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Altair MotionView 2019 Tutorials

MV-1027: Modeling Point-to-Deformable-Curve (PTdCV) Higher-Pair Constraint

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In this tutorial, you will learn how to:

- Model a PTdCV (point-to-deformable-curve) joint

A PTdCV (point-to-deformable-curve) joint is a higher pair constraint. This constraint restricts a specified point on a body to move along a specified deformable curve on another body. The curve may be open or closed, planar or in 3-d space. The point may belong to a rigid, flexible or a point mass. For this, we define a deformable curve on a beam supported at its ends by revolute joints. A mass is constrained to move along the curve with a PTdCV constraint.

Exercise

Copy the file `KG_N_MM_S_50elems2.h3d`, located in the `mbd_modeling\interactive` folder, to your `<working directory>`.

Step 1: Creating points.

Let's start with creating points that will help us locate the bodies and joints as required. We will define points for center of mass of the bodies and joint locations.

1. Start a new MotionView Session. We will work with the default units (kg, mm, s, N).
2. From the **Project Browser** right-click on ***Model*** and select ***Add Reference Entity > Point*** (or right-click the ***Points*** icon on the **Model-Reference** toolbar).

   The **Add Point or PointPair** dialog is displayed.
3. For **Label**, enter `PointbeamInterface1`.
4. Accept the default variable name and click ***OK***.
5. Click on the ***Properties*** tab and specify the coordinates as **X** = `152.4`, **Y**, = `0.0`, and **Z** = `0.0`.
6. Follow the same procedure for the other points specified in the table below:

Point	X	Y	Z
PointbeamInterface2	460.80	0.0	0.0
Point0	183.24	0.0	0.0
Point1	214.08	0.0	0.0
Point2	244.92	0.0	0.0
Point3	275.76	0.0	0.0
Point4	306.60	0.0	0.0

Point	X	Y	Z
Point5	337.44	0.0	0.0
Point6	368.28	0.0	0.0
Point7	399.12	0.0	0.0
Point8	429.96	0.0	0.0

Step 2: Creating Bodies.

We will have two bodies apart from the ground body in our model visualization: the beam and the ball. Pre-specified inertia properties will be used to define the ball.

1. From the **Project Browser** right-click on ***Model*** and select ***Add Reference Entity > Body*** (or right-click the ***Body*** icon on the **Model-Reference** toolbar).

   The **Add Body or BodyPair** dialog is displayed.
2. For **Label**, enter `Beam` and click ***OK***.
3. Accept the default variable name and click ***OK***.

   For the remainder of this tutorial - accept the default names that are provided for the rest of the variables that you will be asked for.
4. From the **Properties** tab, check the ***Deformable*** box.
5. Click on the ***Graphic file*** browser icon, select `KG_N_MM_S_50elems2.h3d` from the `<working directory>` and click ***Open***.

   The same path will automatically appear next to the **H3D file** browser icon.
6. Right-click on ***Bodies*** in the **Project Browser** and select ***Add Body***.

   The **Add Body or BodyPair** dialog is displayed.
7. For **Label**, enter `Ball` and click ***OK***.
8. From the **Properties** tab, specify the following for the ***Ball***:

Body	Mass	Ixx	Iyy	Izz	Ixy	Iyz	Izx
Ball	100	1e6	1e6	1e6	0.0	0.0	0.0

9. For the **Ball** body, under the **CM Coordinates** tab, check the ***Use center of mass coordinate system*** box.

10. Double click on ***Point***.

    The **Select a Point** dialog is displayed.

11. Choose ***Point4*** and click ***OK***.

12. Accept defaults for axes orientation properties.

13. For the **Ball** body, from the **Initial Conditions** tab - check the ***Vx*** box under **Translational velocity** and enter a value of `100` into the text box.

    This sets a value of 100 for the translational velocity of the ball in the X-direction. A somewhat high value of Vx is introduced to make the motion of the ball clearly visible in the animation.

14. Accept all the other default values.

Step 3: Creating Markers.

Now, we will define some markers required for the beam. We will totally define eleven markers here at equal distances along the span of the beam.

1. From the **Project Browser** right-click on ***Model*** and select ***Add Reference Entity > Marker*** (or right-click the ***Markers*** icon on the **Model-Reference** toolbar).

