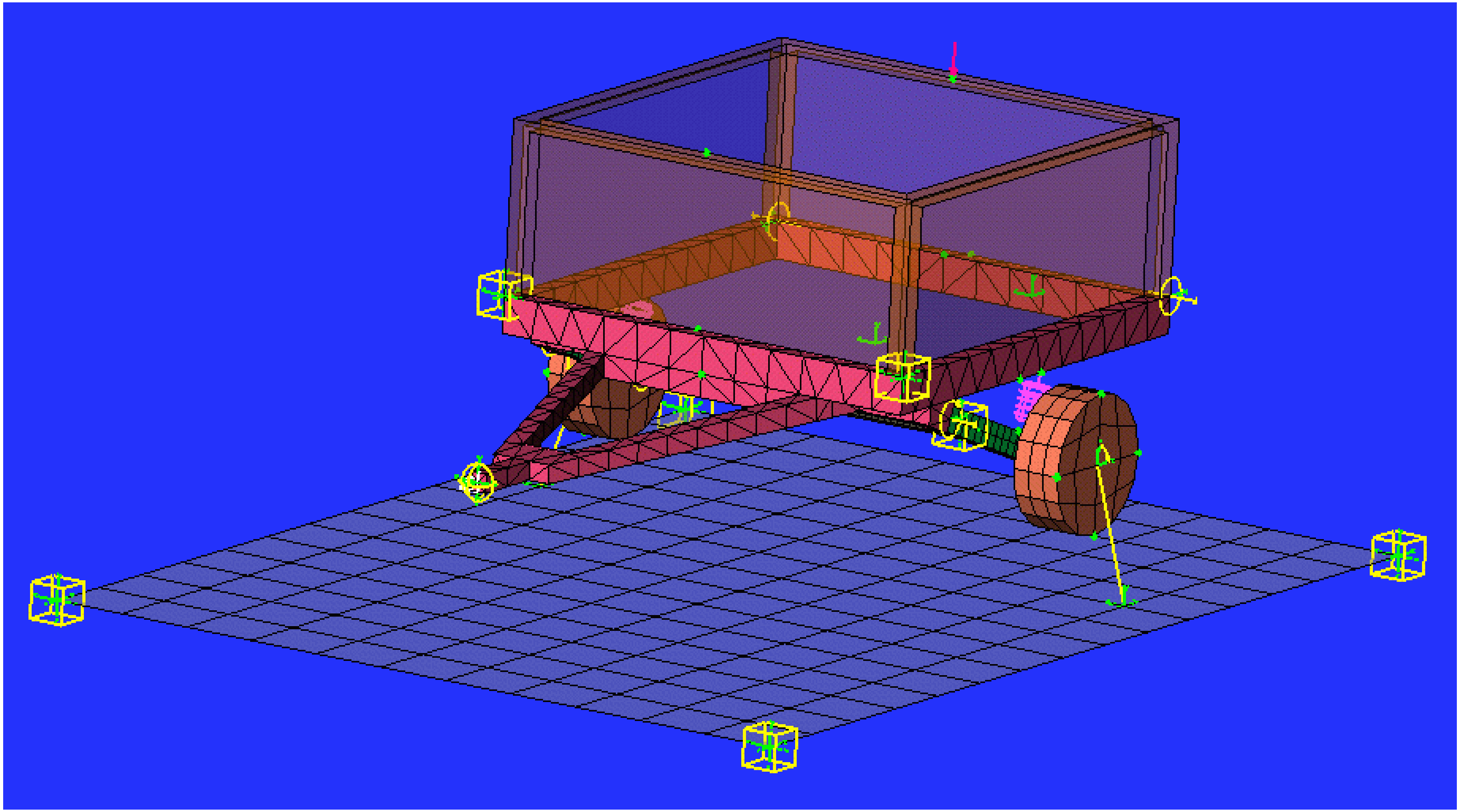
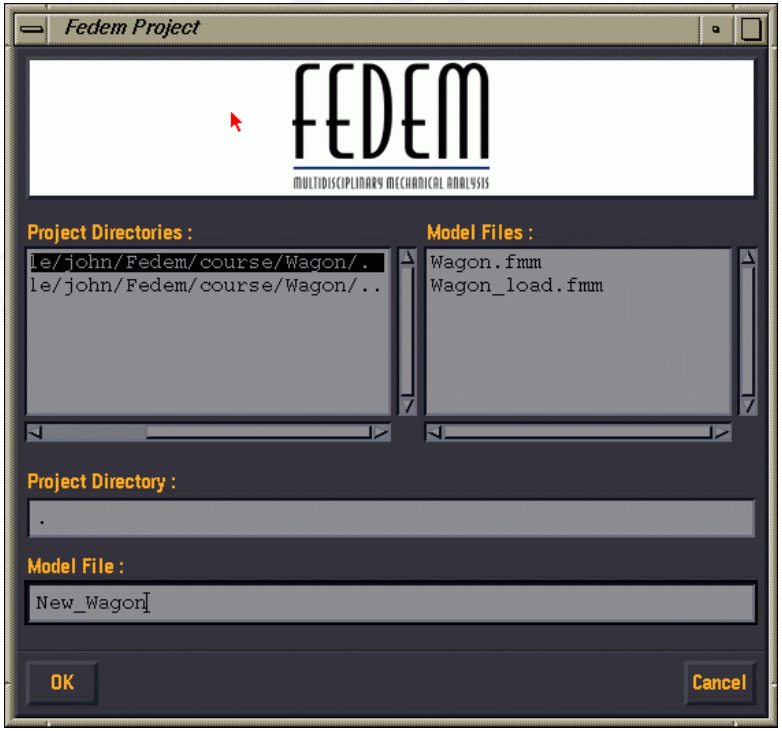
Workshop 3

Basic modeling techniques



Start

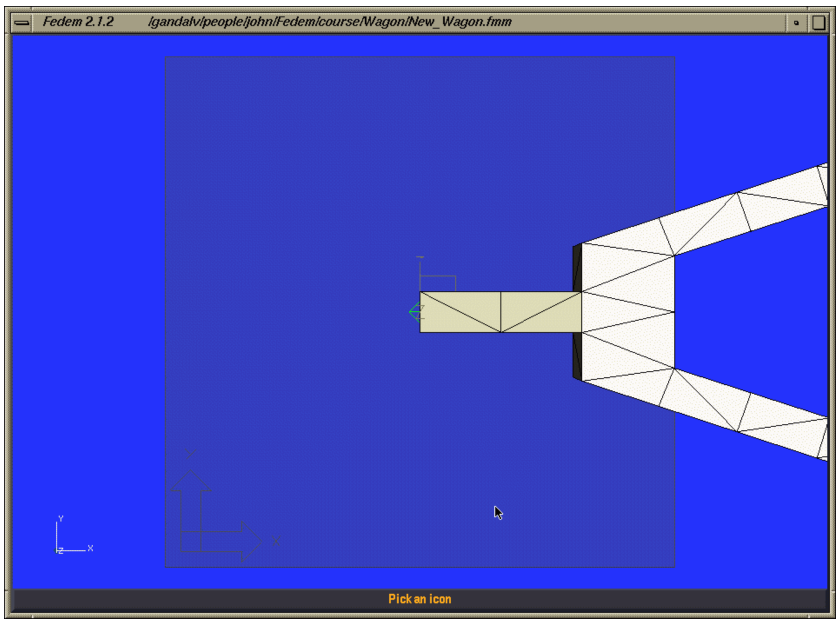
- Go to the ~course/Wagon directory
- Start Fedem by typing fedem at the prompt
- In the *Fedem Project* window, enter a new file name at the *Model File:* entry
- Press OK

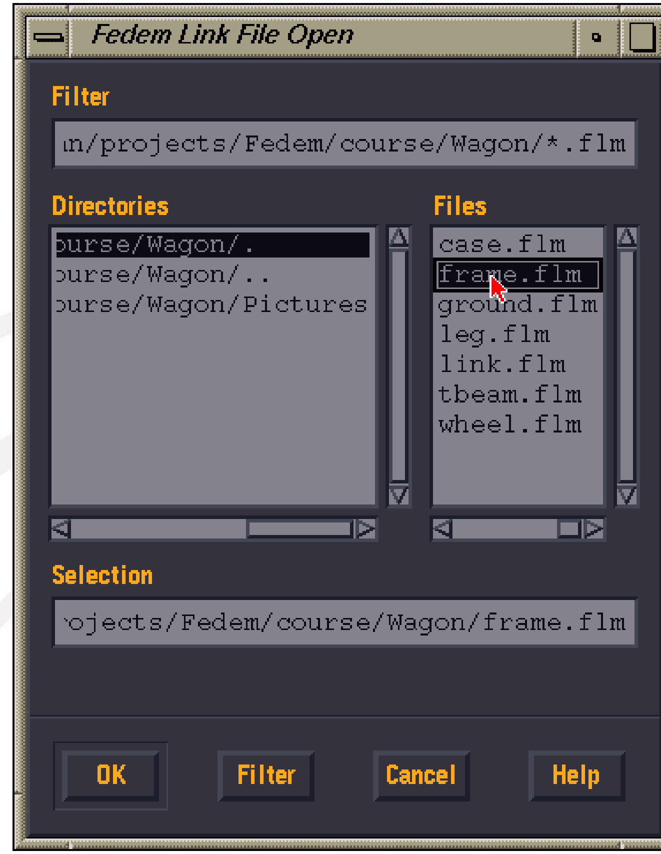


Import the first link

Select the *Import F.E. Link* icon

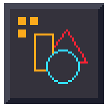
- In the *Fedem Link File Open* select the *frame.flm* file



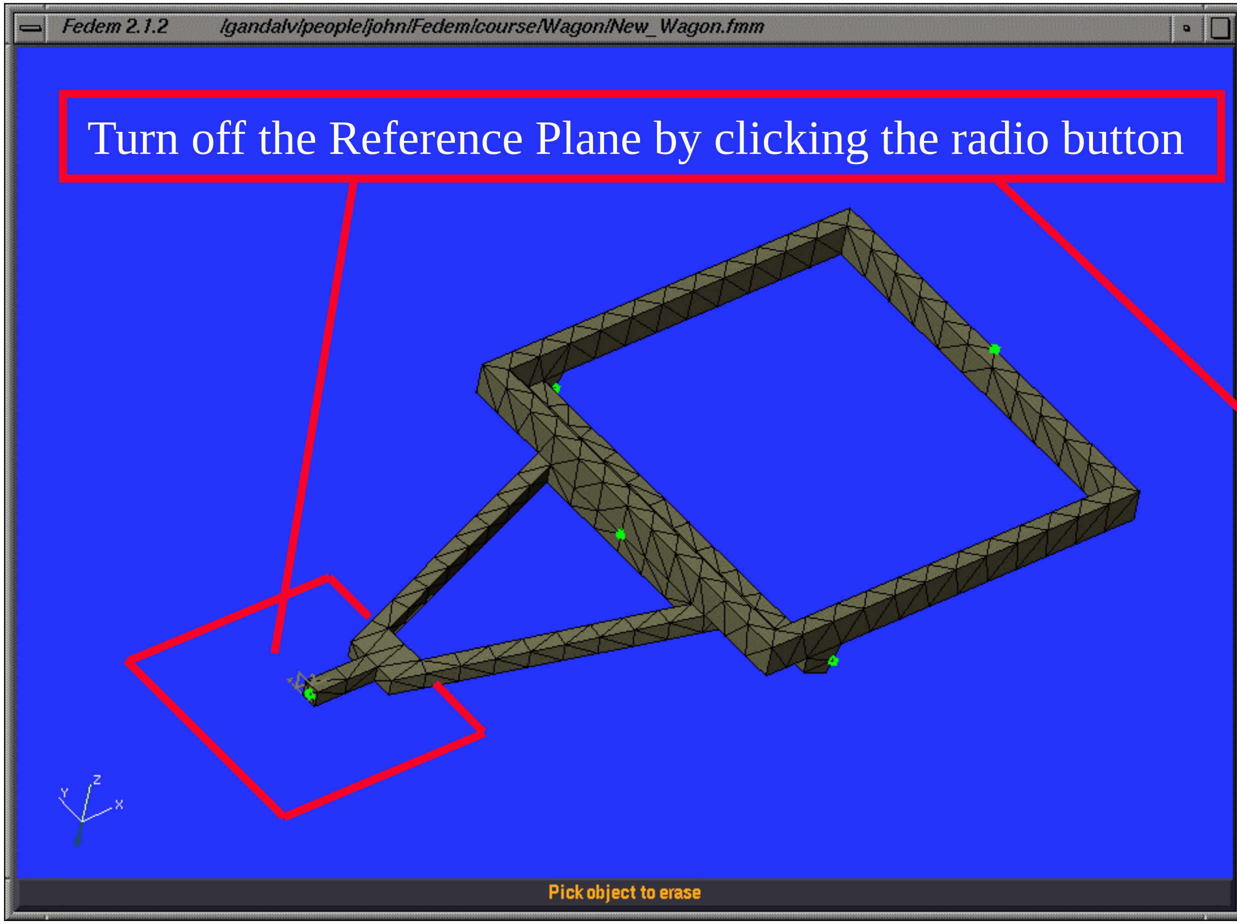


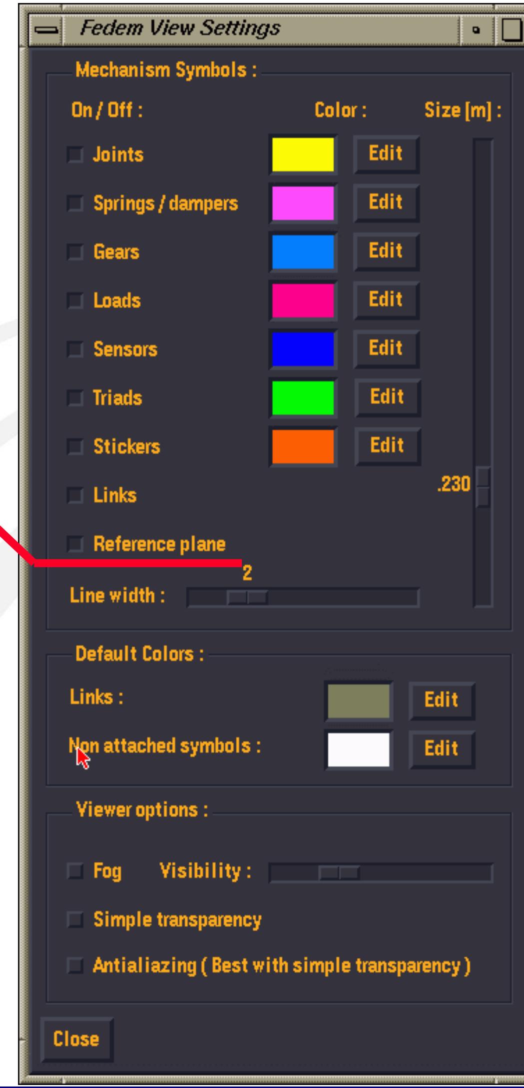
- The **frame** link appear in the modeling window

Turn off the Reference Plane



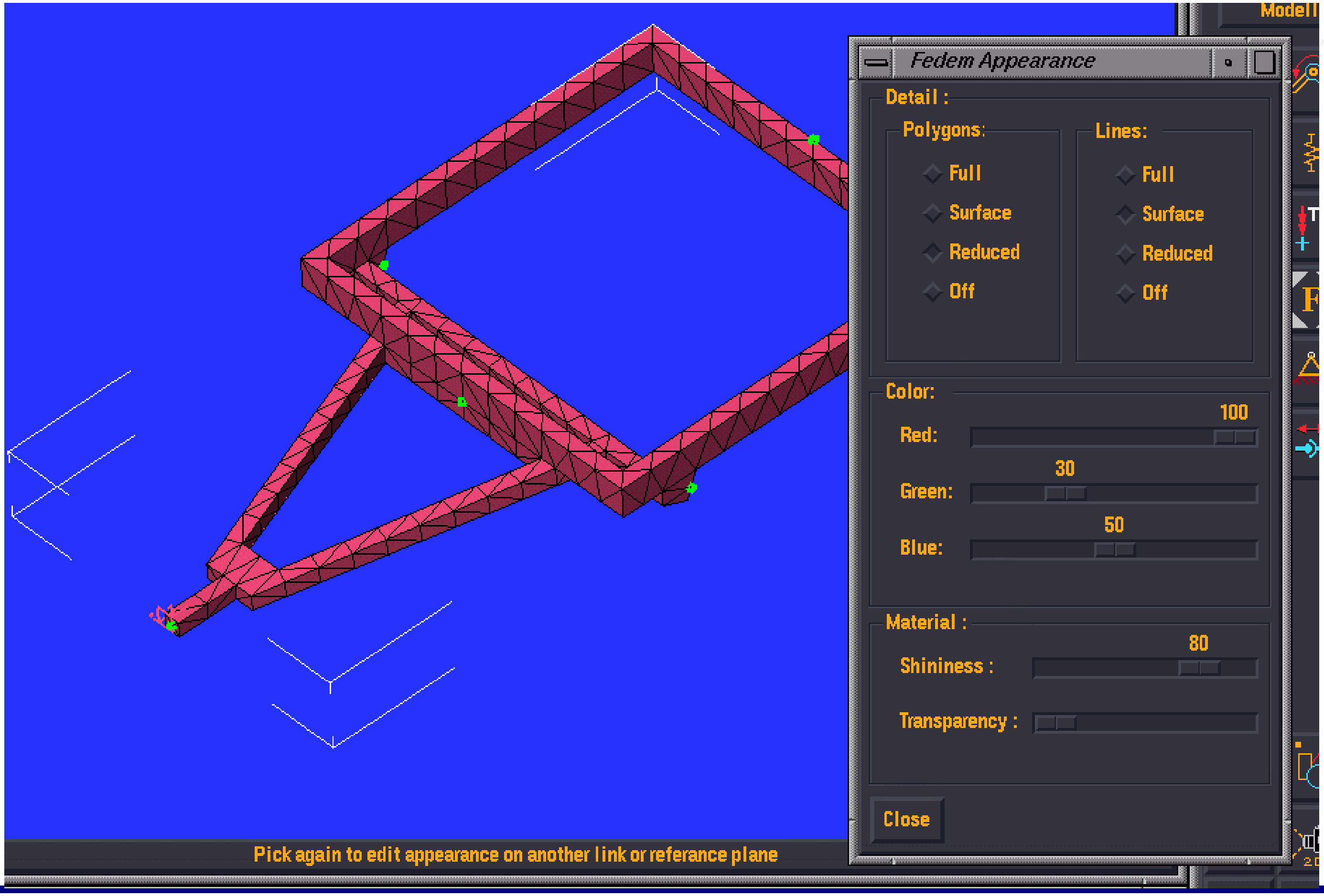
Use the *View Filter* icon to turn off the *Reference Plane*





