Autodesk Inventor Tutorials

by Sean Dotson
www.sdotson.com
sean@sdotson.com

Adaptivity 101

Part One in a Series

Latest Revision: 1/3/03
for R5, 5.3 & R6

Adaptivity is a feature introduced by Autodesk in Inventor R1. Simply, adaptivity is a way to maintain parametric relationships between parts without the user having to keep track of complex equations and relationships. Adaptivity allows a part size or position to change based on the position or size of other features or parts. A simple example is the ability of a linkage rod to grow or shrink in length when the distance between the connection points change. In a non-adaptive modeler the user would be required to define the length of the linkage rod by equations that specify the distance between the connection points. With adaptivity the user simply tellsthe software that the linkage connects to both point A and point B and that the software should determine the length of the rod to make the desired connection.

Adaptivity can also allow a part to change shape or position dynamically while constraints are being driven. This allows users to simulate, to an extent, flexible hoses, springs and other items that deform.

Once you master adaptivity a large number of the lengths, distances and equations that users scribble down on scraps of paper next to the keyboard can be thrown away. No longer do users have to "know" the distance between two points but simple define the adaptive part to be that unknown length.

This is the first in a series of tutorials that will describe different ways to use adaptivity. In this first tutorial we will look at a basic assembly and create a part that will be used adaptively in the assembly.

The data set for the tutorial can be downloaded from:
http://www.sdotson.com/tutparts/adaptdata101.zip
Note files are in R5.3 format. Some colors may differ as I did the screen shots in R6 which supports face colors (for red handle)

Let's first look at the final assembly to see what we will be constructing. (See Figure 1)

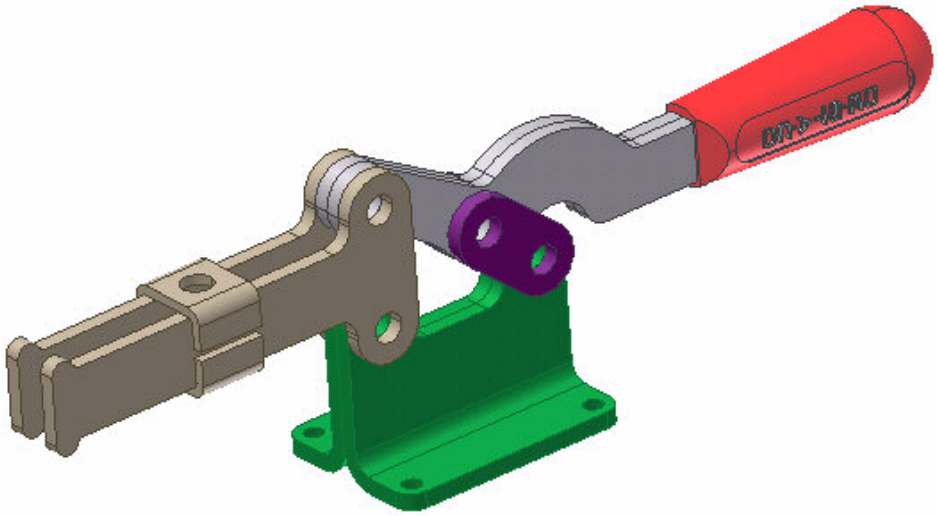

Figure 1 - DeStaCo Clamp

In this example we will be creating the purple linkages that acts as one of the fulcrums of the handle. We will be varying the distnace between the mounting points on the green brackets to show how the purple linkage will change size to accommodate changes to the brackets.

Download the data set and unzip it to a folder. Double click on the **Adapt101.ipj** project file to start Inventor and set the project. Open the file: **Adapt101.iam**

Currently the brown clamp and the red and silver handle are constrained at their pivot points by insert constraints. You can move each of them independently by dragging them around. We want to construct a linkage of a certain length that will cause both the clamp and the handle to be at 90° to the green brackets when in the clamping position. Add a angle constraint between the clamp and the bracket and the handle and the bracket (see Figure 2). This will lock them into the proper position.

