



Altair

HyperWorks

HM-4900: Creating a MADYMO Model

In this tutorial, you will create the MADYMO leg model and define one of the body local coordinate systems.

Model Files

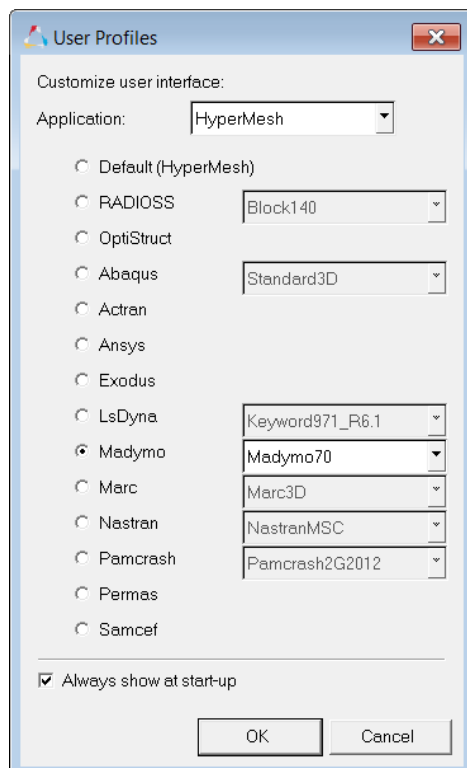
This tutorial uses the `leg_geom.hm` file, which can be found in `<hm.zip>/interfaces/madymo/`. Copy the file(s) from this directory to your working directory.

Exercise: Creating a MADYMO Model

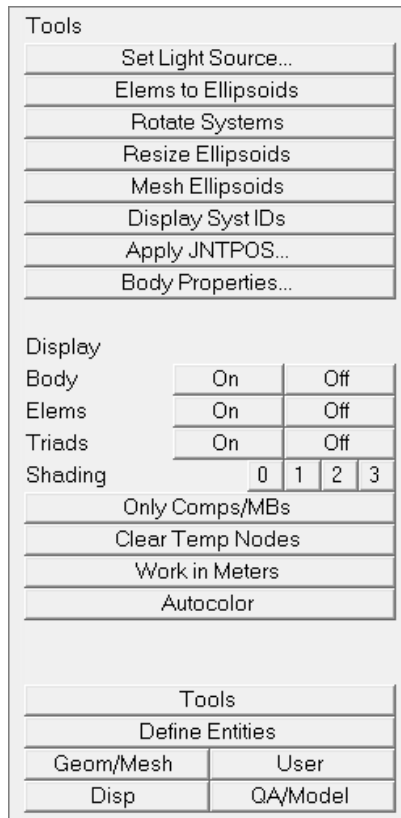
Step 1: Load the MADYMO user profile

The MADYMO user profile configures the user interface to be MADYMO specific. The user profile also loads the XML import reader and MADYMO template file. The template file defines MADYMO specific entity types and attributes versus generic entities.

1. Open HyperMesh Desktop.
2. In the **User Profiles** dialog, select **Madymo**.
3. Set the template drop-down to **Madymo 70**.
4. Click **OK**.



- Open the **Utility** menu by clicking **View > Browsers > HyperMesh > Utility** from the menu bar.



Step 2: Retrieve the model file

The `leg_geom.hm` file contains IGES lines representing the layout of the leg and coordinate systems for bodies and joints.

- Open a model file by clicking, **File > Open > Model** from the menu bar.
- In the **Open Model** dialog, open the `leg_geom.hm` file.

Step 3: Create coordinate systems

The `leg_geom.hm` file contains all the coordinate systems for defining the leg model, except the coordinate system for the femur body.

- From the menu bar, click **Geometry > Create > Systems > Axis Direction**.
- In the panel area, use the **origin** selector to select the center node of the femur area.
- Using the **x-axis** selector, select a node along the length of the leg.
- Using the **xy-plane** selector, select the node along the foot.
- Click **create**.
- Click **return** to exit the **Systems** panel.

Step 4: Create the femur body

1. In the **Model** browser, right-click and select **Create > Multibody** from the context menu.
2. In the **Create multibody** dialog, **Name** field, enter `femur`.
3. Set **Card image** to **RIGID**.
4. Using the **Center of gravity: Node** selector, select the highest, yellow **temp node** (at the center of the femur).
5. Set **Creation method** to **Body system**.
6. Click **Create**.
7. In the **Card Image** dialog, enter `6.0` in the **MASS** field and `0.1` in the **moments of inertia** field.
8. Click **return** to save changes to the body's card image and close the **Card Editor**.
9. Remain in the **Multibody: Create** panel.