Change appearance

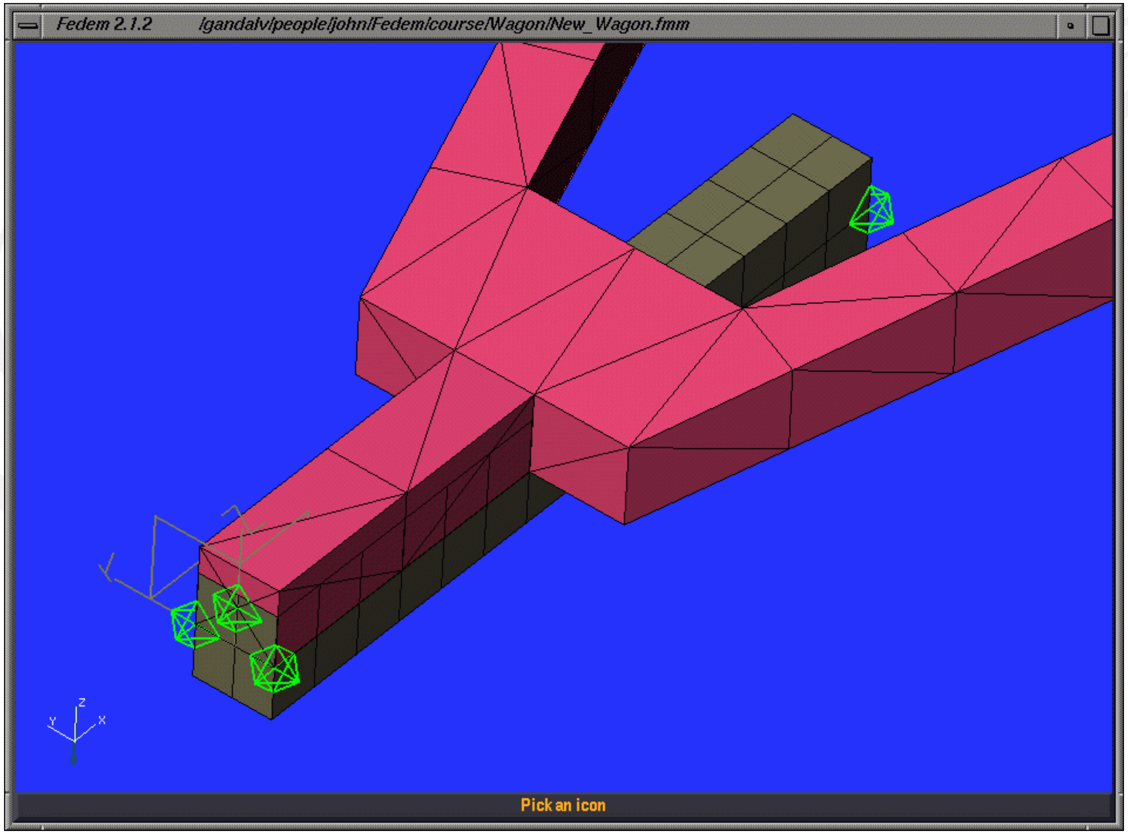
Pick the *Appearance* icon and change the color of the **frame** link to *Red:100, Green:30, Blue:50*



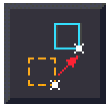
Import the leg link

Use the *Import F.E. link* icon and import the **leg** link into the model

- The new **leg** link occupy partly the same space as the **frame** link

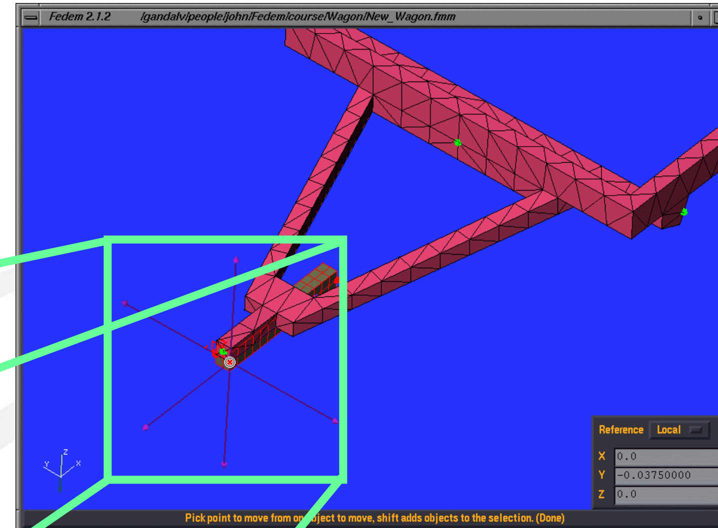


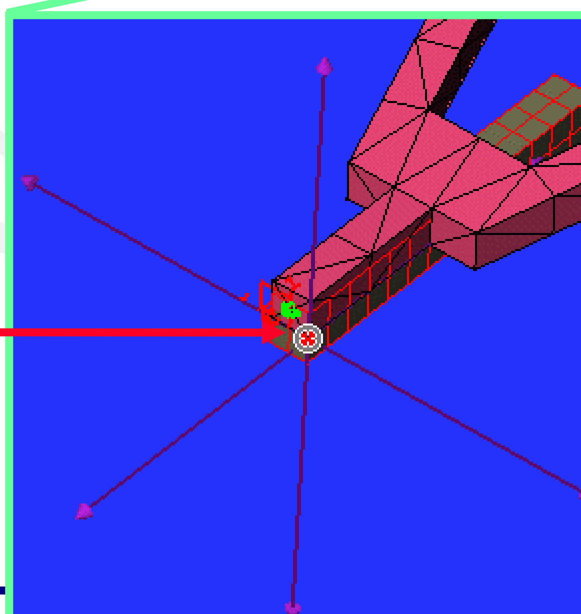
SmartMove



Select the *SmartMove* icon and select Point 1 as shown on the figure below

- Be sure that you pick the point until the **leg** link is highlighted
- Notice the arrows indicating a pure translation of the link (pick twice)



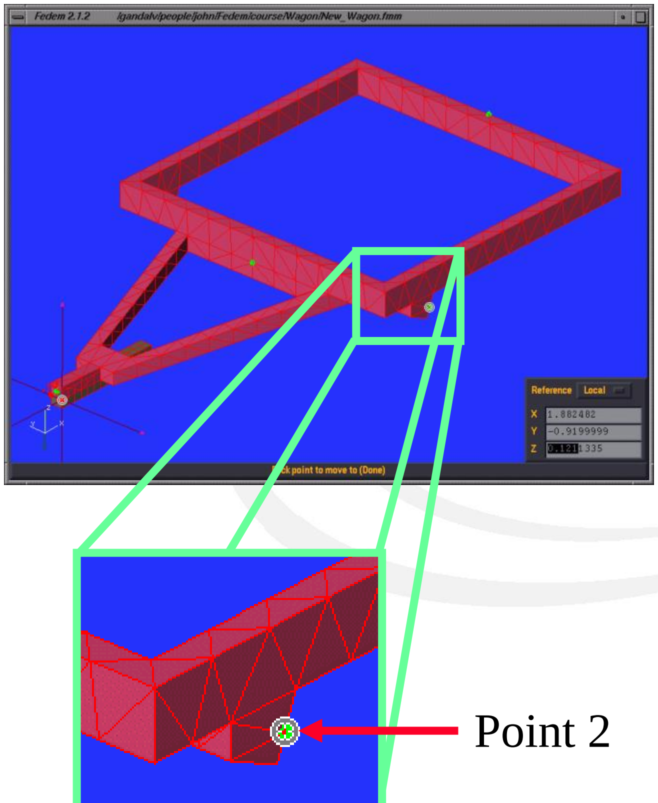


Point 1 with 3D Point Marker

Press "Done" (Middle Mouse Button) to accept the selection

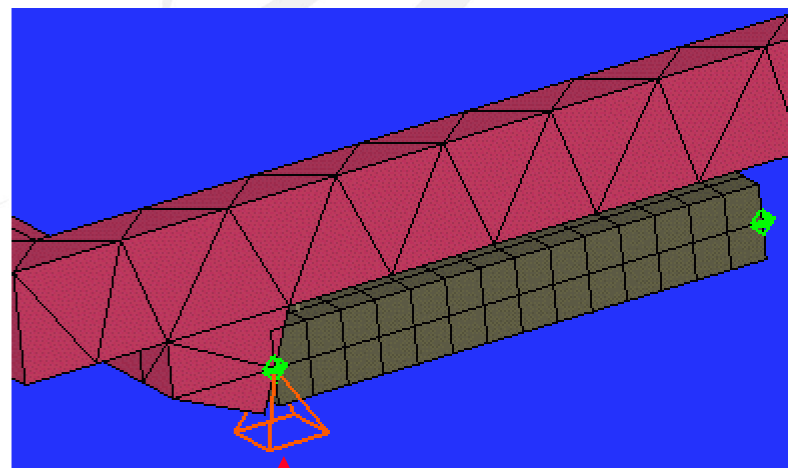
SmartMove

- When the guide ask you to pick point to move to, select Point 2, be sure to highlight the **frame** link



Point 2

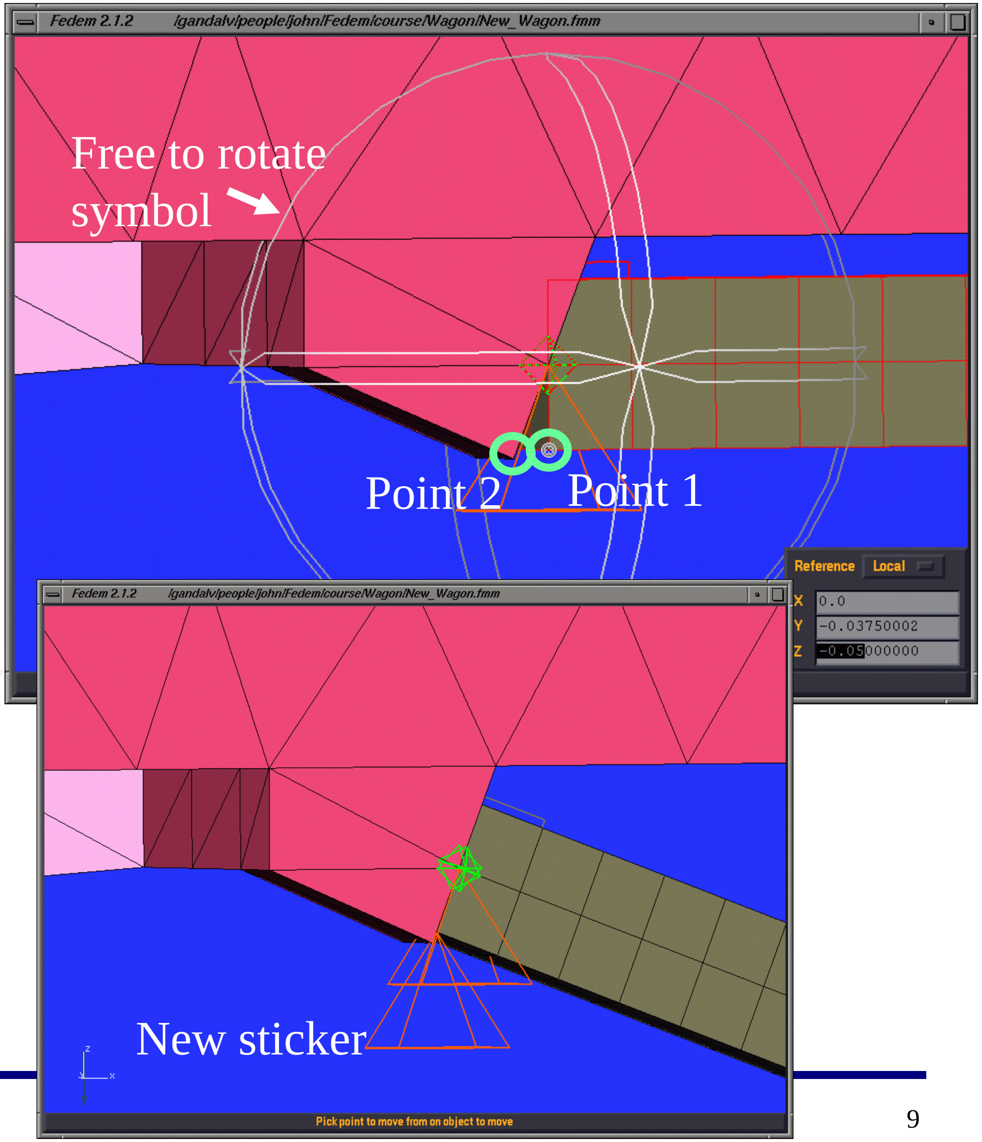
- The **leg** link is translated from Point 1 to Point 2, and a *Sticker* is created at Point 1 (On the **leg** link), constraining the **leg** link from any further translations



Sticker

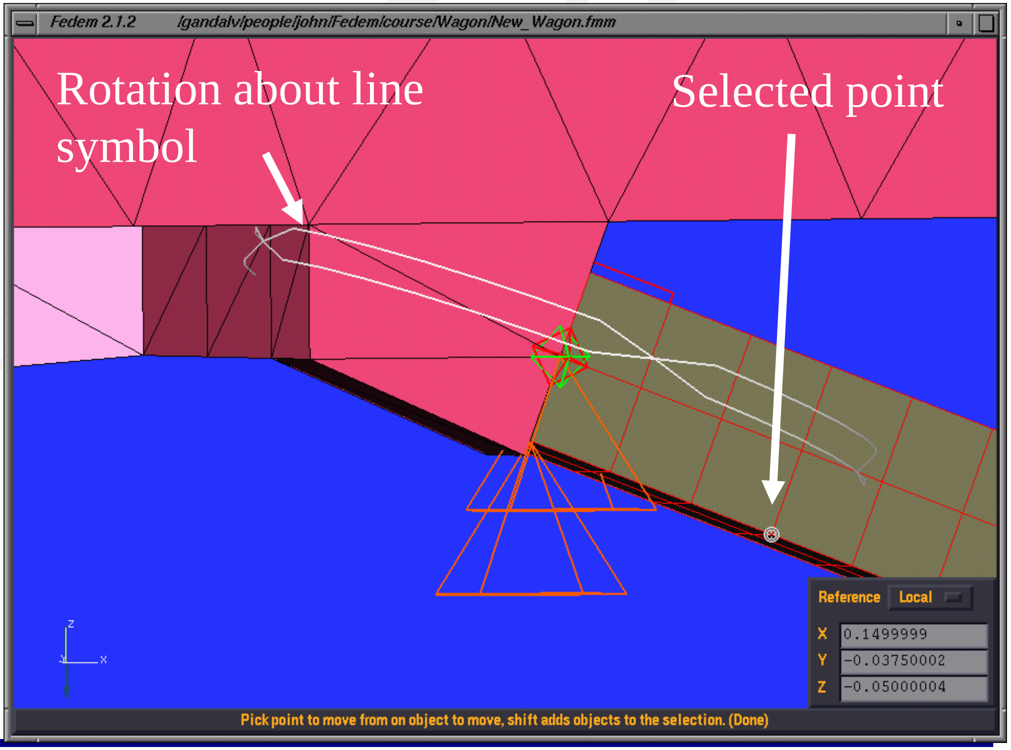
SmartMove

- You should still be in the *SmartMove* command, if not select the *SmartMove* icon again
- Select Point 1, accept
- Notice the Ball symbol, indicating that the **leg** link is free to rotate about the first *Sticker*
- Select Point 2, accept
- The **leg** link is rotated because Point 1 is trying to get as close to Point 2 as possible
- A new *Sticker* is created



SmartMove

- So far we have used one translation and one rotation about a point in our position of the **leg** link. There is still one possible movement for the link to do, rotation abort a line
- Try to pick the proposed point on the **leg** link while you still are in the *SmartMove* command, do not accept
- The *Rotation about line* symbol indicate the rotation axis
- Accept the selection

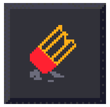


More on Stickers

- Select the same point as the point to move to, since the **leg** link already is in the correct position, accept
- A third *Sticker* is applied to the **leg** link

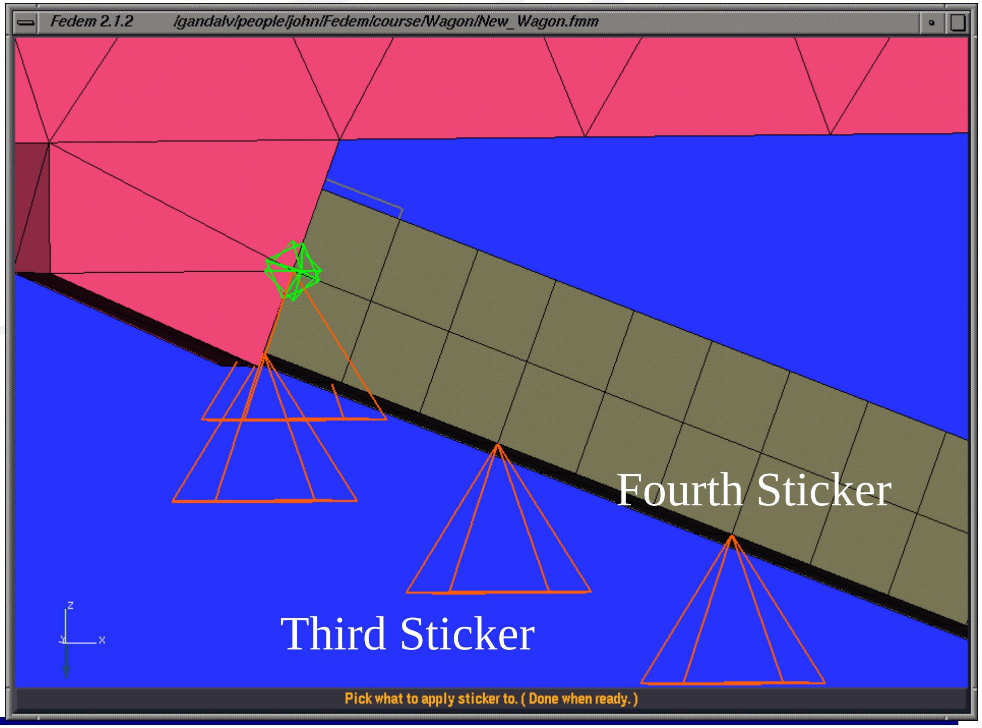
Create a fourth *Sticker* with the *Sticker* command

All *Stickers* may be deleted with the *Erase all stickers* command



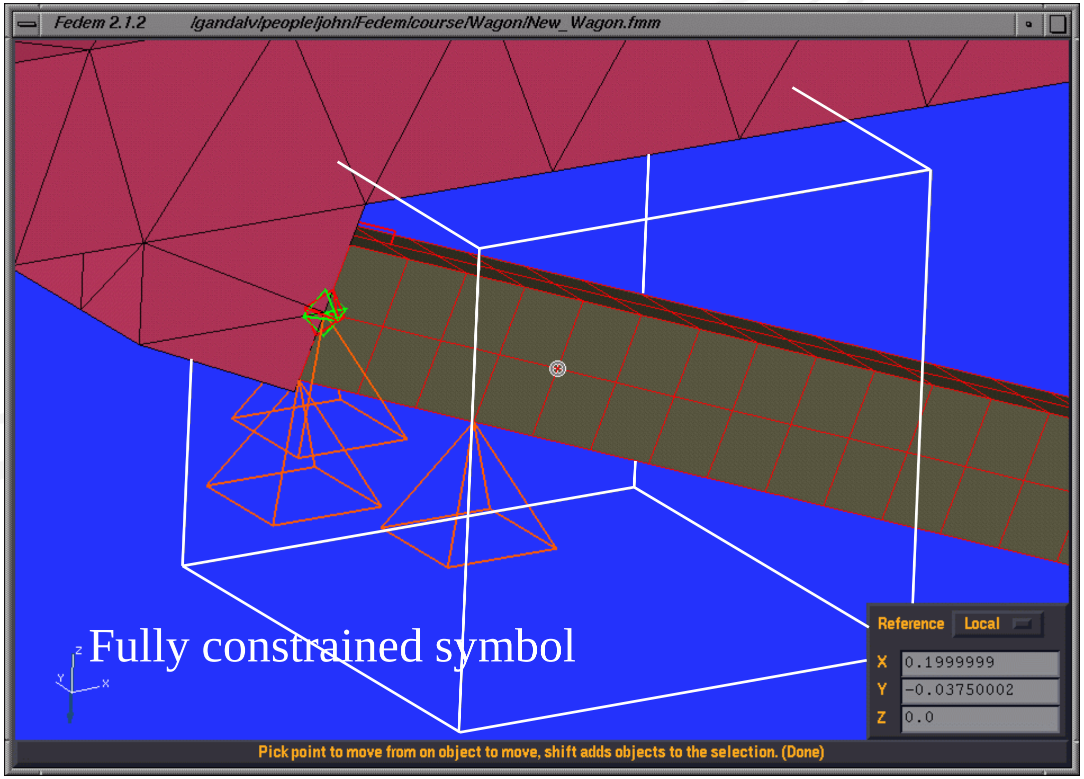
Individual *Stickers* may be erased with the *Erase* command

- Erase the fourth *Sticker*



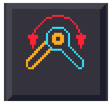
Fully constrained link

- Try to perform a fourth move on the **leg** link. When you select a point on the link to move, the *Fully constrained symbol* appear, indicating that no further position is possible for this link

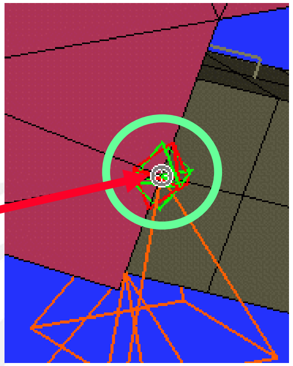


Create a Revolute joint

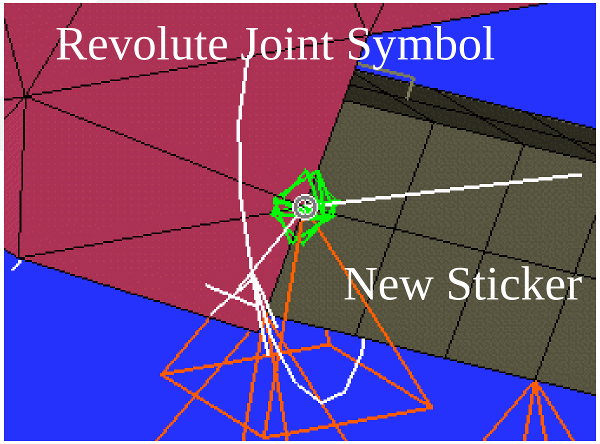
- If you plan to connect two links with a joint, it is wise to create the joint when the links are positioned correctly with regards to each other



Select the *Revolute Joint* command

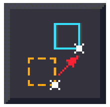


- Pick the node where to put the *Revolute Joint*
- The *Revolute Joint* appear, note that a new *Sticker*, overlying one of the previous *Stickers*, is created in the center of this joint



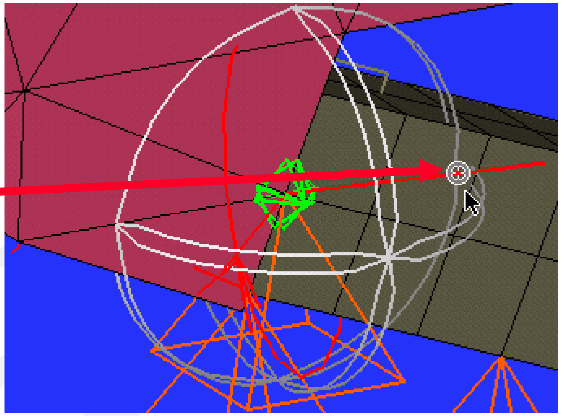
Tip: Picking a surface near the node will create the *Revolute Joint* with the revolute axis perpendicular to the surface

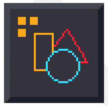
Use SmartMove to position the Revolute Joint



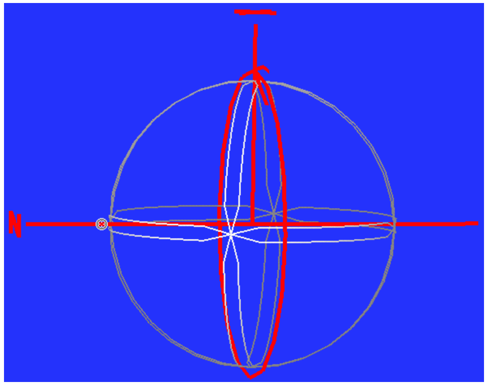
Select the *SmartMove* command

- Pick on the Z-axis for the *Revolute Joint* until the *3D Point Marker* snaps to the axis, and the *Revolute Joint* gets highlighted, accept



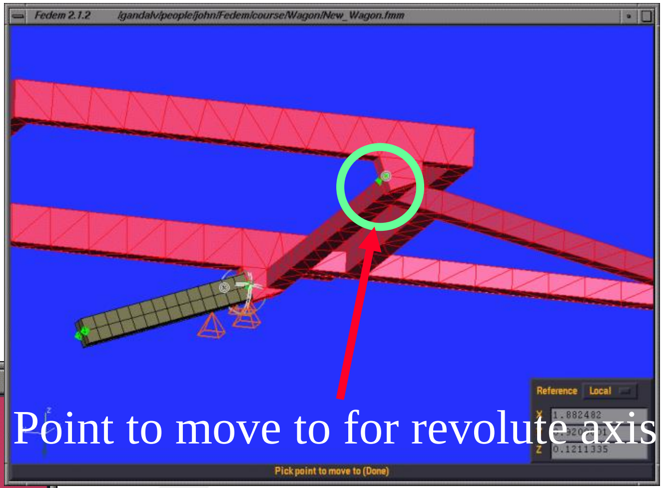


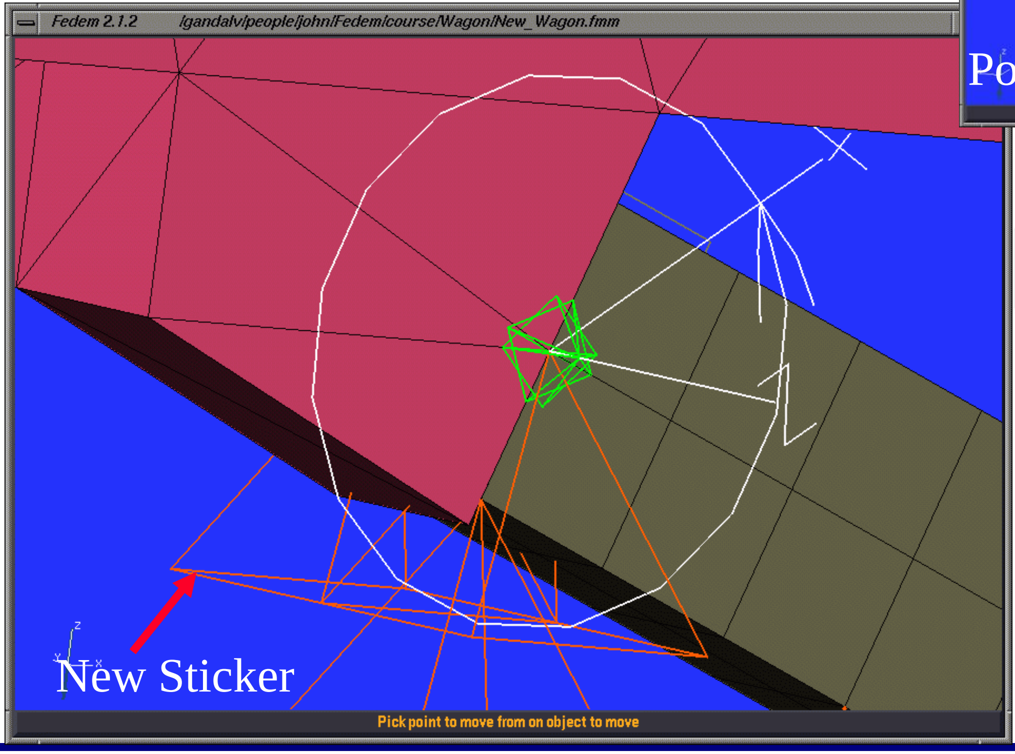
Tip: When you create complex assemblies it may be difficult to select a specific point, i.e. a joint. To make it easier, use *View Filter* and turn of the link, stickers, etc. Then select the point and turn the display of the hidden entities on again



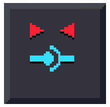
Use SmartMove to position the Revolute Joint

- Pick on the green marker at the opposite side of the **frame** link, accept
- The revolute axis is correct and locked by with a new *Sticker*



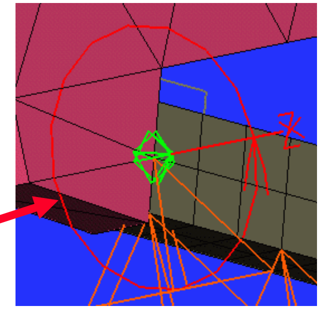


Attach the Revolute Joint

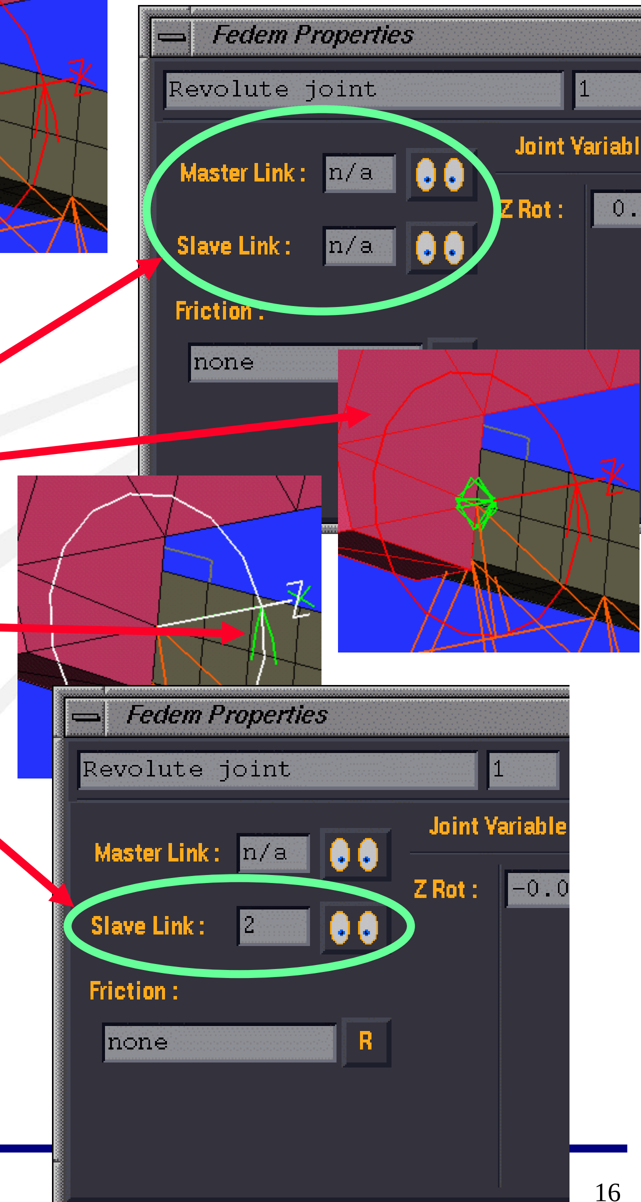


Select the *Attach* icon

- Pick the *Revolute Joint*, accept
  - In the *Fedem Properties* window you can see that the joint in not attached to anything at the moment

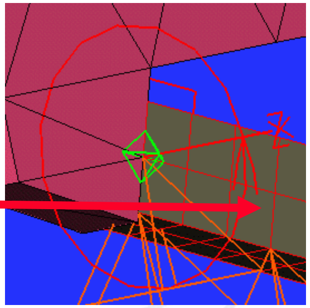


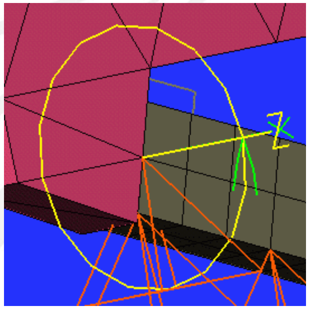
- Pick the first link to attach to, accept
  - The joint slave triad is connected to the link, green arrow
  - and the slave link ID is displayed



Attach the Revolute Joint, cont.

- Pick the *Revolute Joint* again, accept
- Pick the second link to attach to, accept
  - The joint master triad is attached to this link
- The *Revolute Joint* is now attached, and have a yellow and green color
  - *Green color*; joint triads when attached
  - *Yellow color*; joint symbol when attached
- In the *Fedem Property* window the ID for the master link is displayed
- Use the *"Eyes"* to highlight the respective links



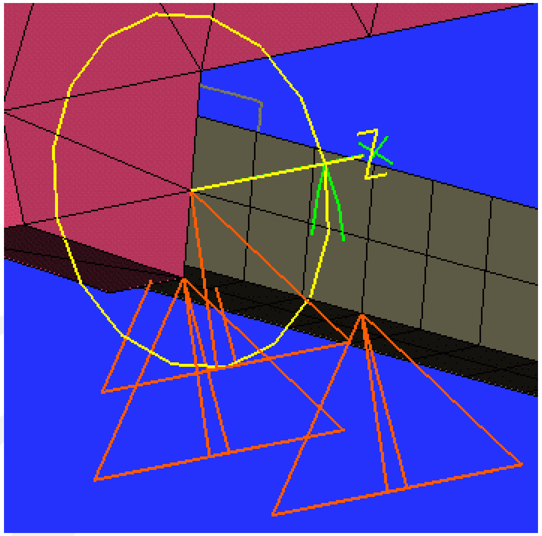


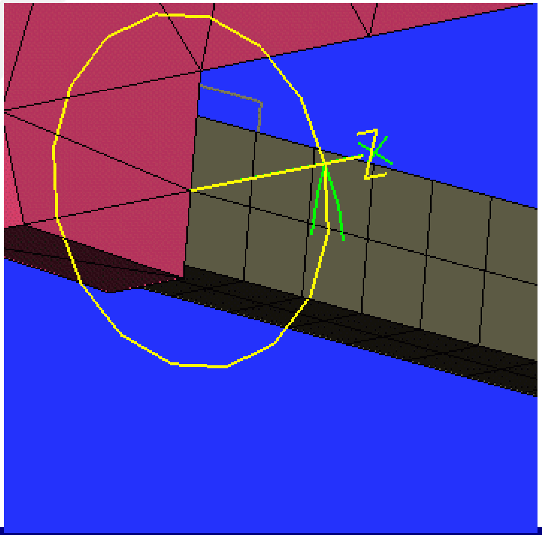
Delete Stickers

- When the links are connected through joints, you may delete the *Stickers* to reduce clutter on your screen

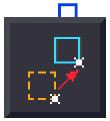
Pick the *Erase all stickers* icon

- All the *Stickers* are deleted





Use the joint with SmartMove

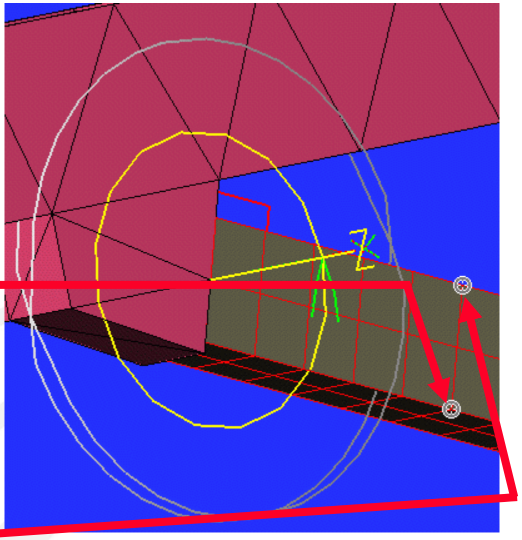


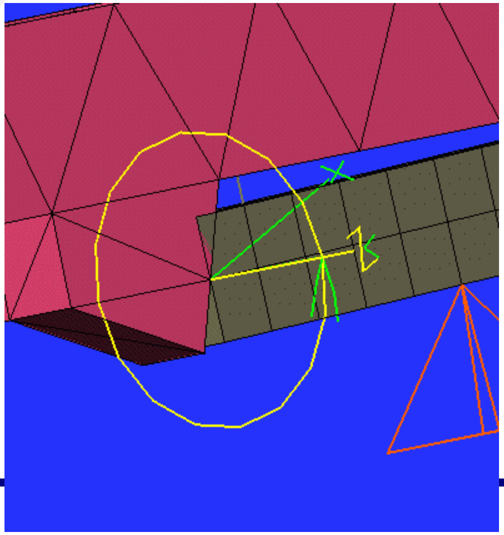
- *SmartMove* can take advantage of the degrees of freedom the joint implies to the links

  Pick point to move, accept

  - Notice that the *Free to rotate about axis* symbol shows that the **leg** link can rotate about the Z-axis for the *Revolute Joint*

- Pick point to move to, accept
- The **leg** link is rotated, and a *Sticker* is created

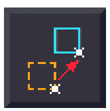




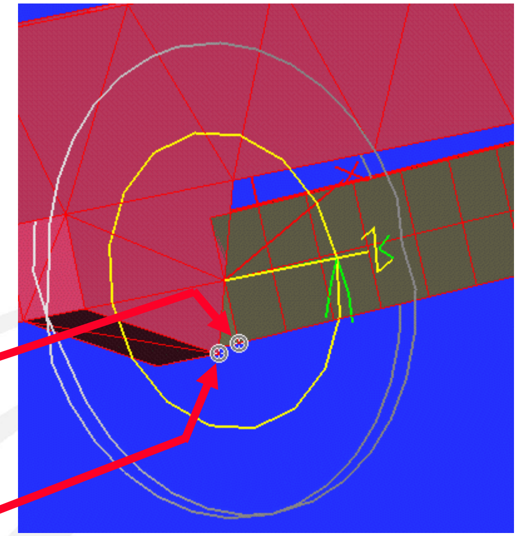
Restore leg link position

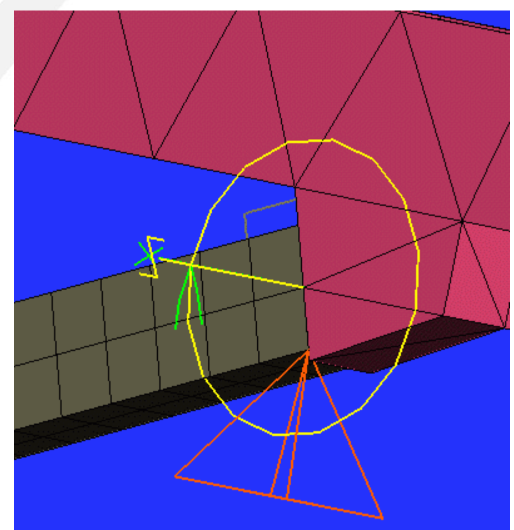
- We want to restore the **leg** link to the previous position

Delete the *Sticker*



Select point to move, accept

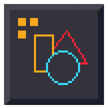




- Select point to move to, accept
- The new *Sticker* will prevent the **leg** link from moving any further, so we will keep it

Change appearance for the leg link

- All new links that are imported into Fedem gets a gray color by default

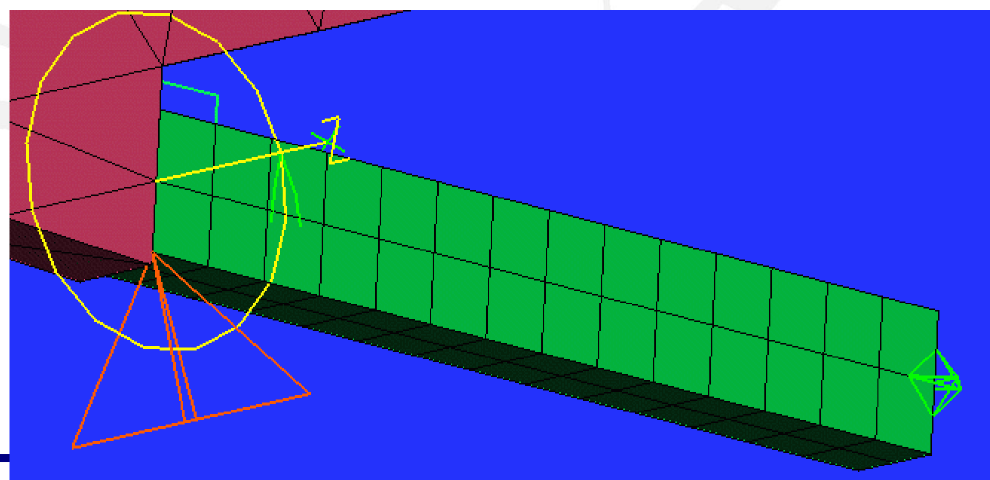


The default color for imported links can be changed in the *View Settings* window

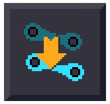
- Before we create the next **leg** link, change the color on the present one

Select the *Appearance* icon and pick the **leg** link

- Change the color to *Red:0, Green:100, Blue:36*

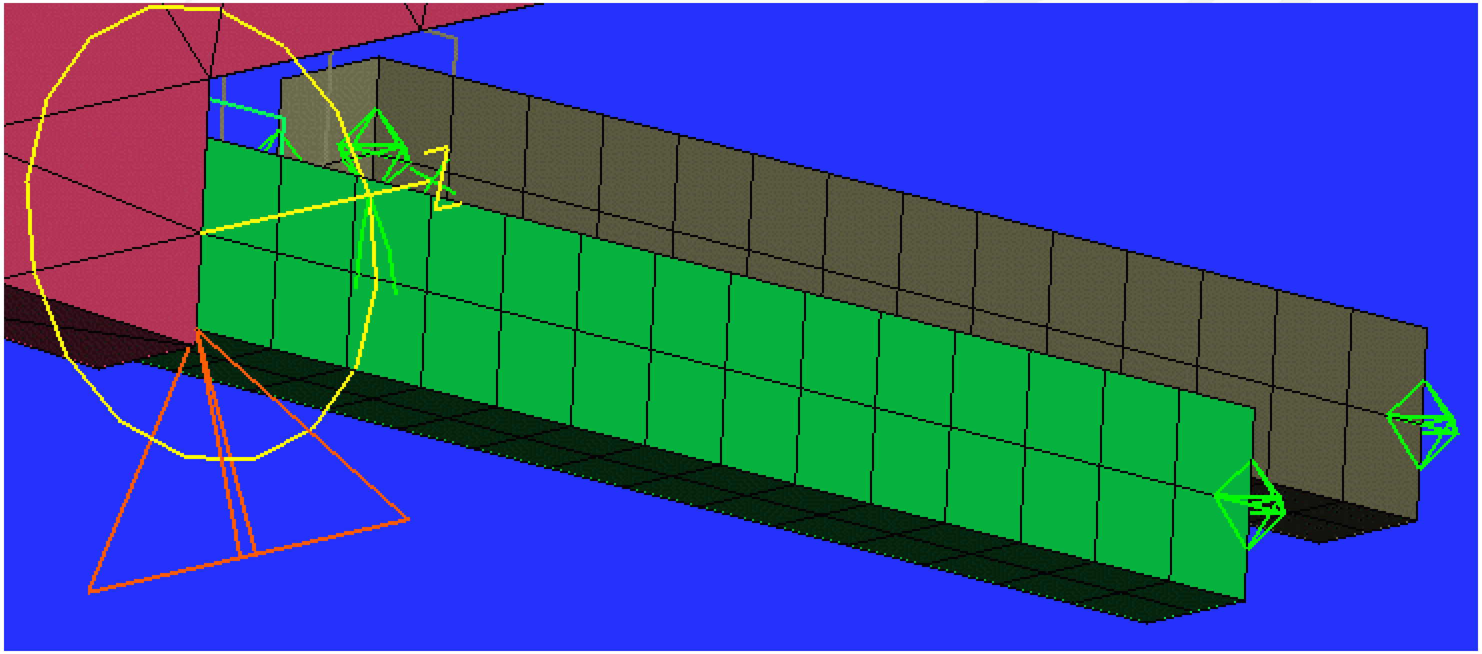


Duplicate the leg link

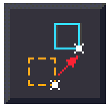


Select the *Duplicate link* icon and pick the **leg** link, accept

- The new link appear at an offset from the original link
  - This is advantageous since the positioning of the new link now only requires one translation

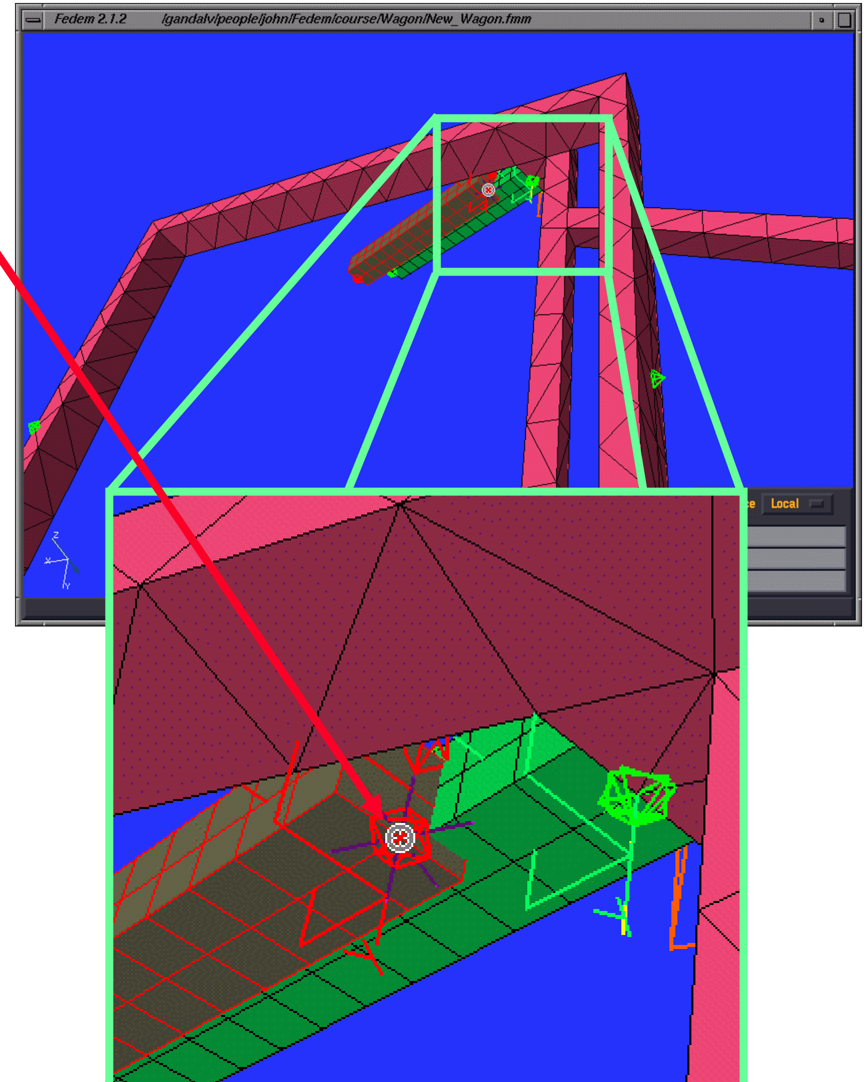


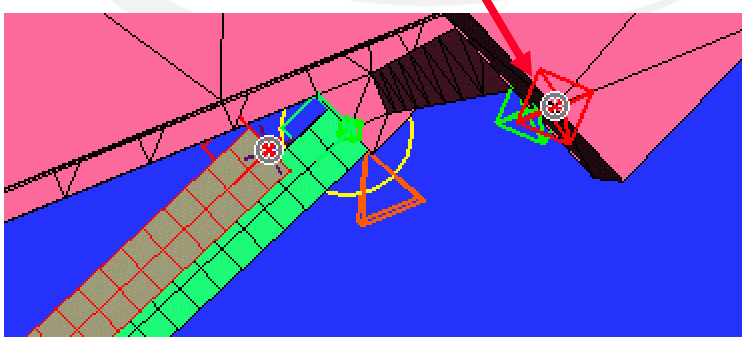
Place the new leg link at the right position



Select *SmartMove* and pick this point as point to move, accept

- Pick this point as point to move to, accept



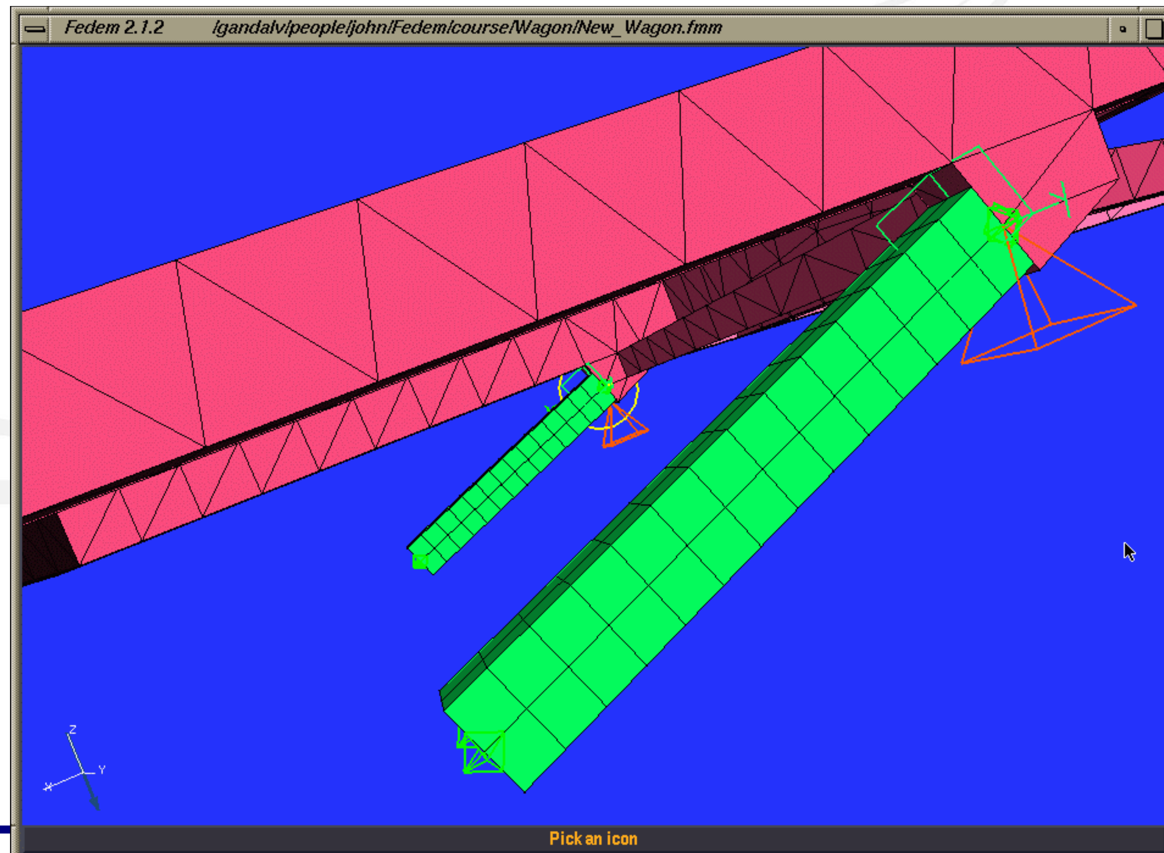


The new leg is in the right position

- Notice that since we duplicated the first **leg** link, we only needed one *SmartMove* to finish the positioning of the second **leg**

Change the color for the new link to match the first **leg**

- *Red:0*
- *Green:100*
- *Blue:36*



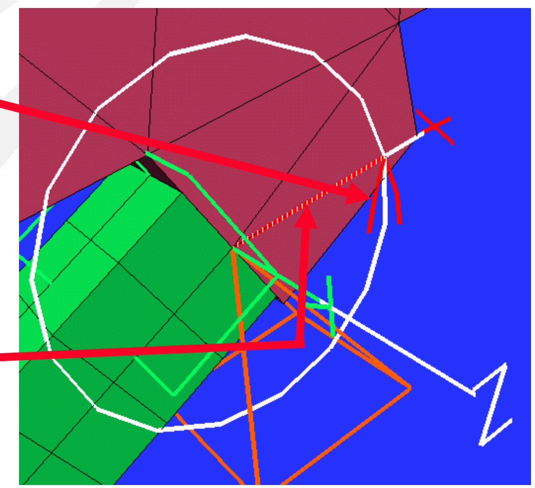
Revolute Joint

Create a *Revolute Joint* between the new **leg** and the **frame**

Tip: Try to pick on the surface near the node where you want to place the joint. Chances are that the revolute axis will be perpendicular to the face

- If the joint have a wrong orientation, use *SmartMove* to align the z-axis

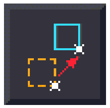
Attach the *Revolute Joint*, this time try to select the joint triads individually



- Pick first the arrow on the *Revolute Joint* symbol
  - This is the slave triad for the joint
- Pick the **leg** as the link to connect the slave triad to
  - The slave triad gets a green color
- Pick the x-axis line
  - This is the master triad
- Pick the **frame** as the link to connect the master triad to
  - Both joint triads are connected, and the joint is yellow and green

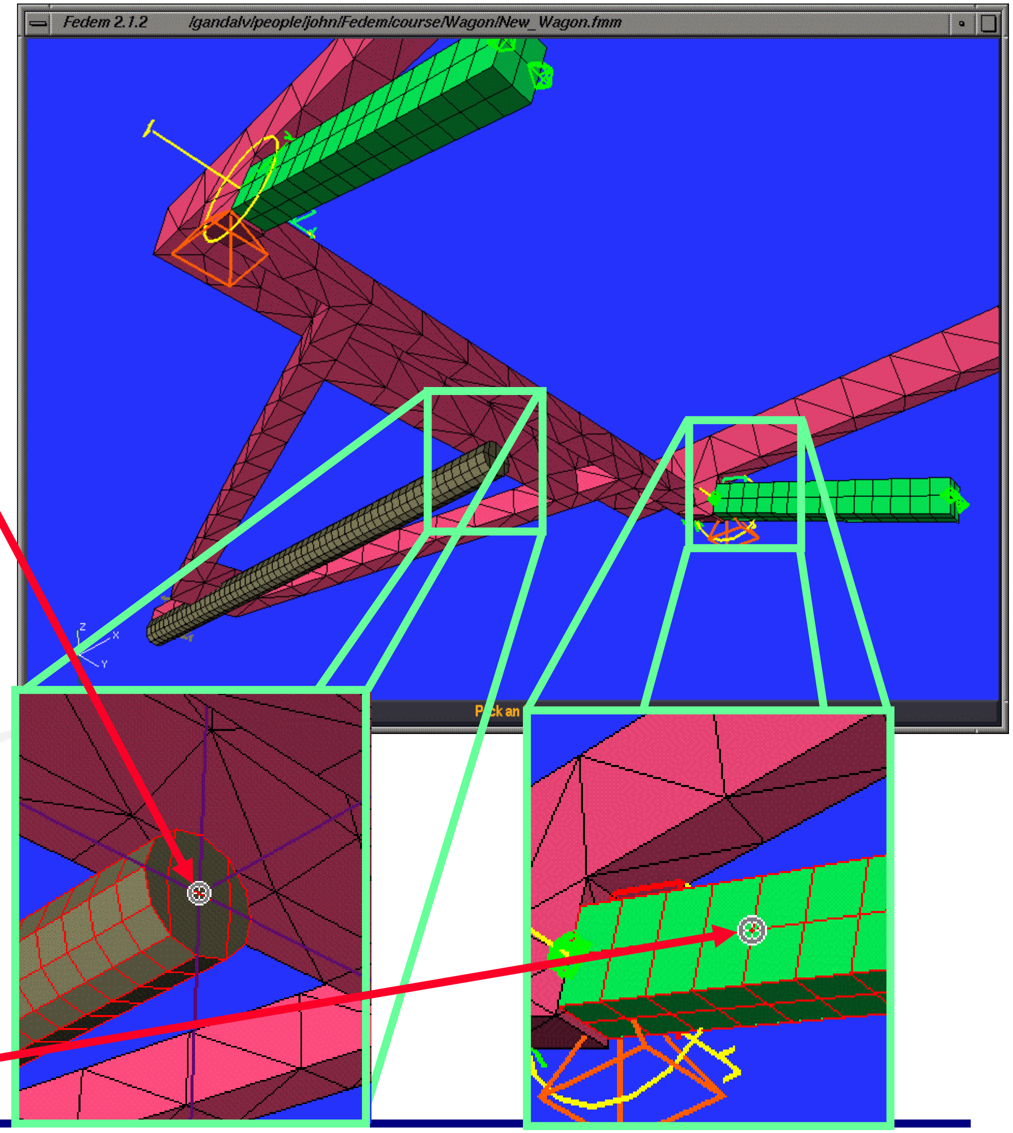
Import the tbeam (torsion beam)

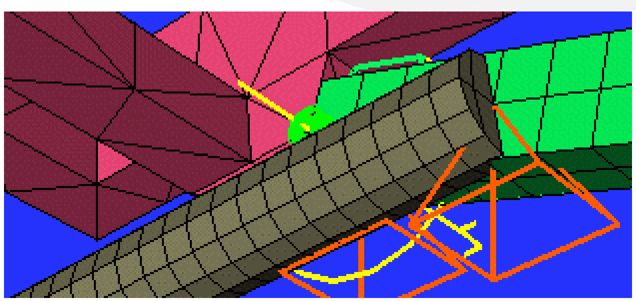
Import the **tbeam** link



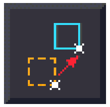
SmartMove the **tbeam**

- Point to move
- Point to move to





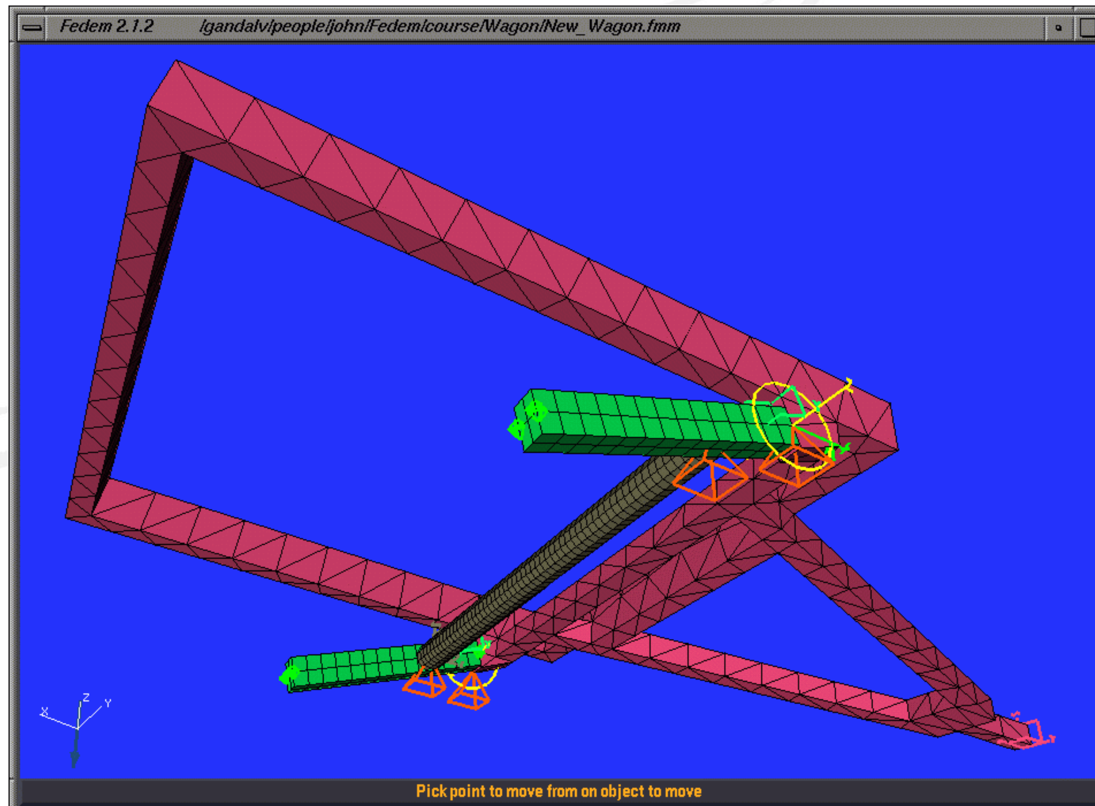
SmartMove the tbeam



Use *SmartMove* to connect the other end of the **tbeam** to the opposite point on the first **leg**

Tip: If for any reason a *SmartMove* operation does not go as planned, just delete the last *Sticker* and try again

Tip: Remember to use the F4 key to pick focus point

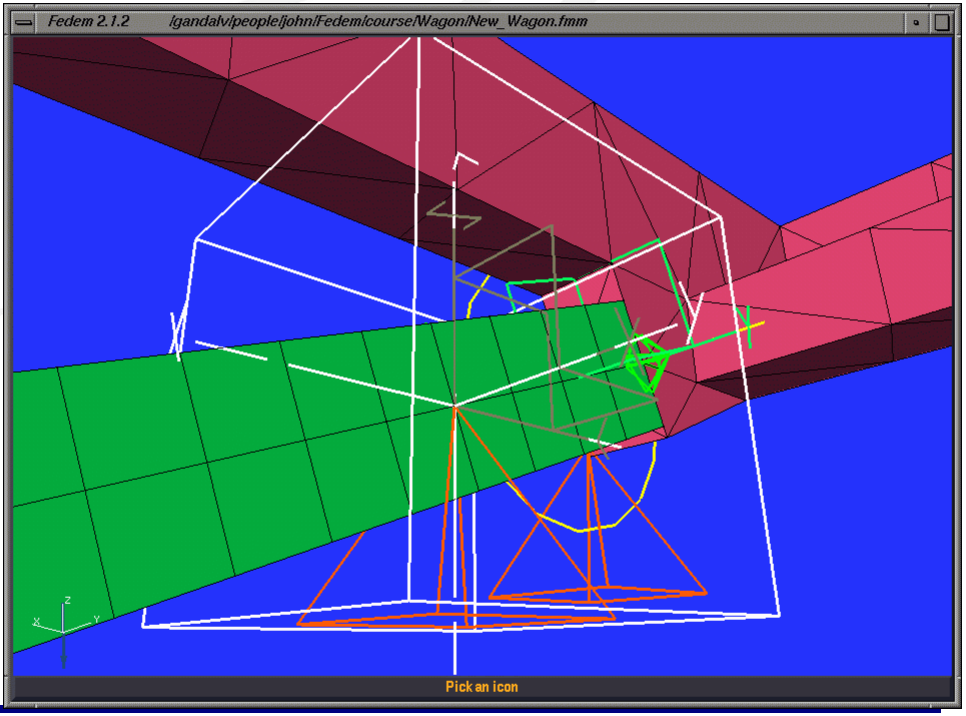


Apply Rigid Joints to the tbeam

To make it easier to place out the *Rigid Joints* that we are going to connect the **tbeam** to the **legs** with, pick the *Appearance* icon and select the **tbeam**

- Set both *Polygons* and *Lines* to *Off*
- The **tbeam** disappear
- Close the *Appearance* window

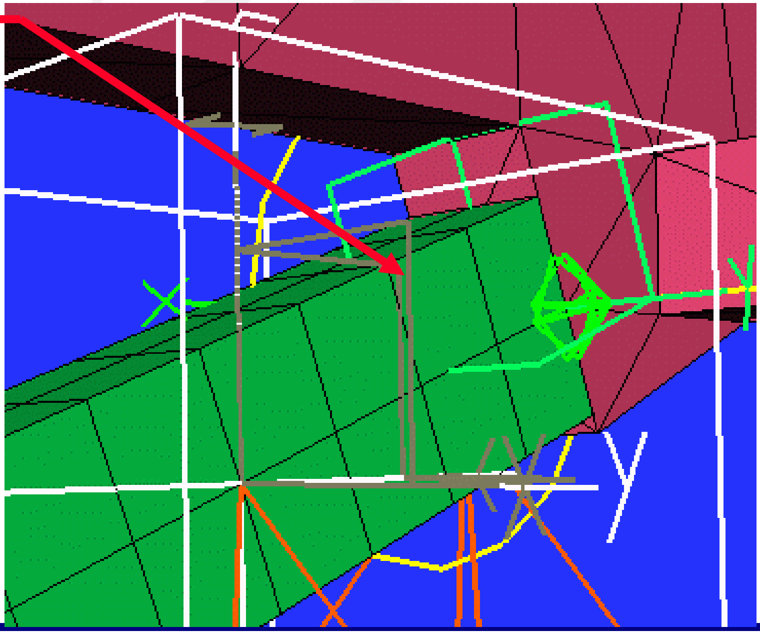
Place one *Rigid Joint* on each **leg**, use the *Stickers* from the *SmartMove* of the **tbeam** as a guide where to put the joints



Make the tbeam visible again

- When both the *Polygons* and the *Lines* in the *Appearance* window are turned off for a link, only the local coordinate system for that link is visible (unless the link contains some rigid elements which will visible as green lines)
- The local coordinate system for a link has the same color as the link

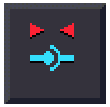
Select the *Appearance* icon, and pick the coordinate system for the **tbeam** link



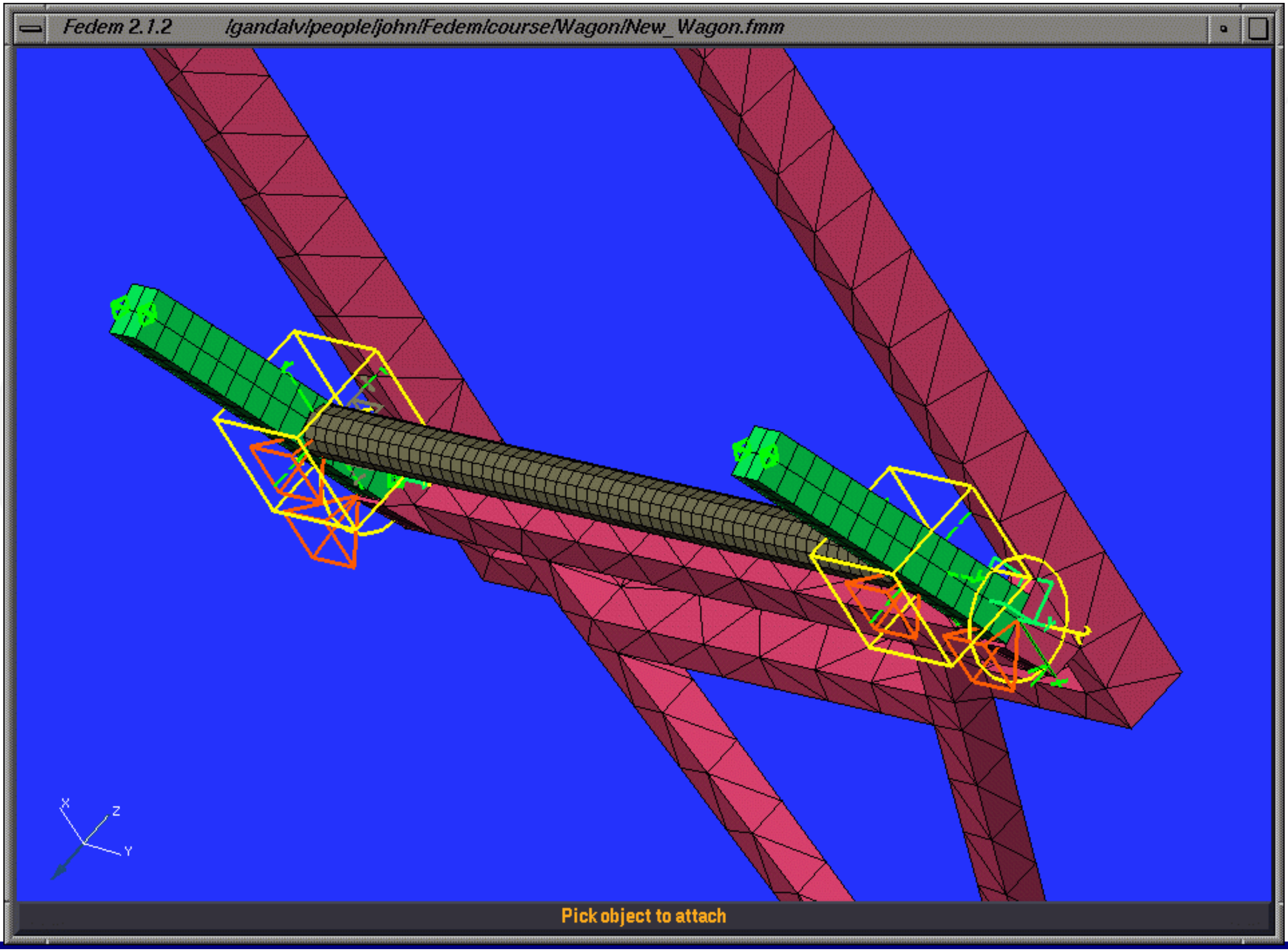
- By accident, the **tbeam** is coincident with the *Rigid Joint* axis in this case

- Set *Polygons* to *Reduced* and *Lines* to *Surface*

Attach the Rigid Joints



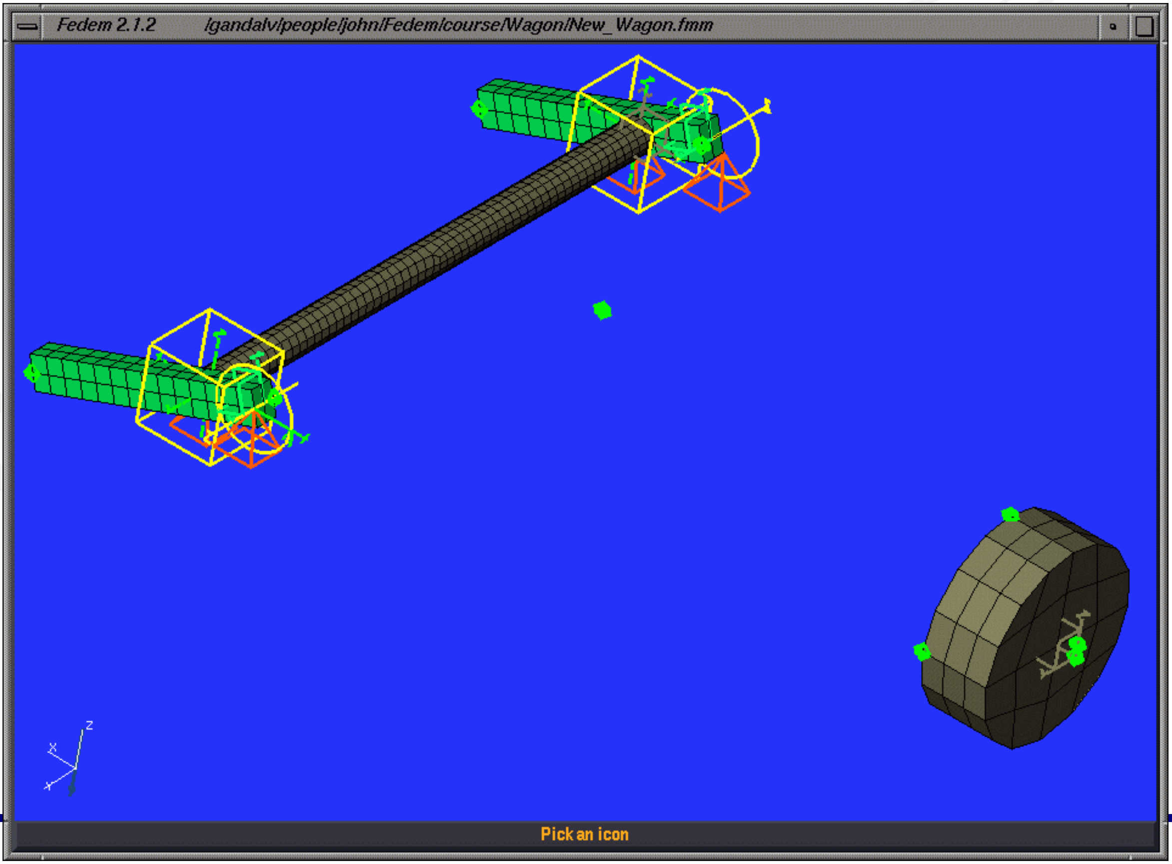
Attach the *Rigid Joints* to the **legs** and the **tbeam**



Hide the frame link and import the wheel link

Hide the **frame** link by setting both *Polygons* and *Lines* to *Off* for this link

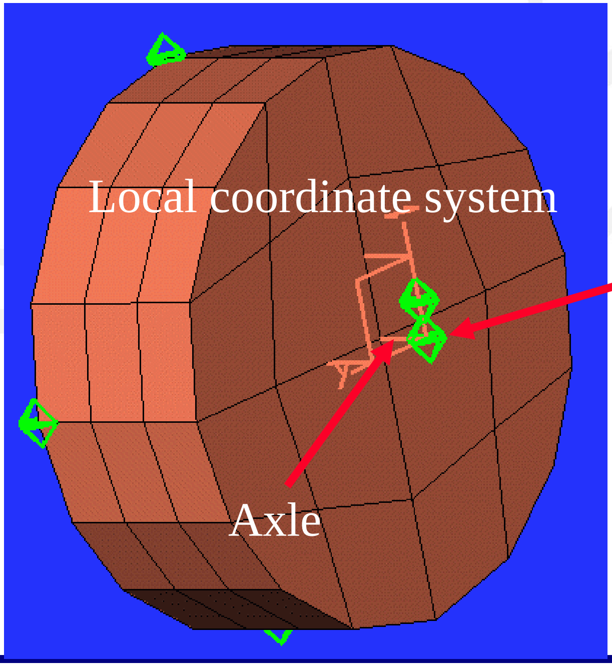
Import the **wheel** link



Wheel

Give the **wheel** a new color, *Red:100, Green:50, Blue:36*

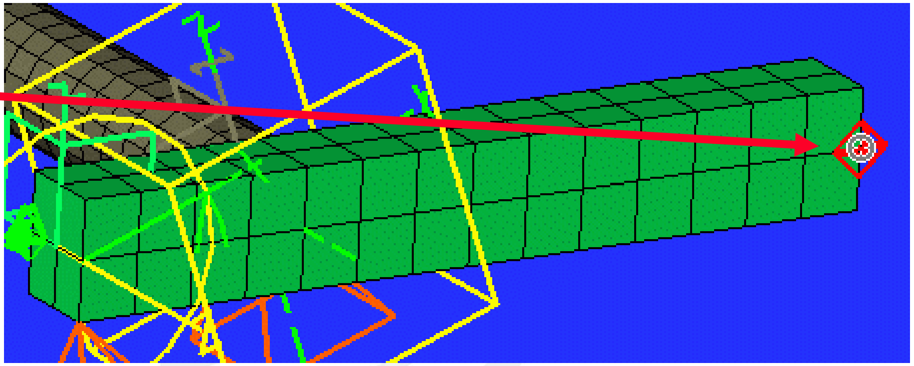
- The **wheel** link is made of shell elements with a beam element as the axle
  - Beam element in Fedem are visualized as lines without the beam cross section
- The beam element goes from the back side of the wheel to the origin of the local coordinate system for the **wheel**

