

Mechanism Design:

Analyzing An Existing Linkage



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Objective:

At the end of this tutorial, you will be able to:

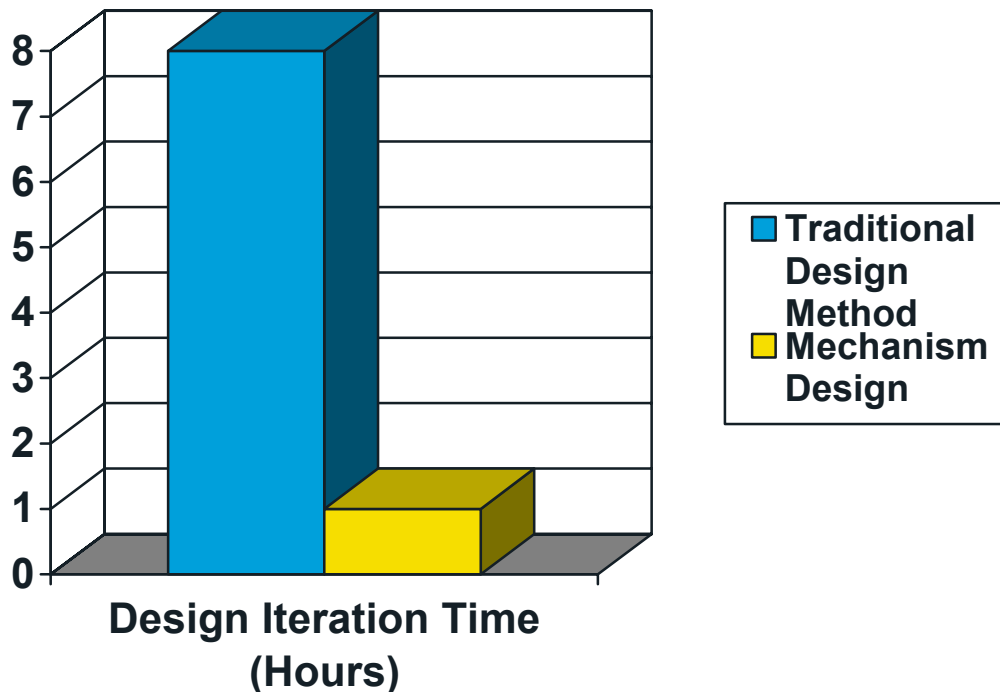
- Explain why Mechanism Design is a tool for early prototype investigation.
- Describe the different types of kinematic joints you can simulate.
- Identify a current project where this module and technique can be applied.

Overview:

When designing linkages for a machine it becomes important to understand the relationships between different parts as they move relative to one another. Further, it can become very complex to check for interferences or lockout situations as it moves through its complete range of motion. Mechanism Design within Pro/Engineer gives you the ability to perform virtual design studies before any parts get manufactured or purchased. This is a powerful capability that lets you make design changes early in the design phase when the cost of change is cheap!