   The **Add Marker or MarkerPair** dialog is displayed.

2. For **Label**, enter `Marker0` and click ***OK***.

3. Under the **Properties** tab, double-click on ***Body***.

   The **Select a Body** dialog is displayed.

4. Choose ***Beam*** and click ***OK***.

5. Under the **Properties** tab, double-click on ***Point***.

   The **Select a Point** dialog is displayed.

6. Choose ***PointbeamInterface1*** and click ***OK***.

   Accept the defaults for axes orientation.

7. Right-click on ***Markers*** in the **Project Browser** and select ***Add Marker*** to define a second marker. Continue adding markers until `Marker10` is reached.

8. For subsequent labels; enter `Marker1`, `Marker2`, etc. until `Marker10` is reached.

9. From the **Properties** tab, always select the **Beam** (after double-clicking on ***Body*** each time).

10. From the **Properties** tab, select ***Point0*** through ***Point8***, and finally ***PointbeamInterface2*** for ***Marker10*** (by double-clicking on ***Point*** every time).

    Always accept the defaults for axes orientation.

    A table is provided below for reference:

Marker No.	Body	Point
0	**Beam**	**PointbeamInterface1**
1	**Beam**	**Point0**
2	**Beam**	**Point1**
3	**Beam**	**Point2**
4	**Beam**	**Point3**
5	**Beam**	**Point4**
6	**Beam**	**Point5**
7	**Beam**	**Point6**
8	**Beam**	**Point7**
9	**Beam**	**Point8**
10	**Beam**	**PointbeamInterface2**

Step 4: Creating Joints.

Here, we will define all the necessary joints except for the PTdCV joint, which will be defined as an advanced joint later. We require two joints for the model, both of them being fixed joints between the beam and ground body.

1. From the **Project Browser** right-click on ***Model*** and select ***Add Constraint > Joint*** (or right-click the ***Joints*** icon on the **Model-Constraint** toolbar).

   The **Add Joint or JointPair** dialog is displayed.

2. For **Label**, enter `Joint0`.
3. Select ***Fixed Joint*** as the type and click ***OK***.
4. From the **Connectivity** tab, double-click on ***Body 1***.

   The **Select a Body** dialog is displayed.

5. Choose ***Beam*** and click ***OK***.
6. Under the **Connectivity** tab, double-click on ***Body 2***.

   The **Select a Body** dialog is displayed.

7. Choose ***Ground Body*** and click ***OK***.
8. From the **Connectivity** tab, double-click on ***Point***.

   The **Select a Point** dialog is displayed.
9. Choose ***PointbeamInterface1*** and click ***OK***.
10. Right-click on ***Joints*** in the **Project Browser** and select ***Add Joint*** to define a second joint.

    The **Add Joint or JointPair** dialog is displayed.
11. For **Label**, enter `Joint1`.
12. Select ***Fixed Joint*** as the type and click ***OK***.
13. From the **Connectivity** tab, double-click on ***Body 1***.

    The **Select a Body** dialog is displayed.
14. Choose ***Beam*** and click ***OK***.
15. From the **Connectivity** tab, double-click on ***Body 2***.

    The **Select a Body** dialog is displayed.
16. Choose ***Ground Body*** and click ***OK***.
17. From the **Connectivity** tab, double-click on ***Point***.

    The **Select a Point** dialog is displayed.
18. Choose ***PointbeamInterface2*** and click ***OK***.

Step 5: Creating Deformable Curves.

Here we will now define the deformable curve on the surface of the beam. The ball is constrained to move along this curve.

1. Click the **Project Browser** tab, right-click on ***Model*** and select ***Add Reference Entity > Deformable Curve*** (or right-click the ***Deformable Curves*** icon on the **Model-Reference** toolbar).

   The **Add DeformableCurve** dialog is displayed.
2. For **Label**, enter `DeformableCurve0`, and click ***OK***.
3. From the **Properties** tab, select ***Marker*** for **Data type**, and ***NATURAL*** for **Left end type** and **Right end type**.
4. Check the box just to the left of the **Marker** collector (which situated to the far right of **Data Type**).

   The intermediate **Add** button is changed to an **Insert** button.
5. Enter `10` into the text box located just to the right of the **Insert** button, and then click on the ***Insert*** button.

