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Introduction

CATIA Version 5 Fitting Simulation

Upon completion of this course the student should have a full understanding of the following topics:

- Creating tracks
- Editing sequences
- Creating replays and playing them back
- Using pathfinder to determine a path
- Performing clash analysis during a fitting simulation

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Fitting Simulation

Fitting simulation often gets confused with Kinematics because it involves motion. The main difference between a fitting simulation and a kinematic simulation is that a fitting simulation moves according to a set path without regard to constraints. A kinematic simulation moves according to defined joints which control the motion of an assembly.

The purpose of fitting simulation is to show how to assemble or disassemble an assembly. This can be useful to create training videos, or just to make sure that it is possible to disassemble or assemble a product in the defined space. The analysis available in Assembly Design only allows for a clash analysis between objects in their static state. In Fitting Simulation, you can perform a clash analysis between objects as they are being disassembled or assembled. Kinematics can perform a clash analysis while an assembly operates.

Since Fitting Simulation does not involve constraints, assembly constraints are unnecessary in order to perform a simulation. However, you would normally want to constrain your assembly in order to have all of the parts located correctly.

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Fitting Simulation

DMU Fitting Simulation is used to record manipulations made to assemblies. You can then use the replays generated for various things, such as analyses, instructional purposes, or demonstrations.

Open the Basic Fitting document located in the *Basic Fitting* directory. This model is a pre-defined assembly. All the constraints are in place and there are no clashes. You will use this assembly to get a feel for what fitting simulation can do.

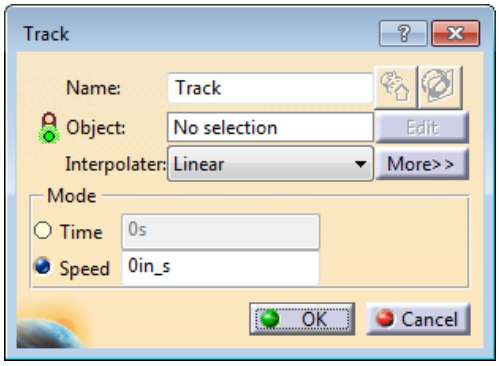
Assemblies that are going to be put into a fitting simulation do not need to be constrained. In fact, fitting simulation ignores all constraints. To make your assembly move according to constraints, you would need to apply kinematic joints.

Creating Tracks

In order to create a simulation, a series of tracks needs to be created. These tracks identify the steps, or movements, of individual parts. The individual track identifies the path for the object, and then a sequence is put together for a collection of tracks and actions.

The first step will be to remove the pulley from the compressor.

Select the Track icon. The *Recorder* and *Player* toolbars and the *Track* window appear.



Name Allows you to name the track

Object Defines the object that is to follow the track. Only one object can be in the track at a time

Edit Allows you to edit the object

Bind Analysis Allows you to attach an analysis to the track

Associate Section Associates a section cut to the track

Interpolater Defines the point interpolation for the track

Time Enables movement to be based on an amount of time for the track

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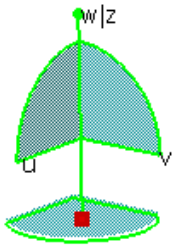
Speed Enables movement to be based on a given speed for the track

Select the *Pulley*. This will snap the compass to the geometric center of the pulley. The compass will be used to manipulate the pulley. The *Manipulation* toolbar appears; this will be discussed later.

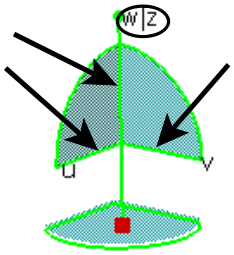
Before utilizing the compass, you will take a closer look at what the compass is, and how it is used.

Compass

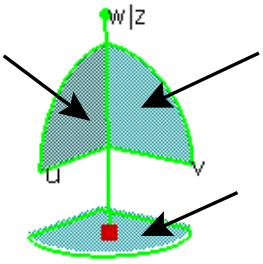
It is important to understand the compass so that it can be used effectively.



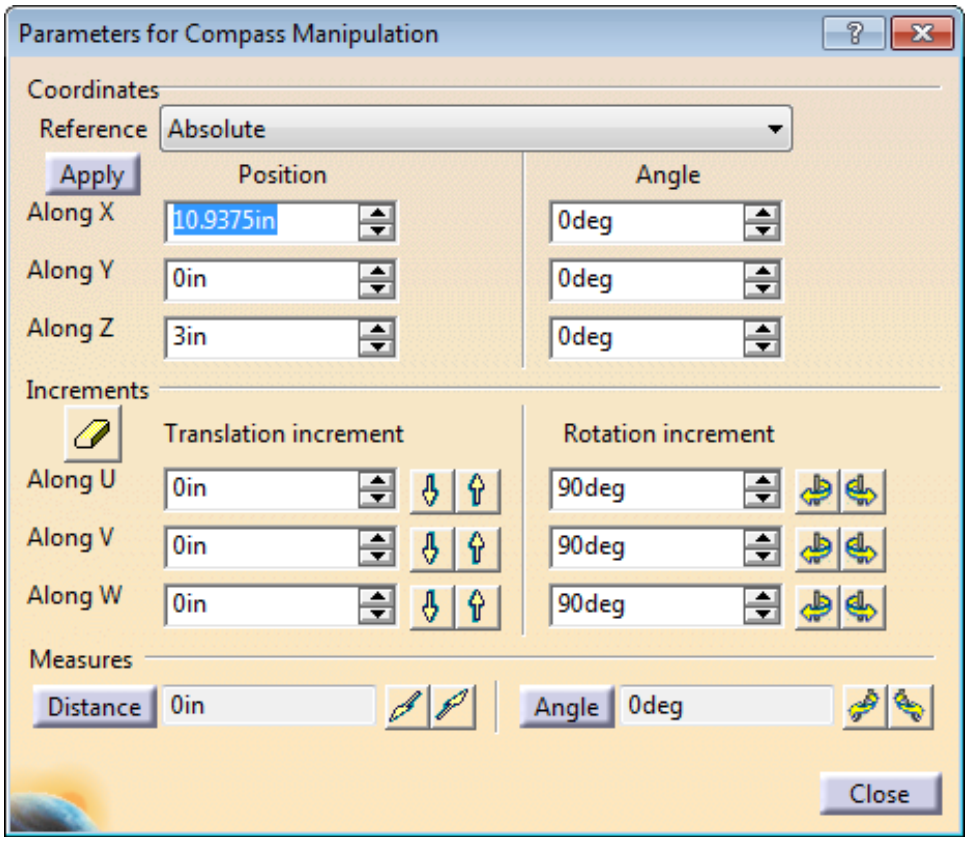
The compass, usually green when attached to geometry, has three main direction vectors: U, V, and W, as shown by the arrows below. Selecting one of the vectors will move the attached object only in the direction of the vector. Normally, the compass will be in the upper right corner of the workspace, labeled X, Y, and Z. When the compass is attached to an object, it is re-labeled to U, V, and W. If one of the vectors is aligned with one of the primary axes, then there will be a pipe (|) symbol and the primary axis is also stated. This can be seen below, circled.



The compass also has the three principle planes, as noted by arrows below. Selecting one of these planes will allow the attached object to move along the selected plane. The rotation arcs, located along the outside of the planes, work the same. Selecting an arc will rotate the object about one of the given axes.