Step 5: Create the tibia body

While in the **Multibody: Create** panel from the previous exercise, complete the following steps:

1. Enter `tibia` in the **name=** field.
2. Click **card image =** and select **RIGID** from the pop-up list.
3. Double-click **N1** to enter the **Node Vector Edit** sub-panel.
4. Enter the following:
 - **x** = `0.0`
 - **y** = `0.0`
 - **z** = `-0.85`
5. Click **return**.
6. Click the yellow **system** selection box under **use this system:** to make it active.
7. Select the orange coordinate system at the center of the tibia.
8. Click **create/edit** to create the body and bring it up in the **Card Editor**.
9. Set **MASS** to `5.0` and the **moments of inertia** to `0.1`.
10. Click **return** to save the changes to the body's card image and close the **Card Editor**.
11. Remain in the **Multibody: Create** panel for the next exercise.

Step 6: Create the ball body

While in the **Multibody: Create** panel from the previous exercise, complete the following steps:

1. Enter `ball` in the **multibody name =** field.

2. Click **card image =** and select **RIGID** from the pop-up list.
3. Click once on **N1** to make it the active selector.
4. Select the yellow temp node at the center of the ball.
5. Click the yellow **system** selection box under **use this system:** to make it active.
6. Click the **system** box again. In the **Id=** field that pops up, enter 7 to select the orange coordinate system at the ball center.
7. Click **create/edit** to create the body and bring it up in the **Card Editor**.
8. Set **MASS** to 0.1 and the **moments of inertia** to 0.01.
9. Click **return** to save changes to the body's card image and close the **Card Editor**.
10. Remain in the **Multibody: Create** panel for the next exercise.

Step 7: Create the ground body

While in the **Multibody: Create** panel from the previous exercise, complete the following steps:

1. Enter `ground` in the **multibody name=** field.
2. Click **card image =** and select **RIGID** from the pop-up list.
3. Double-click **N1** to enter the **Node Vector Edit** subpanel.
4. Enter the following:
 - **x** = 0.0
 - **y** = 0.0
 - **z** = -1.1
5. Click **return**.
6. Click the **switch** to change the value to use body's local system.
7. Click **create** to create the body.
8. Click **return** to leave the **Multibody: Create** panel.

Steps 8- 12: Creating Geometry

Step 8: Create the ground plane

SURFACE.PLANE is defined in the **Planes** panel.

1. Click the **Analysis** page and within the **safety** subpanel, click on **planes**.
2. Type `ground` in the **name =** field.
3. Click **color** and select a color for the plane.
4. Double-click **N1** to enter the **Node Vector Edit** subpanel.
5. Use the tab key to quickly move through the fields. Under **N1**, enter the following:

- **x** = -0.25
 - **y** = 0.25
 - **z** = -1.1
6. Under **N2**, enter the following:
 - **x** = -0.25
 - **y** = -0.25
 - **z** = -1.1
 7. Under **N3**, enter the following:
 - **x** = 0.50
 - **y** = -0.25
 - **z** = -1.1
 8. Click **return**.
 9. Click **multibody=** and select **ground** from the pop-up list.
 10. Click **create** to create the plane.
 11. Click **return** to leave the panel.

Step 9: Create the femur ellipsoid

SURFACE.ELLIPSOID and SURFACE.CYLINDER are created in the **Ellipsoids** panel.

1. While still in the **safety** module, click on **ellipsoids**.
2. Type `femur` in the **base name =** field.
3. Click **color** and select a color for the femur.
4. Click the triangle next to **center:** and select **entities** from the pop-up list.
5. With the **node** selector active, select the node at the center of the femur.
6. Enter the following:
 - **A** = 0.3
 - **B** = 0.1
 - **C** = 0.1
7. Set **orientation:** to **body system**.

Note: If an ellipsoid is created while referencing the wrong body, it can be easily updated in the **Organize** panel.

8. Click **multibody=** and select **femur** from the body list.
9. Activate the **ellipsoid** radio button next to **create:**.
10. Click **create** to create the ellipsoid.
11. Remain in the **Ellipsoids** panel for the next exercise.

Step 10: Create the tibia ellipsoid

While still in the **Ellipsoids** panel from the previous exercise, complete the following steps:

1. Type `tibia` in the **base name =** field.
2. Click **color** and select a color for the tibia.
3. With the **node** selector active, select the node at the center of the tibia.
4. Enter the following:
 - **A** = 0.25
 - **B** = 0.06
 - **C** = 0.06
5. Keep **orientation:** set to **body system**.
6. Click **multibody=** and select **tibia** from the body list.
7. Activate the **ellipsoid** radio button next to **create:**.
8. Click **create** to create the ellipsoid.
9. Remain in the **Ellipsoids** panel for the next exercise.