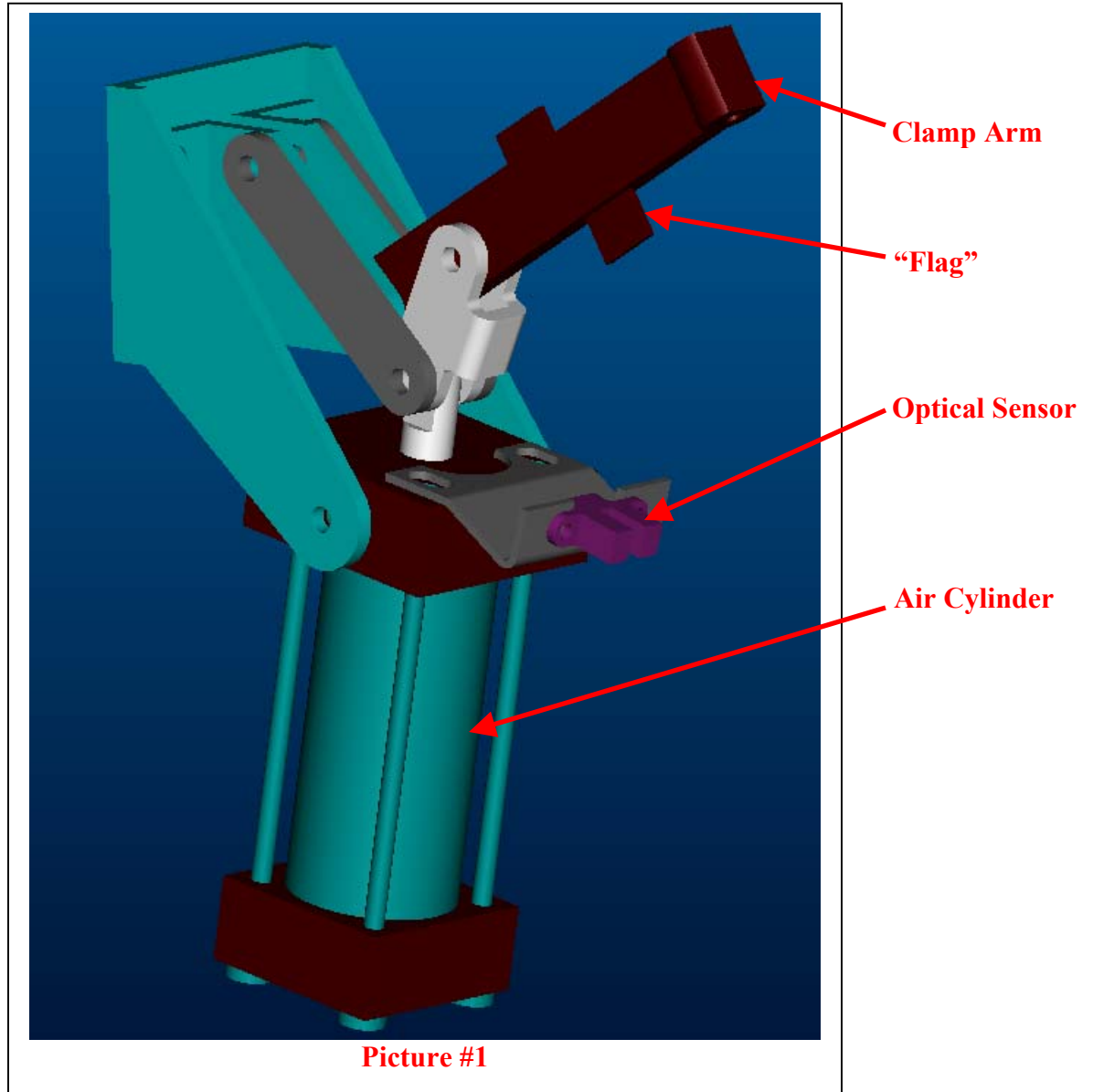
Metric:

The example used in this tutorial was of a clamping mechanism used on a wafer loading machine. This assembly was failing in the field because the range of motion caused a sensor to break off. With Mechanism Design, we were able to investigate the range of motion for several different design iterations in one hour versus the traditional design approach, which can take days!



Tutorial:

The optical sensor on this clamping mechanism is being broke off when the clamp arm extends past it's assumed range of motion. We need to analyze the mechanism and determine the appropriate course of action, whether it's sourcing a new manufacturer for air cylinders or modifying the existing linkage. First, we'll go through and assemble the parts using joint connections and then we'll create a couple of different motion scenarios to run the linkage through.