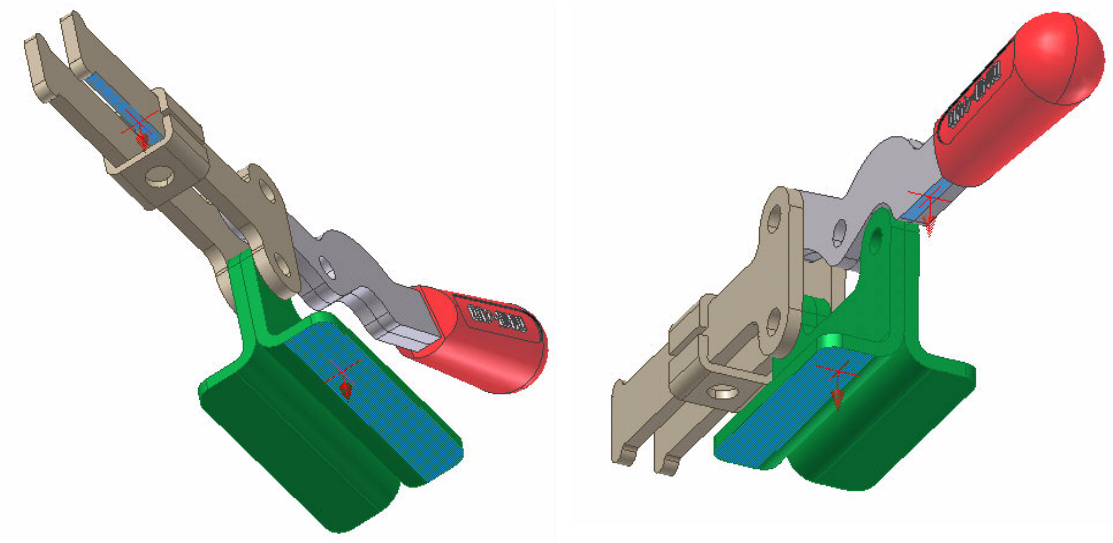

Figure 2 - Angular Constraints Applied

Now neither the handle nor clamp should be able to move freely. It is often required to "lock" down parts before applying adaptive constraints to them. If they are able to move freely there can sometimes be multiple solutions to the adaptive calculations and errors can occur. It is good practice to reduce the degrees of freedom to the minimum before applying adaptive parts to an assembly.

We shall now construct the linkage required to join the handle to the green brackets. Begin a new English (inch) part file and create the sketch as shown in Figure 3. Notice that all of the geometry is fully constrained with the exception of the two right hand circles. We have intentionally left off the dimension between the left and right hand circles so that the part may adapt in length to suit our constraints in the assembly. This is a very important concept and warrants repeating.

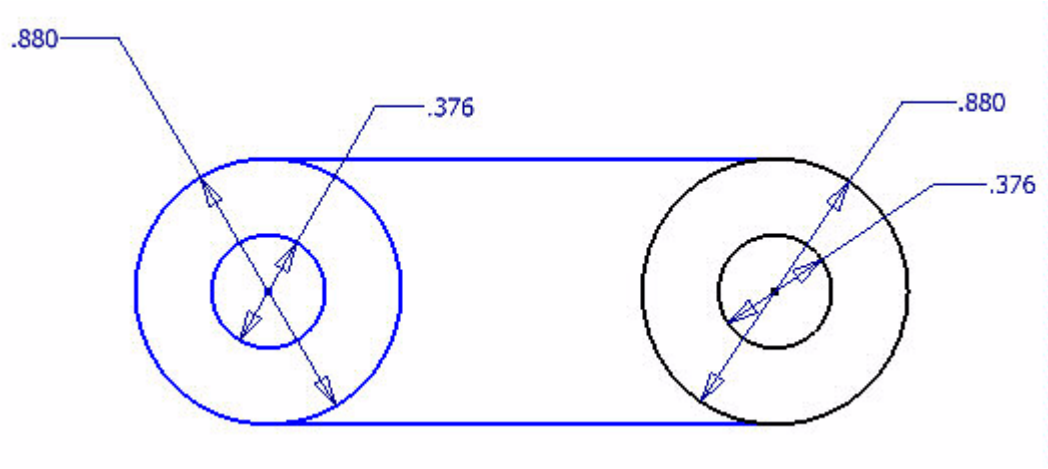

Figure 3 - Linkage Sketch

For a sketch to be adaptive some degree of freedom needs to be left unconstrained. If we fully constrain a sketch it will produce errors if we attempt to constrain it adaptively. (Adaptive features {extrusions and revolutions etc..} will be covered in a later tutorial. An extrusion length must be defined but adaptive parts override this length when required.)

Now extrude the sketch a distance of 0.25". You should have a part like that shown in Figure 4.