Step 11: Create the foot ellipsoid

While still in the **Ellipsoids** panel from previous exercise, complete the following steps:

1. Type `foot` in the **base name =** field.
2. Click **color** and select a color for the foot.
3. With the **node** selector active, select the node at the center of the foot.
4. Enter the following:
 - **A** = 0.16
 - **B** = 0.1
 - **C** = 0.06
5. Change **orientation:** to **system** and click the **system** button to make it active.
6. Select the global triad at the lower left corner of the model window.
7. Keep **multibody=** set to **tibia**.
8. Activate the **ellipsoid** radio button next to **create:**.
9. Click **create** to create the ellipsoid.
10. Remain in the **Ellipsoids** panel for the next exercise.

Step 12: Create the ball ellipsoid

While still in the **Ellipsoids** panel from the previous exercise, complete the following steps:

1. Type `ball` in the **base name =** field.
2. Click **color** and select a color for the ball.

3. Click the triangle switch next to **center:** and select **entities** from the pop-up list.
4. Select the node at the center of the ball.
5. Enter the following:
 - **A = 0.1**
 - **B = 0.1**
 - **C = 0.1**
6. Change **orientation:** to **body system**.
7. Click **multibody=** and select **ball** from the body list.
8. Activate the **ellipsoid** radio button next to **create:**.
9. Click **create** to create the ellipsoid.
10. Click **return** to leave the **Ellipsoids** panel.

Steps 13-15: Creating Joints

Step 13: Create the knee joint

Joints connecting bodies in a multi-bodied system are created in the **create joints** panel.

1. While still in the **safety** subpanel, click on **create joints**.
2. Type `knee` in the **name =** field.
3. Click **type =** and select **REVO** from the pop-up list.
4. Click the **syst entity selection** box under **parent:** and select the **joint parent coordinate** system by clicking on the **coordinate system origin at the knee** and selecting the **purple parent coordinate system** from the coincident selection circle. You can also single-click the **syst** button and enter 4 in the **id=** field that appears.
5. Click the **syst entity selection** box under **child:** to make it active.
6. Select the **joint child coordinate system** by clicking on the **coordinate system origin at the knee** and selecting the **cyan child coordinate system** from the **coincident selection** circle. You can also single-click the **syst** button and enter 6 in the **id=** field that appears.
7. Click the **multibody entity selection** box under **parent:** to make it active.
8. Click on the **femur ellipsoid** in the **model** window to select its body as the parent body.
9. Click the **multibody entity** selection box under **child:** to make it active.
10. Click on the **tibia ellipsoid** in the **model** window to select its body as the child body.
11. Click **create** to create the joint.
12. Remain in the **Multibody Joints** panel for the next exercise.

Step 14: Create the hip joint

While still in the **Multibody Joints** panel from the previous exercise, complete the following steps:

1. Type `hip` in the **name =** field.
2. Keep **type =** set to **REVO**.
3. Click the **syst** entity selection box under **parent:** to make it active.
4. Select the joint parent coordinate system by clicking on the coordinate system origin at the hip and selecting the purple parent coordinate system from the coincident selection circle. You can also single-click the **syst** button and enter 3 in the **id=** field that appears.
5. Click the **syst** entity selection box under **child:** to make it active.
6. Select the joint child coordinate system by clicking on the coordinate system origin at the hip and selecting the cyan child coordinate system from the coincident selection circle. You can also single-click the **syst** button and enter 5 in the **id=** field that appears.
7. Click the toggle next to the **multibody** selection box under **parent:** to set the joint parent body to **reference space**.
8. Click the **syst** entity selection box under **child:** to make it active.
9. Click on the femur ellipsoid in the model window to select its body as the child body.
10. Click **create** to create the joint.
11. Remain in the **Multibody Joints** panel for the next exercise.

Step 15: Create the ball joint

While still in the **Multibody Joints** panel from the previous exercise, complete the following steps:

1. Type `ball` in the **name =** field.
2. Click **type =** and select **FREE** from the pop-up list.
3. Click the **syst** entity selection box under **parent:** and enter 8 in the **id=** field.
4. Click the **syst** entity selection box under **child:** and enter 9 in the **id=** field.
5. Keep the parent body set to **reference space**.
6. Click on the ball ellipsoid in the model window to select its body as the child body.
7. Click **create** to create the joint.
8. Click **return** to leave the panel.

Steps 16-19: Defining Systems of Bodies

Step 16: Define the leg SYSTEM.MODEL

SYSTEM.MODEL, SYSTEM.REF_SPACE, and MADYMO are defined in the **Assemblies** panel. HyperMesh assemblies are collections of collectors. The SYSTEM, BODY, FE_MODEL structure can also be defined in the **Model Browser**. Launching the **Model Browser** before starting this section of exercises provides a visual reference for the model hierarchy.