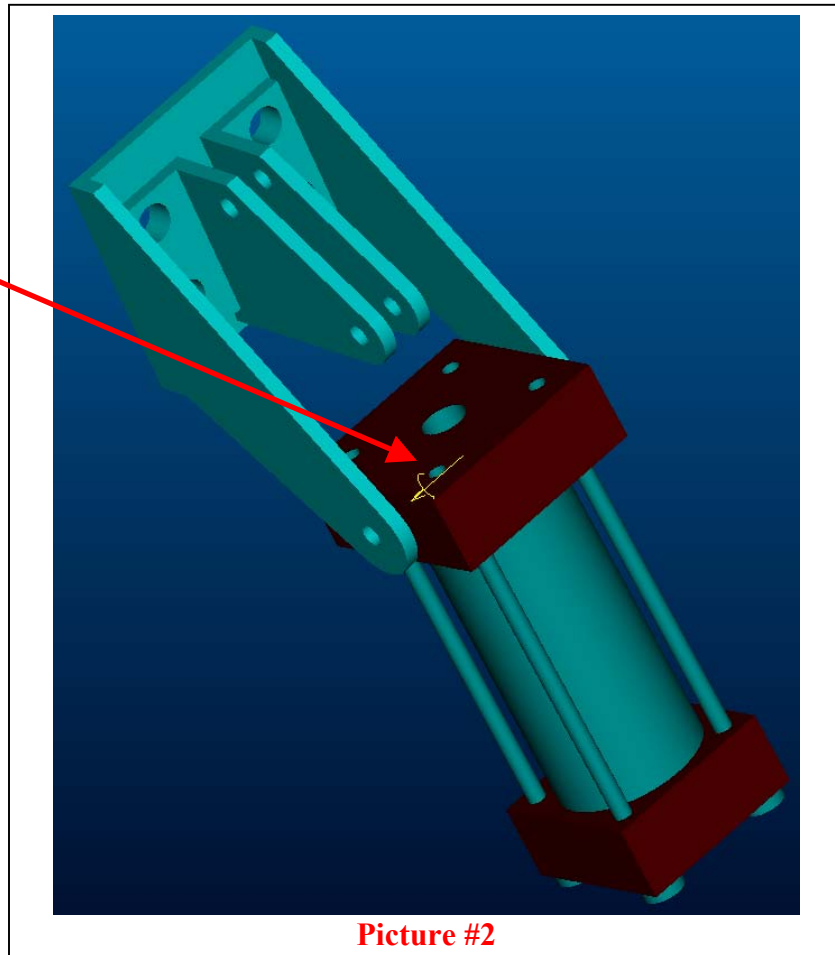


Step 1: Open clamp_mechanism.asm and begin to assemble the components with their respective joints (Picture #2)

- a) Menu Picks: COMPONENT, ASSEMBLE, pick air_cylinder.prt, pick in the constraint dialog box on the blue bar that says “Connections” (this gives you access to connection constraints).
- b) Select PIN as the connection type.
- c) You first must select the appropriate axial references, and then select both of the datum planes in the middle of the part and assembly for the translation reference. The bottom of the dialog box will now say “Connection Definition Complete” if you’ve done this properly.

Note: A pin joint allow one degree of freedom, rotation, and no translation which is how this air cylinder will move when assembled.