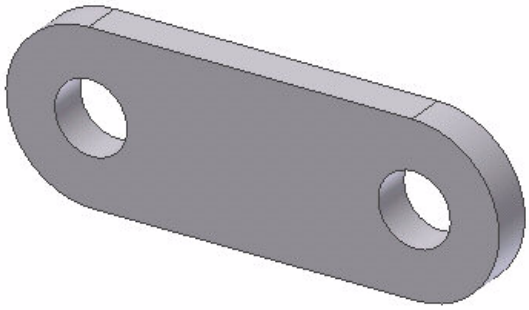

Figure 4 - Extruded Linkage

Now turn your attention to the browser. Right click (an acronym I will be using for this action is **RMB** a.k.a **R**ight **M**ouse **B**utton) on Extrusion1 and select Adaptive. This will make both the sketch and extrusion adaptive. The symbol for an adaptive feature will appear next to the standard extrusion and sketch symbols as shown in Figure 5.

Save this part as **Linkage_01.ipt** and exit the part. Return to the **Adapt101.iam** assembly and insert the newly created linkage. RMB on the linkage in the browser and select adaptive. Parts that are to be adaptive need to be declared as such in both the part file and in the assembly file. The declaration of adaptivity in the part file tells inventor what features or sketches are to be adaptive in that part and the declaration of adaptivity

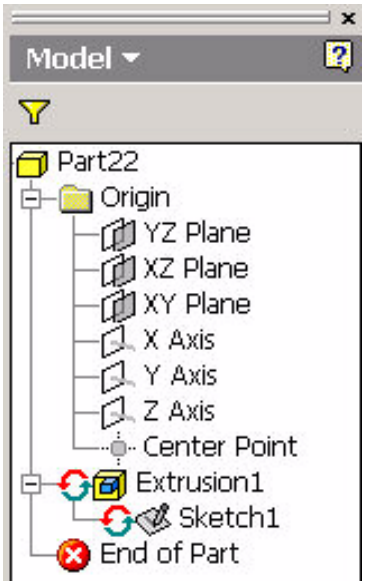

Figure 5 - Making the Extrusion & Sketch

in the assembly tells Inventor that this part is to be used adaptively in this assembly. (More on this latter).

Now place an insert constraint between one of the holes on the linkage and one of the holes in the middle of the handle as shown in Figure 6.

You will notice that in this example the linkage is too long for the desired connection points. Depending on how you constructed your sketch, yours may be too short or too long.

Since the linkage is adaptive we can add another constraint to make the linkage the correct size. Add another insert (or axial mate) between the linkage's other hole and the free hole on the green bracket. If you have followed the instructions correctly the linkage should change length and snap into place.

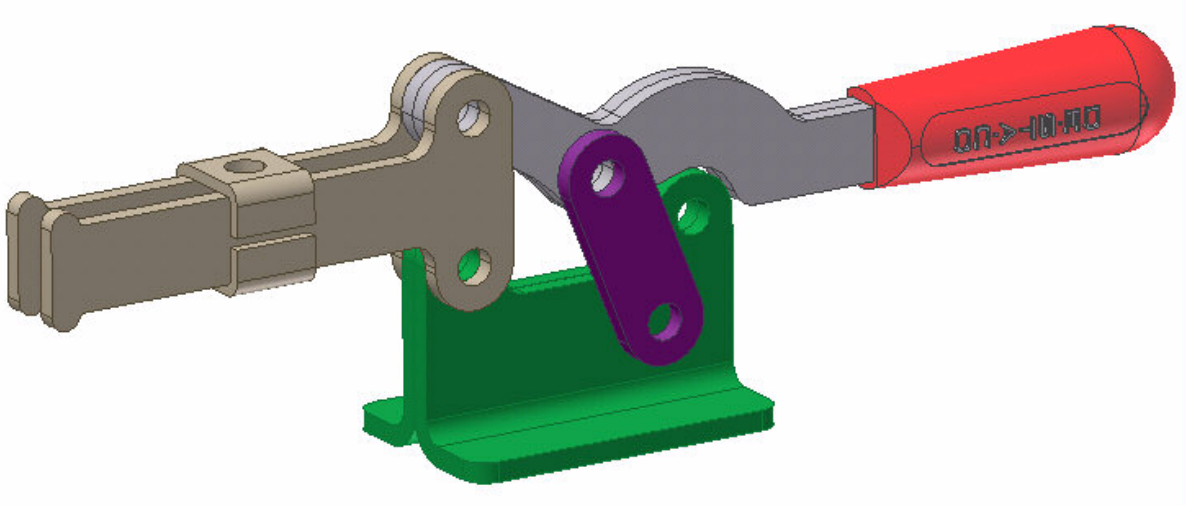

Figure 6 - Constraining the Linkage

If you receive and error message, recheck your parts to make sure you have followed the correct steps. Make sure your part is adaptive in the content of the assembly.