1. While still in the **safety** subpanel, click on **assemblies**.
2. Type `leg_system` in the **assem name =** field.
3. Click **type =** and select **SYSTEM** from the pop-up list.
4. Click the **multibodies entity selection** box to make it active.
5. Click on the **femur and tibia ellipsoids** in the graphics window to include their bodies in the system. Or, click the **multibodies** button again and select the **femur and tibia bodies** from the list and click **select**.
6. Click **create** to create the assembly.
7. Remain in the **Assemblies** panel for the next exercise.

Step 17: Define the ball SYSTEM.MODEL

While still in the **Assemblies** panel from the previous exercise, complete the following steps:

1. Type `ball_system` in the **assem name =** field.
2. Click **type =** and select **SYSTEM** from the pop-up list.
3. With the **multibodies** selection box active, select the ball ellipsoid to include its body in the system. Or, click the **multibodies** button again and select **ball** from the list and click **select**.
4. Click **create** to create the assembly.
5. Remain in the **Assemblies** panel for the next exercise.

Step 18: Define SYSTEM.REF_SPACE

While still in the **Assemblies** panel from the previous exercise, complete the following steps:

1. Type `ref_space` in the **assem name =** field.
2. Click **type =** and select **SYSTEM** from the pop-up list.
3. With the **multibodies** selection box active, select the ground plane to include its body in the system. Or, click the **multibodies** button again and select **ground** from the list and click **select**.
4. Click **create/edit** to create the assembly and bring it up in the **Card Editor**.
5. Click **MODEL** and select **REF_SPACE** from the pop-up list.

6. Click **return** to save changes made to the card image and close the **Card Editor**.
7. Remain in the **Assemblies** panel for the next exercise.

Step 19: Define MADYMO MODEL assembly

While still in the **Assemblies** panel from the previous exercise, complete the following steps:

1. Type `MADYMO_Model` in the **assem name =** field.
2. Click **type=** and select **MADYMO** from the pop-up list.
3. Click the **assem** entity selection box to make it active.
4. Click **assem** again to bring up the assemblies list.
5. Activate the **leg_system**, **ball_system**, and **ref_space** check boxes and click **select**.
6. Click **create/edit** to create the assembly and bring it up in the **Card Editor**.
7. Click on **TIME_STEP** and enter `1e-4`.
8. Click **return** to save changes made to the card image and close the **Card Editor**.
9. Click **return** to leave the **Assemblies** panel.

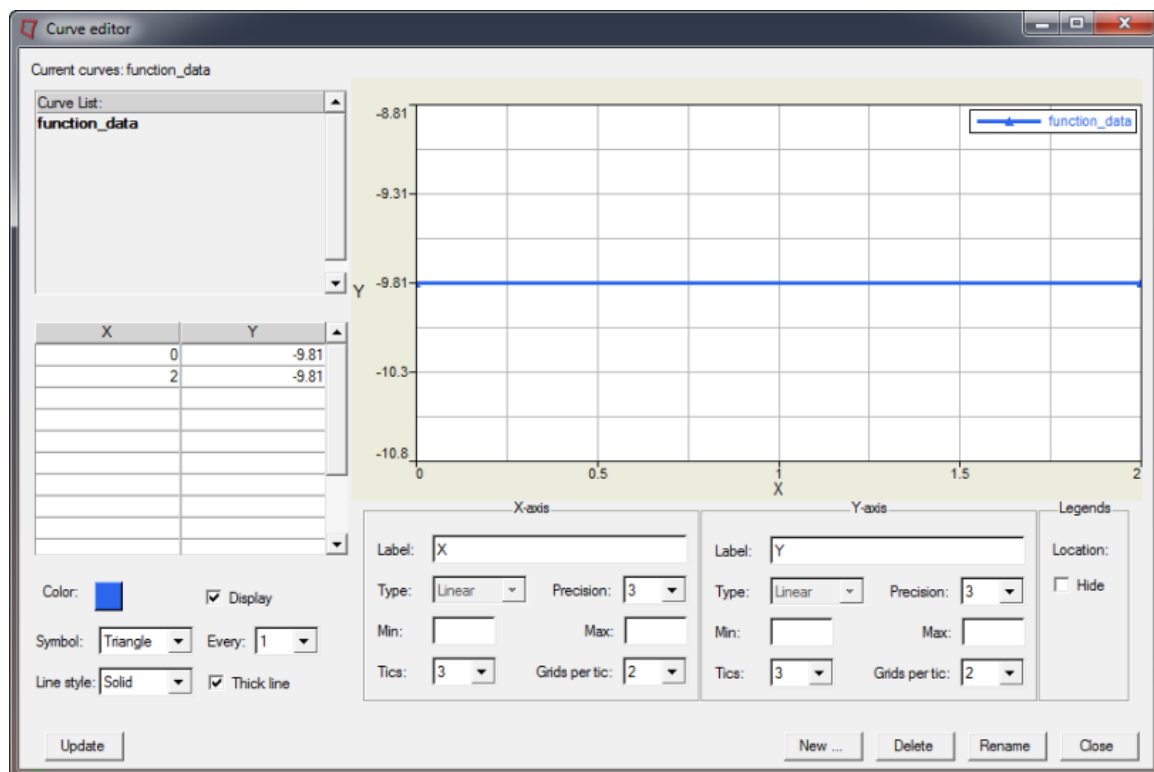
Step 20: Define the initial conditions and position the leg