Dragging the compass is only a guess. You do not know how far the compass has moved, and cannot make precise movements. However, if you double select anywhere on the compass, you will get the *Parameters for Compass Manipulation* window. This will allow you to make more exact movements. Take a quick look.



Coordinates

Apply	Any time the position values have been changed, you have to select the *Apply* button in order for the changes to take effect
Reference	Defines the reference element for the coordinates
Position	Gives the actual position of the compass with respect to the *Reference*
Along X, Y, Z	Shows the X, Y, and Z value of the center (red dot) of the compass
Angle	Shows the rotation angles of the compass about the X, Y, and Z axes of the *Reference*

Increments This allows the compass to be manipulated by increments, not just by set values. The icon will reset all of the increment values to zero.

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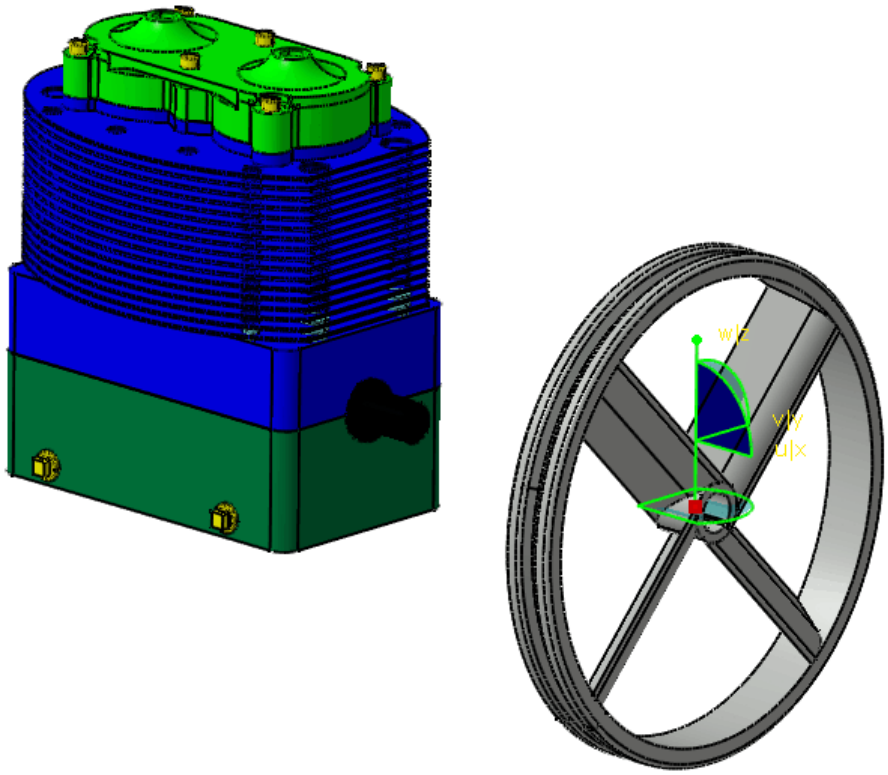
Translation increment	This is an incremental translation along one of the axes. Selecting the down (negative direction) or up (positive direction) arrows next to the value field will move the compass the specified amount in that direction
Rotation increment	This is an incremental angle movement about one of the axes, again with a negative or positive rotation

Measures Allows you to measure a distance or angle

Distance	This will allow you to measure the distance between two elements. You can then move along that direction in either negative or positive increments of the measured distance
Angle	This will allow you to measure the angle between two elements. You can then rotate in either negative or positive increments of the measured angle

With all that in mind, you are going to start manipulating the track.

Select and hold the *U* axis vector and drag the pulley away from the part. The U axis vector is noted as *U|X*, meaning it is parallel to the X axis. Move the cursor to the vector so that it highlights, then just select and hold it while moving the mouse away from the compressor body. Since you selected the U axis, the pulley will only move in the U axis direction. The pulley should look something like the following picture.



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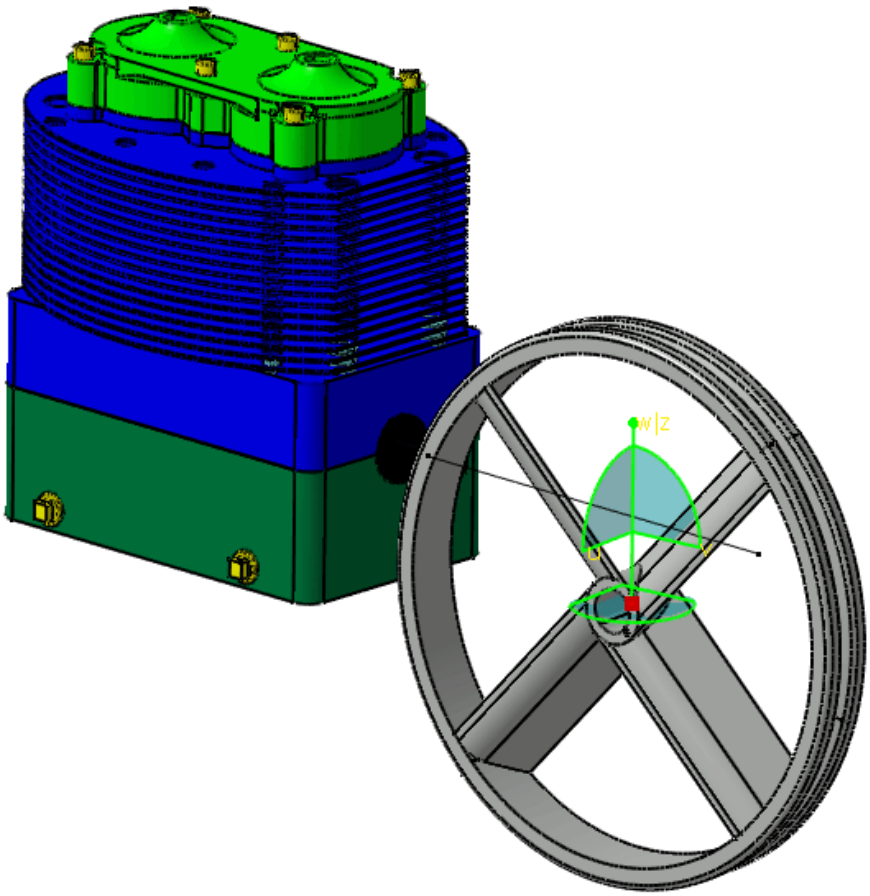
Now the position needs to be inserted into the simulation.

Select the Record icon. This icon can be found in the *Recorder* toolbar. This will create the first step of the track. Notice the line running from the original position to the new position. You should also note the time has changed. The time may vary, but this is not a concern as to the exact number.

Rotate the pulley about the W axis approximately 90°. This is done by selecting the rotation handle at the bottom of the compass and dragging it around the W axis.

Drag the pulley along the U axis a short distance. The pulley and compressor should appear similar to the following image.



Select the Record icon again. This will insert the next step. Now view the track that was created.

Select the Skip to Begin icon. This is located in the *Player* toolbar. This will snap the pulley back to the beginning of the track.

Select the Parameters icon. This is located in the *Player* toolbar. The *Player Parameters* window appears.

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Change the *Sampling Step* to 5s and select the Play Forward icon. The pulley will now move along the track in increments of 5s per step.

Change the *Sampling Step* to 3s and select the Play Backward icon. Now the pulley moves back to the original position, this time slower.