So now you want to make sure the clamp assembly works correctly. Suppress the two angle constraints between the handle and the bracket and the clamp and the bracket. (See Figure 7).

You can now grab the purple linkage and move it. The handle and clamp will move along with the linkage in a kinematically correct manner. This clamp will now be parallel with the ground when the handle is parallel to the ground. Of course you could

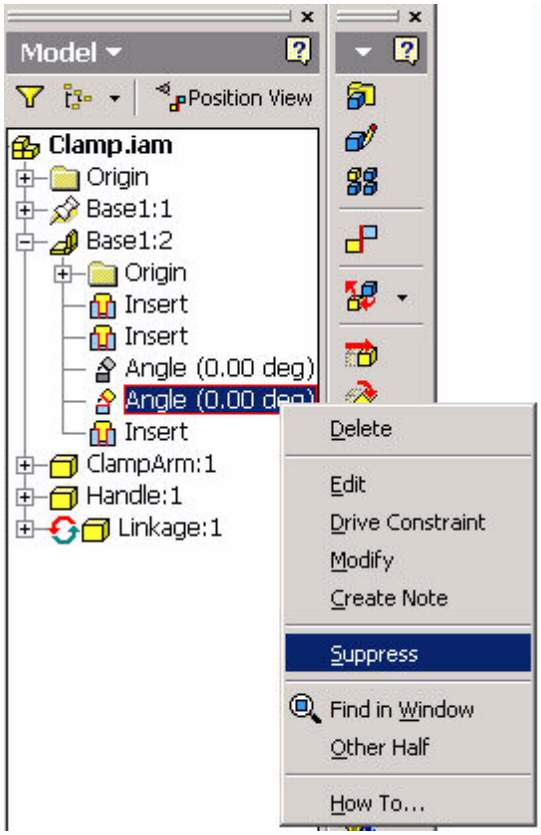

Figure 7 - Suppressing Constraints

have set up the initial constraints such that the handle was 15° off parallel when the clamp was parallel to the ground. In fact you can still do that by un-suppressing the constraints and editing them to suit your needs. The length of the adaptive linkage will change to fit thes new constraints.

Figure 8 shows the handle with the linkage in position.

You can now add a second instance of the linkage to the assembly to constrain into position on the opposite side of the handle. After you insert this instance RMB on it. You will notice that the Adaptive command is grayed out. Why is this? Let's take a moment to discuss the finer points of adaptive parts.

The reasoning is actually quite simple. Since an adaptive part can change size and shape in relation to its surroundings you cannot use the same part adaptively more than one time.

For example you could not use this same linkage part in another handle and have it be adaptive. If it were to change size in **Handle1.iam** then it would also change shape in **Handle2.iam**.

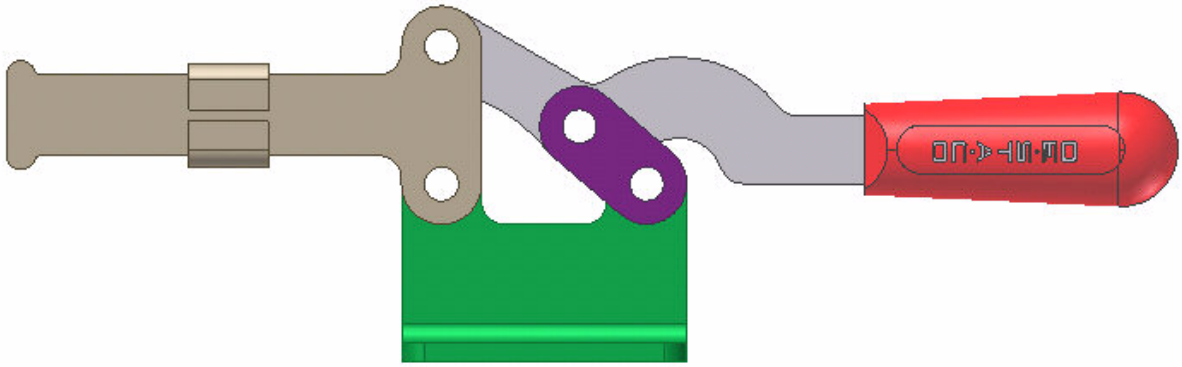

Figure 8 - Clamp with Green Bracket at 3.125"