1. While still in the **safety** subpanel, click on **dummy**.
2. Activate the **incremental** radio button.
3. Click on the **triangle** switch next to the **yellow selection** box and select **multibodies** from the pop-up list. **Multibodies** is used for positioning ellipsoid rigid body models and **comp** is used to position finite element and facet dummy models.
4. Enter `10` in the **increment** field.
5. Select the **femur ellipsoid**. HyperMesh automatically searches up to the next joint in the hierarchy and down through all the joints, bodies, and ellipsoids below in the hierarchy.
6. Rotate the hip by:
 - using the **<** and **>** buttons next to **x rot** to rotate the hip child joint coordinate system about the x axis of the hip parent joint coordinate system.
 - entering rotation values in the **current** fields.
7. Select the tibia or foot ellipsoids. HyperMesh automatically searches up to the next joint in the hierarchy.
8. Rotate the knee by:
 - using the **<** and **>** buttons next to **x rot** to rotate the knee child joint coordinate system about the x axis of the knee parent joint coordinate system.
 - entering rotation values in the **current** fields.
9. Click **return** to leave the **Dummy** panel.

Step 21: Apply gravity and create vector data in HyperMesh

A **gravity vector** is applied by defining the vector in HyperMesh then applying the vector to a system of bodies in the **Curve Editor**.

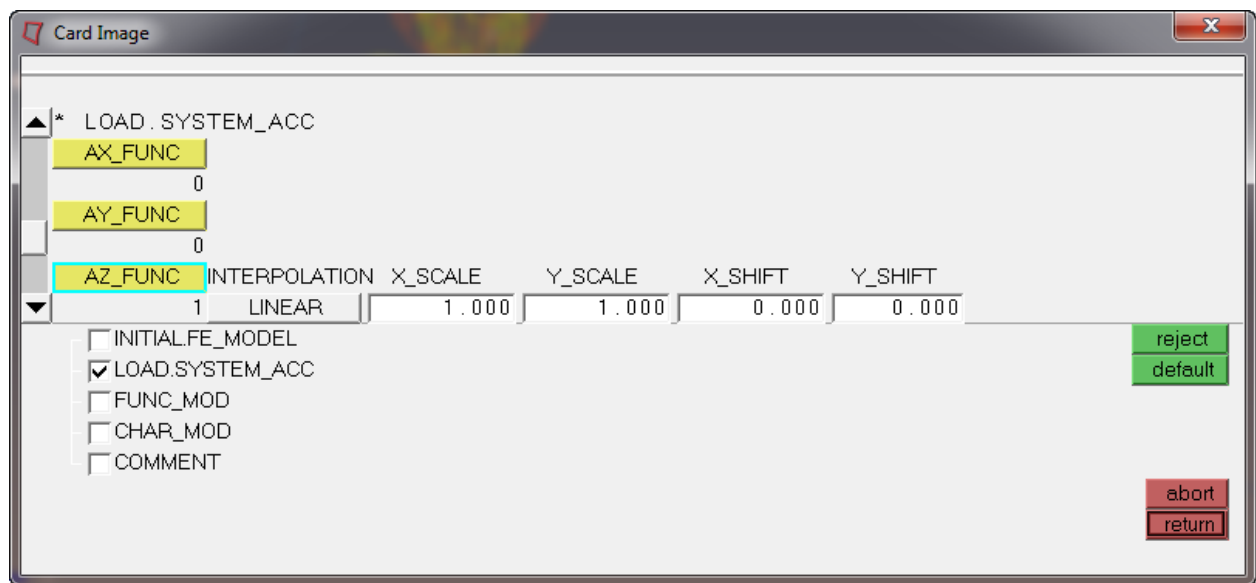
1. Click **XY Plots** > **Curve Editor**.
2. Click on **New...**
3. Enter `function_data` in the **Name=** field.
4. Click **proceed**.
5. Select **function_data** in the top left corner.
6. In the table, in the first row, enter:
 - In the **X** column, enter 0
 - In the **Y** column, enter -9.81
7. In the second row of the table, enter
 - In the **X** column, enter 2
 - In the **Y** column, enter -9.81
8. Select a color, and activate the **Display** checkbox.
9. Set the **Symbol** field to **Triangle**.
10. Set the **Line Style** field to **Solid**, and activate the **Thick line** checkbox.
11. Click **Update**.
12. Click **Close** to close the **Curve Editor**.



Step 22: Apply the gravity vector to the dummy

The gravity vector is applied by card editing the HyperMesh assembly which represents the dummy system of bodies.

1. Right click on the **leg_system** assembly in the **Model Browser** and pick **Card Edit**.
2. Activate the **LOAD.SYTEM_ACC** checkbox.
3. Click once on the yellow **AZ_FUNC** curve selection box to make it active.
4. Click on **AZ_FUNC** and select **function_data**.
5. Click **return** to save the changes and leave the card image.
6. Click **return** to exit the **Card Editor** panel.
7. Repeat steps 1-5 for **ball_system**.



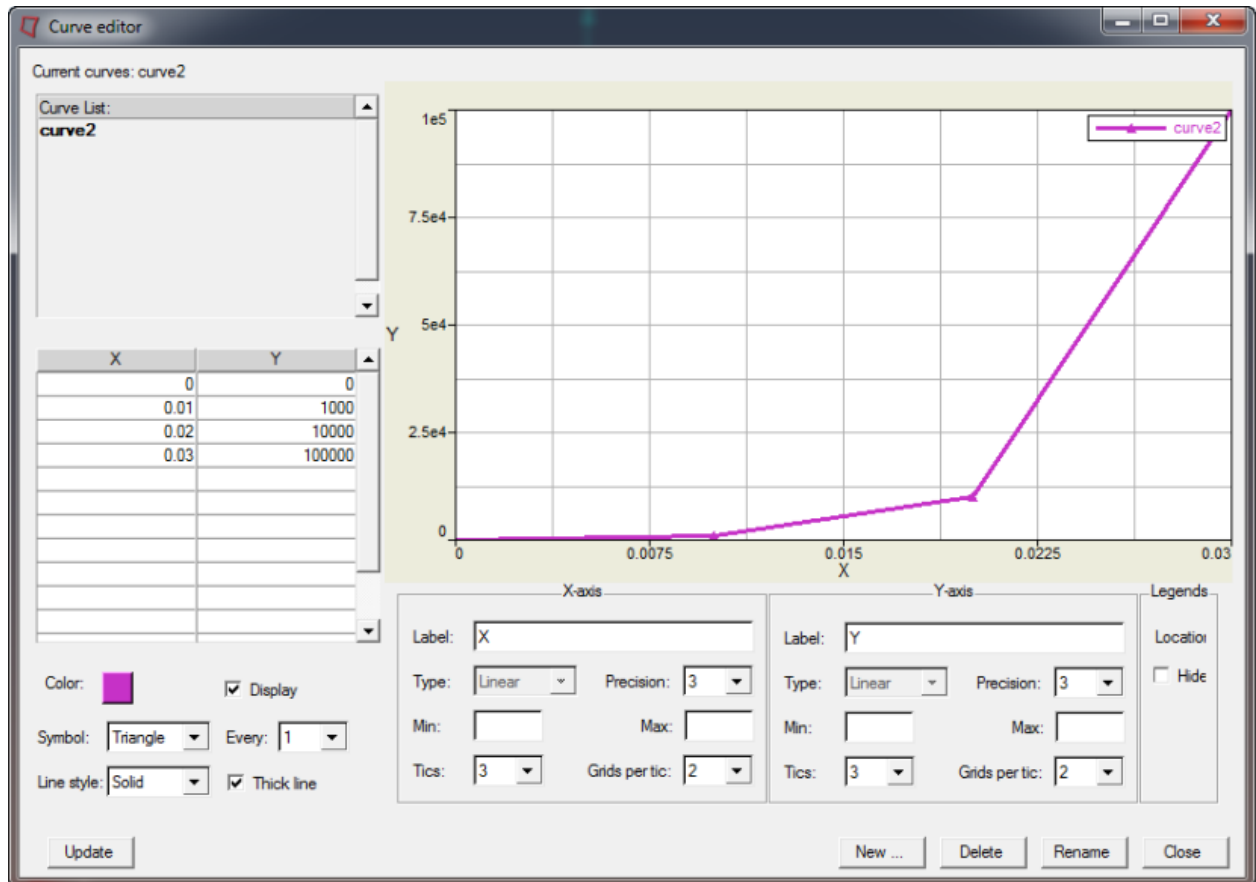
Steps 23-25: Create ball ellipsoid characteristics

Ellipsoid characteristics are properties of ellipsoids and are defined as HyperMesh properties cards.

