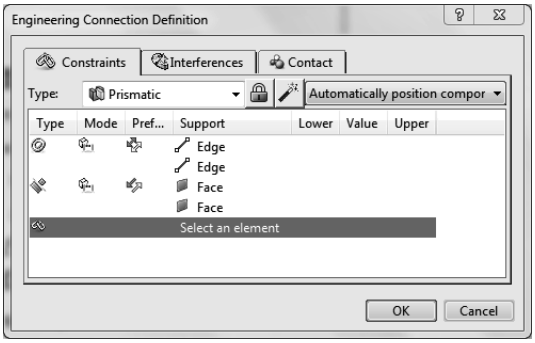
As soon as this is done, the two parts move and the two edges become coincident.



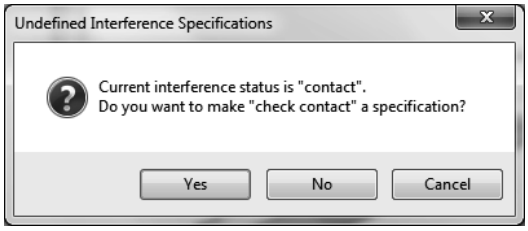


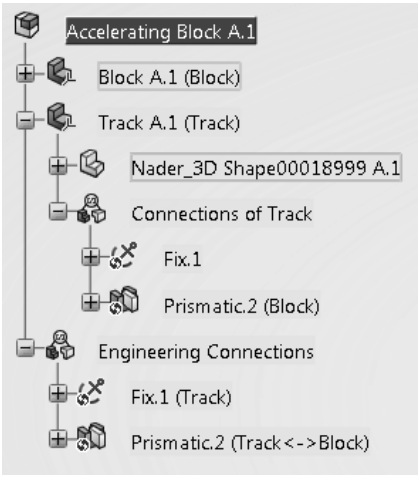
The task, however, is not complete yet. We must establish a constraint between the faces. These two faces must remain in contact. While the dialogue box is open, select the top face of the Track and the bottom face of the block as shown. The dialogue box records these actions.





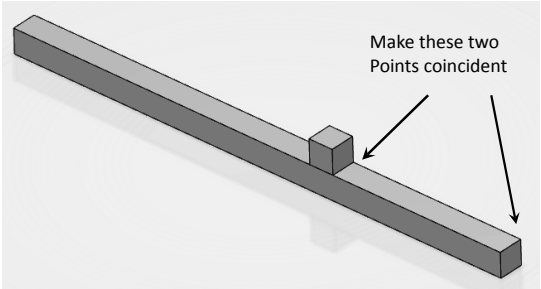
As soon as the selection is made the following window opens. Select "Yes." The tree clearly shows the presence of a prismatic joint.



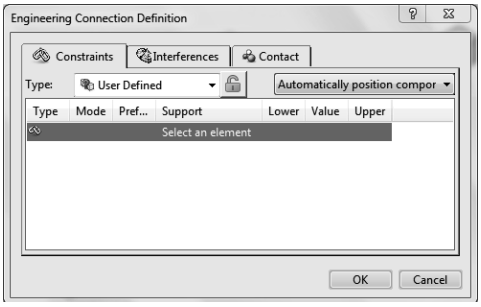


The marking indicates that the constraint needs to be updated. This can be achieved with the update icon  .

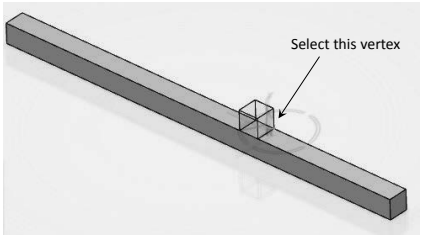
The Block may be positioned in the middle of the track. For convenience, it is better if the Block is at the end of the track. One way to achieve this is to create a constraint between the corners of the block and track. This constraint, however, will be deleted; otherwise, it becomes a "Spherical" joint preventing movement of the Block.

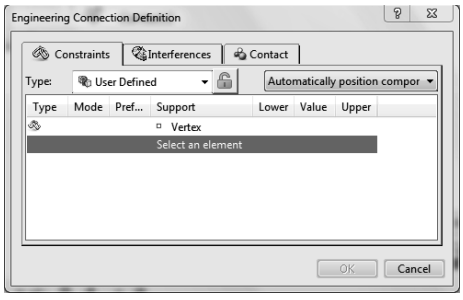


Click on the Engineering Connection icon  .
The dialogue box shown on the right opens up.

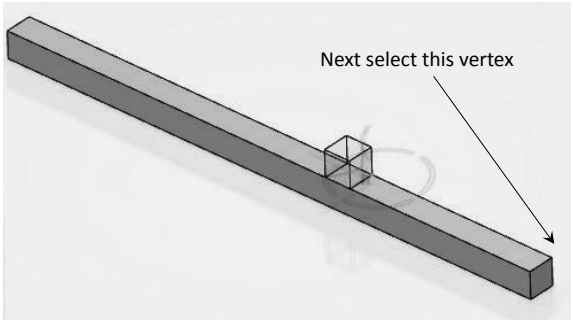


From the screen, select the vertex of the Block as shown.





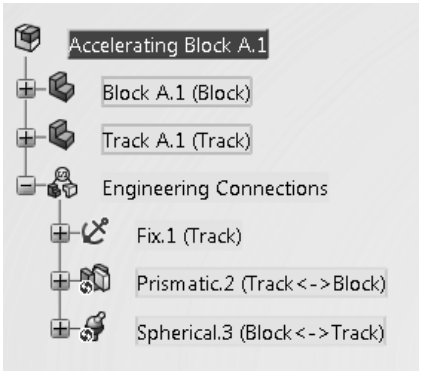
Next select the vertex of the Track below.



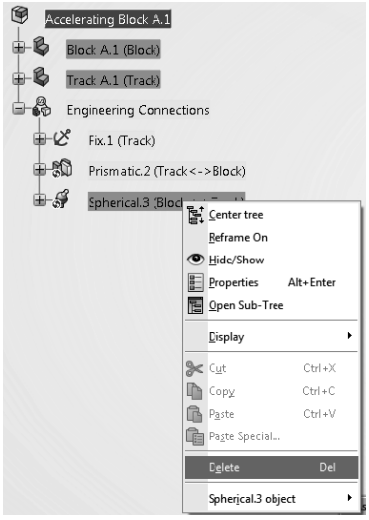
As soon as the vertex is selected, the above dialogue box opens. From this box, select "New connection" and press "OK."

Once again you are prompted for the following window. As in the earlier case, select "Yes."

The presence of the "Spherical" joint is confirmed in the tree. As indicated earlier, this "Spherical" joint must be deleted. The sole purpose of the constraint was to position the Block at the end of the Track.

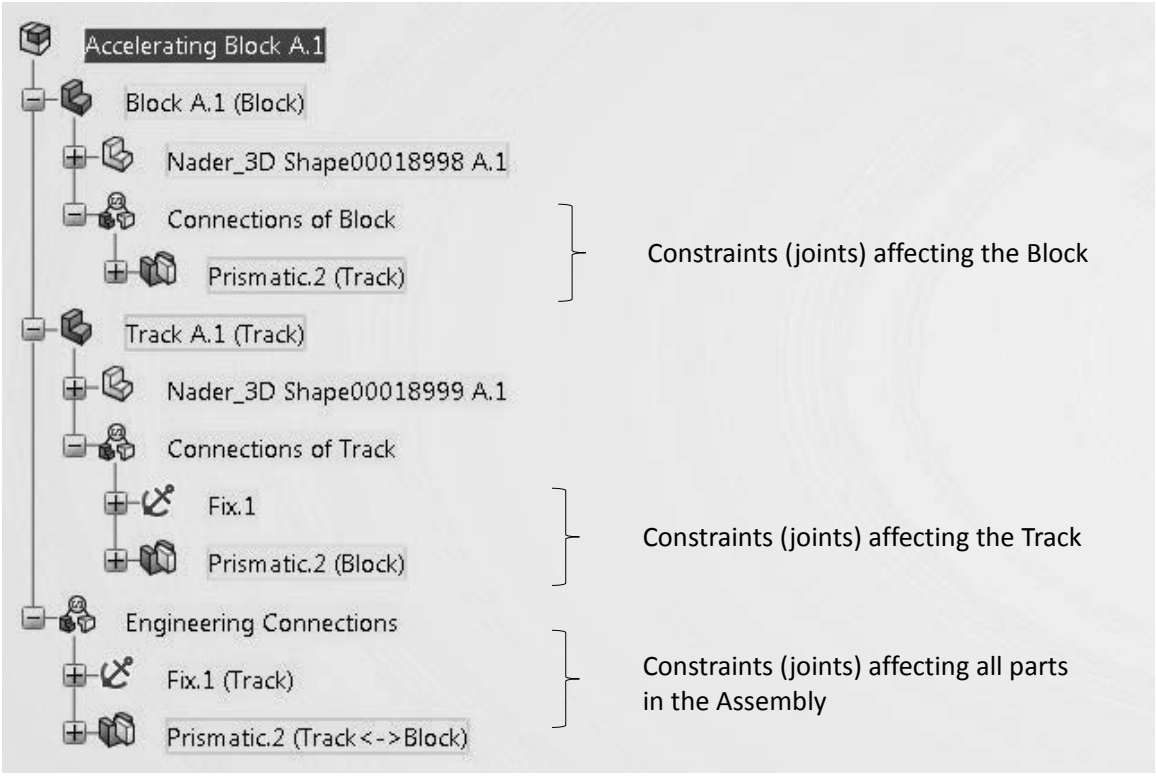


Point the cursor to the branch with "Spherical" joint, right click and "Delete."



Finally, update the constraint by using the update icon  .