Here is what is going on in the background. The *Sampling Step* controls how often the display is updated. CATIA knows the exact location of the pulley at each moment in time, but does not display it. By setting the *Sampling Step* to 3 seconds, you are indicating that you want the display to be updated every three seconds (seconds not necessarily being real-time seconds). If you change the *Sampling Step* to be 10 or 100 seconds, CATIA would replay the same simulation, but only update the display every 10 or 100 seconds. It is somewhat similar to having a strobe light in a dark room and then watching the people move. The movement is jerky if the strobe has a long display, however the faster the strobe flashes, the smoother the movement of the people. With the computer however, setting the *Sampling Step* to a very small value (0.001 seconds for example) will cause the simulation to run very slowly.

Change the *Sampling Step* to 10s and the *Temporization* to 0.5s, then select the Play Forward icon when done. Notice what the *Temporization* does for the replay. Every step (ten seconds in this case) the simulation pauses. This pause is the half second *Temporization*.

Set the *Temporization* back to zero and select the Parameters icon. *Temporization* can become annoying when you are not closely analyzing the simulation.

Select *OK* to the *Track* window. This finishes the track. Notice in your tree you now have a *Tracks* branch, with one track, *Track.1*.

Next the drain plugs will be removed. If you remember, tracks can only contain one object at a time, so they will have to have separate tracks.

Select the Track icon and set the object to be the back drain plug (*Drain Plug.1*). This will start the track with the back drain plug being the track object.

Drag the drain plug straight out (along the V axis) approximately the distance of the pulley.

Select the Record icon, then select *OK* when done. This will create a simple track to move the drain plug straight out.

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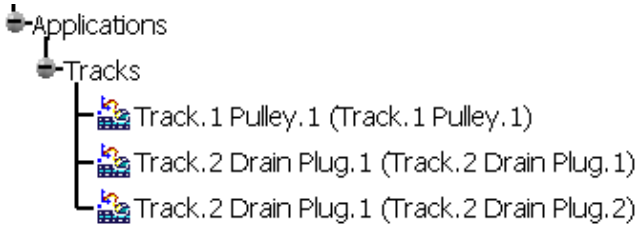
The front drain plug also needs to be simulated. However, instead of creating an entirely new track, the same track used for the first drain plug will be used for the second.

With the third mouse button, select on the second track (*Track.2 Drain Plug.1*) and select *Copy*. This will copy the track into the clipboard.

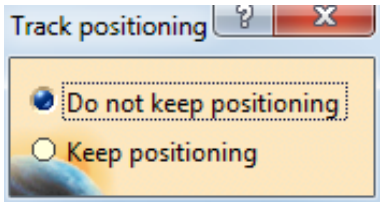
With the third mouse button, select on the main *Tracks* branch, then select *Paste*. This pastes the track back into the assembly.



Now the track needs to be modified to work with the other drain plug.

Double select on the third track (the one you just pasted). This will bring up the *Track* window again.

Select the *Object* field. This is going to bring up the *Track Positioning* window.

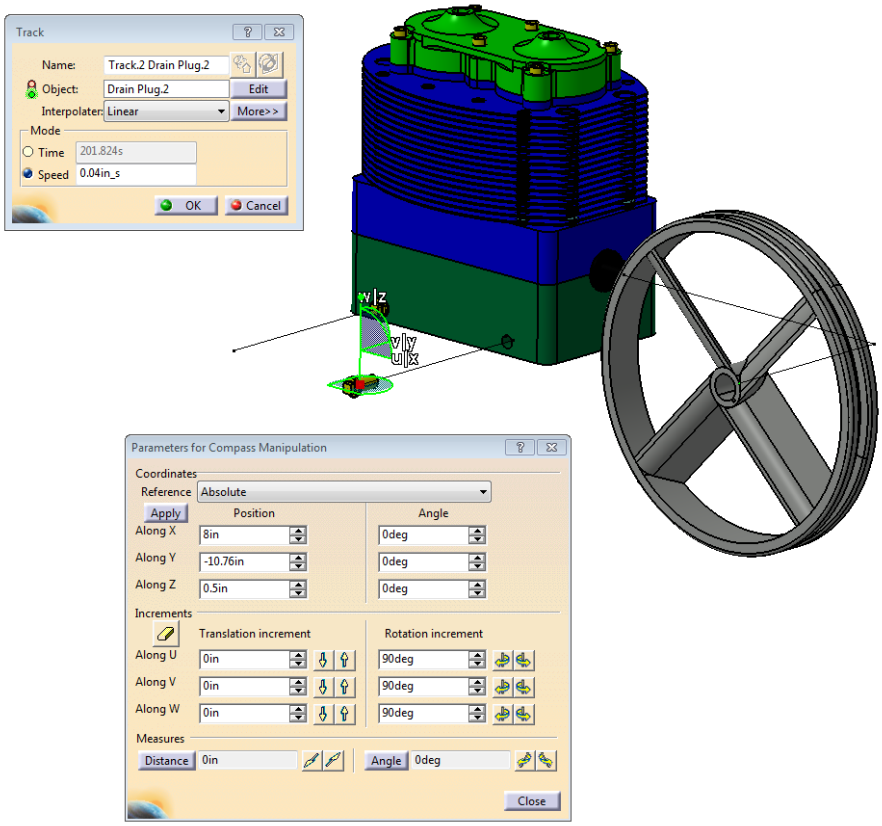


This window is ascertaining where the track will be placed. CATIA knows there is already a track in place, but the object is going to be changed. It wants to know if you want to keep the track in the current position or not. By keeping the track in the current position, the track will act on the new object, but the track guide (the line that denotes the track position) will still be in the current position. This is generally not a good idea. You will want to leave this window on the option of *Do not keep positioning*.

Select the front drain plug. The track moves to the other drain plug.

Select the Skip to Begin icon and play the track forward. This moves the drain plug out to the end of the track.

With the drain plug at the end of the track, double select on the compass. This is going to display the compass manipulation window.



Change the *Translation increment* for *Along W* to 2.0in. This will make any movement along the W axis to be in two inch increments.

Select the Up Arrow next to the *Along W* translation increment. This moves the drain plug two inches along the positive W axis.

Two inches is not quite far enough.

Select the Up Arrow again and select *Close* when done. This will make the total motion to be four inches along the positive W direction.

Select the Record icon. Notice what happened. Not only did the four inch movement get applied to the second track, but also the first. This is due to the fact that the two are copies of each other.

Note: You can also press the Insert key on the keyboard instead of selecting the record icon. This can make recording multiple points much faster.

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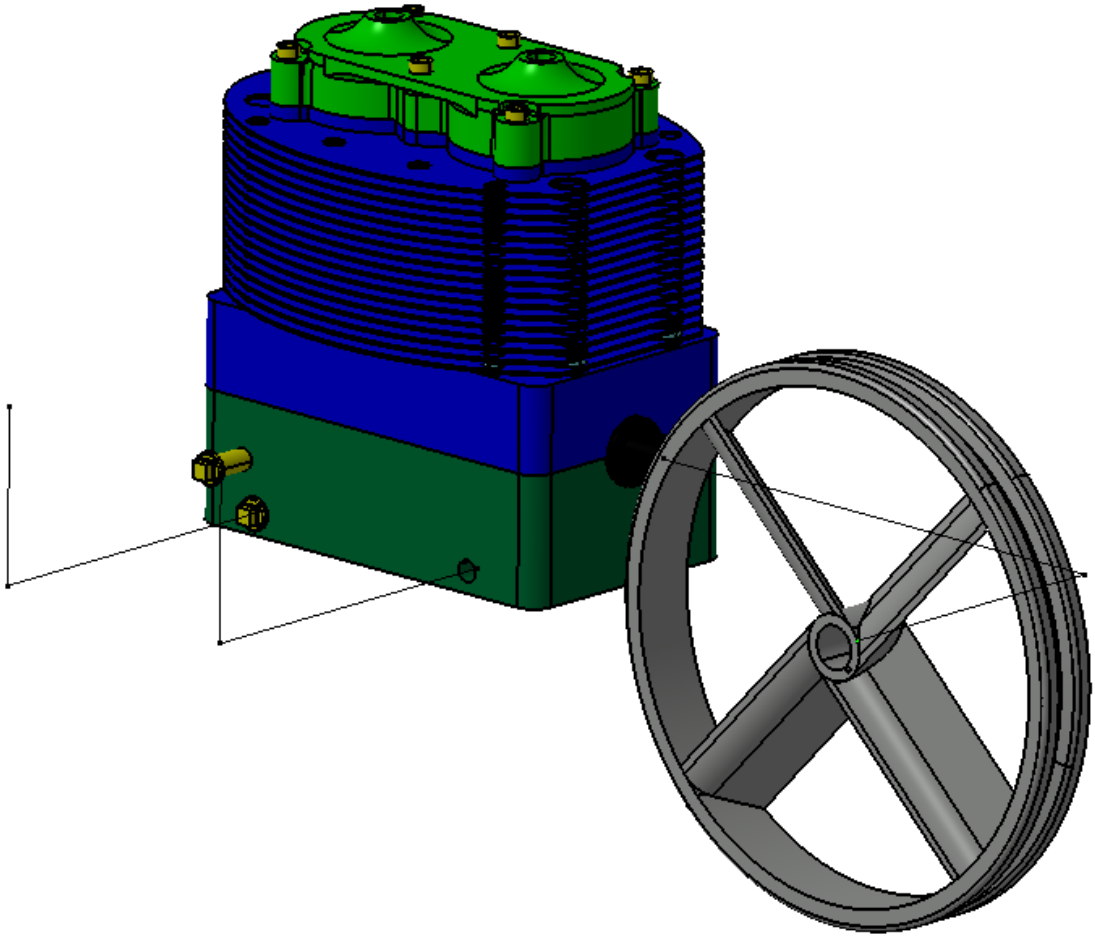
Copying and pasting a track links the two together. Therefore, whenever one of the two tracks are changed, the other will update with the new changes. If they do not automatically update, select the third mouse button on the un-updated track, select the track object from the contextual menu, and select *Update*.

Select *OK* when done. This will finalize the new track.



Those are the basic steps for creating tracks. There are a few more advanced features that will be investigated later. Next, the actions will be covered.

This would make a good point to save your fitting simulation.

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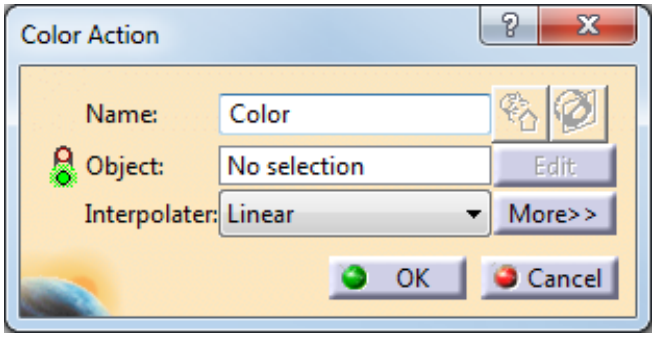
Color Action

Color actions are very simple. They create an action that changes the color and transparency of an object. When creating a fitting simulation, you may want to emphasize one of the parts of the simulation, and changing the color of the object would be a good method to attract attention.

Select the Color Action icon. The *Color Action* window appears. The options are very similar to the track options.



Select the *Pulley*. This is the *Object* that you are going to have change color. In order to change the color you will use the *Graphic Properties* toolbar.

Change the color to a bright yellow. You can do this by selecting the down arrow next to the color. The color of the pulley changes to bright yellow. You can also change the transparency level using the box next to the color.

Select the Record icon. This will record the color change.

Select the Skip to Begin icon. This will take you to the beginning before the color change occurs.

Select *OK*. This finalizes the color action. A *Color Actions* branch will appear in the specification tree.

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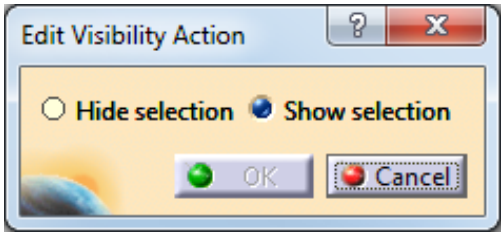
Visibility Action

Visibility actions are just as simple as the color actions. The visibility action will either hide or show objects.

Select the Visibility Action icon. This will display the *Edit Visibility Action* window. This is located under the Color Action icon.



As you can see, there are only two options that allow an object to be hidden or shown.

Select the front drain plug. Notice the drain plug looks transparent. This just denotes that it will be hidden when the action is performed.

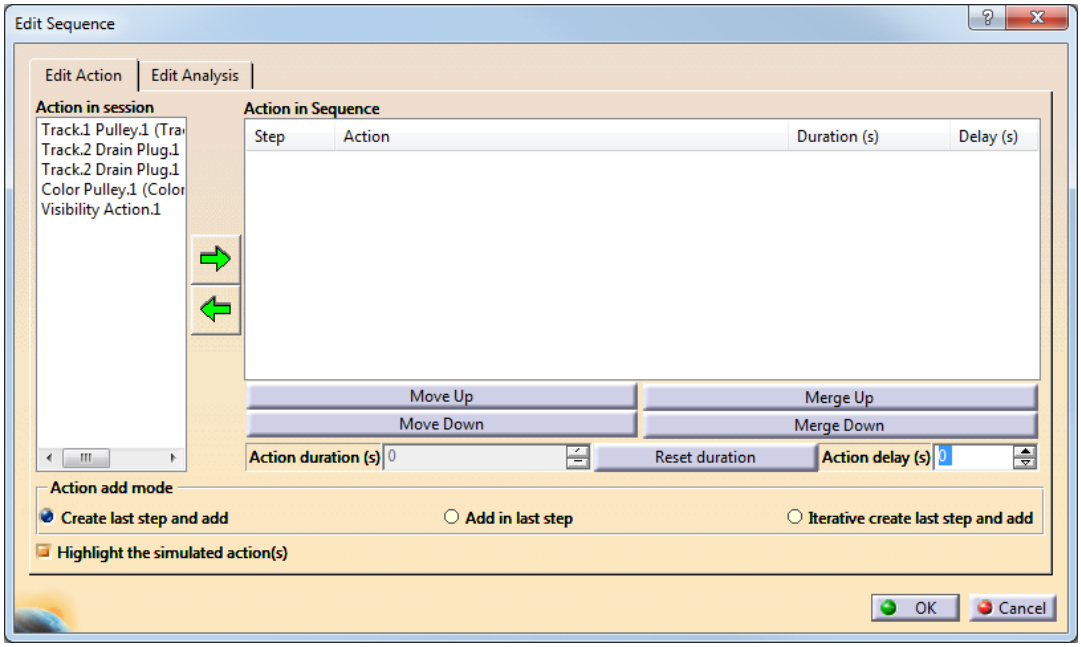
Select *OK* when finished. This is the last type of action to create.