Pin Joint

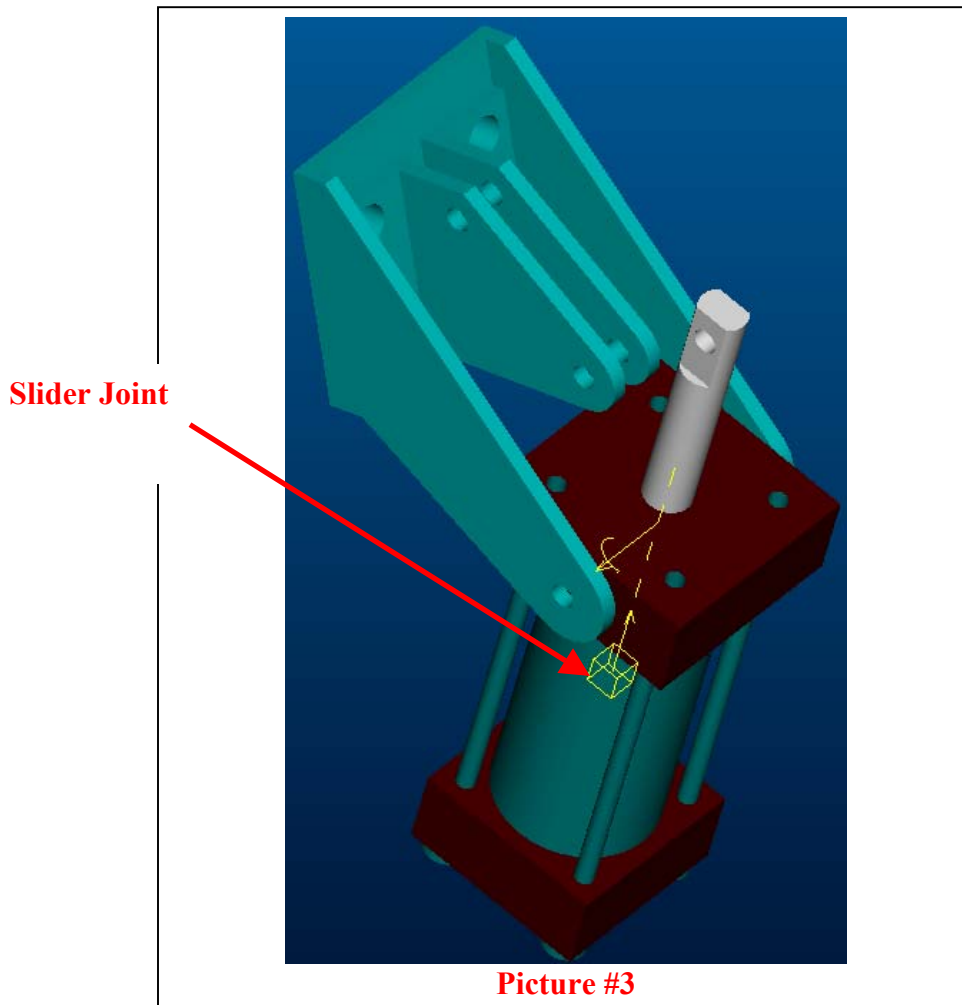


Picture #2

Step 2: Assemble the cylinder shaft using a slider (Picture #3).

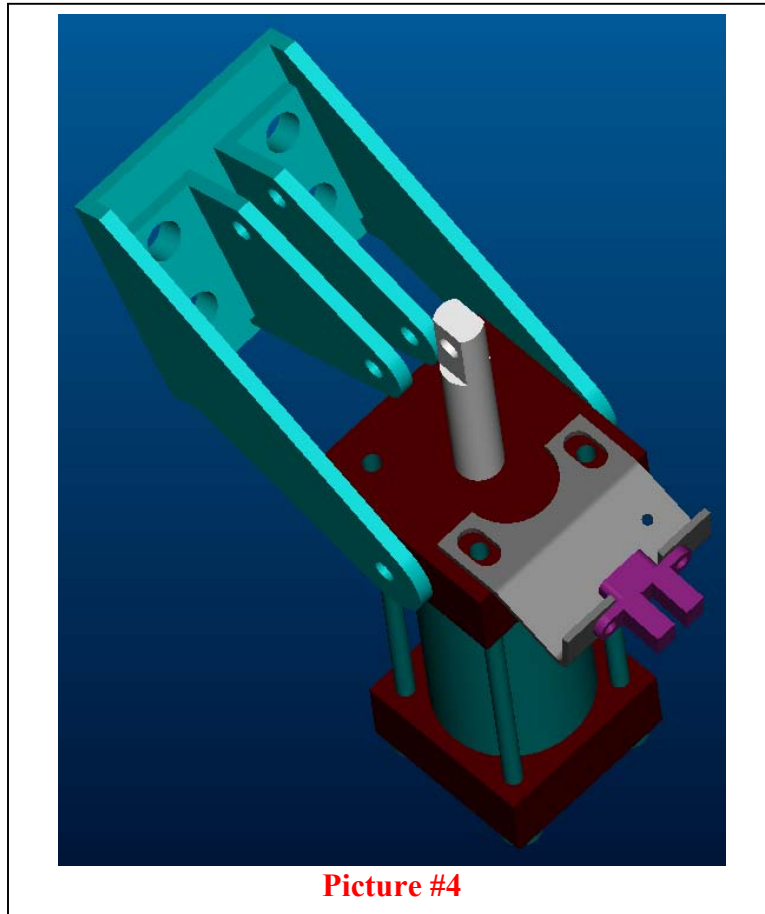
- a) Menu Picks: COMPONENT, ASSEMBLE, select cylinder_shaft.prt
- b) Pick in the constraint dialog box on the blue bar that says “Connections”
- c) Select SLIDER as the connection type.
- d) Select the appropriate axial reference on both the shaft and the cylinder, then select the “middle” datum planes on both the shaft and the cylinder. Check for “Connection Definition Complete”.

Note: A slider joint also allows only one degree of freedom, translation along an axis but no rotation between the parts, which is exactly how the shaft behaves in real life.