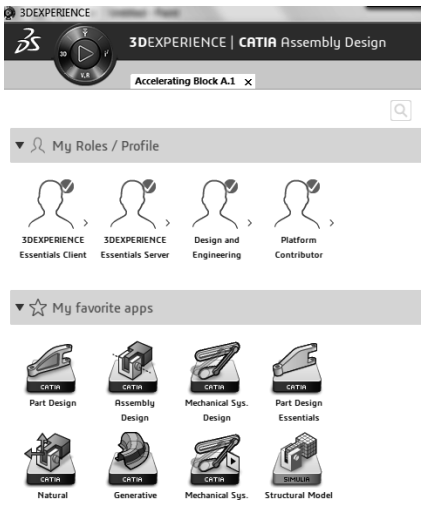
It is worth mentioning that the constraints applied so far (or the joints created so far) appear not only in the assembly but are also reflected in the individual parts. See the tree shown below.



Creating the Mechanism in the Mechanical System Design App.

Locate the compass on the top left corner of the screen, and select the South sector (i.e., V+R sector) as shown on the right. Scroll through the applications and select the Mechanical System Design App 

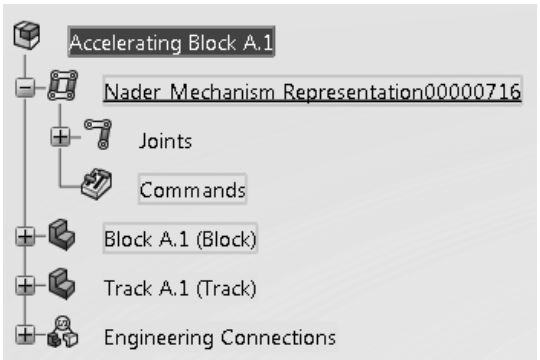
.

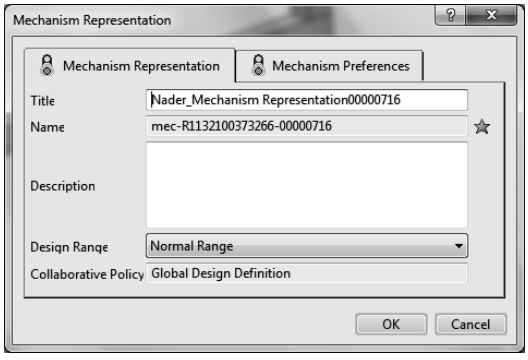


The row of icon in the bottom of your screen changes and will appear as displayed below.

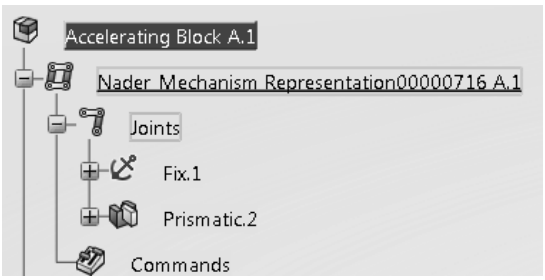
Select the icon "Mechanism Representation" icon  .

This selection leads to the following dialogue box. Needless to say, customized names can be used. Click on "OK." The tree reflects the selection.



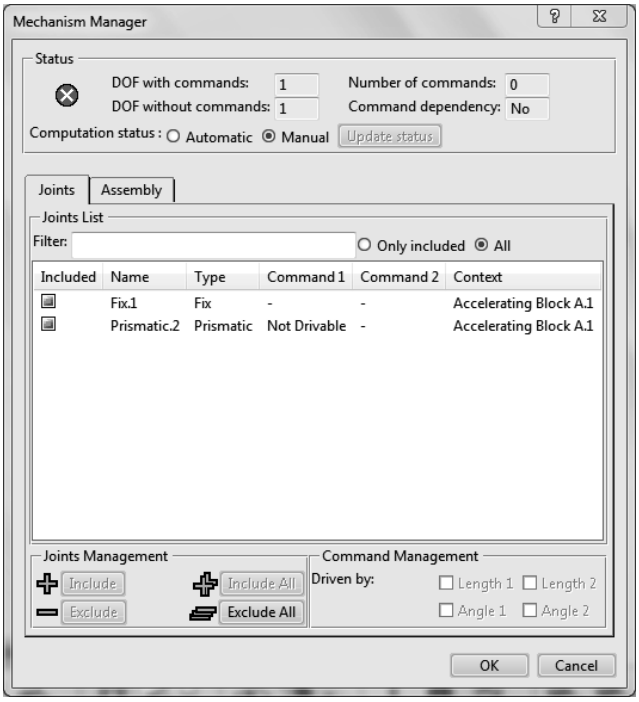


The tree indicates that two joints have been created but there are presently no commands present.



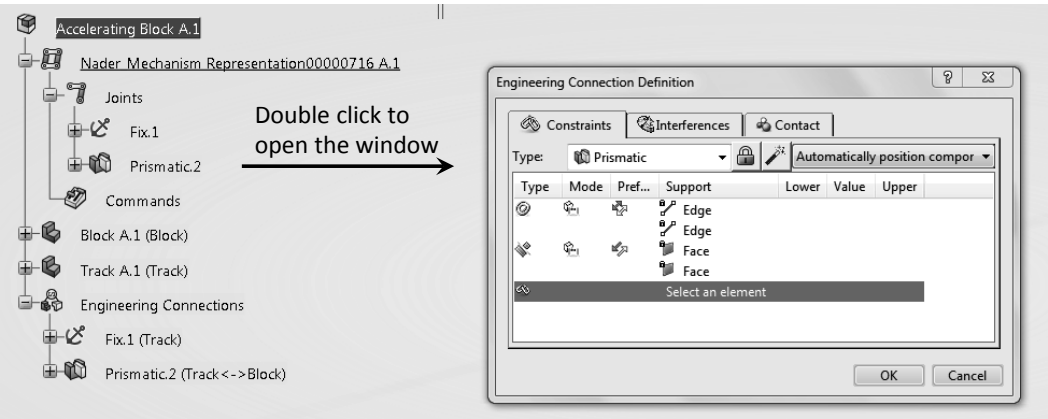
Select the "Mechanism Manager" from the bottom of your screen by left clicking on  .

The "Mechanism Manager" dialogue box opens up as shown below.

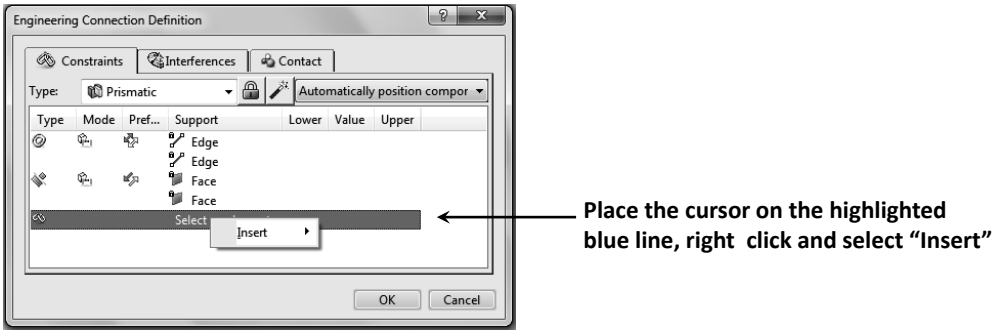


The icon  on the top left corner is an indication that there is no command associated with the mechanism and, therefore, it cannot be simulated yet.

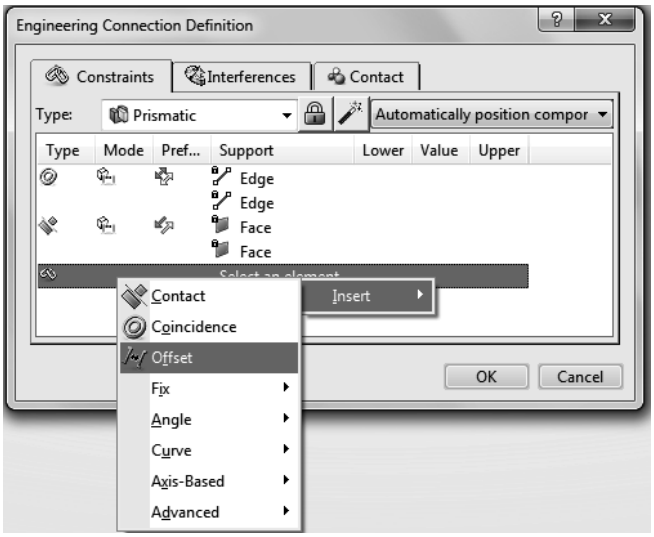
To address this issue, double click on the "Prismatic" joint in the tree. This can be done from any location where the joint is displayed. The most natural choice is from the joint branch on the top of the tree.



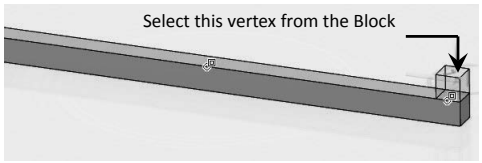
Place the cursor on the highlighted blue area, right click and select "Insert."

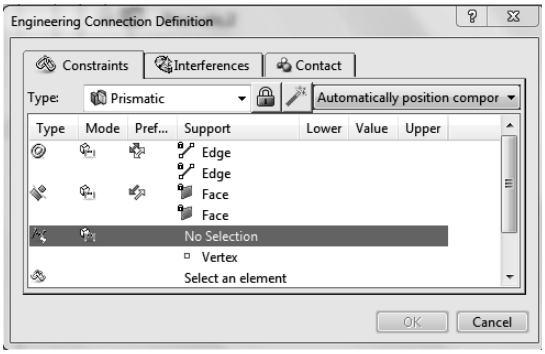


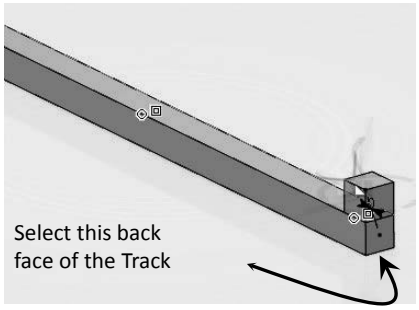
From the supplied list, select "Offset" as shown.

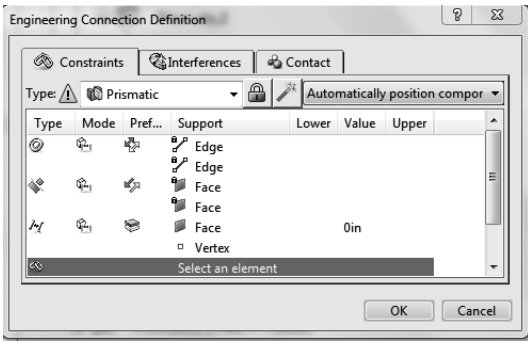


For the offset, select a vertex of the Block followed by the back face of the Track. These are displayed in the following figures.

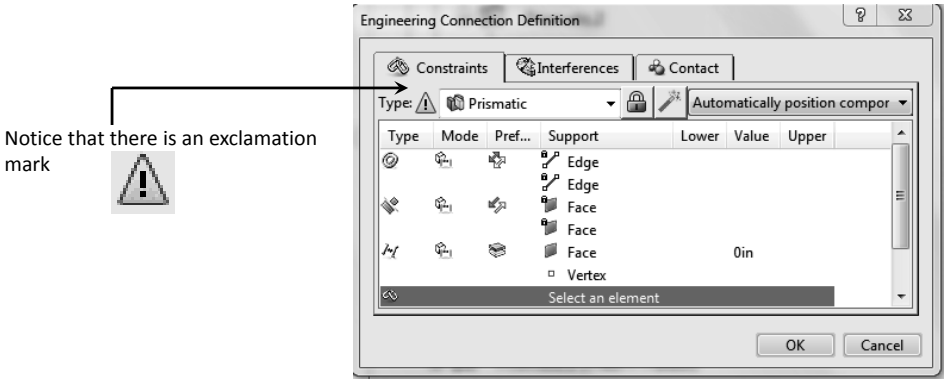




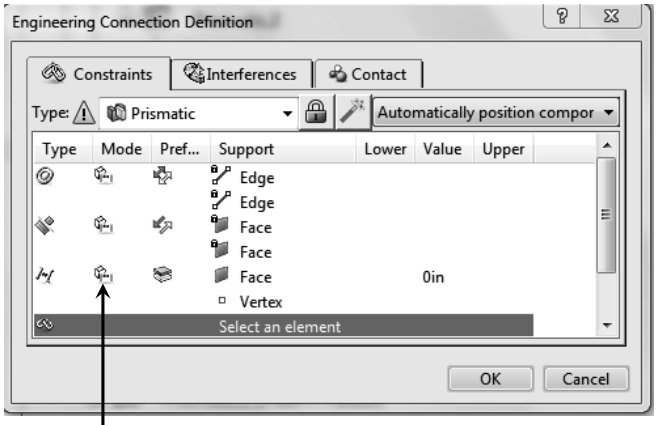




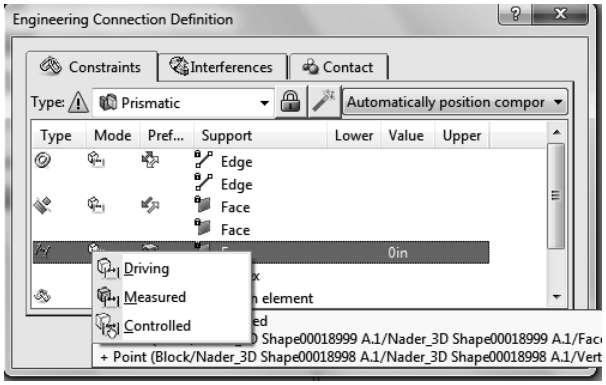
Note that as soon as the selection is completed, a warning sign (exclamation mark) appears in front of "Type Prismatic."



It is important to address this issue now. Point the cursor to the line where the "Offset" is and the location shown (the Mode column) on that line. Right click and select "Controlled." This instruction is very critical and the reader may have to try it a few times before getting it to work; see detailed figures on the next page.



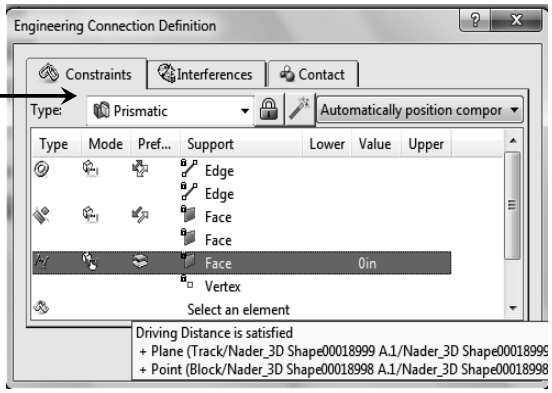
Point the cursor to this location and right click.



Right Click and select "Controlled"

Upon completing this task, the "Warning" (exclamation sign ⚠) is gone as shown below.

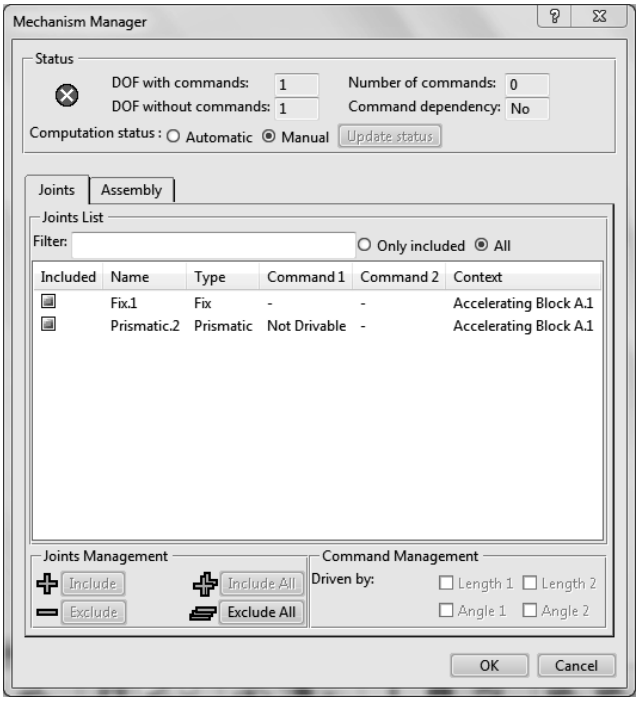
Notice that the Exclamation mark is gone.



Finally, update the constraint by selecting the update icon  .

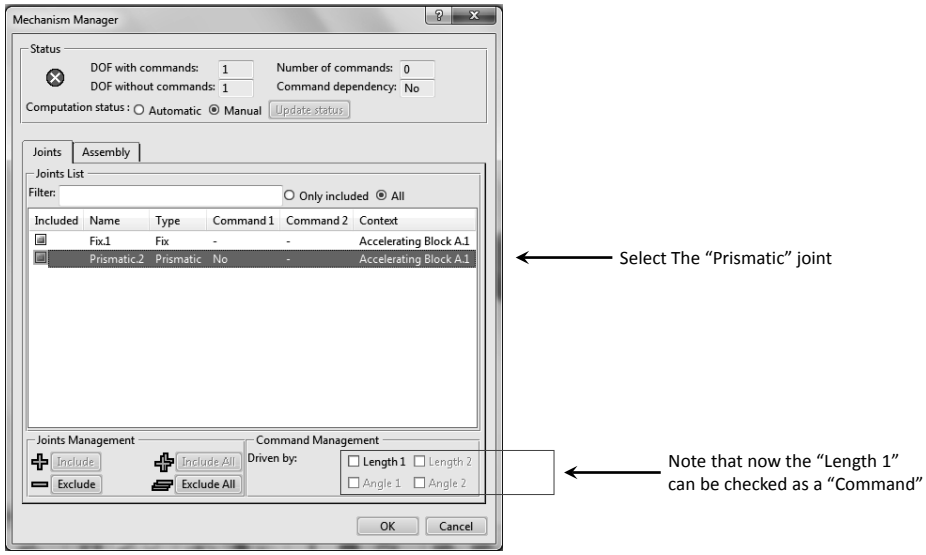
Once again, select the "Mechanism Manager" from the bottom of your screen by left clicking on  .

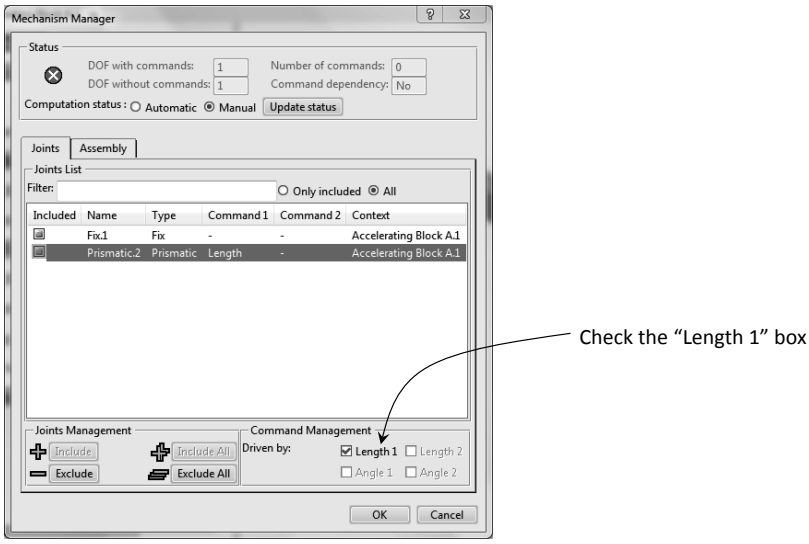
The "Mechanism Manager" dialogue box opens up as shown below.



The icon  is still in the top left corner as an indication that there is no command associated with the mechanism and therefore it cannot be simulated yet. So on the surface, it seems that the last three pages have not changed the picture. However, that is not the case as will be discussed next.

In the "Mechanism Manager" window, select the "Prismatic" joint which will be highlighted. In the bottom right corner, there is a section titled "Command Management." Notice that by defining the "offset" earlier, now one can select "Length 1" as a desire command. Therefore, check this box.

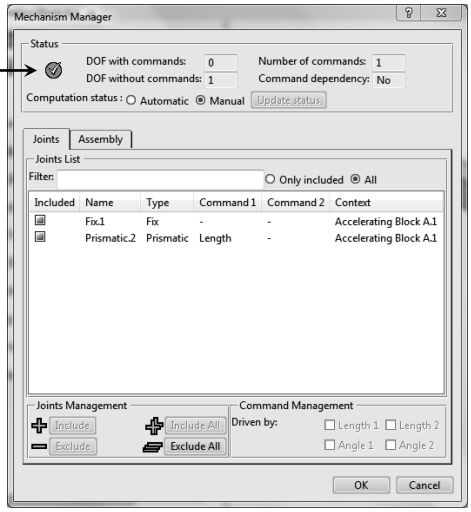




Select "OK" which then closes the window.
Once again, select the "Mechanism Manager" from the bottom of your screen by left clicking on  .

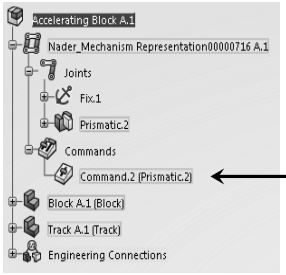
Now the situation is different. The status on the top left corner of the window has changed to green and the mechanism can be simulated.

Status has changed to green



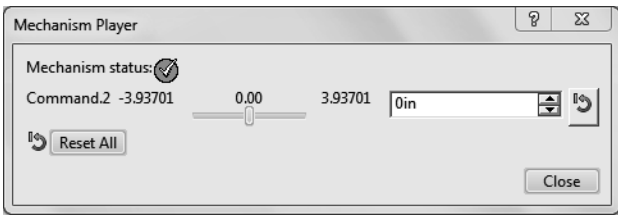
One should also pay attention to the DOF count and compare it before the selection of "Length 1" as a command. See the comparison on the right.

The Tree clearly indicates that a "Command" has been created.



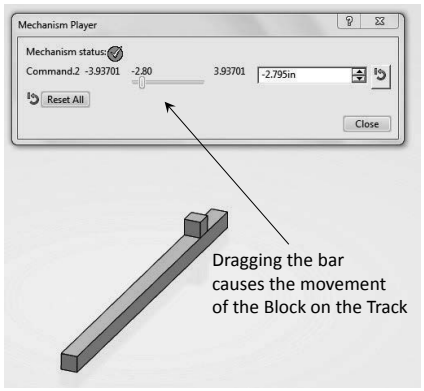
Note that a "Command" has now been created

Double clicking on the "Command" in the tree opens the "Mechanism Player" dialogue box shown on the right. This problem has one degree of freedom and therefore there is a single "Sliding Bar." By dragging the sliding bar to the left or to the right, the Block begins to move along the Track. The number 3.937 means it can make a

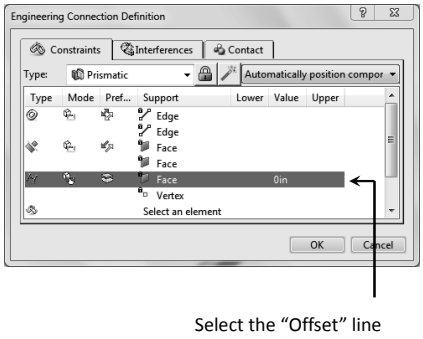


move to the left and to the right by 3.937 in. The range of movement can be changed as explained next.

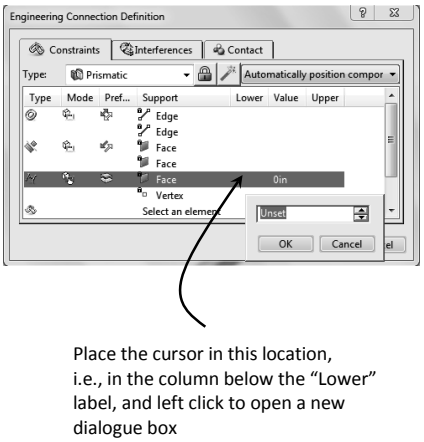
The "Reset All" button positions the Block in the original location which is the zero distance.



Double click on the "Prismatic" branch in the tree to open the corresponding dialogue box. Select the line dealing with the "Offset" constraint as shown on the right.

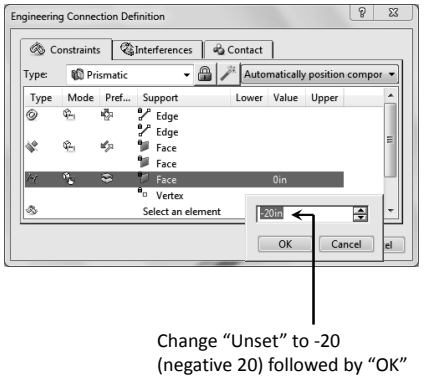


Place the cursor in the location shown, in the column below the "Lower" label, and left click to open a new dialogue box. Initially, the value is "Unset."



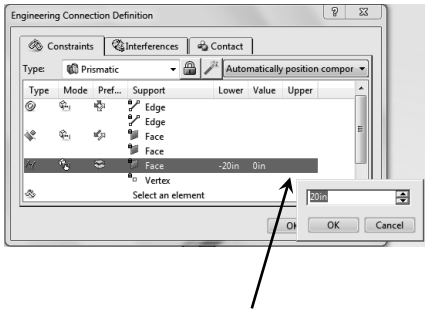
The "Unset" value in the box should be changed to -20 (negative 20).

Next you will set the "Upper" value of the movement of the Block.



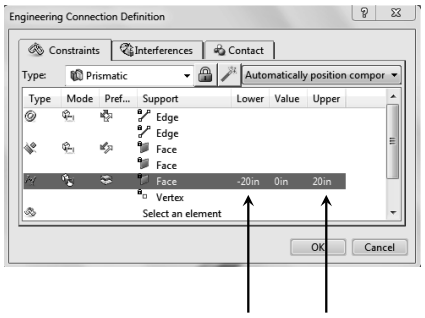
Place the cursor in the location shown in the column below the "Upper" label and left click to open a new dialogue box. Initially the value is "Unset."

The "Unset" value in the box should be changed to 20 (positive 20).



Place the cursor in this location, i.e., in the column below the "Upper" label, and left click to open a new dialogue box

The range of movement of the Block is between -20 and +20 in. The zero position corresponds to the Block being at the end of the Track.

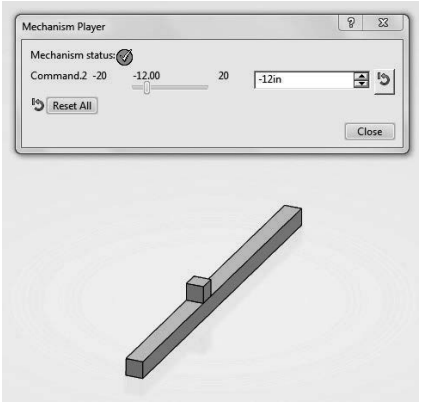


The range of movement of the Block is between -20 and +20 in. The zero position corresponds to the Block being at the end of the Track.

Double clicking on the "Command" from the tree opens the "Mechanism Player" window and by dragging the sliding bar, the Block moves in the range of -20 to 20 in. as shown below.

Before you introduce some physics into the problem (specifying the constant acceleration), it is a good idea to delete any limits which were imposed on the "Lower," "Value," and "Upper" columns.

This can easily be achieved by opening the "Prismatic" joint window, selecting the "Offset" row, placing the cursor in the proper column. You then right click and pick "Unset."



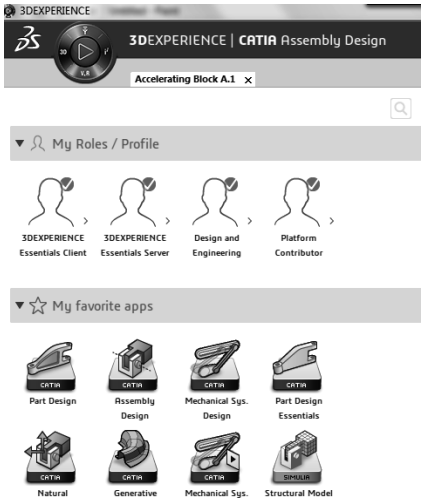
This has to be done until no values appear for "Lower," "Upper," "Value."

Finally update the constraint if necessary by selecting the update icon  .

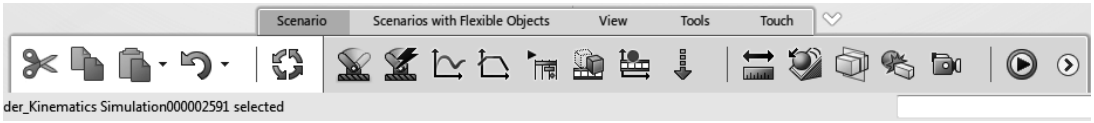
Creating the Physics and Simulating the Desired Kinematics

Locate the compass on the top left corner of the screen, and select the South sector (i.e.,V+R sector) as shown on the right. Scroll through the applications and select the Mechanical System Experience App 

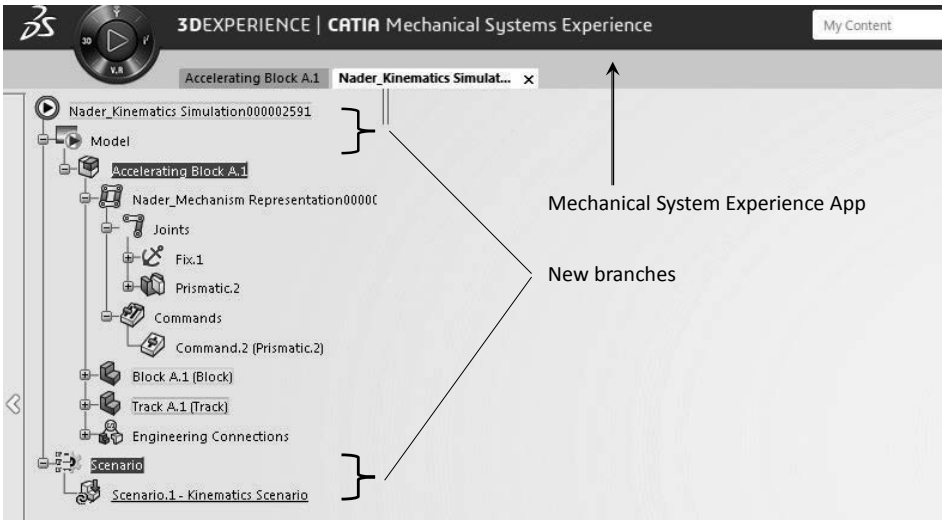
.



The row of icons on the bottom of your screen changes and will appear as displayed below.

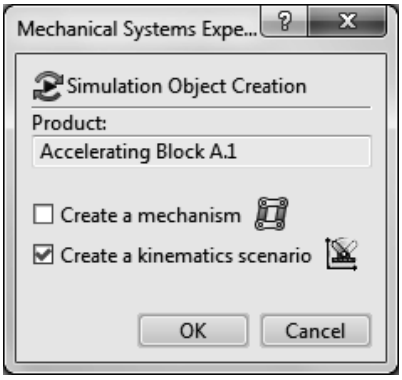


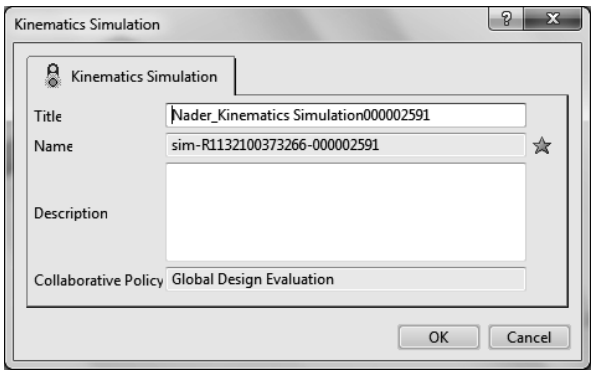
The top of your screen indicates that you are now in the "Mechanical System Experience" App.



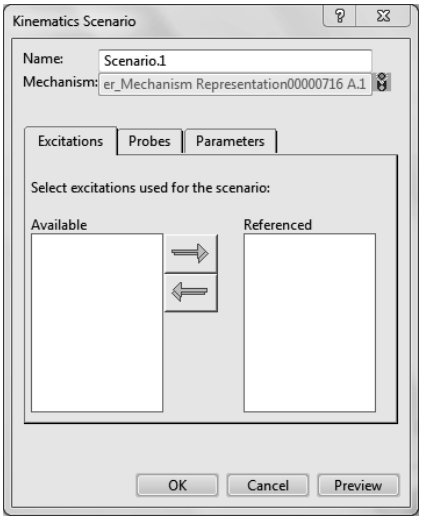
This application is where the physics of the problems can be specified, and kinematics results including graphs of displacement, velocity and acceleration can be generated.

As soon as you land in this application, the following two dialogue boxes appear where you can select defaults, or customize the names as you see fit.



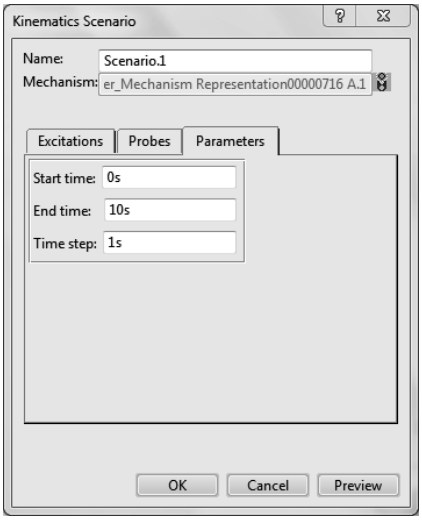


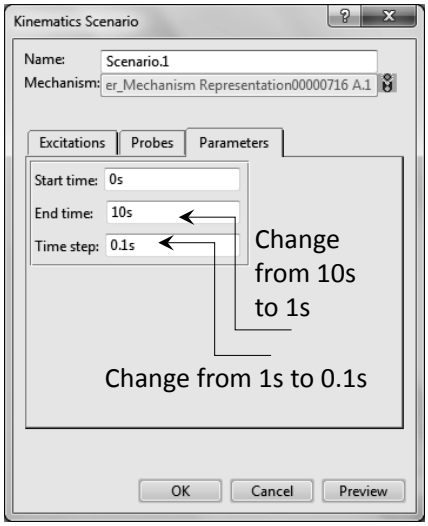
The third window popping up is shown on the right. This defines the "Scenario" created for the mechanism. The window shown has three tabs. Click on the "Parameters" tab.



The parameters specified are the "Start time," "End time," and the "Time step." For the present problem, change the "End time" to 1s and the "Time step" to 0.1s.

The "Probe" tab, if selected, does not contain any information as nothing has been defined yet.





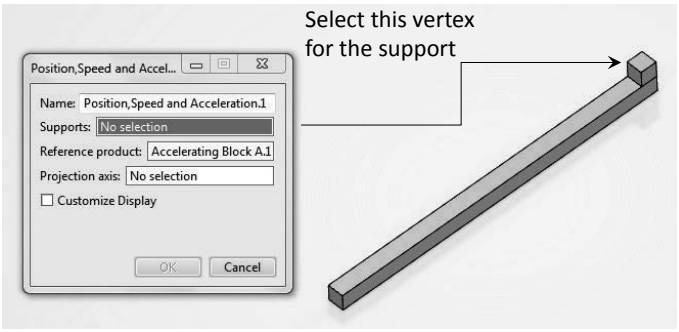
Select the "Position, Speed and Acceleration Probe"

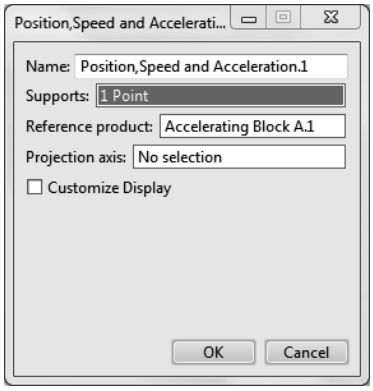
from the bottom row of icons.

The plan is to plot the position, velocity, and the acceleration of the top vertex of the Block as a function of time.

The following pop up window allows you to pick the appropriate point.

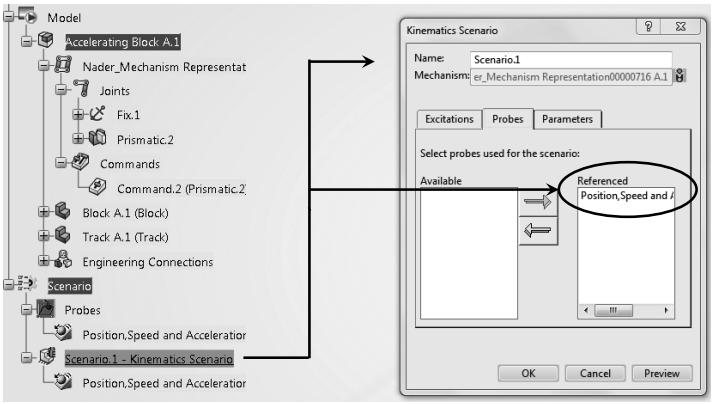
For the "Supports," select the indicated vertex of the Block. See the figure below.





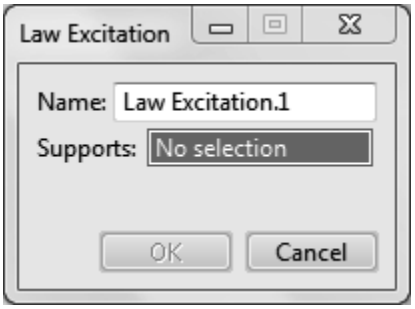
The probe is now created and displayed in the tree.

Double clicking on the "Scenario" branch opens the "Kinematic Scenario" dialogue box as shown on the right. Now, if the "Probes" tab is selected, the field is no longer empty and it contains the information on the vertex (point) selected.

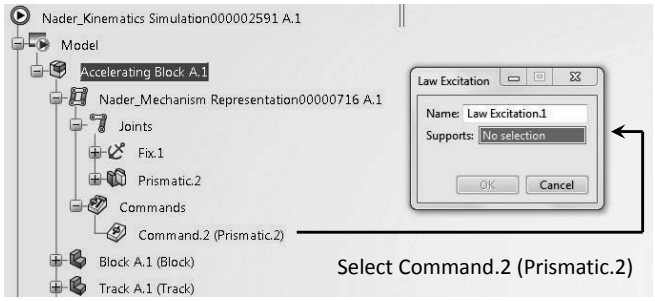


From the bottom row of icons (the action bar), select the "Law Excitation" icon  .

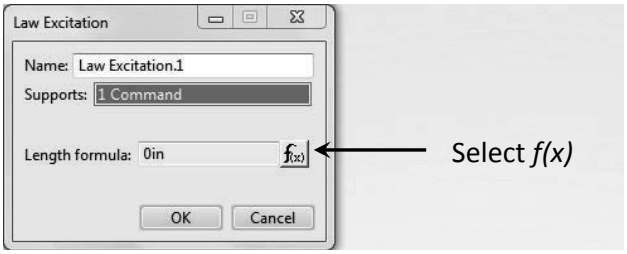
The following dialogue box opens up.



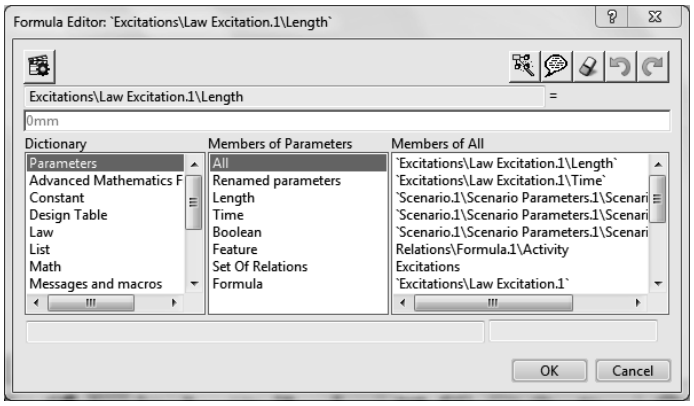
For the "Supports" select the "Command.2 (Prismatic.2)" from the tree.



Next, from the same dialogue box, while it is open, select "*f(x)*."



The window shown on the right pops up. This is a very important dialogue box named "Formula Editor" and it enables you to write equations defining the physics of the problem.

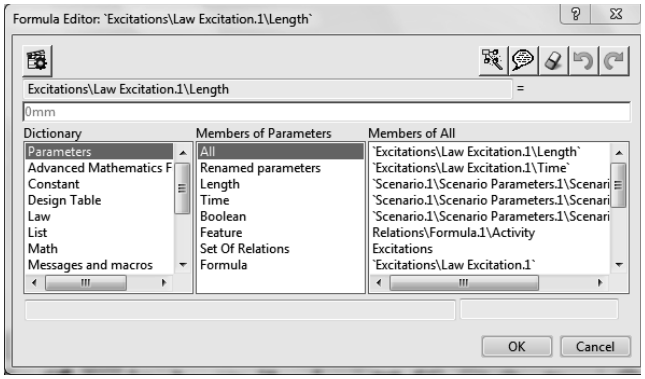


In the first section of this chapter it was assumed that the Block has a constant acceleration and, therefore, the position of the Block as a function of time is given by

$$s(t) = t^2 = 1in\ (t/1s)^2$$

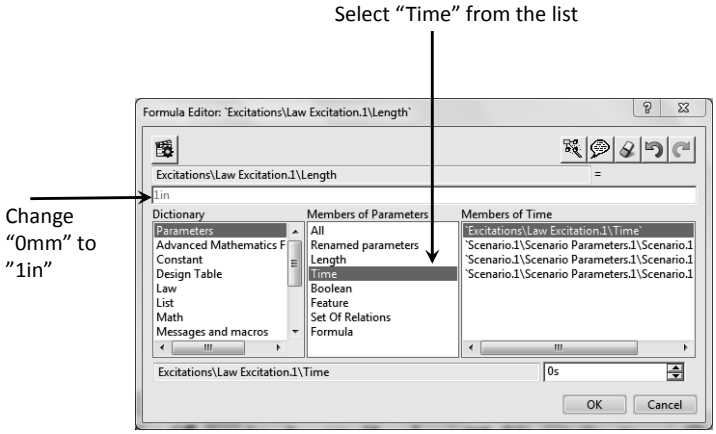
Note that the equation above must be dimensionally correct; i.e., the appropriate information must be included. The unit of s(t) is inches; therefore, the time is non-dimensional (dividing by 1s), and the prefix 1in is introduced.

One has to follow a sequence of actions in this dialogue box to input the proper formula.

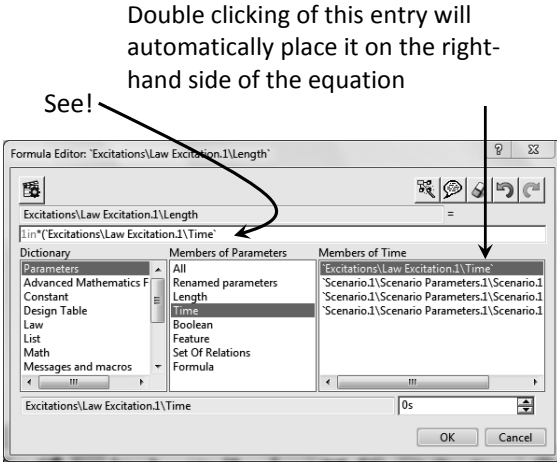


Retype the field so that it starts with "1in" instead of "0mm." Select the "Time" from the list.
The table indicates that the actual database name for time is

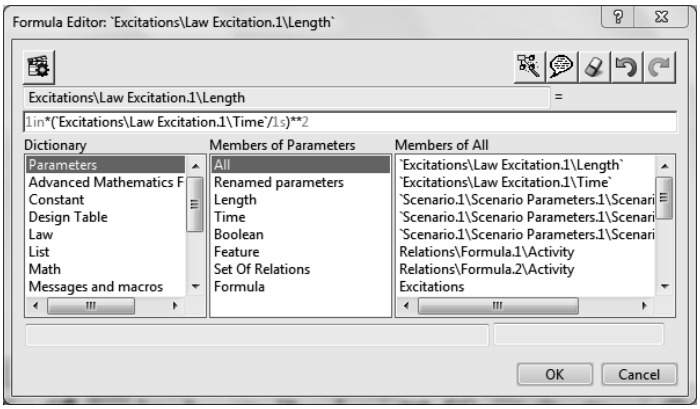
"Excitations\Law Excitation.1\Time"



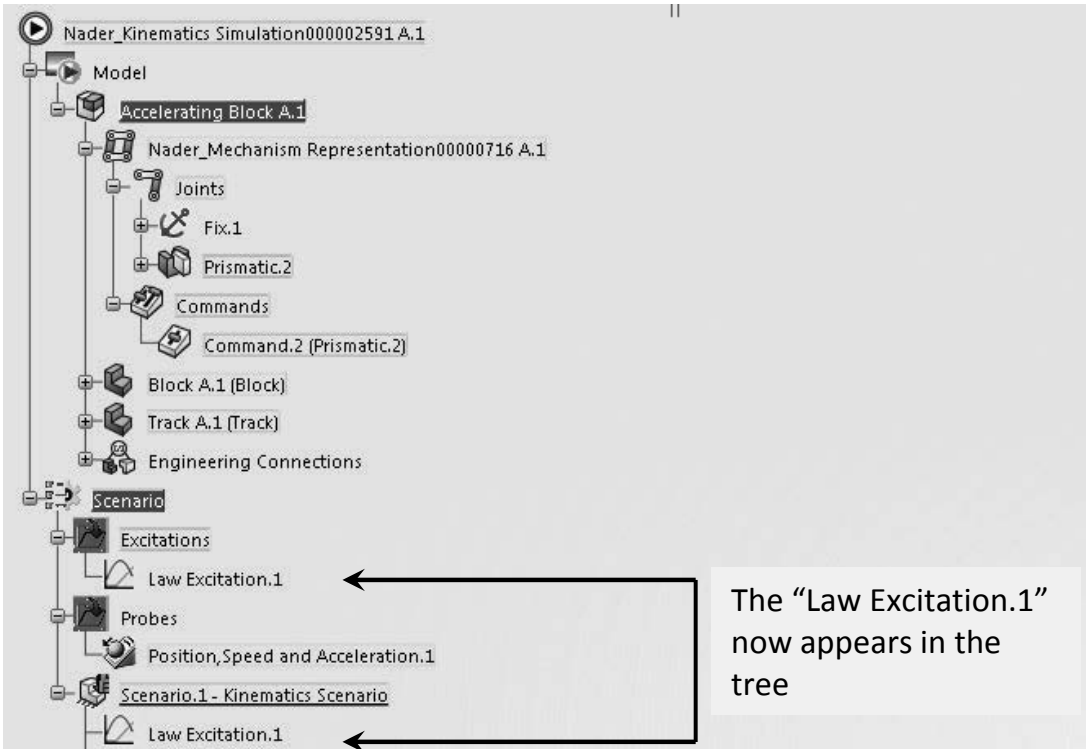
After changing the entry to "1in" you need to type the equation first by typing "*" which is the multiplication operator. Then, within parentheses, the word '**Excitations\Law Excitation.1\Time'**. An alternative way is to double click on the name from the "THIRD" column. This automatically places it in the desired location.



Next, complete the equation as shown below.



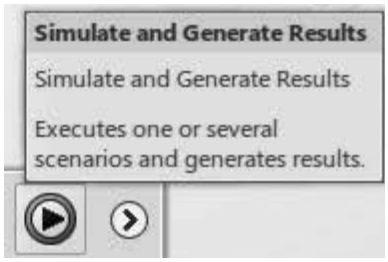
The “Law Excitation.1” now appears in the tree.



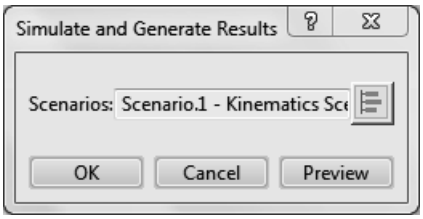
Finally, update the tree by selecting the update icon  .

You are now ready to simulate the mechanism. From the bottom row of icons, select the

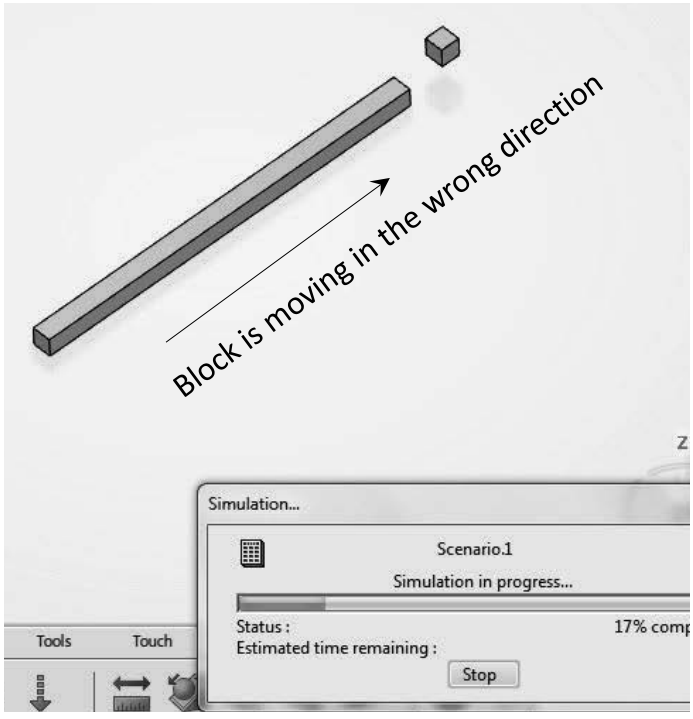
"Simulate and Generate Results" icon  .



Press "OK" and close the window that pops up. This is the "Simulate and Generate Results" window.

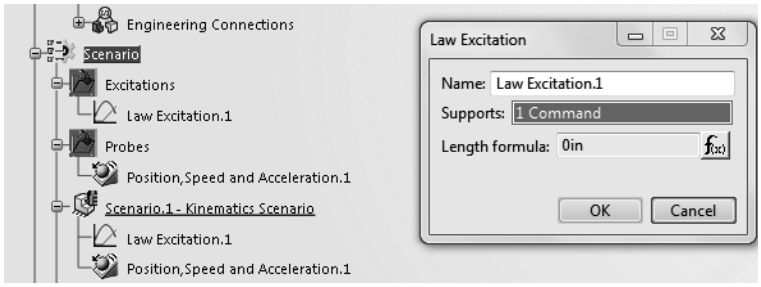


Taking a close look at the screen, you will see that the Block starts moving on the Track; however, it may be moving in the wrong direction as shown on the right. This can easily be fixed.

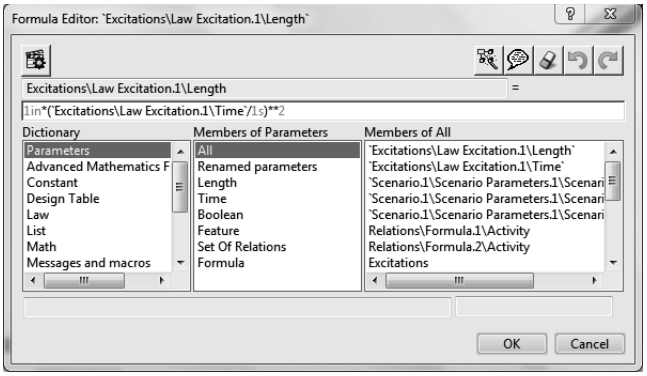


The steps to fix the direction are explained on the next page.

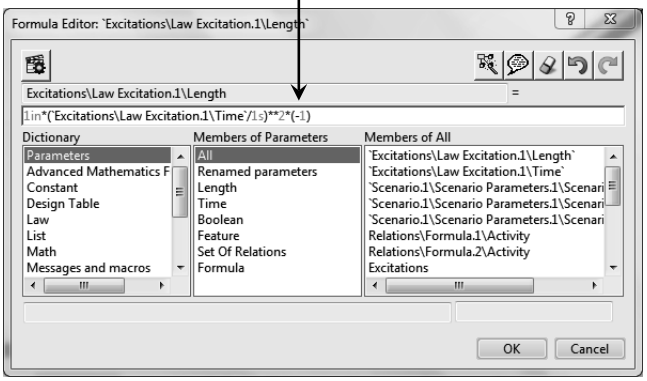
Double click on either one of the "Law Excitation.1" branches in the tree to open the dialogue box, followed by selecting "*f(x)*" in this dialogue box.



In the resulting dialogue box, multiply the right-hand side of the equation describing the length by a factor of "-1."

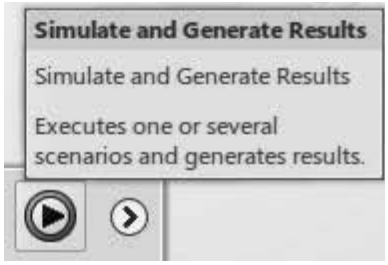


Multiply by a factor of (-1)



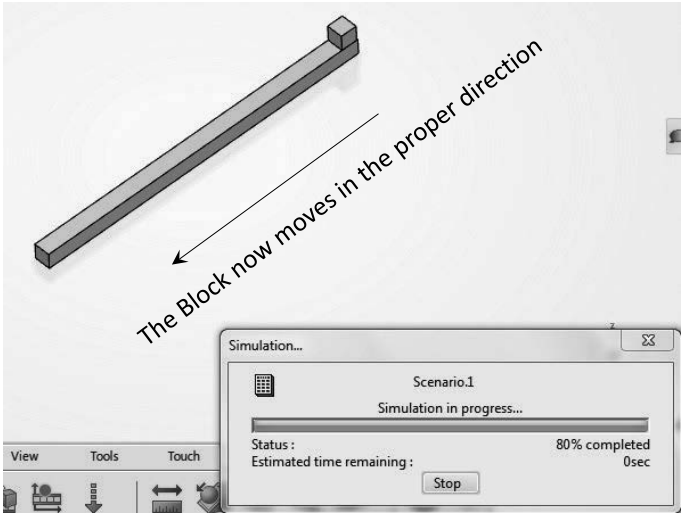
Repeat the steps already described on top of page 2-25. From the bottom row of icons (action bar), click on the "Simulate and Generate Results"

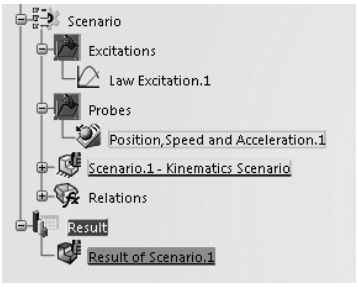
.



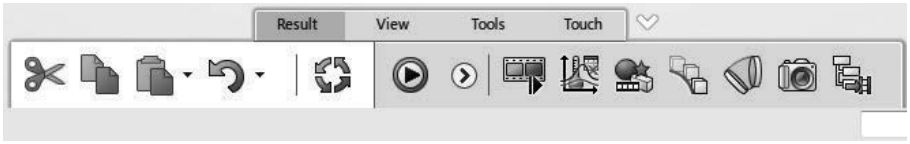
The block now moves in the other direction as desired.

Also note that the results for "Scenario.1" have been generated as indicated in the bottom of the tree.



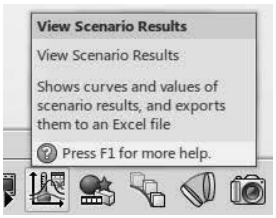


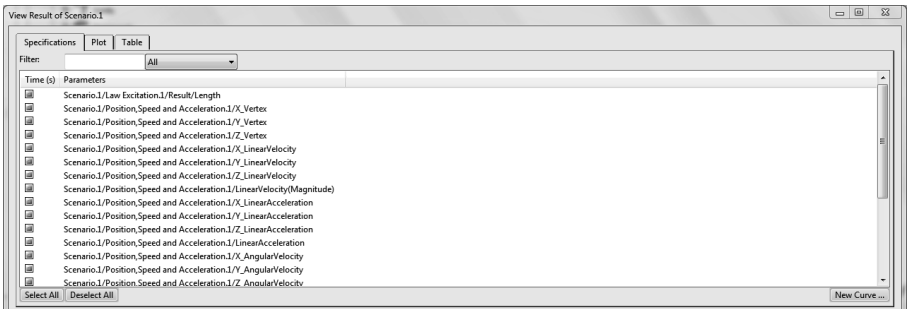
The final step is to create several plots which will confirm the physics imposed.
If you are not already in the "Results" tab, double click on the "Results of Scenario.1" branch in the tree to land you there. The bottom row of icons will look as shown below.



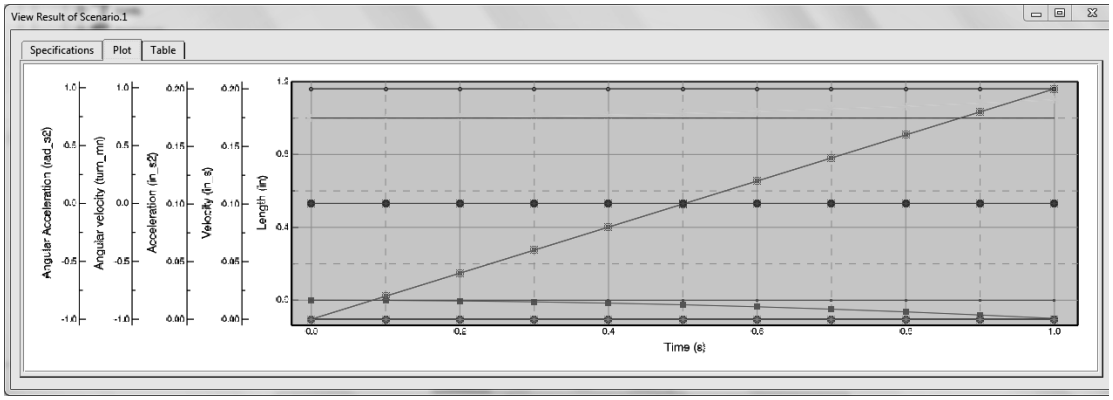
Select the icon "View Scenario Results"  from the bottom row.

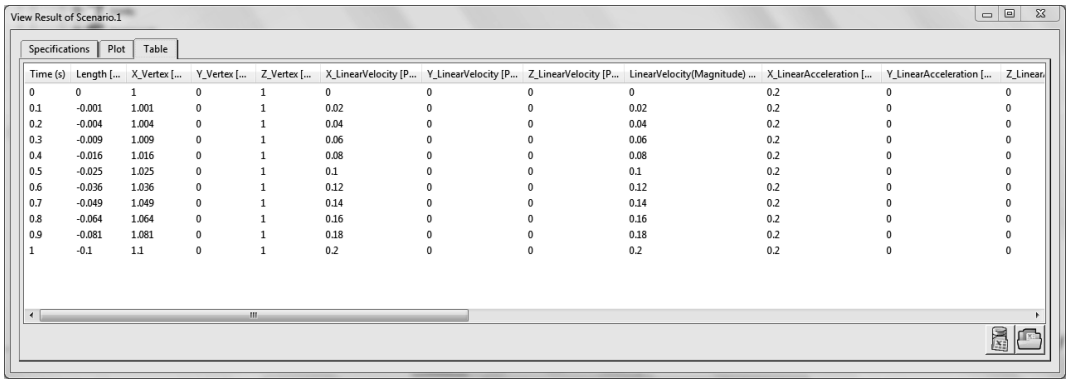
The following window opens.