Since this is the case, users often run into problems with not being able to make parts adaptive because the option is grayed out. This is often due to the fact that the part is currently being used as adaptive in another assembly. You can easily check (and remedy) this by opening the part and selecting Tools / Document Settings / Modeling. Check to see if the **Adaptively Used in An Assembly** box is checked. If it is, then this

part is already being used adaptively and therefore cannot be adaptive in a second assembly. If you know for a fact that it is not being used adaptively in another assembly you can uncheck this box and save the part. This often occurs if you tried to use it adaptively in a scratch assembly and then abandoned it. Or deleted the part but did not save the assembly. The adaptive option should now be active in your browser RMB menu.

So back to the assembly. When you inserted the second instance of the linkage it was not adaptive but it was the same size as your adaptive instance of the linkage. So you can use the same part in your assembly multiple times if they will always be the same size (such as in this example).

"Ok" you say, "Big deal, I could have created that linkage easily without adaptivity."

That is true however to do this you would have to have measured the distance between the two holes and remembered it or written it down on your scrap of paper. If you wanted to do this by parametrics it would have involved a series of trigonometric equations describing the position of hole1 and hole2. Now we are going to go one step further and change the size of our green bracket.

"But then I have to measure again" you say. Not with adaptivity.

First un-supress the angular constraints on the handle and clamp to get it back into the original position. Open the bracket file and edit Face1. Change the 3.125" side to 3.5". Update and save the file. Return to the assembly and update. The bracket should have grown and the linkage should have changed shape to match. You can now suppress the angular constraints and move the handle and clamp.

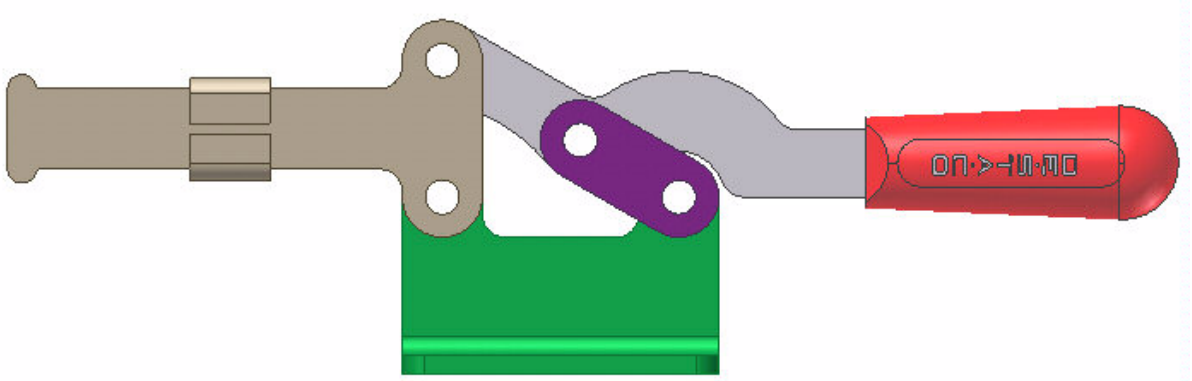

Figure 9 - Clamp with Green Bracket at 3.5"

This shows the power of adaptivity. We made no measurements and no equations but created a part that is able to adapt to a variety of new shapes and sizes depending on other geometry we change.

After you are satisfied with the size and shape of your adaptive parts it is often a good idea to make then un-adaptive. While there is usually not a problem leaving them adaptive, you can sometimes encounter situations where multiple solutions again exist and this can cause problems. Using adaptivity to make the parts temporarily "stretchy" and then locking them into shape is a good design practice.

In the data set is a file named **Clamp.iam.** This is the completed assembly that you can examine if you have problems. The adaptive part is **Linkage.ipt.**

NOTE: The clamp and handle parts are derived parts and therefore their features cannot be edited. All other parts are native Inventor files.

We could have created this linkage in-context using projected geometry. This technique will be covered in a future tutorial.

In the next installment of this series of tutorials we will look at another example of a simple adaptive part but one that has multiple adaptive features, that each adapt independently of one another, in one single part file.

In future installments we will address how to create in-content adaptive parts using projected geometry, the details of cross part association errors, dynamically adaptive parts (like flexible tubing) and how to drive constraints in sub-assemblies involving adaptivity.