Step 3: Assemble the sensor bracket and sensor (which are fixed relative to the cylinder)

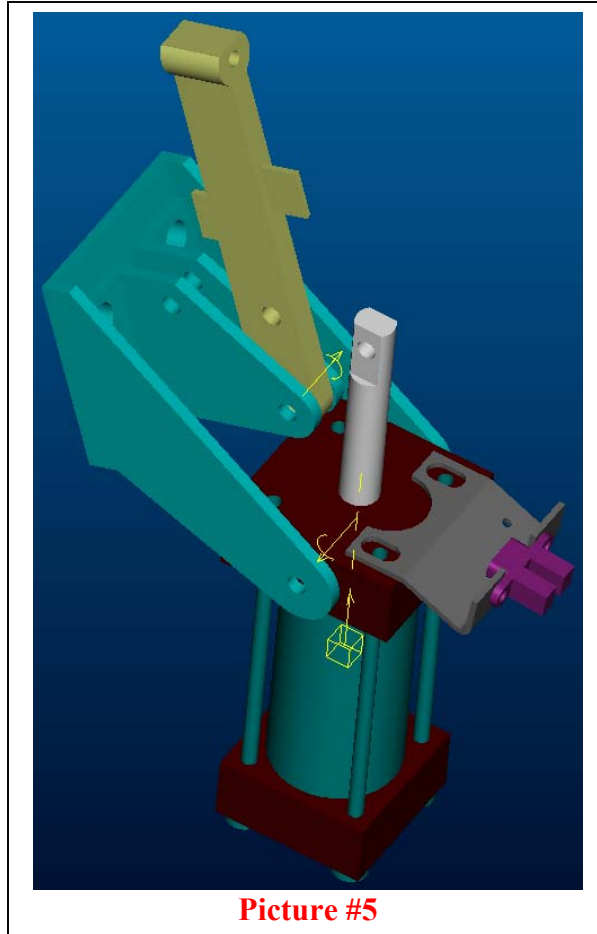
- a) Using regular assembly constraints, assemble both parts as shown below (Picture #4).



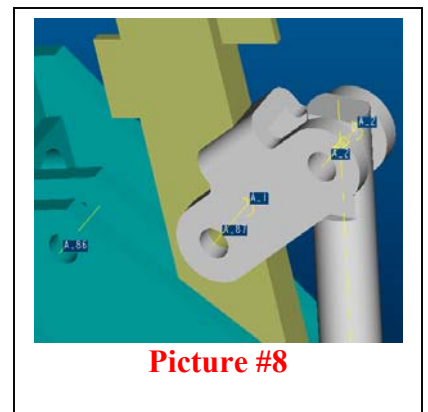
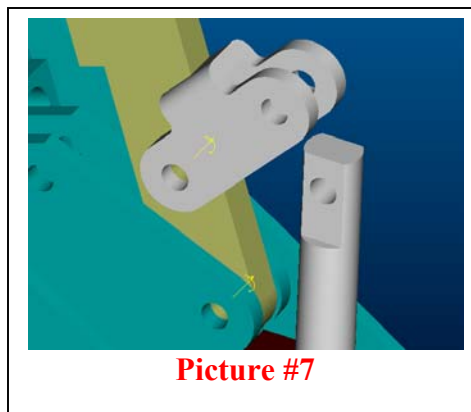
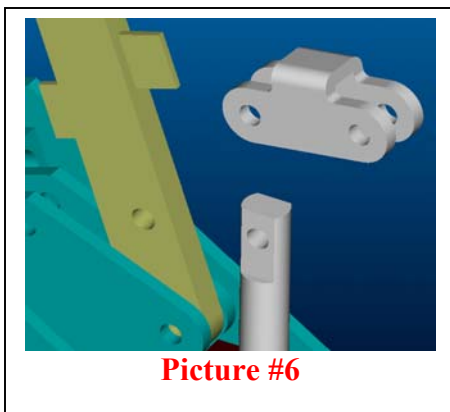
Step 4: Test the motion of parts up to this point.

- a) On the main menu pick MECHANISM, DRAG, and then pick anywhere on the top of the cylinder shaft.
- b) You can now move the cylinder shaft back and forth while at the same time allowing the cylinder to rotate. Pro/Engineer now respects the kinematic constraints of all the components and moves them accordingly.

Step 5: Assemble the clamp arm using a “Pin” joint as shown in Picture #5.