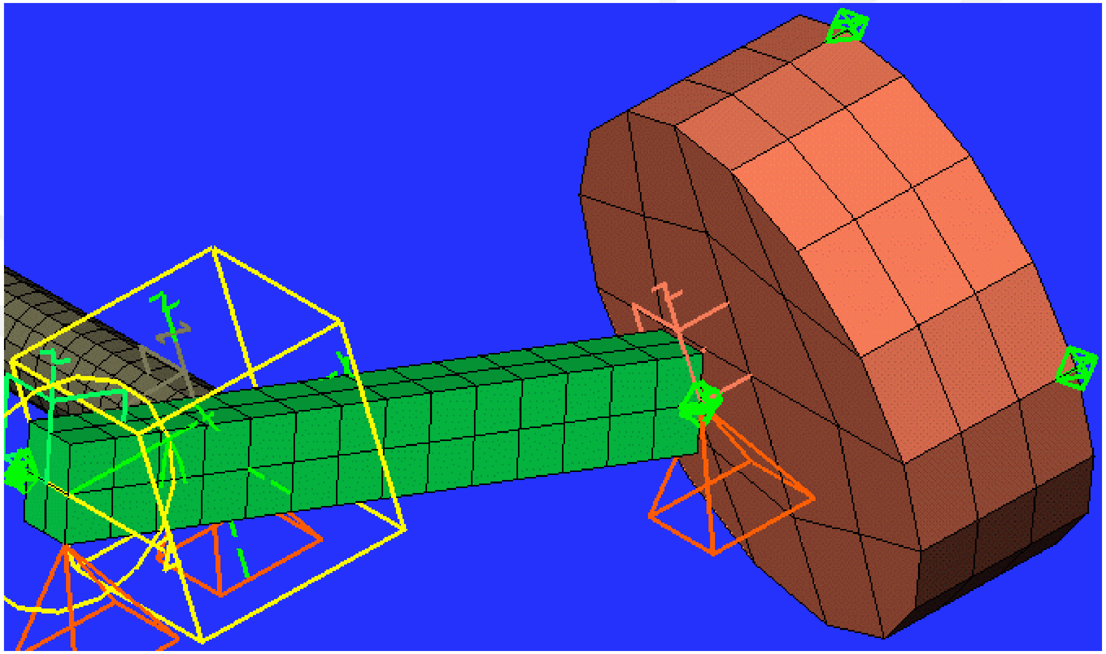


Select *SmartMove* and pick the end of the beam as point to move

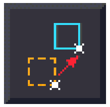
Move the wheel to the first leg

- Select this point as point to move the **wheel** to, accept

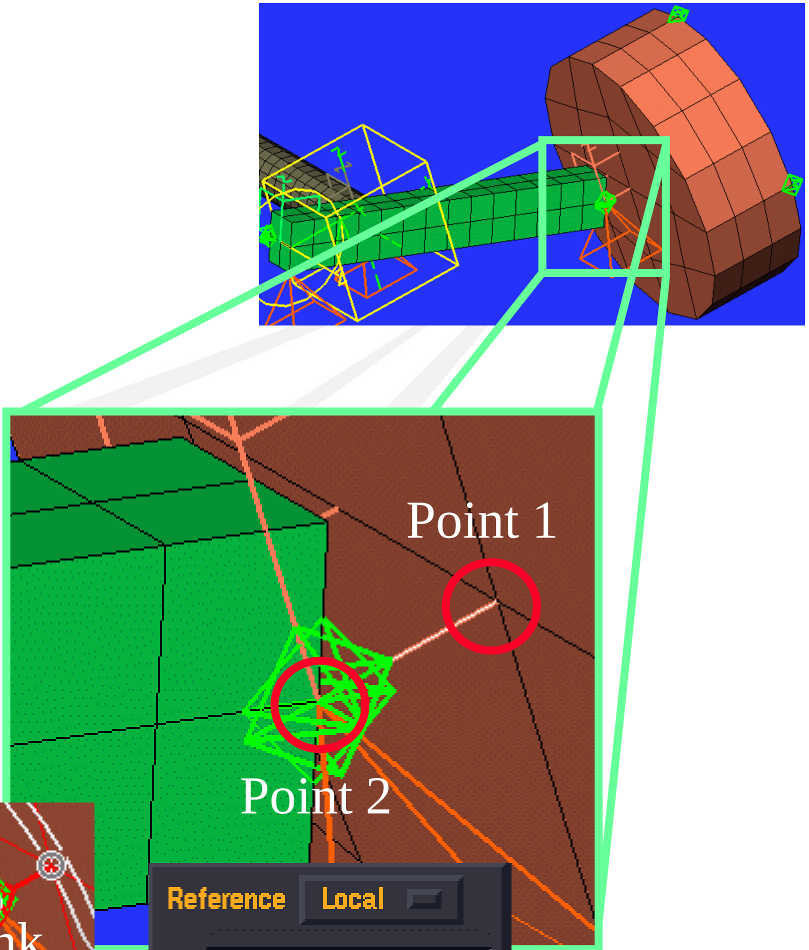


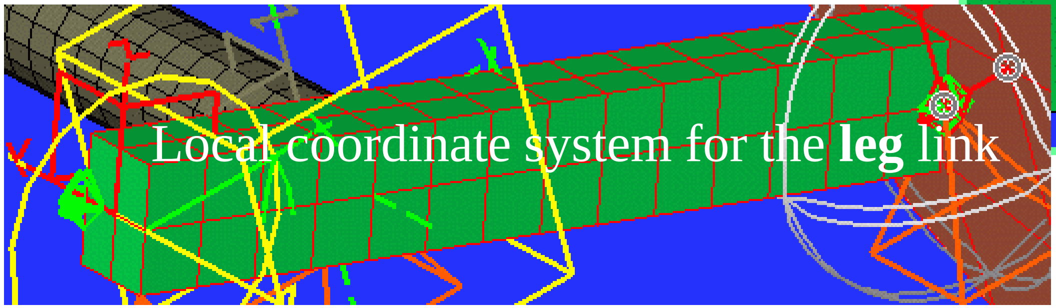


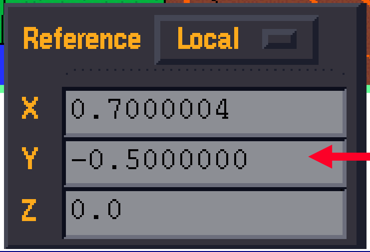
Use the Odometer to position the wheel



- Select Point 1, accept
- Select Point 2, be sure to highlight the **leg** link, do **not** accept
- Look at the local coordinate system for the link, and change the y-coordinate in the *Odometer* to -0.5. Remember to press Enter
  - Notice that the *3D Point Marker* moves to the new point
- Accept with MB2



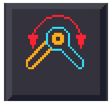




Edit the y-coordinate

Create Revolute Joints for the wheels

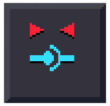
The **wheel** is obstructing the view we need to create the *Revolute Joint* that are going to connect the **wheel** and the **leg**, so use the *Appearance* command to “turn of” the **wheel**



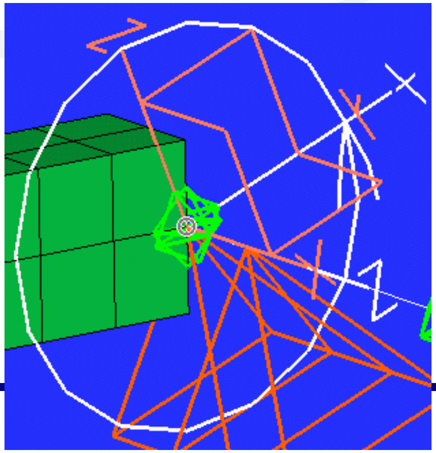
Create and position a *Revolute Joint* at the end of the **leg**

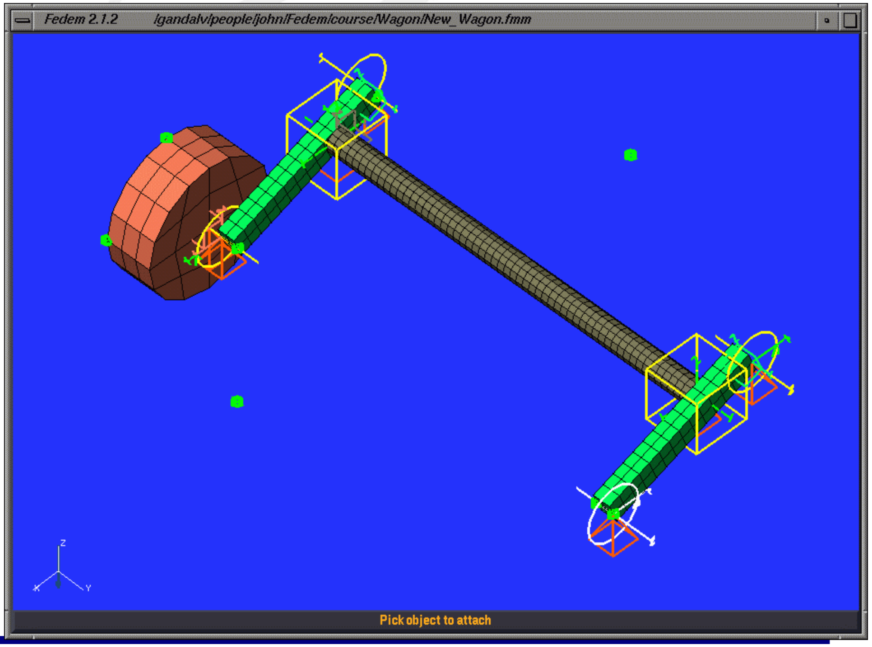
- While we still are in the process of creating *Revolute Joints*, create a joint at the same position on the other **leg**

“Turn on” the wheel again



Attach the *Revolute Joint* to the **wheel** and the **leg**





The second wheel

Import the second **wheel**

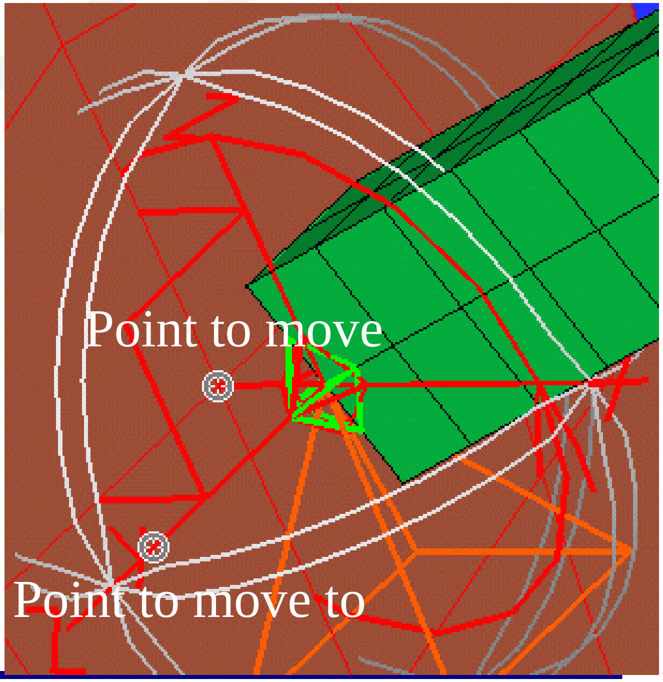
Change the *Appearance* to *Red:100, Green:50, Blue:36*

Move the second **wheel** to the second **leg**

- This time we are going to use the z-axis of the *Revolute Joint* for the next move
  - Select the z-axis as the point to move to

Attach the *Revolute Joint*

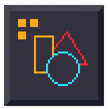
Delete all *Stickers*



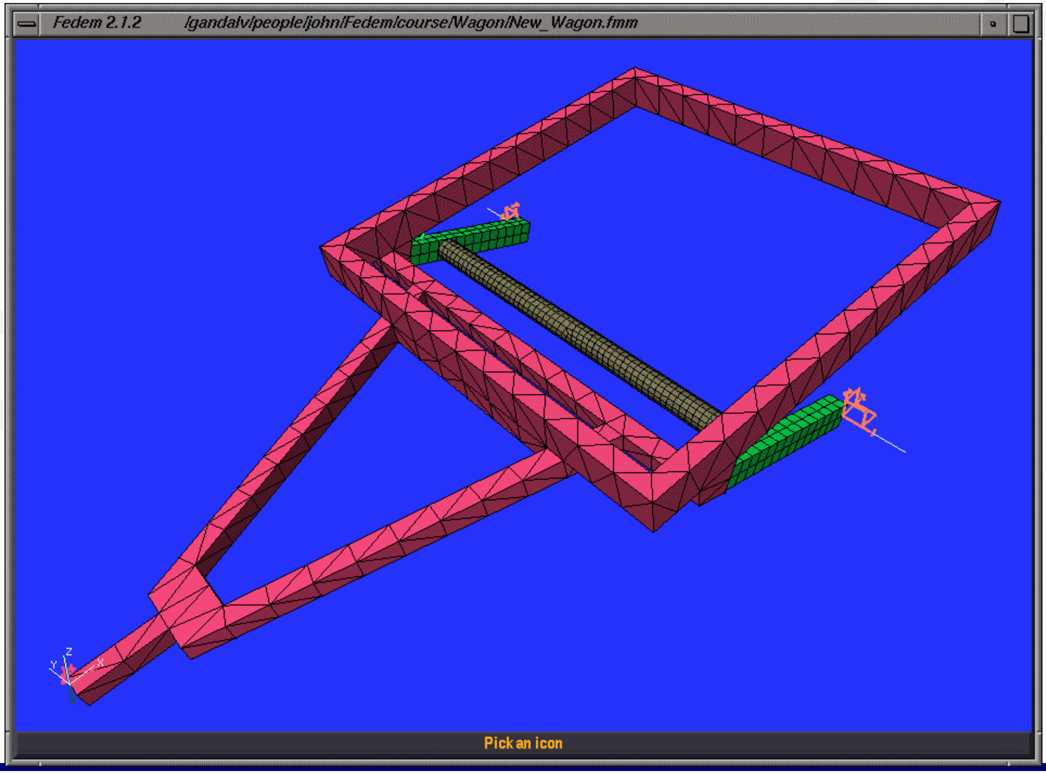
Clearing the View

- To make it easier to work with the model, we are going to turn off some entities and links

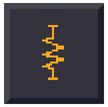
First, hide the **wheels** and turn on the **frame** link



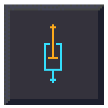
In the *View Settings*, turn off *Joints* and *Triads*



Create springs and dampers

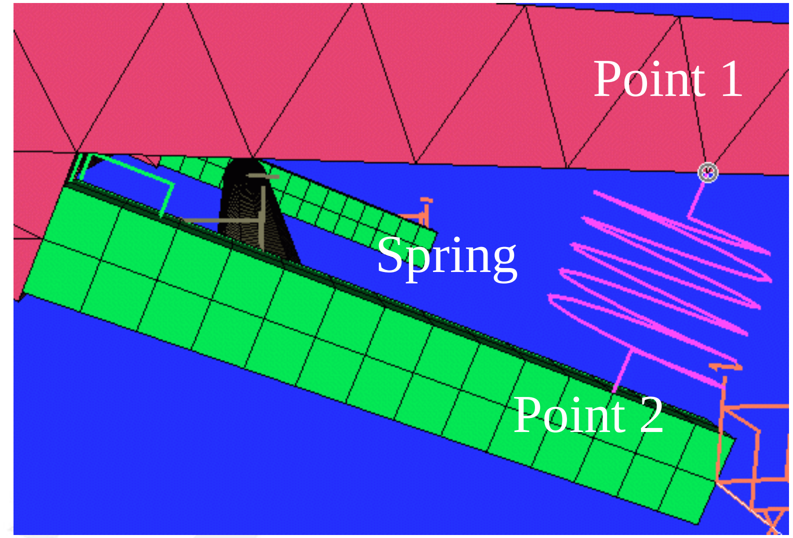


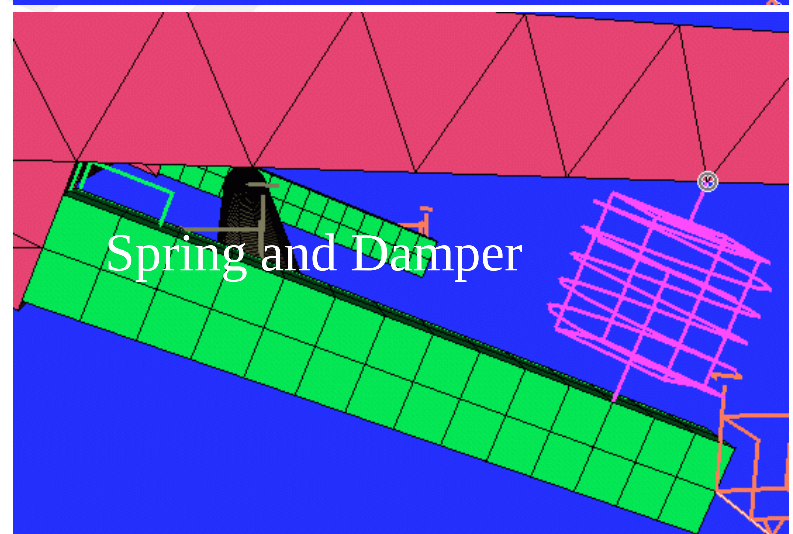
Select the *Create Spring* command and pick the indicated points for the spring



Select the *Create Damper* command and place the Damper between the same points

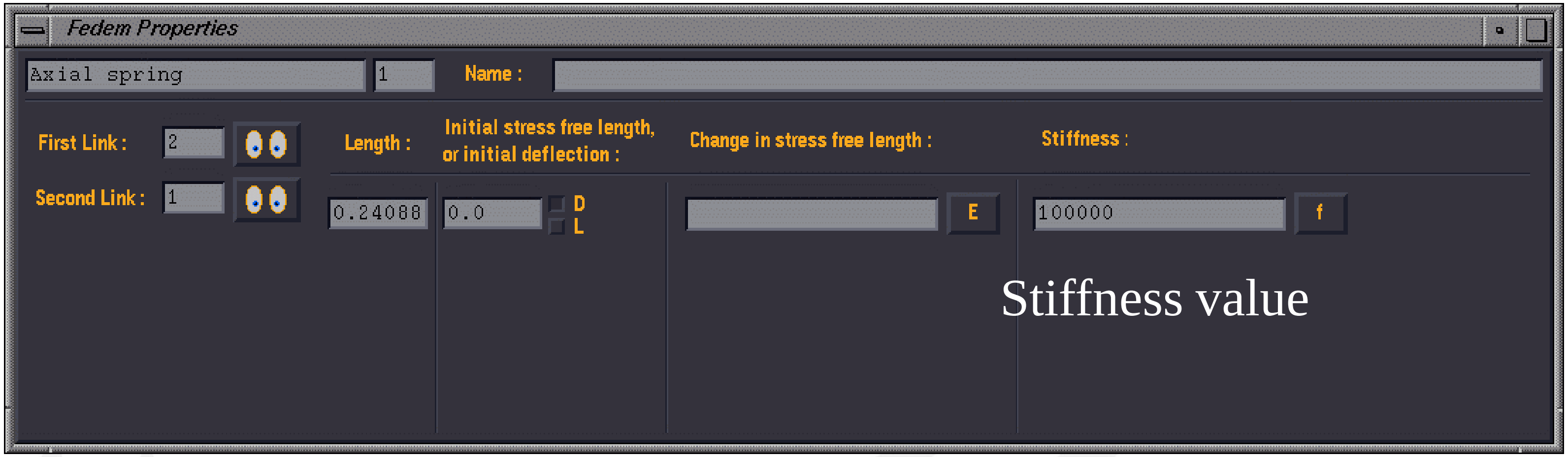
- Similar, create a *Spring* and a *Damper* on the other side of the Wagon, too.