Step 23: Create the function curve using the Curve Editor

1. Click **XY Plots > Curve Editor**.
2. Click on **New...**
3. Enter **curve2** in the **Name=** field.
4. Click **proceed**.
5. Select **curve2** in the top left corner.
6. In the table, in the first row, enter:
 - In the **X** column, enter 0

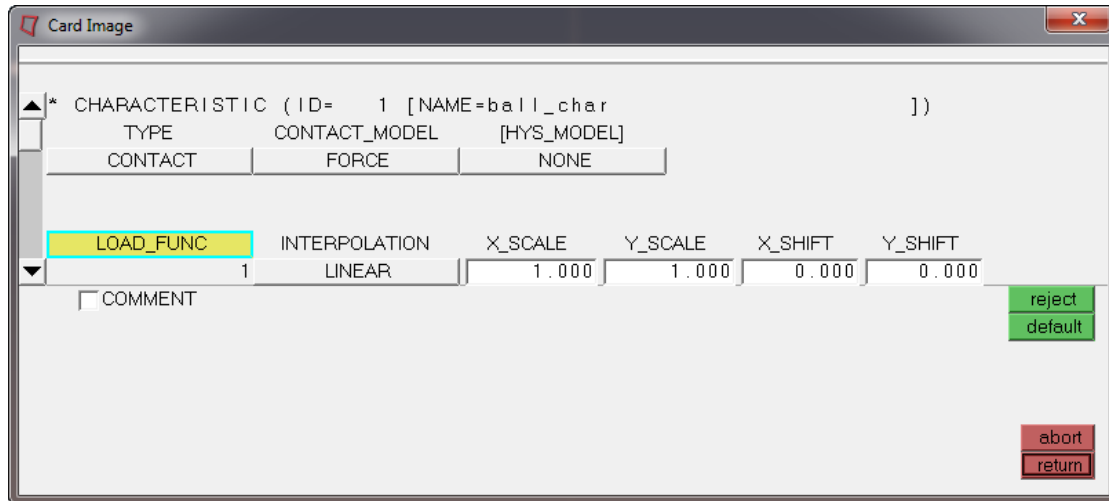
- In the **Y** column, enter 0
7. In the second row of the table, enter
 - In the **X** column, enter 0.01
 - In the **Y** column, enter 1000
 8. In the third row of the table, enter
 - In the **X** column, enter 0.02
 - In the **Y** column, enter 10000
 9. In the fourth row of the table, enter
 - In the **X** column, enter 0.03
 - In the **Y** column, enter 100000
 10. Set the **Symbol** field to **Triangle**.
 11. Set the **Line style** field to **Solid**.



13. Click **Update**.
14. Click on **Close**.


Step 24: Create the property for ellipsoid

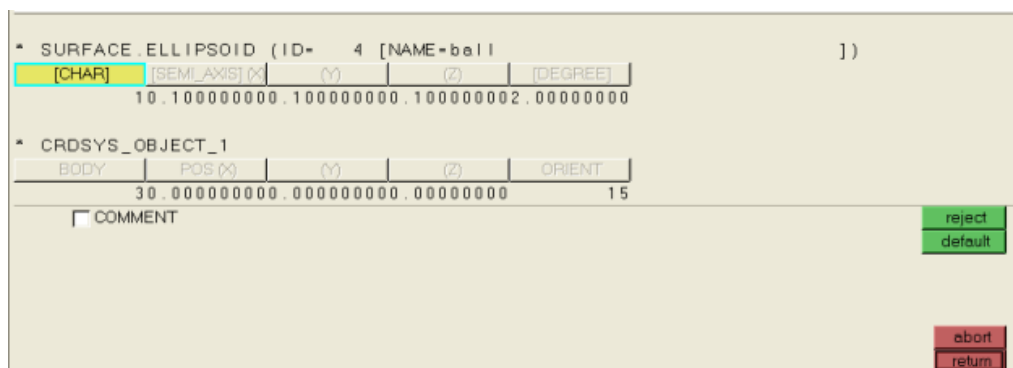
1. Right click in the **Model Browser** and pick **Create > Property**.
2. Enter `ball_char` in the **Name=** field.
3. Click **card image=** and select **CHAR** from the pop-up list.
4. Click the **Card edit property upon creation** to activate the option
5. Click **Create** to create the property and open the **Card Editor**.
6. Click **LOAD_FUNC** and select the created characteristic **curve2**.