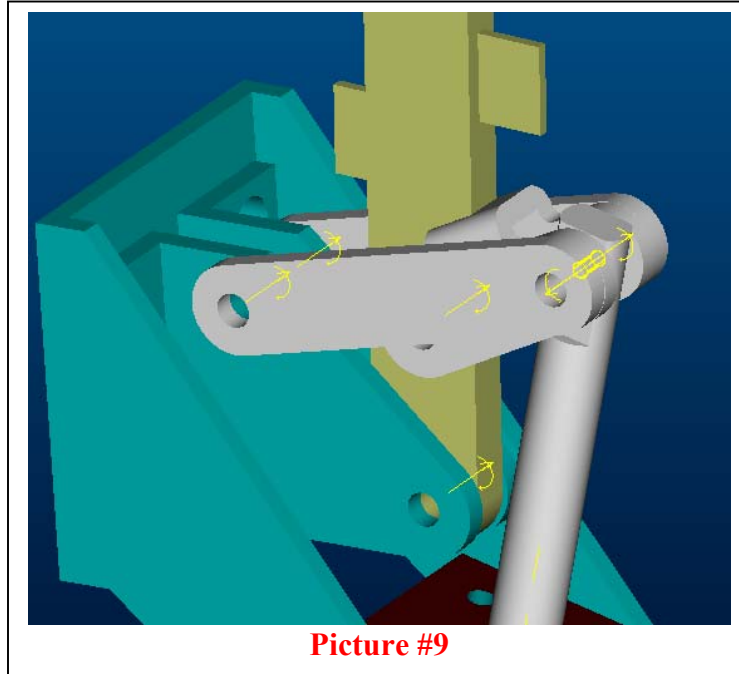


Step 6: Assemble the short link to the clamp arm using a “Pin” joint (Picture #7) and then add an additional “Cylinder” joint connecting it to the cylinder shaft (Picture #8).



Step 7: Assemble the long links to the side plates using a “Pin” joint on one end and a “Cylinder” joint on the other. When finished, it will look like Picture #9.

Note: Remember that we are creating a virtual prototype and thus it cannot be over constrained using two “Pin” joints.



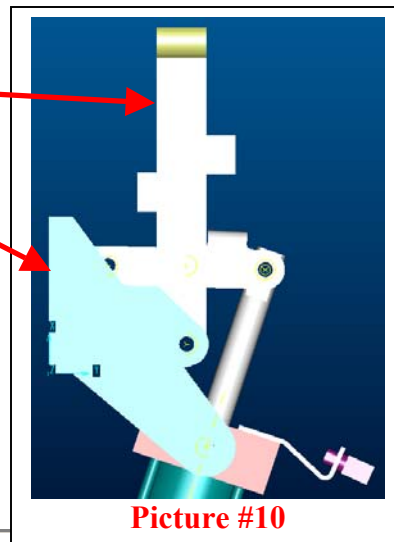
Picture #9

Now we're ready to define our motion drivers!

Step 8: Create a snapshot of the fully open position.

- Select MECHANISM, MODEL, DRAG
- Pick the CONSTRAINTS tab and then the ORIENT icon.
- Select the back surface of both the clamp arm and the mounting bracket to align them together. The assembly should be in the fully open position now.
- Select the CONSTRAINTS tab and then the SNAPSHOT icon, name the snapshot “Open”. Now even if you were to move the mechanism to another position, you can quickly get back to the open position by double clicking.

**Orient these
two surfaces**

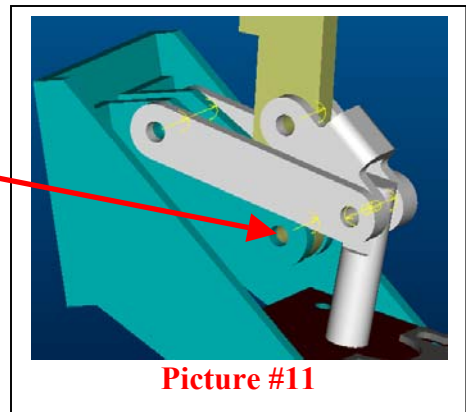


Picture #10

Step 9: Create a driver to rotate the mechanism through 92° of travel.

- a) Select MECHANISM, MODEL, DRIVERS, ADD
- b) Pick joint shown in Picture #10 as the driven joint.
- c) Select the PROFILE tab, click SET ZERO
- d) Pick the same surfaces you did in Step 8 and then APPLY, OK. This steps assures us that the mechanism will begin with this as it's "Zero" position.
- e) Pick "Velocity" as the type of driver, "Constant" as the magnitude with a value of 9.2. Select GRAPH and you can see what this will do over the course of it's run. As you can see it's a constant slope until it reaches 10 seconds where it will be at position (10 sec * 9.2 deg/sec) or 92°.
- f) Select OK, CLOSE

Select this joint
axis for driver



Step 10: Create a motion definition.