Enter values for the springs and dampers

- Select the *Springs* and enter a *Stiffness* value of 100000, press Enter

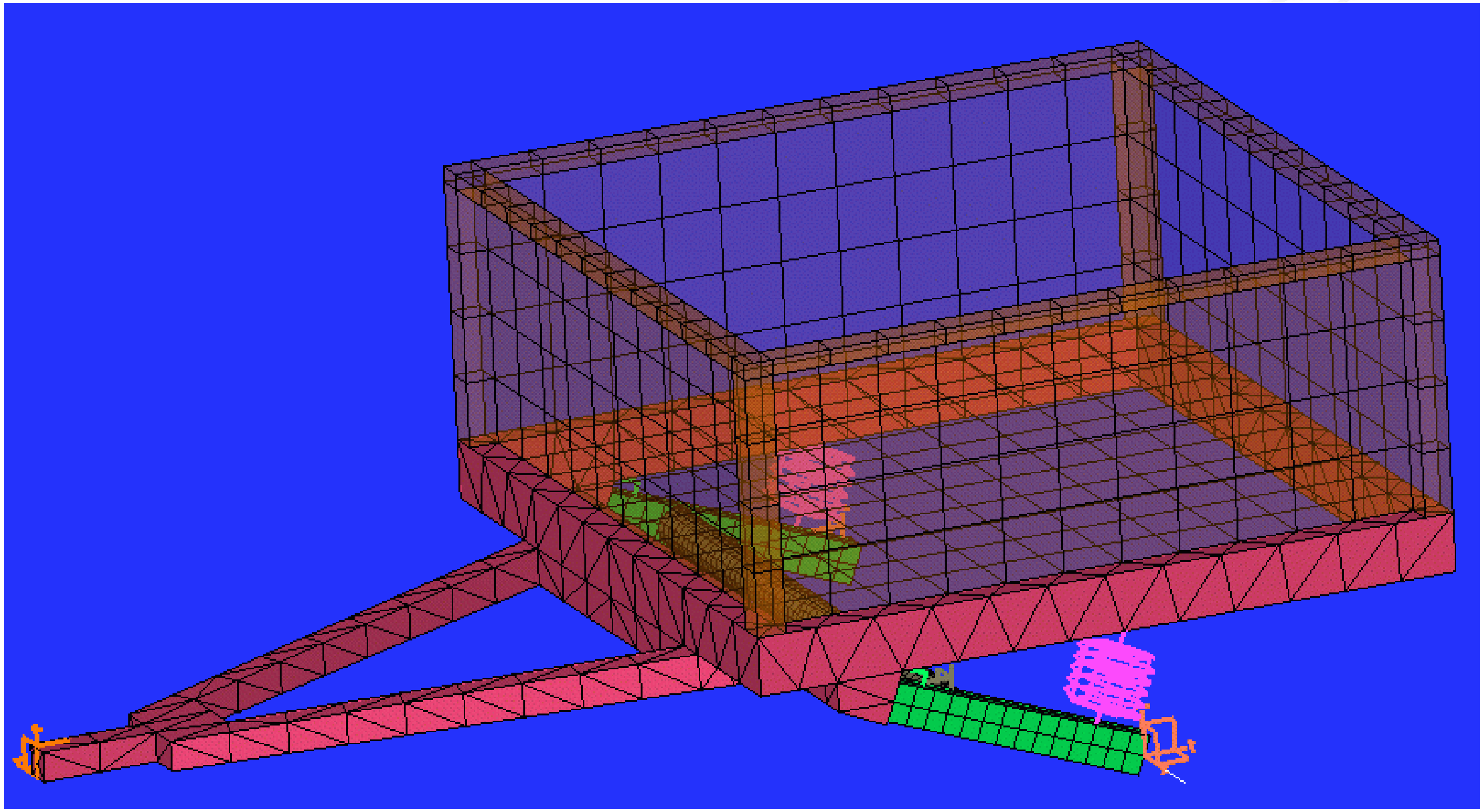


- Select the *Dampers* and enter a *Damper Coefficient* of 10000, Enter

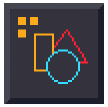
Import the case link

Import the **case** link

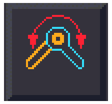
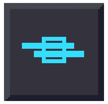
Change the *Appearance* to *Red:100*, *Green:50*, *Blue:0* and *Transparency* to *70*



Connect the case to the frame

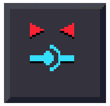


Turn on *Joints*

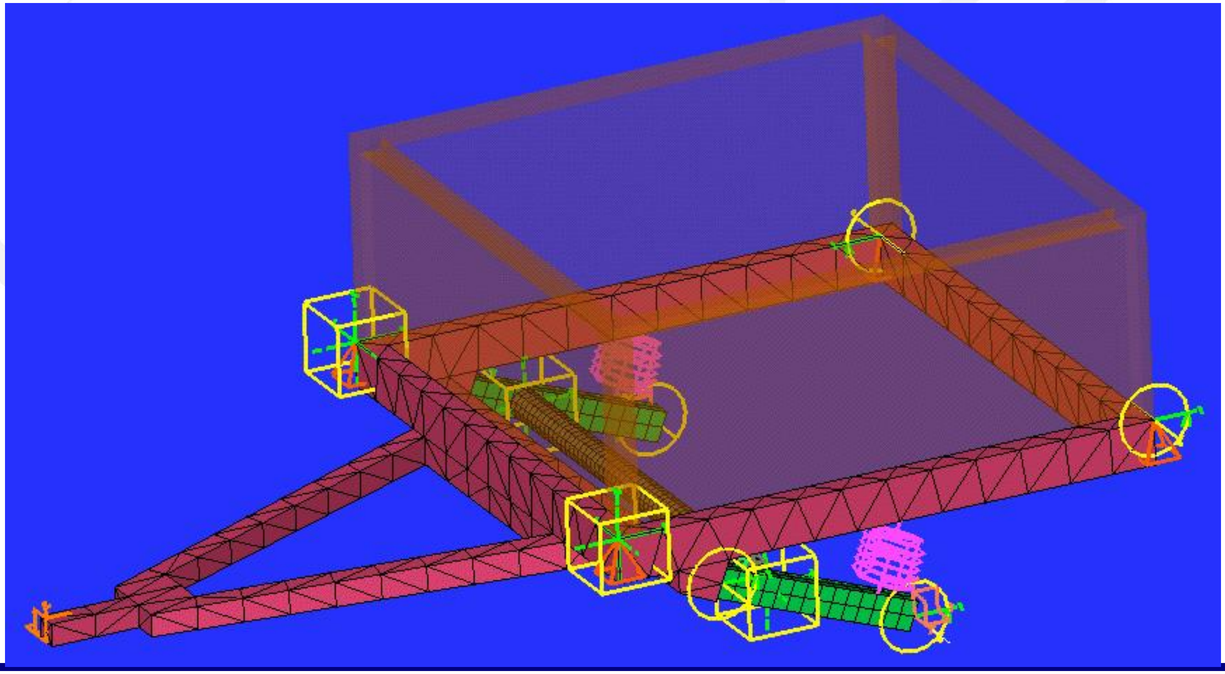
 

Create *Revolute Joints* at the back end, and *Rigid Joints* at the front end of the **case**

- Align the z-axis for the *Revolute Joints*



Attach the joints



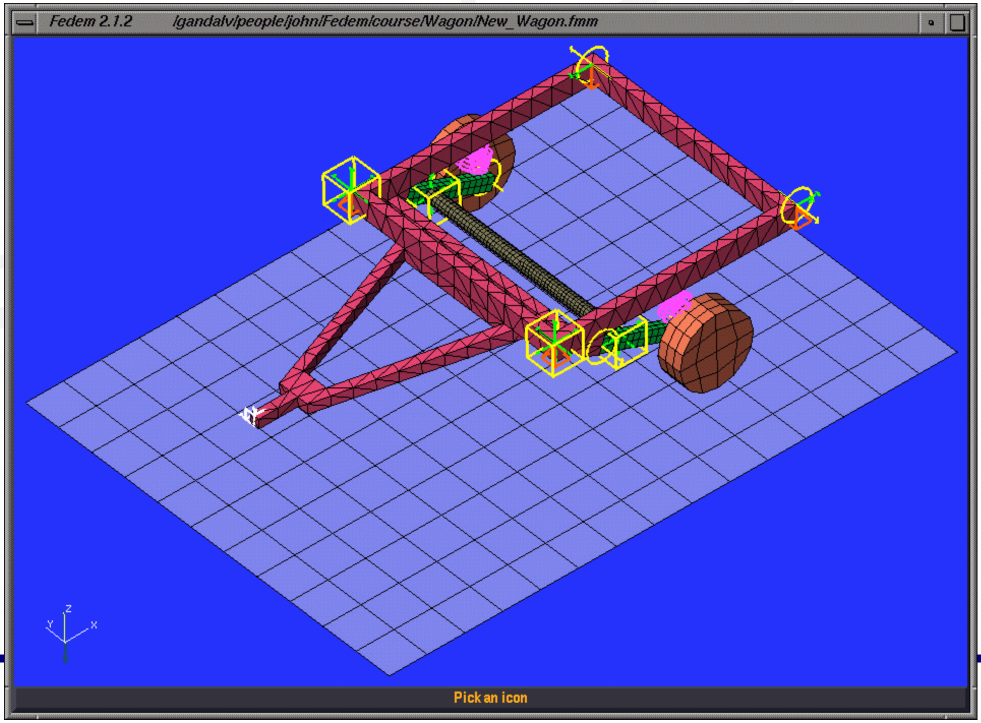
Import the ground link

- In this modeling example we are using a link as “ground”, or road for the Wagon

Turn off the **case** link, and turn on the **wheels**

Import the **ground** link

Change the *Appearance* for the **ground** to *Red:100*, *Green:100*, *Blue:100*, *Transparency:50*



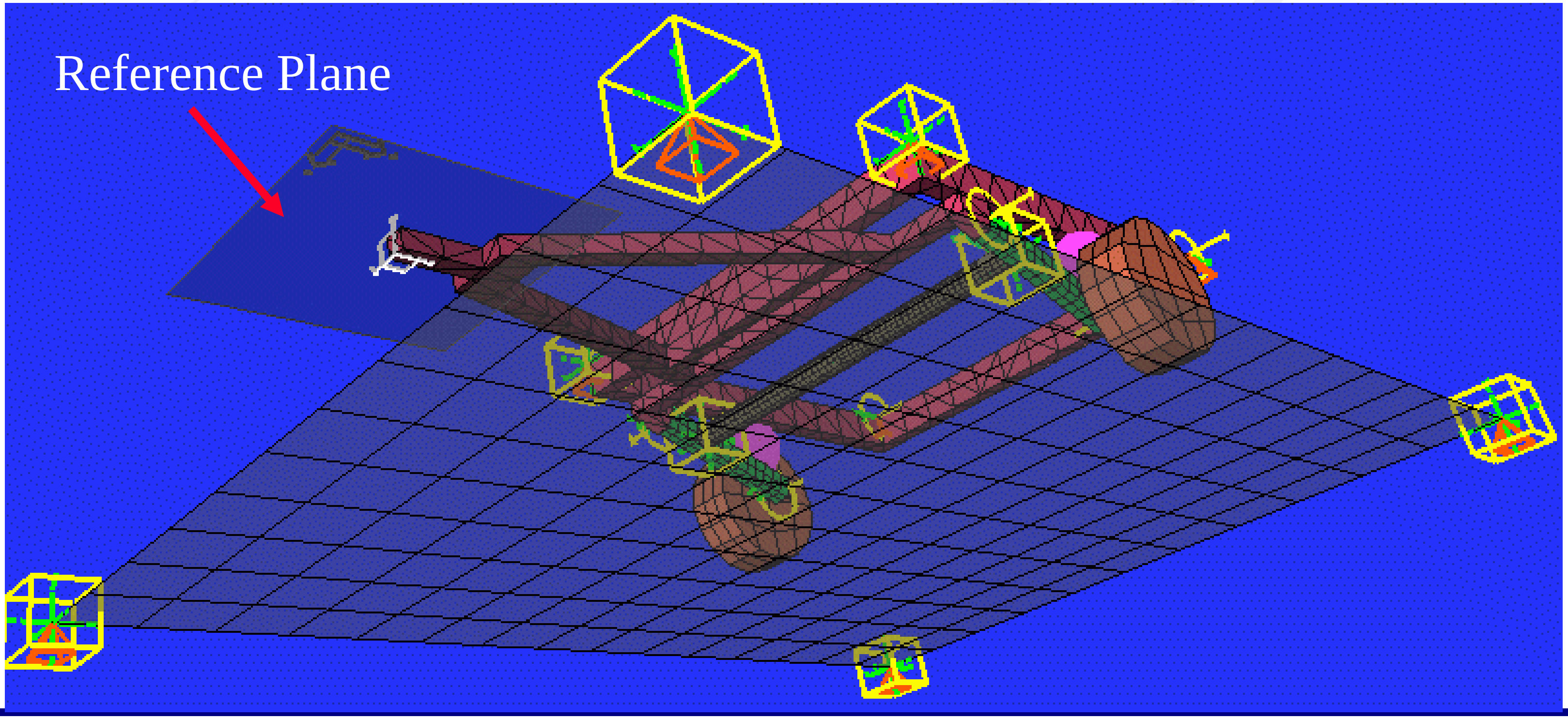
Attach the ground link to the Reference Plane

Create *Rigid Joints* at the corners of the **ground**

Turn on *Reference Plane*

Attach the *Rigid Joints* to the **ground** and the *Reference Plane*

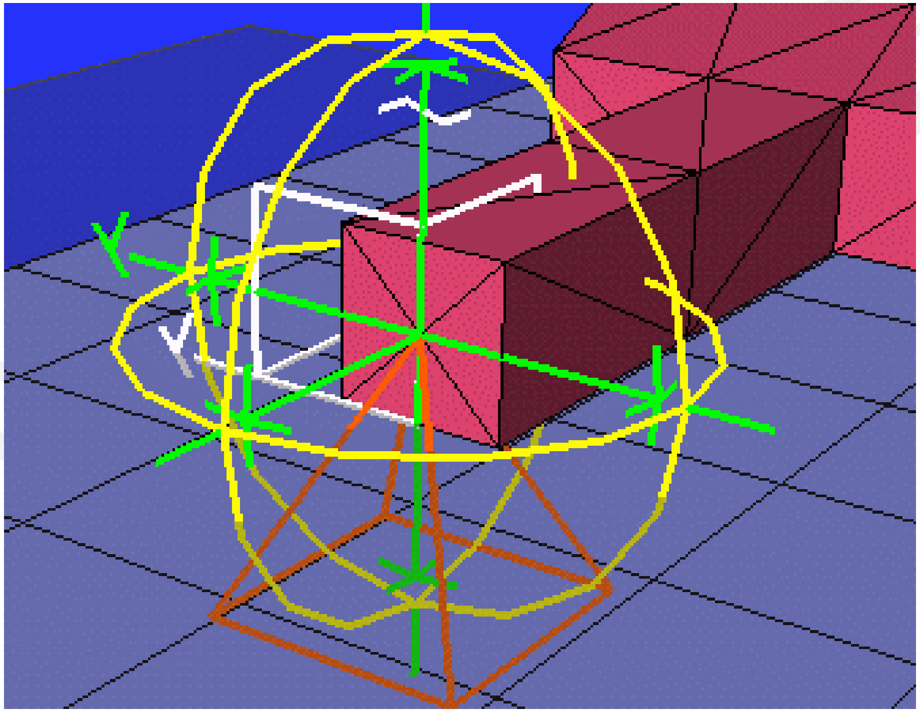
- Pick joint, pick *Reference Plane*, pick joint, pick **ground**



Attach the front of the Wagon to the Reference Plane

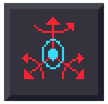
Create a *Ball Joint* at the front end of the **frame**

Attach the *Ball Joint* to the *Reference Plane* and the **frame**



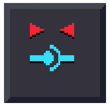
Attach the wheels to ground

Delete all *Stickers*



With *Free Joints*, you have to independently select where to put the *Master Triad* and the *Slave Triad* for the joint