Now that you have all the actions and tracks created, it is time to make a sequence.

Sequences

A sequence is an ordered set of events. All of the tracks and actions that you have created so far can be merged into a sequence. The benefit of a sequence is the ability to control the timing of events. For example, both the drain plugs use the same track. With a sequence, one drain plug track can take three seconds to complete the track, while the other drain plug track can take only one second. The order of events is also controlled.

Select the Edit Sequence icon. This will display the *Edit Sequence* window. There are a few options and areas in the *Edit Sequence* window, so take a closer look.



Action in session	These are all the actions that can be added to the sequence. All of your tracks, as well as other actions, are in this area
Action in Sequence	This is where your sequence will appear. By selecting one of the actions in the session, then selecting the right arrow, the action will be merged into the sequence
Move Up/Down	Change the order of the actions in the sequence
Merge Up/Down	Merging actions together will make them occur at the same time. For example, merging a track and a color action will make them happen simultaneously
Action Duration	Defines the length of time for each action in seconds
Action delay (s)	Defines how long the action will delay before it occurs
Action add mode	Specifies how the next action gets added to the sequence
Highlight the...	Specifies that the actions will appear highlighted when running a sequence

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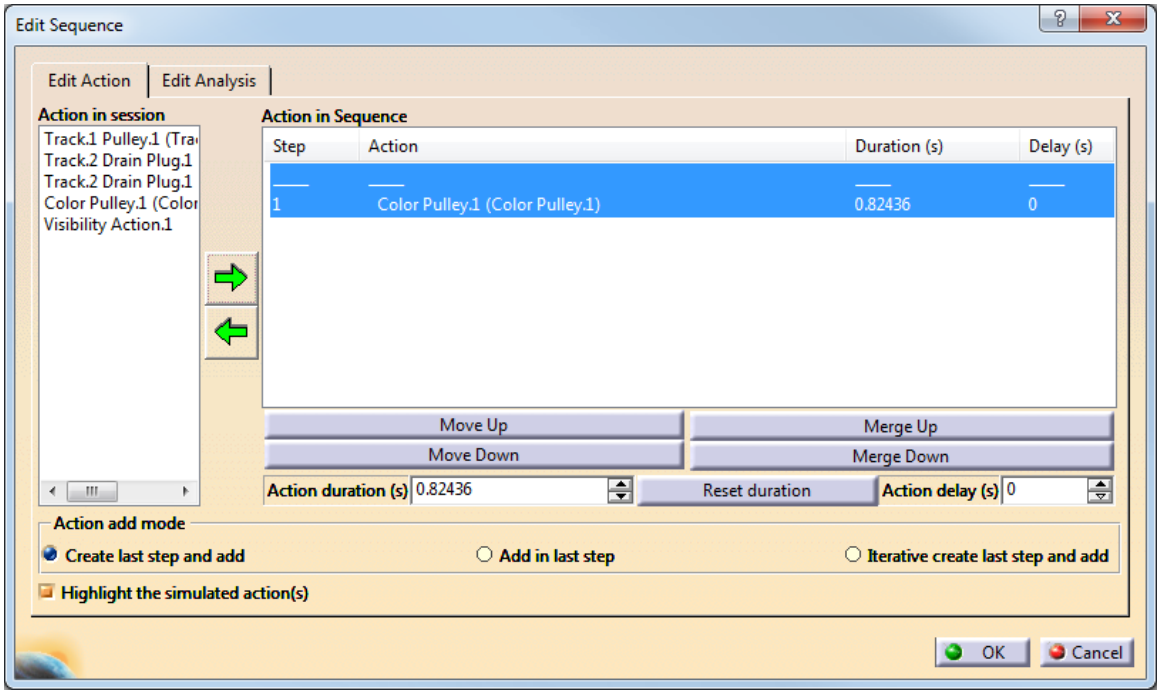
The first operation that should occur is the color action for the pulley and then the track action of the pulley being removed. This will be followed by both of the drain plugs being removed, and then the first drain plug being hidden.

None of the tracks have unique names. This makes it difficult to determine which track goes with which operation. Fortunately, there are only three tracks, but in a large fitting simulation, there may be hundreds of tracks. Next time, the tracks will get renamed after they are created to ease the process.

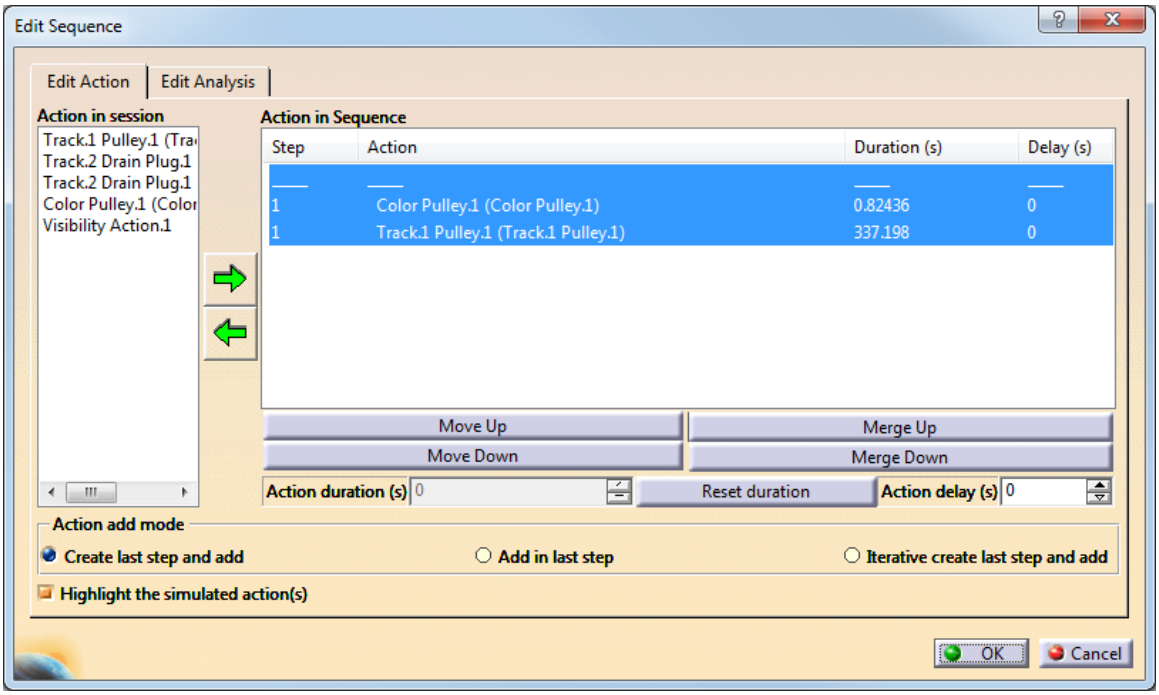
Select *Color Pulley.1* and select the Right Arrow. This will place the action in the sequence.



Notice the duration is set. The color action will occur over that time, gradually changing colors. A visibility action occurs instantly and will not have a duration.

Select *Track.1Pulley.1(Track.1Pulley.1)* and select the Right Arrow again. This will place the pulley removal track right after the color change action. In this case it will not matter if these two happen consecutively (two different steps) or simultaneously (all in the same step), but good technique would suggest that since you want both the color to change and the pulley to be removed at the same time, it would be best to put them into simultaneous mode.

With the second step highlighted, select the *Merge Up* button. This is going to merge the two steps together.