7. Click **return** to save the changes and exit the panel.

Step 25: Assign the characteristic

1. Click the **Card Edit** icon  and click **ellipsoids**.
2. Select the **ball ellipsoid**.
3. Click **edit**.
4. Click twice on **CHAR** to bring up the property list.
5. Select **ball_char**.



6. Click **return** to save the changes and exit the card image.
7. Click **return** to exit the **Card Edit** panel.

Steps 26-30: Defining contacts

Contacts are created in the **Contacts** panel. A MADYMO GROUP consists of a single entity LIST or multiple LIST cards. LIST and GROUP cards are both defined in the HyperMesh **Entity Sets** panel.

Step 26: Create a GROUP for the foot contact surface

1. Click **Tools > Create > Sets**.
2. Enter `foot_ellipsoid_list` in the **name=** field.
3. Click the toggle next to **entity** to set the selector to **ellipsoids**.
4. Graphically select the foot and tibia ellipsoids, or click **ellipsoids** and click on **foot** and **tibia** in the list.
5. Click **create** to create the entity set.
6. Click the toggle next to **entity** to set the selector to **sets**.
7. Enter `lower_leg_group` in the **name=** field.
8. Click on the **sets** selection box.
9. Activate the **foot_ellipsoid_list** check box and click **select**.
10. Click **create** to create the entity set.
11. Remain in the **Entity Sets** panel for the next exercise.

Step 27: Create a GROUP for the ball contact surface

While still in the **Entity Sets** panel, complete the steps below:

1. Enter `ball_ellipsoid_list` in the **name=** field.
2. Click the toggle next to **entity** to set the selector to **ellipsoids**.
3. Select the **ball** ellipsoid.
4. Click **create** to create the entity set.
5. Click the toggle next to **entity** to set the selector to **sets**.
6. Enter `ball_group` in the **name=** field.
7. Click on the **sets** selection box.
8. Activate the **ball_ellipsoid_list** check box and click **select**.
9. Click **create** to create the entity set.
10. Remain in the **Entity Sets** panel for the next exercise.

Step 28: Create a GROUP for the ground contact surface

While still in the **Entity Sets** panel, complete the steps below:

1. Enter `ground_plane_list` in the **name=** field.
2. Click the toggle next to **entity** to set the selector to **mbplanes**.
3. Select the ground plane by clicking on it in the model window or click **mbplanes** and click on **ground** and click **select**.
4. Click **create** to create the entity set.
5. Click the toggle next to **entity** to set the selector to **sets**.
6. Enter `ground_group` in the **name=** field.
7. Click on the **sets** selection box.
8. Activate the **ground_plane_list** check box and click **select**.
9. Click **create** to create the entity set.
10. Click **return** to leave the panel.

Step 29: Define the Ball to Foot contact

1. Click **BCs > Create > Interfaces**.
2. Activate the **create** radio button.
3. Enter `ball_to_foot` in the **name=** field.
4. Click **type=** and select **MB_MB** from the pop-up list.
5. Click **create** to create the contact definition.
6. Activate the **add** radio button.
7. Click twice on the master **sets** selection box.
8. Activate the **ball_group** check box and click **select**.
9. Click the master **update** button.
10. Click twice on the slave **sets** selection box.
11. Activate the **lower_leg_group** check box and click **select**.
12. Click the slave **update** button.
13. Remain in the **Contacts** panel for the next exercise.


Step 30: Define the Ground to Ball contact

While still in the **Contacts** panel, complete the steps below:

1. Click the **create** radio button to open the subpanel.
2. Enter `ground_to_ball` in the **name=** field.
3. Click **type=** and select **MB_MB** from the pop-up list.
4. Click **create** to create the contact definition.

5. Activate the **add** radio button.
6. Click twice on the master **sets** selection box.
7. Activate the **ground_group** check box and click **select**.
8. Click the master **update** button.
9. Click twice on the slave **sets** selection box.
10. Activate the **ball_group** check box and click **select**.
11. Click the slave **update** button.
12. Activate the **card image** radio button in the **Contacts** panel.
13. Click the green **edit** button.
14. Enter 0.1 for **FRIC_COEF**.
15. Click **return** to leave the **Card Image** panel.
16. Click **return** to exit the panel.

Step 31: Export and run for finite time

1. Right click on the **MADYMO_Model** assembly in the **Model Browser** and click **Card Edit**.
2. In the card image, enter 0.05 in the **TIME_END** field.
3. Click **return** to save the changes and exit the card image.
4. Click the **Export Solver** icon  to export the MADYMO file.
5. Use the file browser to specify an XML filename and click **Save**.
6. Solve the saved file using the MADYMO solver.
7. View the results by loading the KIN3 file in the