   Eleven **Marker** collectors are displayed.

6. Click on the individual collectors.

   The **Select a Marker** dialog is displayed.

7. Select all the markers one by one, starting from **Marker 0** to **Marker 10**.

Step 6: Creating Advanced Joints.

Now we will define the advanced PTdCV joint.

1. From the **Project Browser** right-click on ***Model*** and select ***Add Constraint > Advanced Joint*** (or right-click the ***Advanced Joints*** icon on the **Model-Constraint** toolbar).

   The **Add AdvJoint** dialog is displayed.

2. For **Label**, enter `AdvancedJoint 0`.

3. From the **Connectivity** tab select: ***PointToDeformableCurveJoint***, ***Ball*** for **Body**, ***Point4*** for **Point**, and ***DeformableCurve 0*** for **DeformableCurve**.

Step 7:Creating Graphics.

Graphics for the ball will now be built here.

1. Click the **Project Browser** tab, right-click on ***Model*** and select ***Add Reference Entity > Graphic*** (or right-click the ***Graphics*** icon on the **Model-Reference** toolbar).

   The **Add Graphics or GraphicPair** dialog is displayed.

2. For **Label**, enter `Graphic0`.

3. For **Type**, choose ***Sphere*** from the drop-down menu and click ***OK***.

4. From the **Connectivity** tab, double-click on ***Body***.

   The **Select a Body** dialog is displayed.

5. Choose ***Ball*** and click ***OK***.

6. Again from the **Connectivity** tab, double-click on ***Point***.

   The **Select a Point** dialog is displayed.

7. Choose ***Point4*** and click ***OK***.

8. From the **Properties** tab, enter `2.0` as the radius of the ***Ball***.

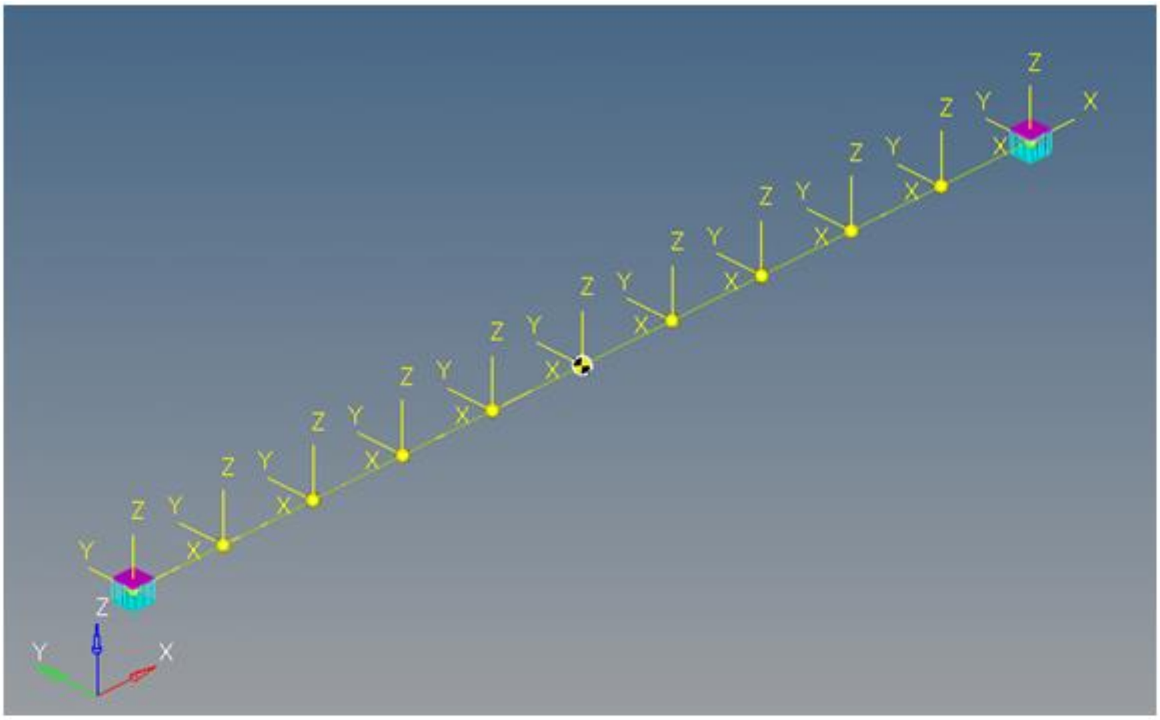
9. From the **Visualization** tab, select a color for the ***Ball***.