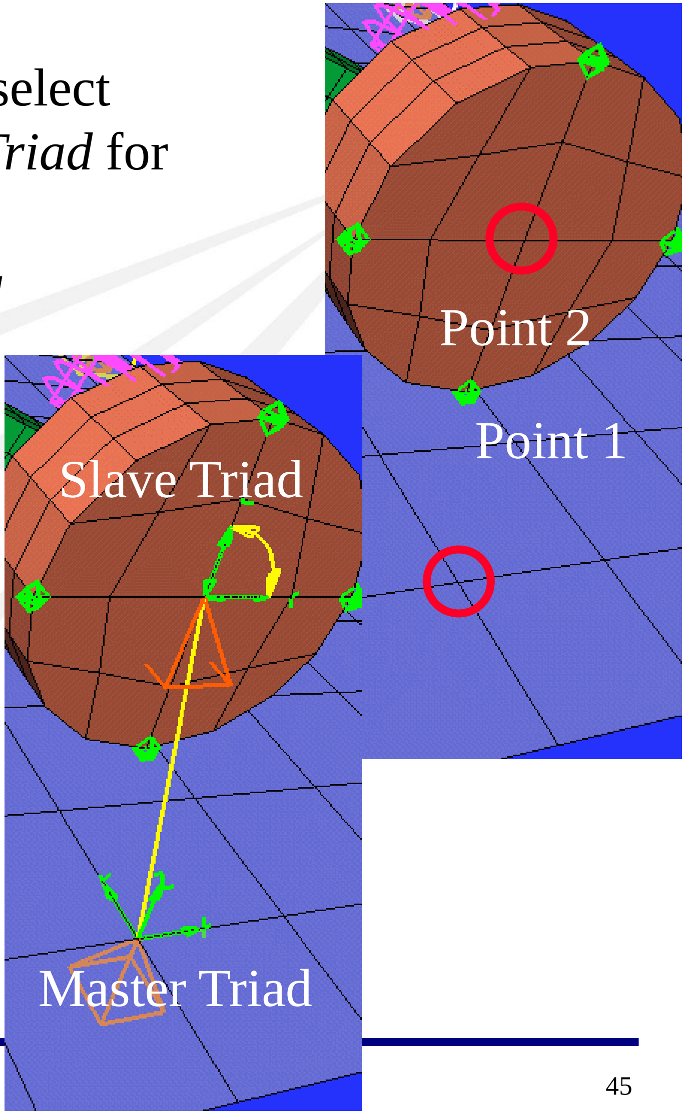
- Pick Point 1 as where to put the *Master Triad*
- Pick Point 2 as where to put the *Slave Triad*



You also have to attach the joint triads independently

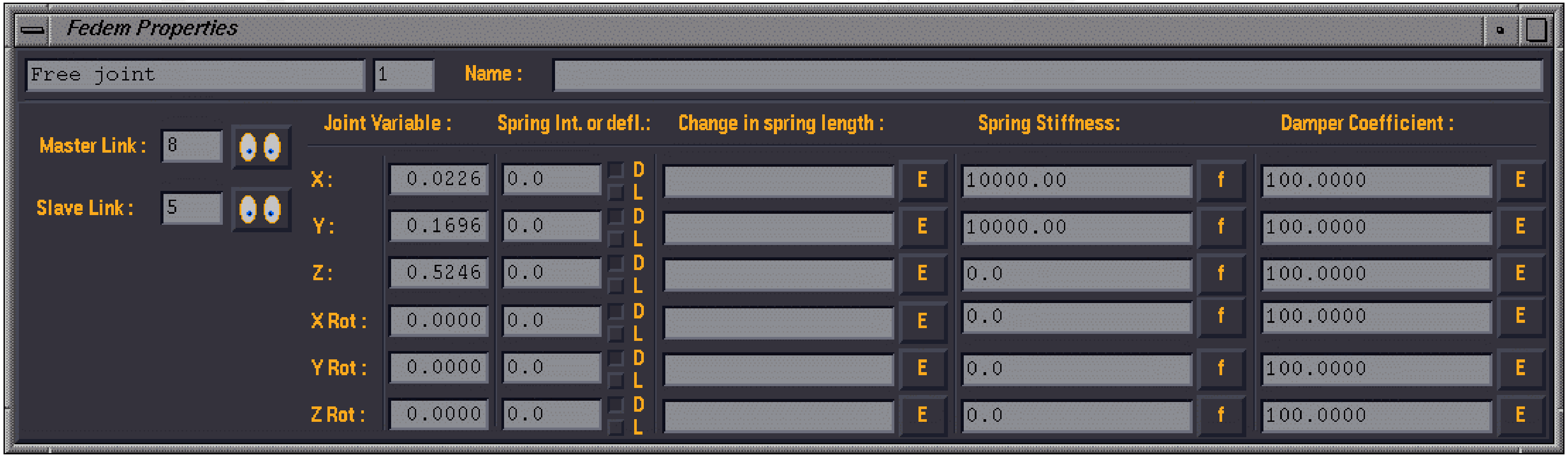
- Attach the *Master Triad* to ground
- Attach the *Slave Triad* to the wheel

- Repeat the operations at the other side of the Wagon



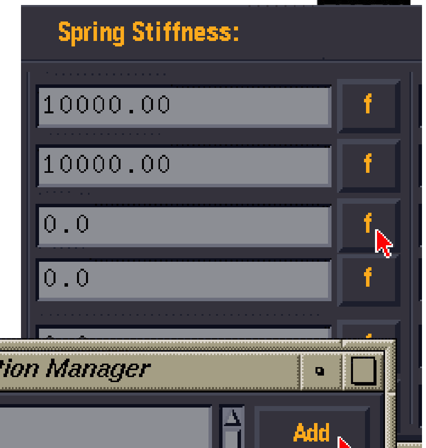
Set Free Joint values

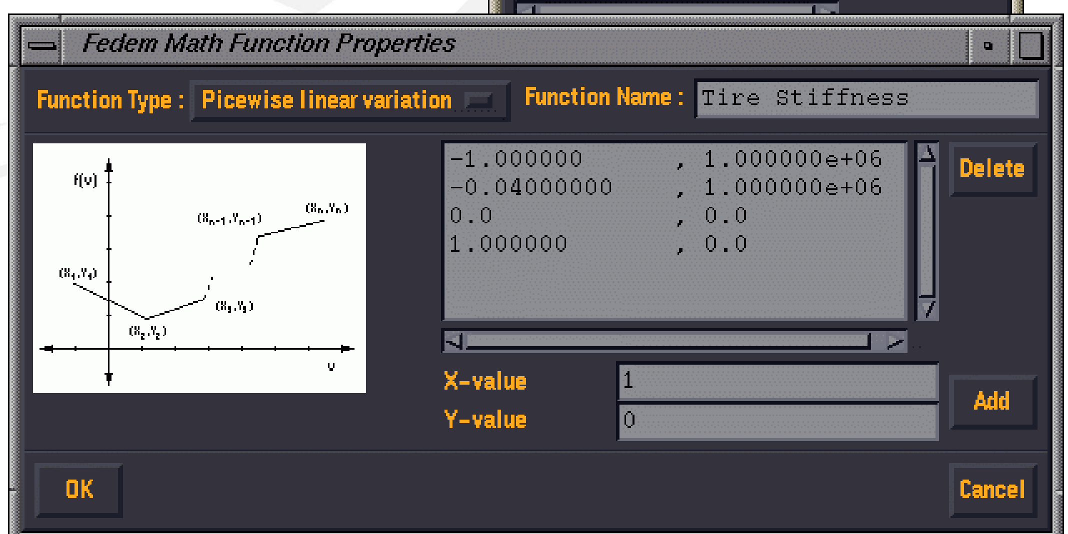
- Select one of the *Free Joints*
  - Pick the yellow line on the *Free Joint* symbol
- Note that the X, Y, Z, X Rot, Y Rot and Z Rot are all with reference to the coordinate system for the *Master Triad*
- Set the *Spring Stiffness* for the X and Y direction to 10 000
- Set the *Damper Coefficient* for all directions and rotations to 100
- Remember to press Enter when you have entered the values



Set Free Joint values, cont.

- We are going to use a non-linear spring in the Z-direction
- Select the *f* button by the *Spring Stiffness* Z entry
  - This brings up the *Function Manager*
  - Select *Add*
- In the *Fedem Math Function Properties:*
  - Give the function a name: *Tire Stiffness*
  - Enter the x and y-values, press *Add* to register
  - The x-value is spring deflection
  - The Y-value is spring stiffness
- Press *OK* in the *Fedem Math Function Properties* and the *Function Manager* window





Set Free Joint values, cont.

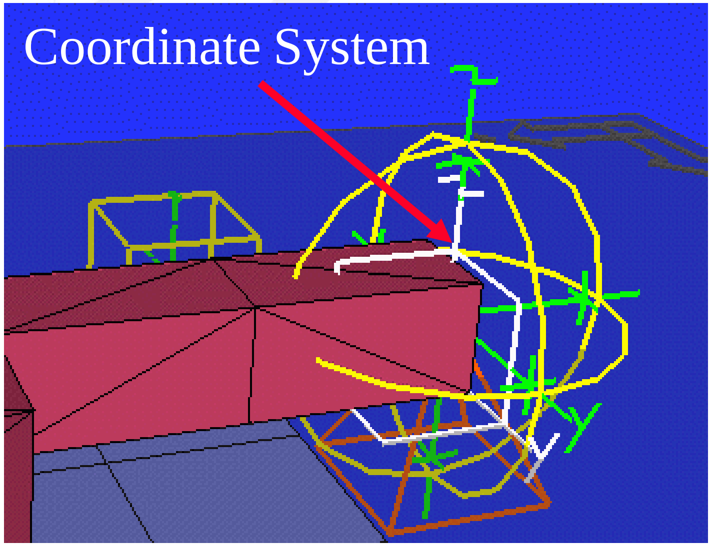
- Repeat for the *Free Joint* on the other side of the Wagon
- This time, reuse the *Tire Stiffness* function in the *Function Manager* for the *Z Spring Stiffness* value

Make the case link visible again

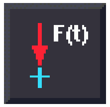
- The coordinate system for the **case** link is coincident with the coordinate systems for the **frame** and the **ground** links, and is situated at the front end of the **frame**

Select the *Appearance window*

- Pick several times on the coordinate systems to cycle through the links, watch the *Property Window* to see which link you have picked
- Change *Polygons* to *Reduced*
- Change *Lines* to *Surface*

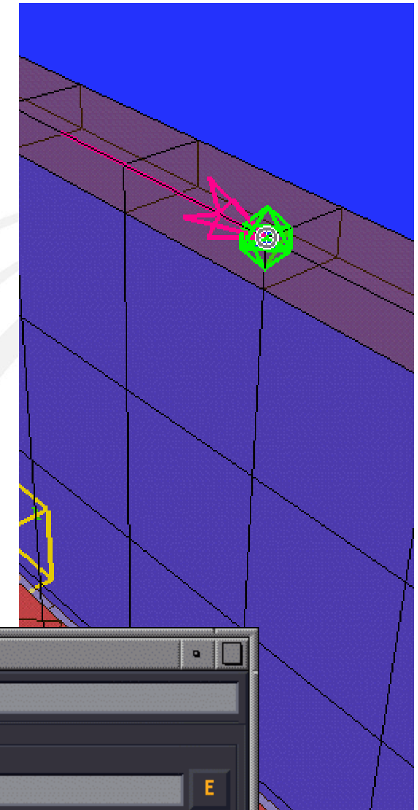


Apply a Force to the Wagon



Select the *Create Force* icon

- Pick the *Triad* at the back end of the Wagon
  - The *Force* symbol is pointing at the selected point
  - The direction way vary, it depends on where you picked before the *3D Point Marker* snapped to the *Triad* (the *Triad* is highlighted) or the node where the *Triad* is located (the **case** link is highlighted)

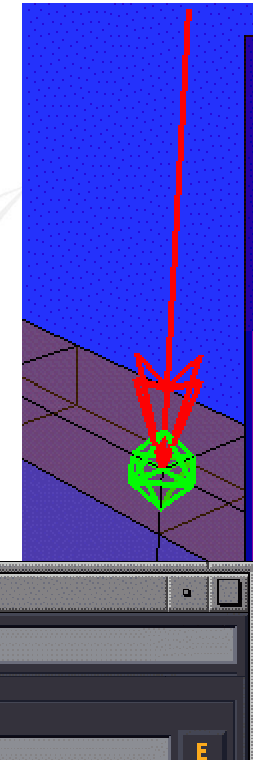


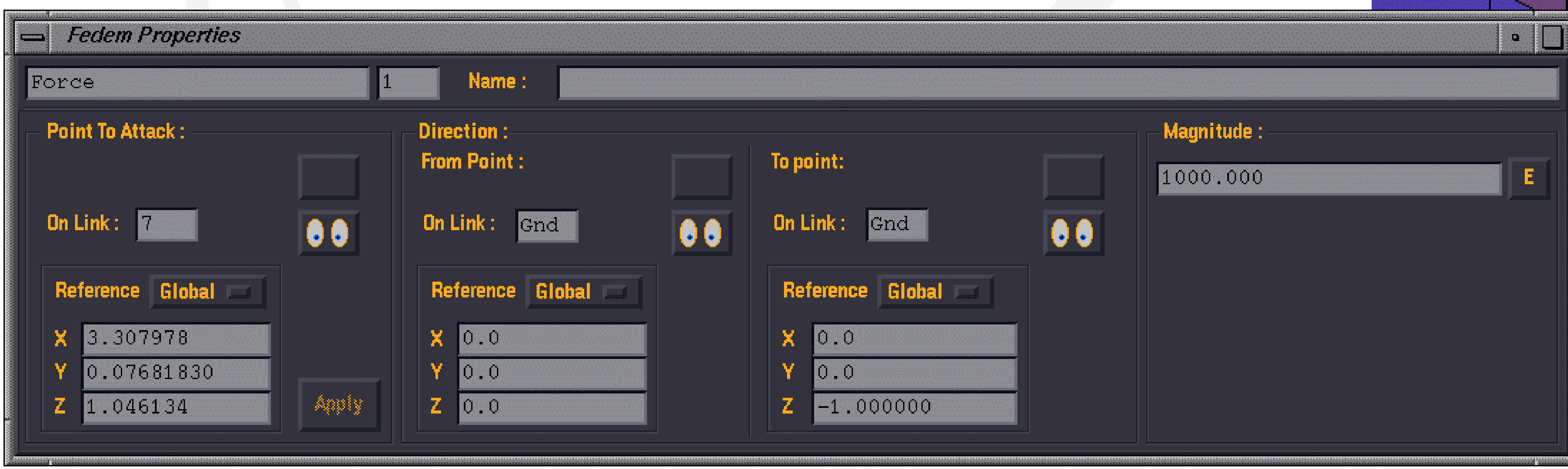
Select the *Force* symbol

- The *Property Window* for the selected *Force* appear

Force Property Window

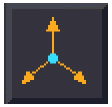
- Note that *Point To Attack* is on link 7, the **case** link
- The *Direction* has reference to the *Reference Plane* (Gnd), and is given in Global coordinates
  - Change the coordinates according to the picture, remember to press Enter
- The *Force* is now acting in the Global negative Z-direction
- Enter a *Magnitude* of 1000 Newton





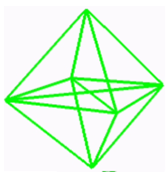
Add some cargo

- We are going to use *Triads* as lumped mass points



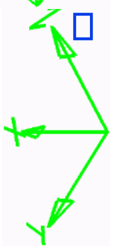
Select the *Create Triad* icon, and place two triads at the bottom of the **case**

- Select nodes on one side inside the **case** to get a non-symmetric load



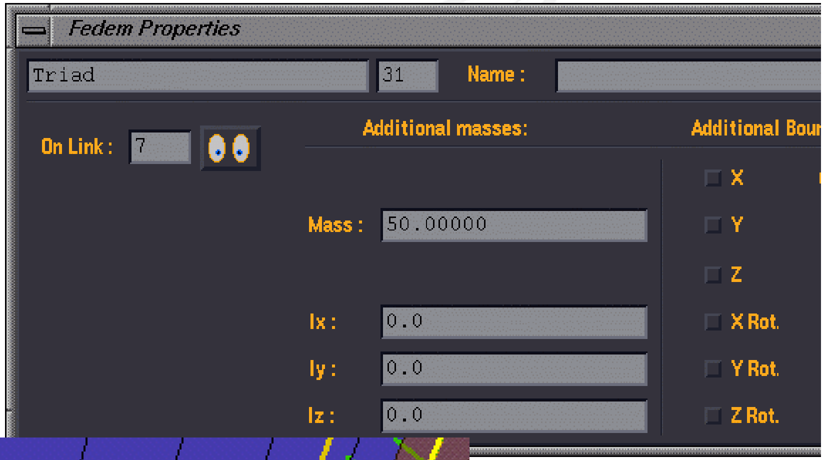
Pick one *Triad*

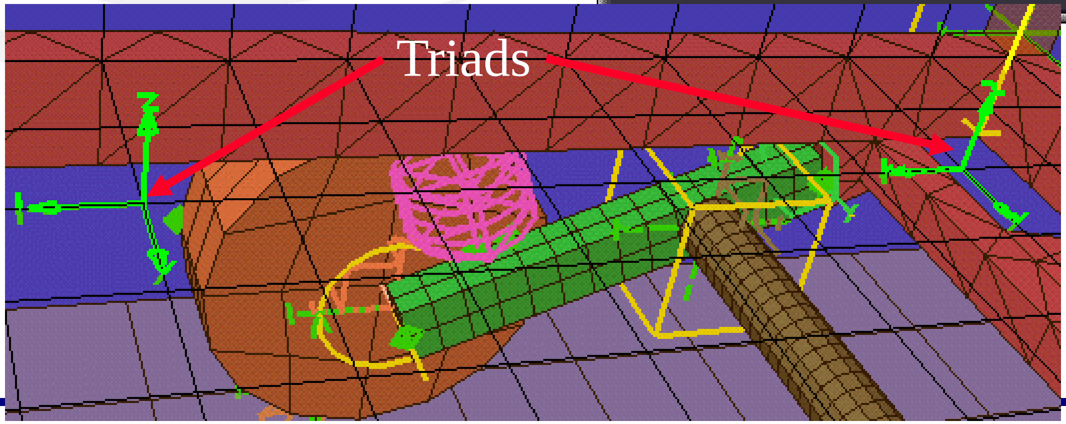
- Give the *Triad* a mass of 50kg



The *Triad* symbol changes to a green coordinate system

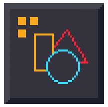
- Do the same with the other *Triad*





Clean up the view

 Erase all *Stickers*

 Reduce the *Line width* and the *Size* of the symbols

 Set *Lines* to *Reduced* for the **case** link