Notice that both the actions now have step 1 beside them. This means that both actions will be performed at the same time. You can have as many actions occur simultaneously as you want.

With *Track.1Pulley.1* in the first step selected, change the *Action Duration* to 10. This will make the first action take ten seconds.

Select *Track.2 Drain Plug.2 (Track.2 Drain Plug.1)*, and then hold down CTRL and select *Track.2 Drain Plug.2 (Track.2 Drain Plug.2)*. This will highlight both of the track actions in the *Action in session* field.

Select the Right Arrow to add them to the sequence. This makes them part of the sequence. Notice both are added to one step. This is a good method to add two actions that are to happen simultaneously.

Change the duration for *Track.2Drain Plug.2 (Track.2 Drain Plug.1)* to 15, and the duration for *Track.2Drain Plug.2 (Track.2 Drain Plug.2)* to 5. To change the duration, just select *Track.2 Drain Plug.2 (Track.2 Drain Plug.1)* and then change the duration to 15. Do the same for *Track.2 Drain Plug.2 (Track.2 Drain Plug.2)*.

Even though both actions are happening at the same time, it is possible to have one action last longer than the other.

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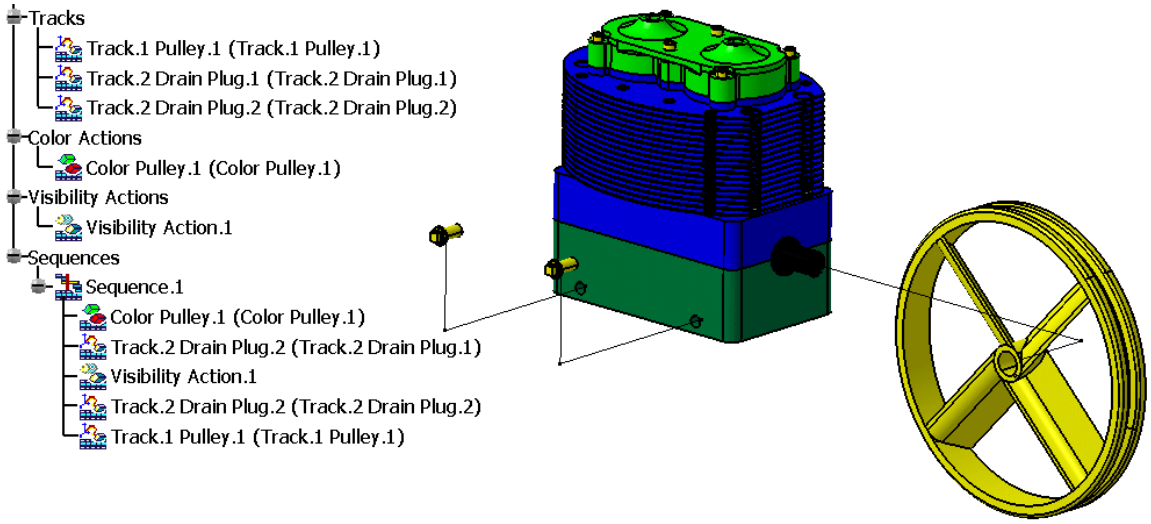
With no *Actions in Sequence* selected, select *Visibility Action.1* and add it to the sequence. Just select in a blank white area in the *Action in Sequence* area, then select *Visibility Action.1*, and then the right arrow. This will insert step three into the sequence. Now replay the sequence.

Select the Skip to Begin icon. **Make sure the *Sampling Step* is set to 1s.** To check the *Sampling Step* just select the parameters icon.

Select the Play Forward icon. **Select *OK* to the *Edit Sequence* window when done.** Notice the total time took 25 seconds. This is the ten seconds for the first step, and the 15 seconds of the second step. The five seconds for the one track is contained within the 15 seconds.

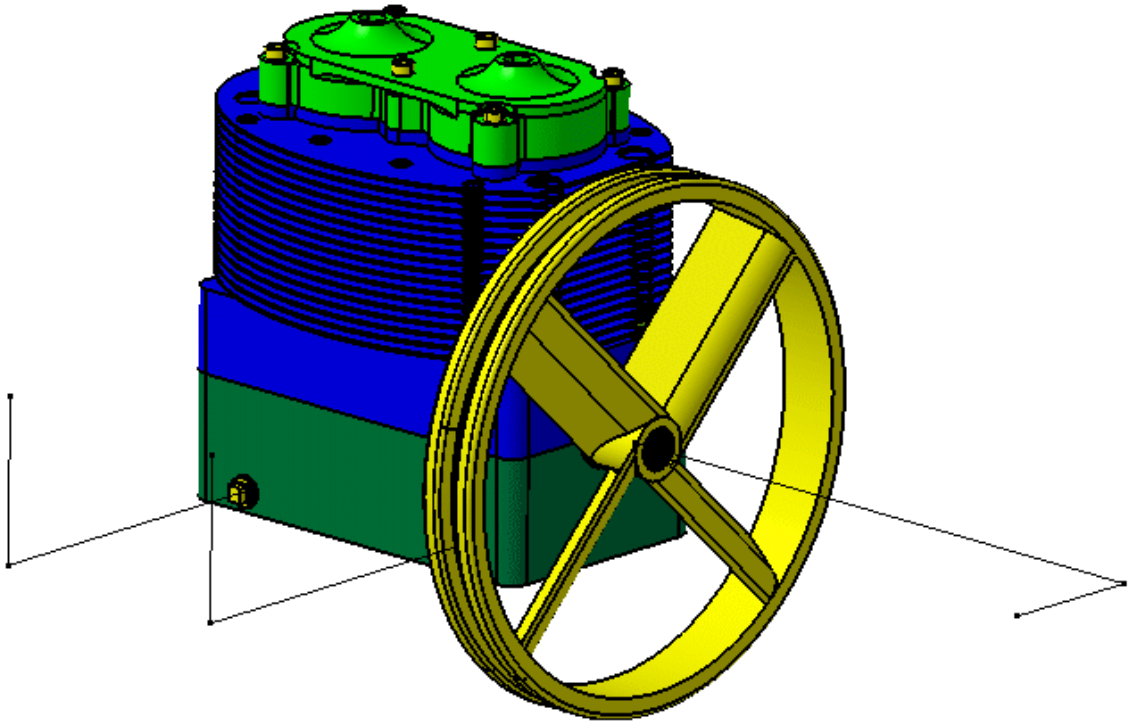
Also note the disappearance of the front drain plug. This is due to the hide command in the visibility action.



Notice all of the objects are still moved away from the assembly. This can be easily remedied.

Select the Reset Position icon. This snaps the assembly back to the position it was when the assembly was brought into the fitting simulation.

This would make a good point to save your assembly.



Next, the bolts holding the head will be removed. There are two methods to remove all of the bolts. One method would be to create a simulation track for each one, copying and pasting the track, of course. The other method would be to group the bolts together in a shuttle.

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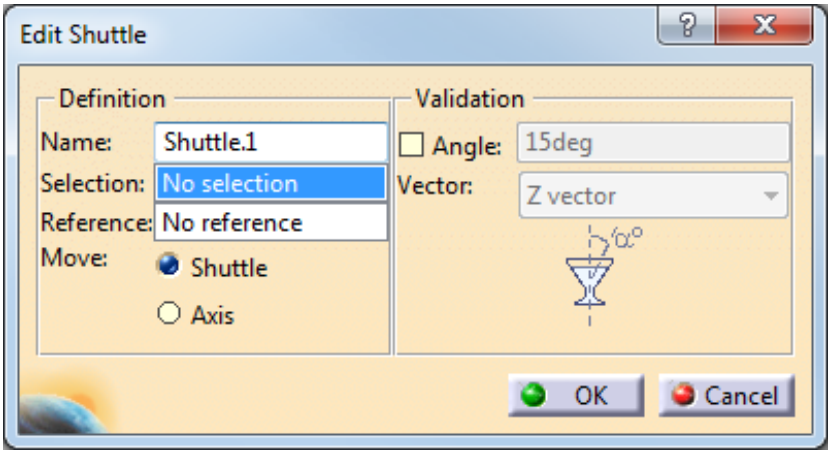
Shuttles

Select the Shuttle icon. This will display two windows. One window will be the *Preview* window. This window shows what is currently in the shuttle. The second window is the *Edit Shuttle* window. This window has a bit more information to it.



Definition

Name This is the name of the shuttle. It is always advisable to name the shuttles with a unique and clear name

Selection Defines what is selected for the shuttle

Reference A shuttle can be referenced back to another shuttle. This will allow it to move with the shuttle that it is referenced to

Move Controls what gets moved with the shuttle

Validation Validation is used with the path finder icon. It will keep the object from rotating beyond a certain angle, about a given axis

Angle Defines the maximum angle the object can rotate

Vector Defines what axis the maximum angle can occur around

Select the six bolts around the top of the compressor. The six bolts get added to the shuttle. Notice the compass and axis (the small hand with a box) is placed on the first bolt you select. The placement of the axis is not important in this case. If all six bolts were selected beforehand, the axis would be placed in the geometric center of the bolts.

Change the name of the shuttle to Head Bolts and select *OK* when finished. This will finish the shuttle. The validation options will be left alone for the moment. This also adds another branch in the tree for the shuttles. The shuttle can now be put into a track, and later, into a sequence.

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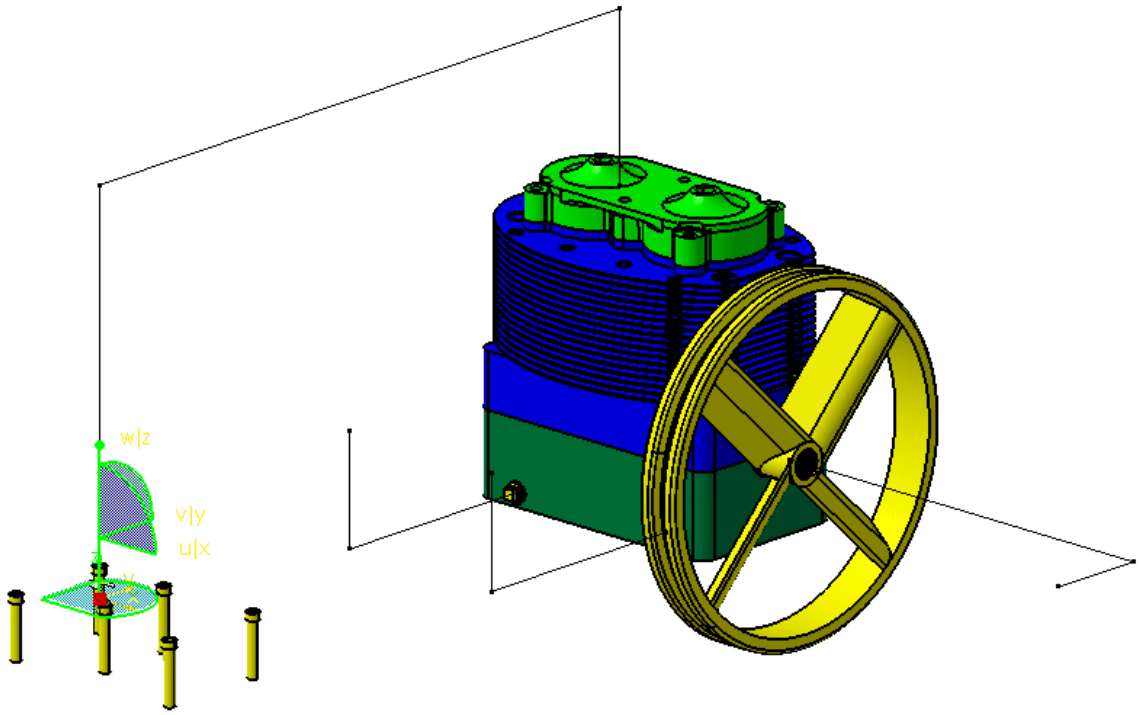
Select the Track icon and then the *Head Bolts* shuttle. This will start a track using that shuttle. Since you are only moving the shuttle, you can, at any time, add or remove objects from it.

Move the bolts straight out, over, then down to create the track. Make sure you record each movement in order to create the appropriate track. The bolts should end up similar to the following picture.



Skip to the beginning of the track, make sure your *Sampling Step* is 10s and play it forward. This is just to make sure the simulation works as you want. Notice the straight corners of the simulation track. This is due to the *Interpolater* being set to linear.

Change the *Interpolater* to *Composite spline*. You will not notice anything different in the track visualization.

Skip to the beginning of the track and play it forward again. This time notice what is happening, the bolts slow down, and then speed back up as they go around a corner.

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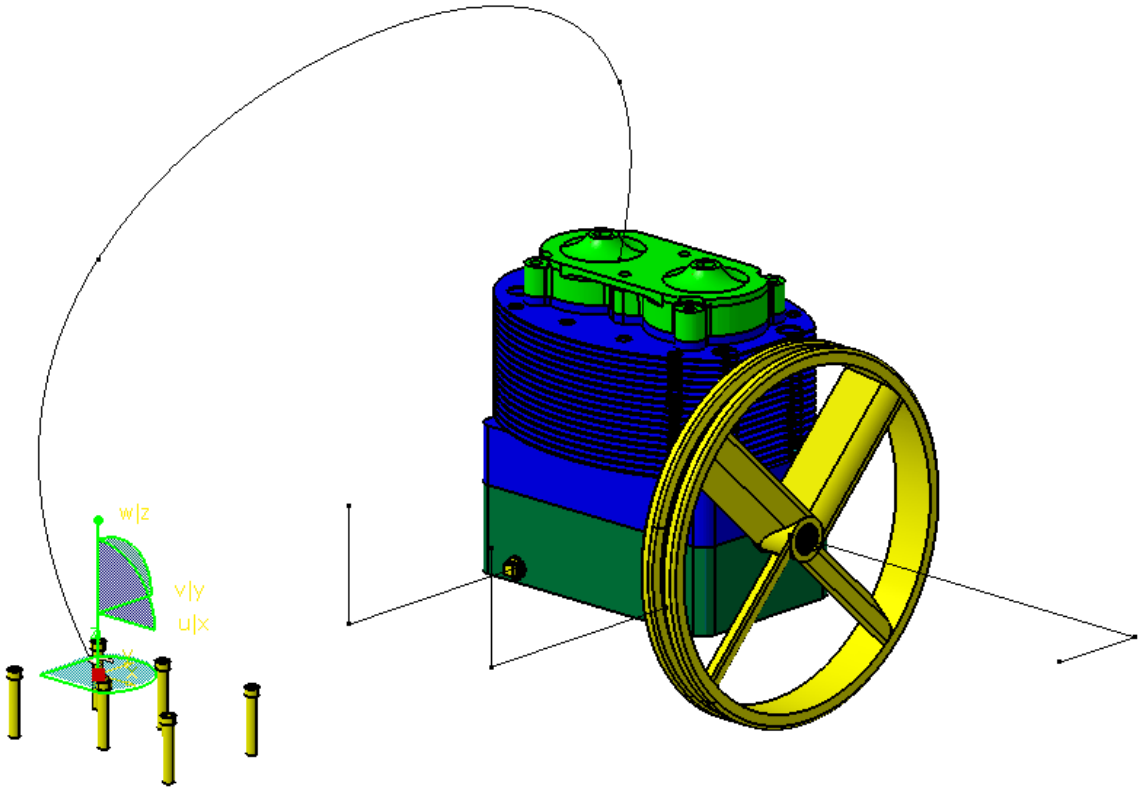
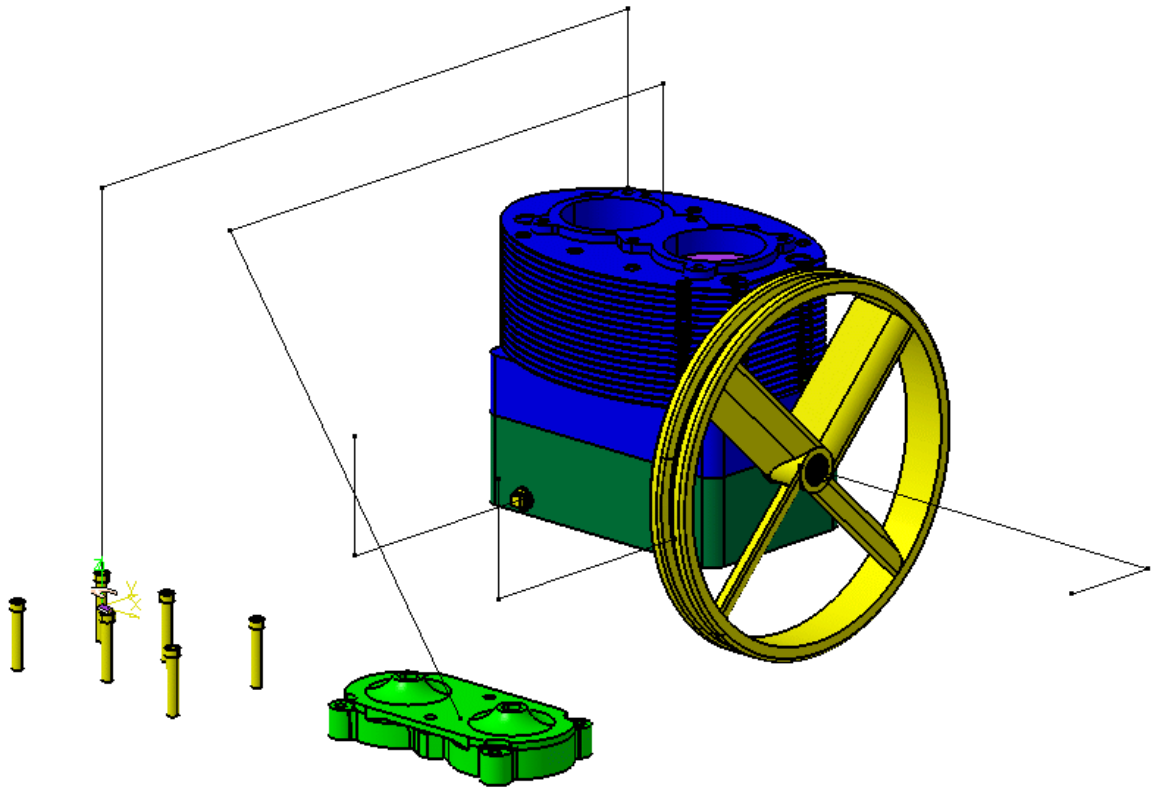
Change the *Interpolater* to *Spline*. This time you will notice a definite change in the track path. In this mode, the recorded points act as anchor points for the spline.



Skip to the beginning of the track and play it forward again. The bolts move in a very nice and fluid motion, but this is not what you are after. The bolts cannot simply move sideways out of the head. Instead, they need to pull straight out.

Change the *Interpolater* back to *Composite spline* and select *OK* when done. This will leave the bolts pulling straight out of the block.

Create a track of the green head being pulled off of the compressor. Move the head over by the bolts. The result should look something similar to the image below.



Create a shuttle for all of the aqua bolts at the bottom of the cylinder head and call it <u>Cylinder Bolts</u>. The bolts are the .5x3 and .25x3 bolts. There are twelve bolts total.

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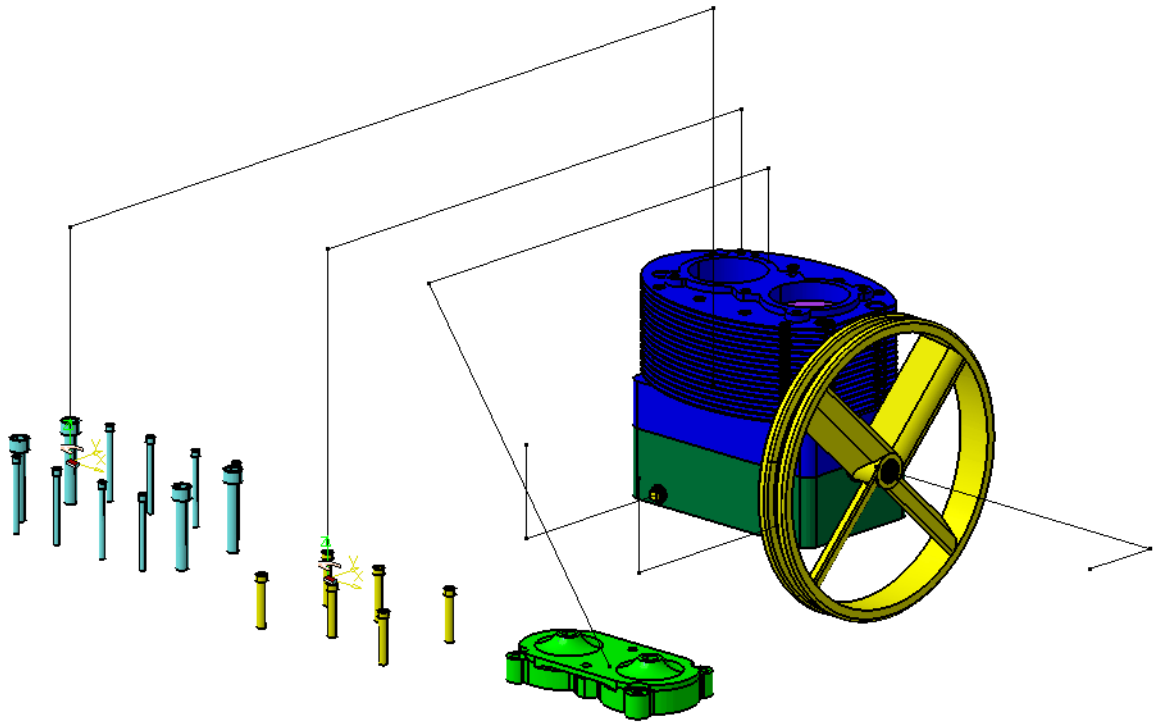
Create a track to remove the bolts from the assembly. Move the bolts over to the same area as the rest of the parts. The track should appear something like what is shown.



One more track is to be created. This time, however, you are going to create it on-the-fly in a sequence.