Step 8: Return to the Bodies Panel.

1. Click the ***Body*** icon  on the **Model-Reference** toolbar.
2. For the beam which has already been defined, click on the ***Nodes*** button.

   The **Nodes** dialog is displayed.
3. Uncheck the ***Only search interface nodes*** box and then click on ***Find All***.
4. Close the **Nodes** dialog.

   At the end of these steps your model should look like the one shown in the figure below:



One final comment before running the model:

This type of constraint does not ensure that the contact point will stay within the range of data specified for the curve. Additional forces at the end need to be defined by the user to satisfy this requirement. If the contact point goes out of range of the data specified for this curve, the solver encounters an error (unless additional forces are defined to satisfy this). In that case, one has to change the initial velocities for the ball, or increase the range of data specified for the curve, or run the simulation for a shorter interval of time.

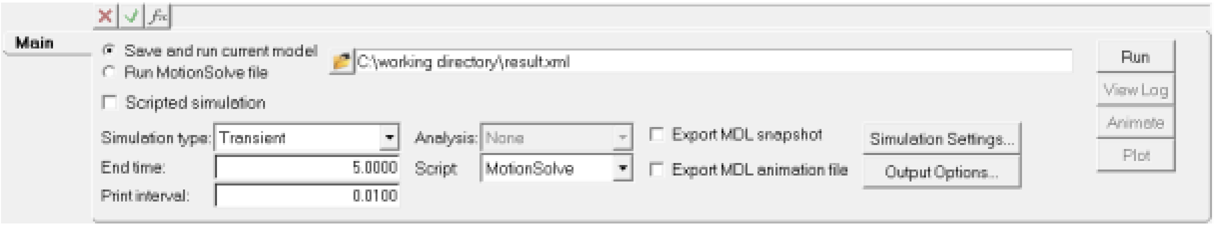
Step 9: Running the Model.

We now have the model defined completely and it is ready to run.

1. Click the **Run** icon on the **Model-Main** toolbar.

   The **Run** panel is displayed.

2. From the **Main** tab, specify values as shown below:



3. Choose the ***Save and run current model*** radio button.
4. Click on the browser icon and save the file as `result.xml`.
5. Click ***Save***.
6. Click the ***Check Model*** button on the **Model Check** toolbar to check the model for errors.
7. To run the model, click the ***Run*** button on the panel.

   The solver will get invoked here.

Step 10: Viewing the Results.

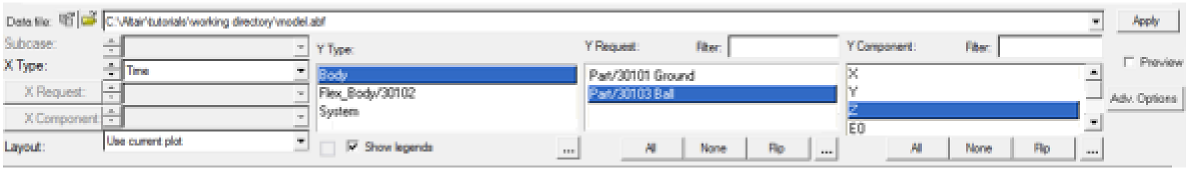
1. Once the solver has finished its job, the **Animate** button will be active. Click on ***Animate***.

   The icon can be used to start the animation, and the icon can be used to stop/pause the animation.

   One would also like to inspect the displacement profile of the beam and the ball. For this, we will plot the Z position of the center of mass of the ball.

2. Click on the ***Add Page*** icon and add a new page.
3. Use the ***Select application*** drop-down menu to change the application from ***MotionView*** to ***HyperGraph 2D*** .
4. Click the ***Build Plots*** icon on the **Curves** toolbar.
5. Click on the browser icon and load the `result.abf` file.

6. Make selections for the plot as shown below:



We are plotting the Z position of the center of mass of the ball.

7. Click ***Apply***.

The profile for the Z-displacement of the ball should look like the one shown below: