

Degrees of Freedom Nodes

This example will give you an understanding of and how to create Degrees of Freedom Nodes

What are Degrees of Freedom Nodes?

A 'Degree Of Freedom' node common referred to as a '**DOF**' node controls all the geometry in the tree below it and provides a "Local Coordinate System". The DOF nodes attributes define a range of translational, rotational motion and scaling of all the geometry attached below the DOF node. For example, a DOF node can be used to specify the hinge point and the angle through which a door swings or define the axle pivot point of a wheel and for a steerable wheel its angular turning constraints.

The range of motion is specified relative to a local coordinate system, and the transformations it contains are applied to all descendants of the DOF node. This ensures that the effects of multiple degrees of freedom accumulate naturally in the database hierarchy. Consider the example of a hand attached to an arm. When you move the arm, the hand also moves because its geometry is a descendent of the arm DOF. The wrist of the hand bends and rotates relative to the position of the arm because the wrist is controlled by a DOF node that specifies its range of motion, and the wrist DOF node is a descendant of the arm's DOF node.

Note that some Scene-graphs API's such as Vega or Performer also use the term **DCS** (Dynamic Coordinate System) when referring to DOF nodes, the term DOF and DCS can typically be used interchangeably

The objective of this example is to begin to understand the practical use of DOF nodes for defining local coordinate systems that can be use for the articulation of geometry. While completing the example we will also learn and reinforce the following modeling skills:

- Create a new OpenFlight database
- Saving Databases
- Short Cuts to Tools and Commands
- Using the Tracking Plane, Setting position and size
- Changing the Selection Mode
- Selecting Faces, Groups and Object
- Creating and Name Group, Object and DOF nodes
- Setting Parent Nodes
- Selecting Nodes (Group, Object, DOF)
- Selecting Faces
- Creating Geometry
- Using the Rectangle tool
- Using the Circle tool
- Using the Wall Plus tool
- Using the peak tool
- Creating Construction points
- Setting the tracking plane to the construction points
- Using the Colour Palette to select colours
- Using the Property Tool box to insert colours
- Using the Property Tool box to retrieve a colour from a face
- Creating DOF nodes
- Setting DOF nodes rotational limits
- Using the DOF Viewer Tool
- Using the Position DOF tool
- Positioning DOF Nodes

Create a simple example DOF Nodes

Create a Base Structure

1. First close any Open Flight files that are currently Open
2. Create a **new** database (*Ctrl + N*)
3. Save the file and set the file name as **"dofExample1.flt"**
4. Set the tracking plan to XY
5. Set the grid size to 5
6. Set the group g2 as the parent node (*alt + left Mouse on the node*)
7. Set the selection mode to Object (*shift + O*)
8. Create an Object Node and set the name of the node to **"base1"** (*ctrl + J*)
9. Set the **"base1"** object as the parent node (*alt + left Mouse on the node*)
10. Set the selection mode to Face
11. Create a rectangle, 1st corner at 10.0 , 10.0 and the 2nd corner at 25.0, 25.0
12. Select the new rectangle
13. Start the Wall Plus tool or Bevel Plugin, set the subdivision, height and width to 3.0, make sure that "Keep Bottom" is not selected and "Both sides Visible" is not selected (see image 1), and click OK
14. Select the top face of the wall base
15. Use the "Construct Average Vertex" tool to create a construction point in the middle of the selected face (see image 2)
16. Select the **"base1"** object node

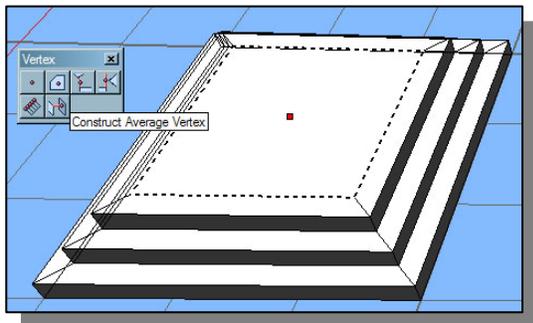


Image 2 : Construction Point

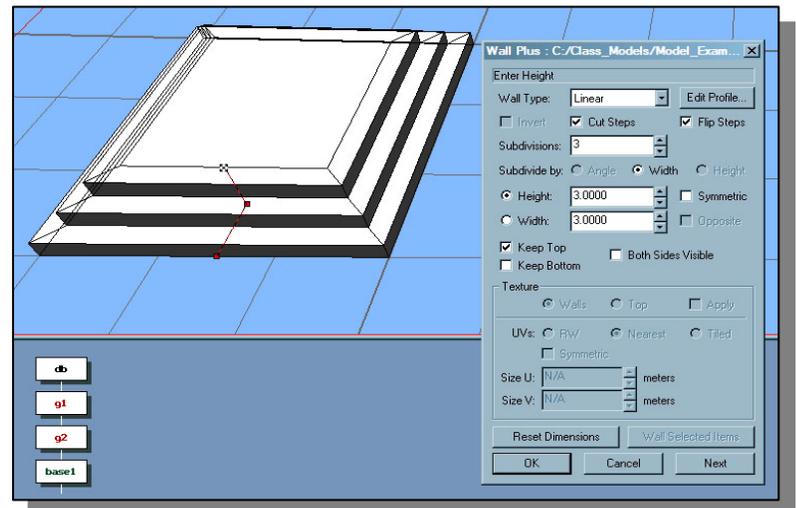


Image 1: Base Extruded with Wall Plus Tool

17. Open the colour palette select a light yellow colours and apply the colour to the **"base1"** node (*ctrl + R*)
18. Shade the **"base1"** node (*ctrl + G*), set the shading mode to "Lit"

19. Save the file (*ctrl + S*)

Create a Rotatable Structure

20. Use the CTR tracking plan tool to center the tracking plane grid on the construction point we created above
21. Set the grid size to 2
22. Open the colour palette and select a light Red colour and close the palette
23. Set the group **g2** as the parent node (*alt + left Mouse on the node*)
24. Set the selection mode to Object (*shift + O*)
25. Create an Object Node and set the name of the node to "**axel1**" (*ctrl + J*)

26. Set the "**axel1**" object as the parent node (*alt + left Mouse on the node*)

27. Set the selection mode to Face

28. Start the geometry circle tool,

29. Set the number of sides to 12

30. Select the construction point as the center (*middle mouse*)

31. Set the radius to 2 units and click ok (see image 3)

32. Select the new red circle

33. Start the Wall Tool (*shift +W*), set the height to 16, and unselect "Keep Bottom", click OK

34. Set the grid off set to 15

35. Select the "**axel1**" object

36. Use the slice tool

37. Open the colour palette and select a light blue colour

38. Select the faces on the "**axel1**" object, that are now above the tracking plane grid, but do not select the top, and set the selected faces to the light blue colour (*ctrl +R*)

39. Open the colour palette and select a light green colour

40. Select one of the blue faces and set is colour to light green (*ctrl +R*) (see image 4)

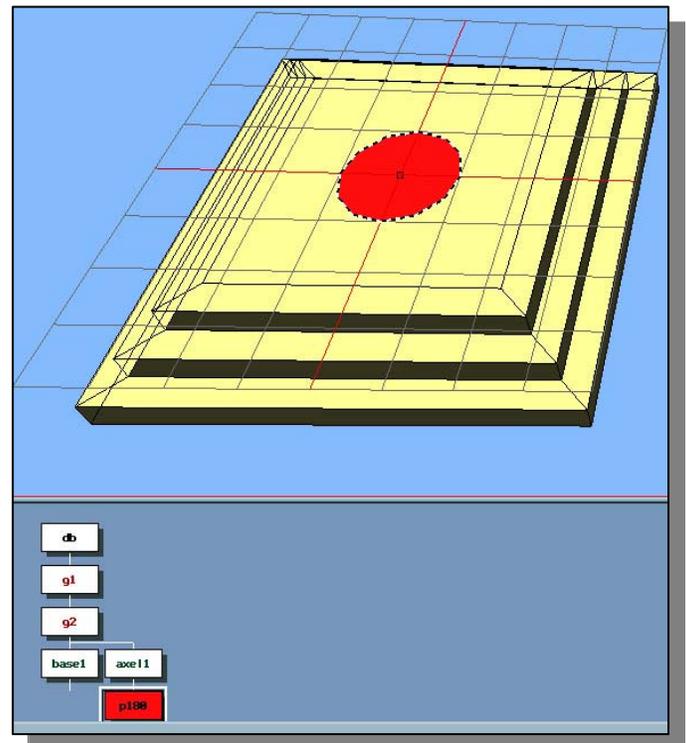


Image 3: Axle Base

41. Set the group **g2** as the parent node (*alt + left Mouse on the node*)
42. Set the selection mode to Object (*shift + O*)
43. Create an Object Node and set the name of the node to **"greenspar"** (*ctrl + J*)
44. Select the light green face and drag or attach the green face to the **"greenspar"** object
45. Start the wall tool (*ctrl +W*) and set the height to 9, click OK
46. Set the **"axel1"** object as the parent node (*alt + left Mouse on the node*)

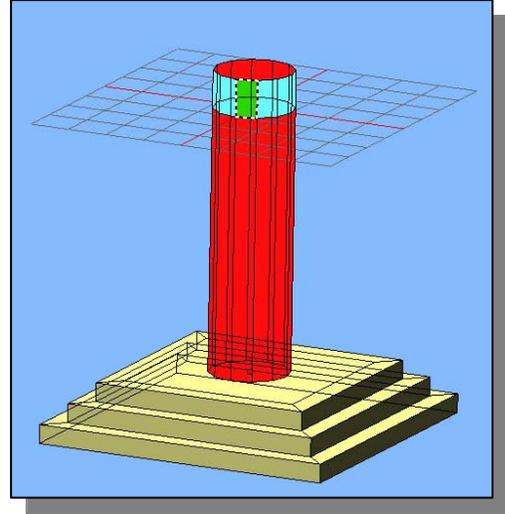


Image 4: Raised Axle

47. Select one of the light blue faces and use the properties **"Colour from Node"** tool set the current primary colour to light blue
48. Select all the light blue faces
49. Start the Wall Tool (*ctrl +W*) and set the height to 9, click OK
50. Select the top red circle of the axle and use the peak tool (*shift + P*) to create a peaked cap
51. Select the **"axel1"** object and Shade the node (*ctrl +G*), set the shading mode to **"Lit"** (see image 5)
52. Save the file (*ctrl + S*)

Create a DOF Node

The next stage is to create a Degree of Freedom (DOF), set some rotation constraints on the new DOF node and

53. Set the group **g2** as the parent node (*alt + left Mouse on the node*)
54. From the **"Create toolbox"**, select the DOF button to create a new DOF node
55. Set the DOF nodes name to **"axle1 Dof"**
56. Attach the **"axel1"** object node as a child to the **"axle1 Dof"** node
57. Select the **"axle1 Dof"** node and open it attribute page (*ctrl + =*)
58. Select the Rotate tab and set the 'Constrain check' to ON for Yaw (heading), set the maximum for the Yaw to **360** and the step to **5**, close the attribute dialog, all the other constraints should be left/set at 0.0
59. Save the file (*ctrl + S*)

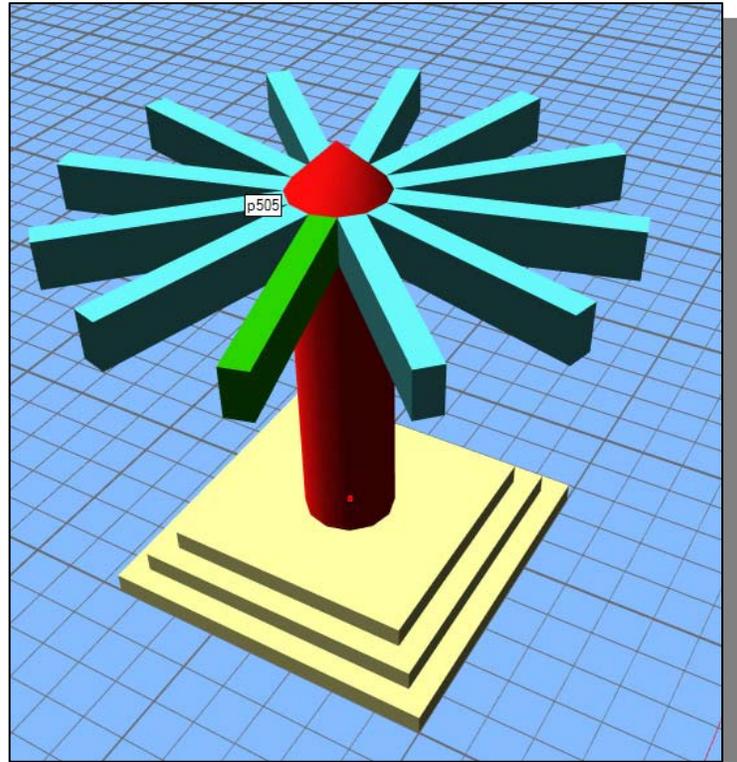


Image 5: Finished Axel

Testing the DOF Nodes Rotation

In this stage we are going to use the ‘DOF Viewer” (image 6) tool to exercise (animate) the DOF nodes constraints. The DOF viewer is located in the Main Menu/Local-DOF Menu

The DOF Viewer allows you to preview one or more DOF nodes simultaneously to show how they will interact together. For each DOF, the Translate, Rotate, and Scale attributes are all considered.

When the DOF Viewer is first opened, all currently selected DOF nodes will be included for previewing and shown in the list box on the left of the tool.

If no DOF nodes are currently selected, then all DOF nodes with non-zero step increments set on at least one of the attributes in the model are eligible for previewing.

Note:

It is highly recommended that you **always** save your work before using the ‘DOF Viewer” tool, I have found this tool to crash often enough to always save.

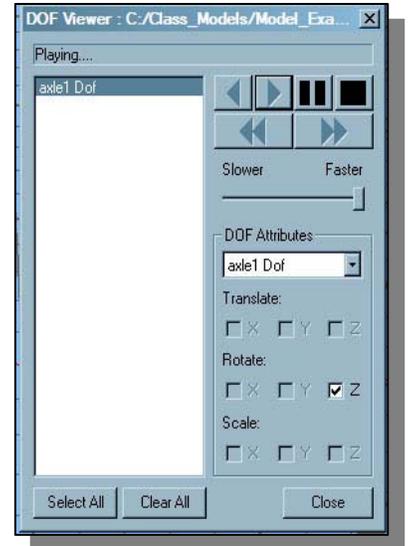


Image 6: DOF Viewer

Exercising the DOF “axle1 Dof” node

- 60. Select the “axle1 Dof” node from the hierarchy view, or you could set the Selection Mode to DOF from the ‘Mode’ Toolbox or ‘Mode’ drop down menu and then select the geometry with the left mouse to select the “axle1 Dof” node
- 61. Open the DOF Viewer tool from the Main Menu/Local-DOF/DOF Viewer.
- 62. Click on the Play forward or backwards button  to start the DOF moving or rotating within the constraints we have set
- 63. You should see the geometry underneath the “axle1 Dof” node will not rotate (see images 7 & 8) , unfortunately we can see that that geometry is rotating around the origin where the DOF node is currently positioned and does not spin around on top of the base as we might have expected

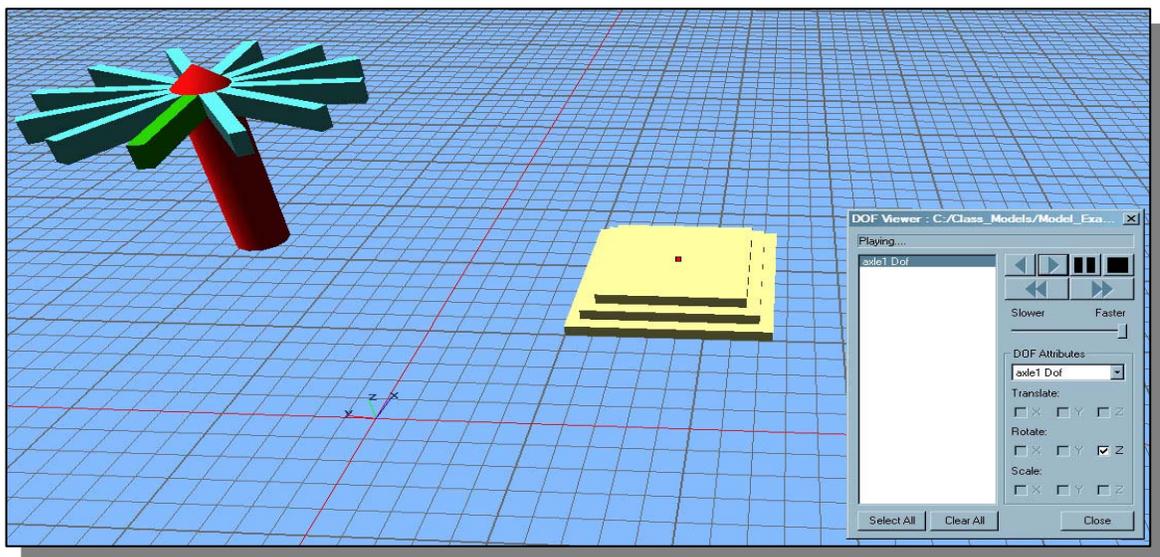


Image 7: Testing the DOF node’s Constraints

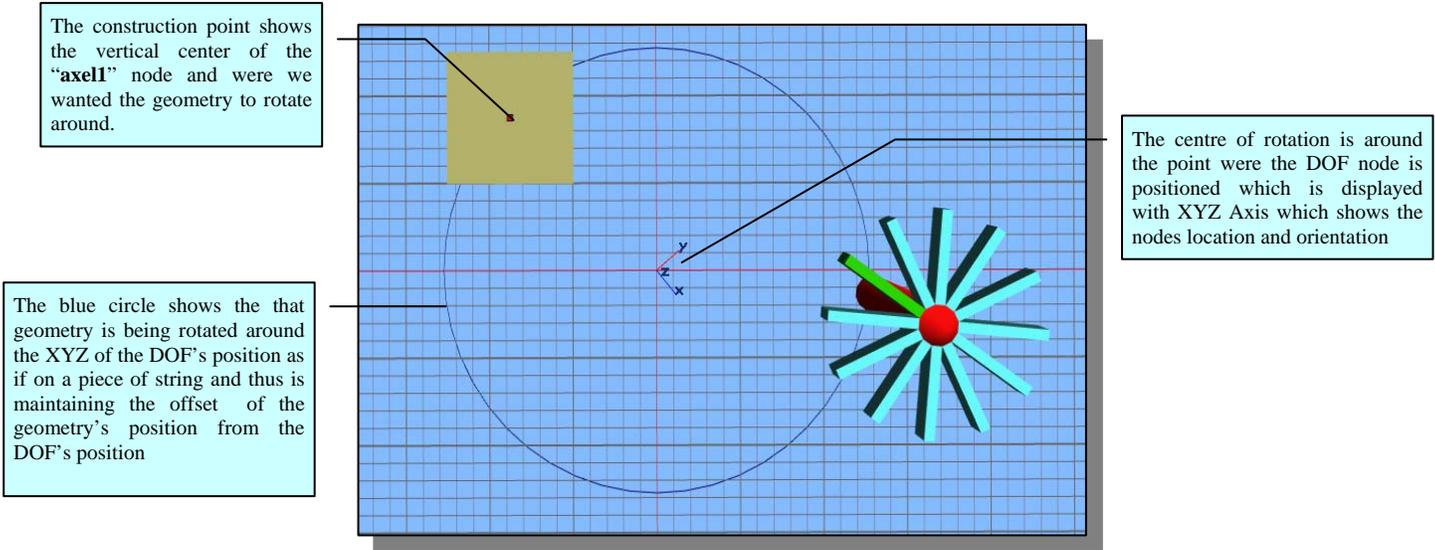


Image 8: Wrong Rotation

What Went Wrong?

Well nothing went really wrong, the behaviour we are seeing is quite correct, as was mentioned above the DOF node provides Local Coordinate system and thus children of the DOF node will be positioned with respect to the DOF nodes position

When a DOF node is created it is positioned at the origin, thus we see our geometry attached to the "axle1 **Dof**" node swings around the origin when we exercise the constraints.

In order to have the geometry rotate around the construction point we placed at the base we will need to position the DOF node there

Positioning A DOF Node

64. Select the "axle1 **Dof**" node from the hierarchy view, or you could set the Selection Mode to DOF from the 'Mode' Toolbox or 'Mode' drop down menu and then select the geometry with the left mouse to select the "axle1 **Dof**" node
65. To position the DOF node we need to use the "Position Dof" tool, found on the "Main Menu/Local-DOF/Position Dof..." (see image 9), note the tool will not start if you do not have a DOF node selected
66. Select the 'Origin' radio check on the Position DOF tool
67. Click on the construction point with the middle mouse, this should move the DOF node to the construction point (see image 9).

Note that in the coordinate panel the new center and position of the DOF node is shown in the Current section. Currently in Creator the Coordinate Panel is the only place you can find the actual position and center of a DOF node (See how to get Dof Position at the end of this document)

68. In this case we are not going to change the orientation of the DOF node so click on OK to close the tool and finish the positioning of the DOF node

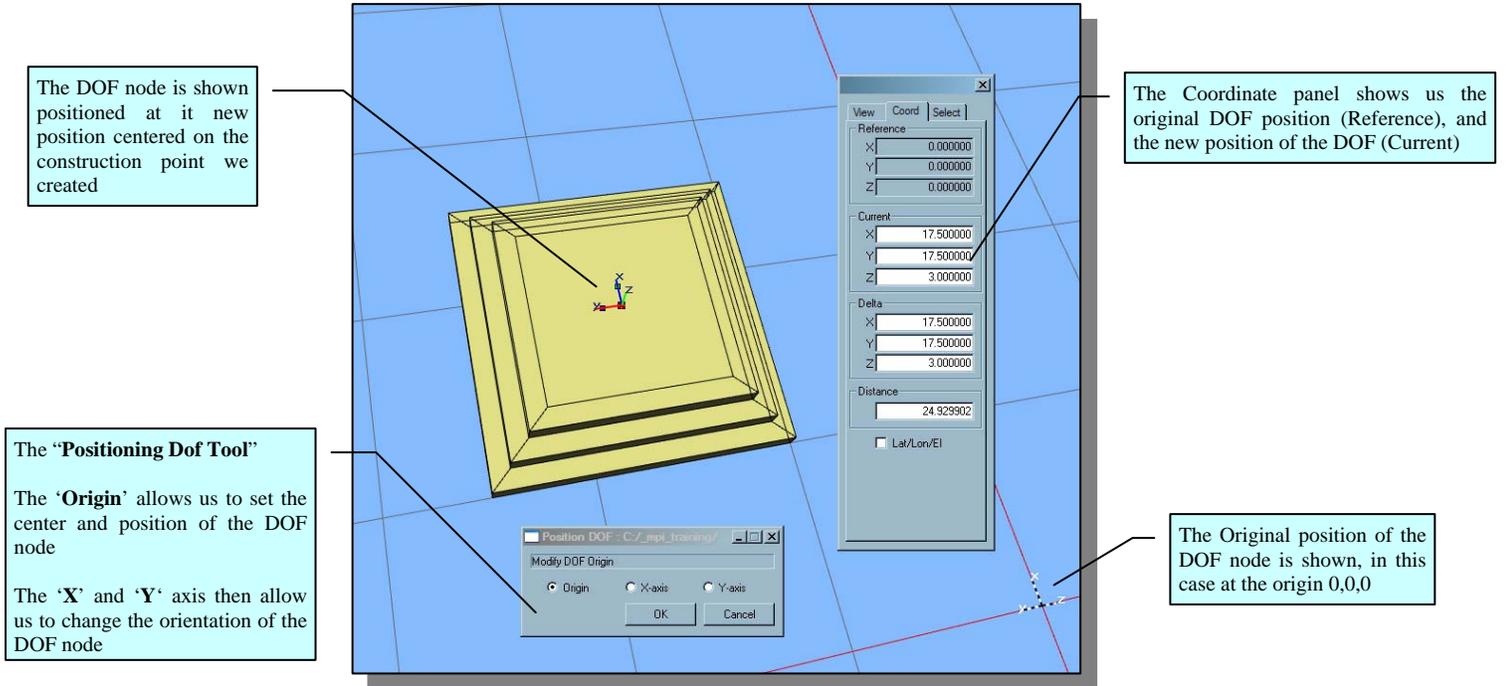


Image 9: Position DOF node at the Pivot Point

69. Save the file (*ctrl + S*)
70. Select the “**axle1 Dof**” node
71. Open the DOF Viewer tool form the Main Menu/Local-DOF/DOF Viewer.
72. Click on the Play forward or backwards button . to start the DOF moving or rotating within the constraints we have set
73. If you have positioned the DOF node correctly the geometry should now be rotating on the spot without orbiting.

How to Retrieve the Current Position of DOF Node

Currently Creator does not have an easy way of seeing the center position of a DOF node it is not displayed in the attributes of the DOF node. The following is one method of displaying

- Open Coordinate Panel (Main Menu/View/Track Coordinate...)
- Select the DOF
- Start Position DOF tool
- With the Middle mouse click on the DOF's origin
- The position of the DOF node will now be displayed in the 'Current' section of the coordinate panel

Note currently there is no easy way to retrieve the orientation of the DOF node