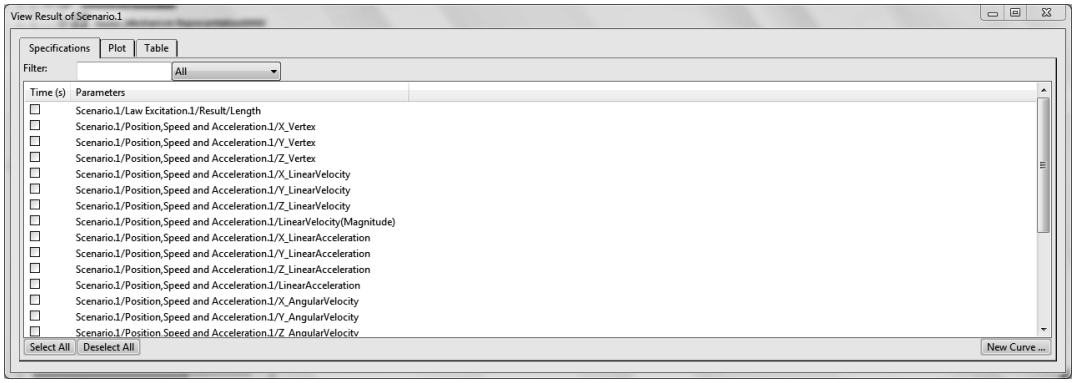
This window has two more tabs where certain default plots have been generated and data stored. The contents of the two tabs when selected are displayed in the following two figures.



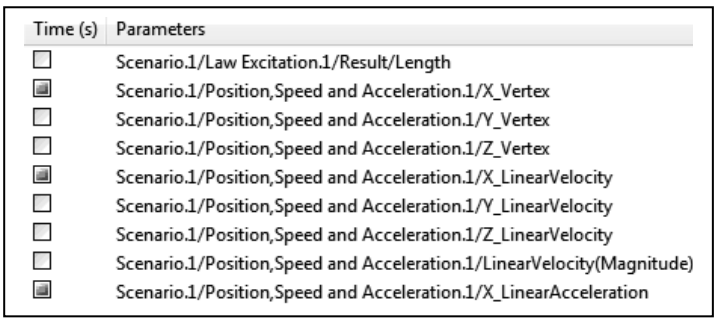


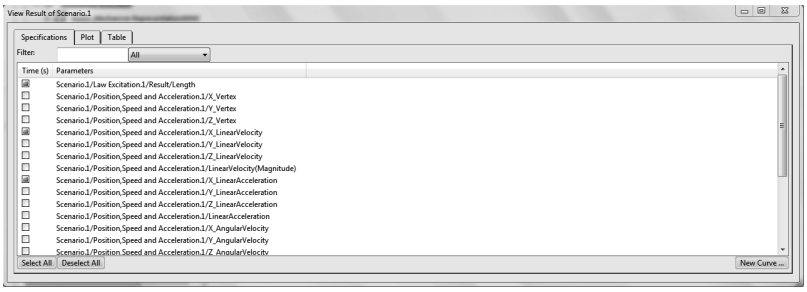
Time (s)	Length [...	X_Vertex [...	Y_Vertex [...	Z_Vertex [...	X_LinearVelocity [P...	Y_LinearVelocity [P...	Z_LinearVelocity [P...	LinearVelocity(Magnitude) ...	X_LinearAcceleration [...	Y_LinearAcceleration [...	Z_Linear...
0	0	1	0	1	0	0	0	0	0.2	0	0
0.1	-0.001	1.001	0	1	0.02	0	0	0.02	0.2	0	0
0.2	-0.004	1.004	0	1	0.04	0	0	0.04	0.2	0	0
0.3	-0.009	1.009	0	1	0.06	0	0	0.06	0.2	0	0
0.4	-0.016	1.016	0	1	0.08	0	0	0.08	0.2	0	0
0.5	-0.025	1.025	0	1	0.1	0	0	0.1	0.2	0	0
0.6	-0.036	1.036	0	1	0.12	0	0	0.12	0.2	0	0
0.7	-0.049	1.049	0	1	0.14	0	0	0.14	0.2	0	0
0.8	-0.064	1.064	0	1	0.16	0	0	0.16	0.2	0	0
0.9	-0.081	1.081	0	1	0.18	0	0	0.18	0.2	0	0
1	-0.1	1.1	0	1	0.2	0	0	0.2	0.2	0	0

Click the first tab “Specifications” once again, and use the button “Deselect All” in the bottom left corner of the window to clear the list. You will then select the variables that are of interest by checking the boxes in the left margin.

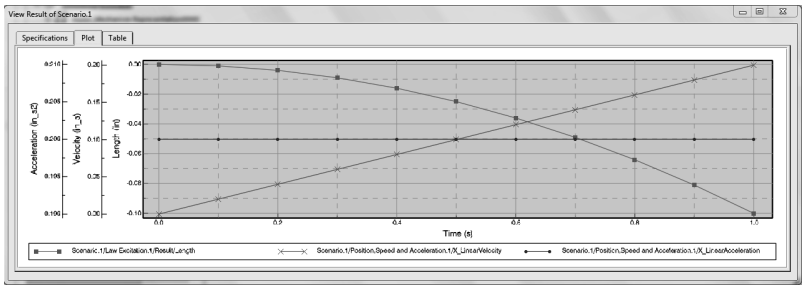


The geometry/orientation in the present problem is such that the block travels along the "X-axis." This being the case, check the following three boxes.

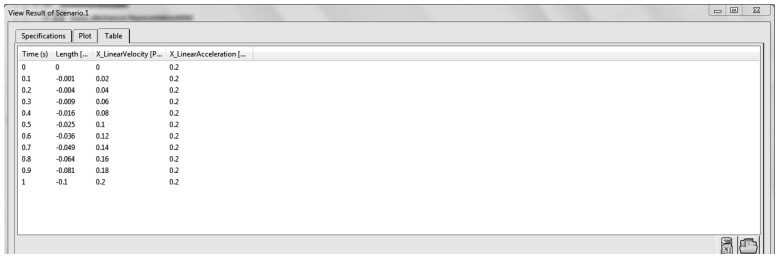




Now select the "Plot" tab from this window. You will see the plot of position (parabolic curve), velocity (the linear curve), and the acceleration (flat line) are displayed.

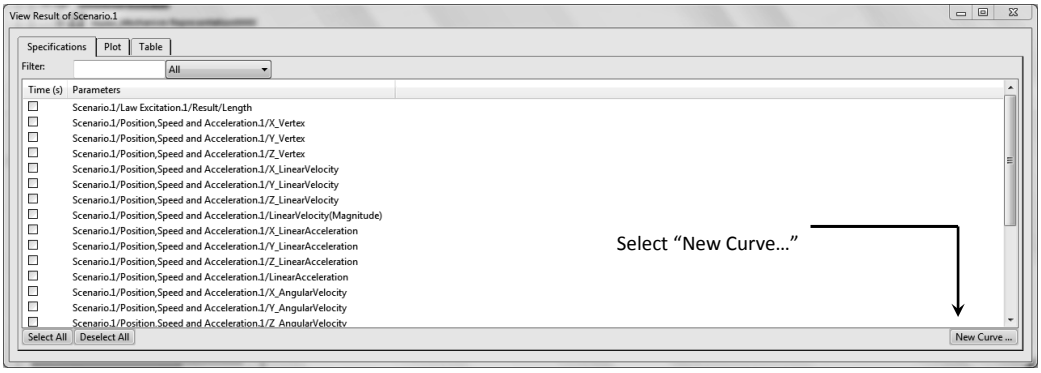


Finally select the "Table" tab to see the stored values.

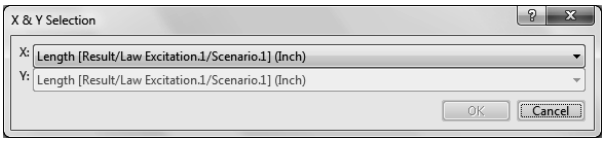


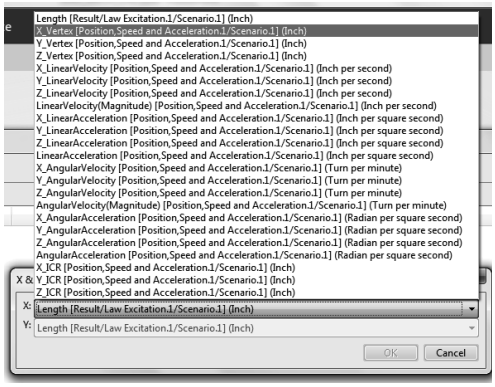
The above generated graphs are the selected variables plotted as a function of time. It is also possible to generate graphs of any two variables against each other. On the next page, the graph of x-position of the Block against the x-velocity of the Block is generated.

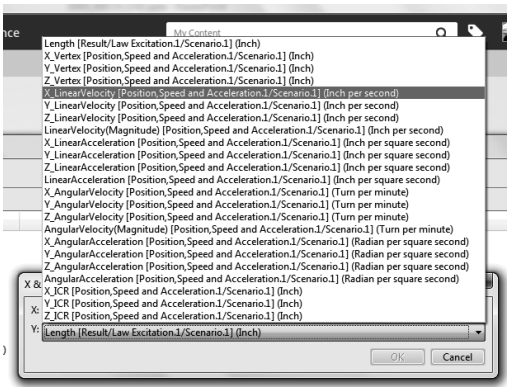
Select the button “New curve…” in the bottom right margin of the window “View Results Scenario.1.”



The “X-Y Selection” window pops up. From the available menus, choose the variables shown below.







The result will be a plot of the x-position of the Block vs. the x-velocity of it. Click on “OK” to close the dialogue box and generate the desired graph.