- a) Select RUN MOTION, ADD, OK
- b) Highlight your motion definition and select RUN. You'll now see the mechanism traverse through a 92° arc.
- c) Optional: to see the effect of different angles, go back to your driver definition and put in another value like 10 (this equates to 100°).

Step 11: Playback the motion profile and investigate any interferences.

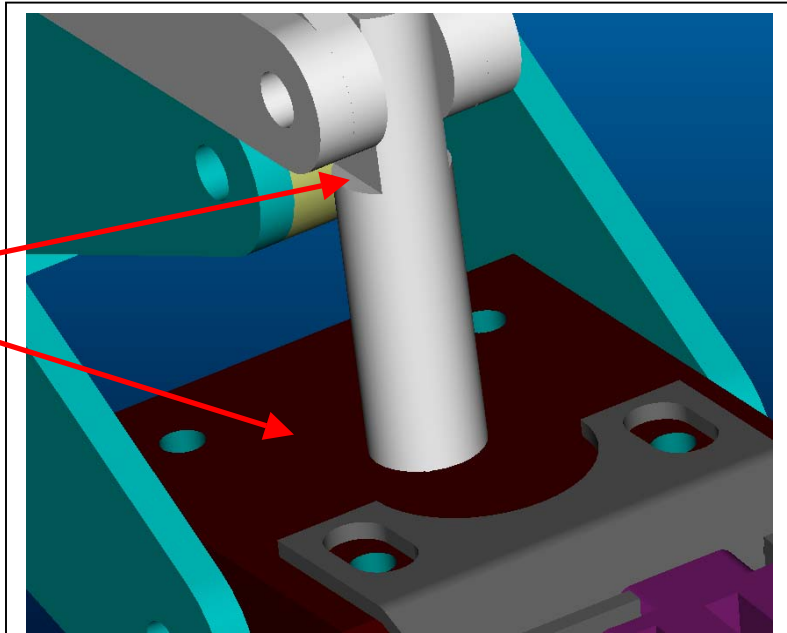
- a) Select RESULTS, PLAYBACK, GLOBAL INTERFERENCE, PLAY
- b) Now you have a "Tape Player" that controls the playback of your motion. You'll notice that at the extremes of it's motion (around 100°), it will highlight in red where the interference occurs.

Optional

Step 12: Setup a translation driver for a specified 1.00" stroke length on the air cylinder.

- a) Start from Step 7.
- b) Select MODEL, DRIVERS, ADD, select driven entity PLANE
- c) Pick the top surface of both the shaft shoulder and the top of the air cylinder. This is going to be the "Zero" starting position for our motion.
- d) Select POSITION as the type and RAMP as the magnitude. Enter in .1 for the "B" value. A is the starting value and B is the slope. You can select GRAPH to see the profile. Change some of the A and B values to see the effect on the Graph. When finished, go back to A=0 and B=.1 which will give us 1".
- e) Select OK, CLOSE, RUN MOTION, ADD, select DRIVER tab and remove Driver #1 from the list of active drivers.
- f) Select OK, and then RUN. Now the cylinder shaft will travel through a 1" range of motion.

Select these two surfaces
for translational driver



Picture #12

Quick Summary of Steps

- 1) Understand the relative kinematic motion between all moving parts.
- 2) Assemble components using "Connection" constraints.
- 3) Create snapshots of the critical positions such as open or closed.
- 4) Create a driver on the appropriate joints.
- 5) Create a motion definition using the appropriate driver.
- 6) Run the motion!

Key Vocabulary for Mechanism Design:

Drag: *The ability to pick a location on a part and using the mouse, move the assembly through it's range of motion. Also with the drag function is an ability to snapshot a particular orientation (see Snapshot).*

Driver: *The entity that "powers" your mechanism. Drivers can be either translation or rotational in nature and their behavior is described with a profile such as position, velocity, or acceleration.*

Joint: *Any assembly constraint within Pro/Engineer where you would like to have relative motion between two parts.*

Set Zero: *Allows you to control where the starting point will be for drivers. This should always be done so your motion profile starts where you expect it to rather than a default assembly position.*

Snapshot: *A way to capture a specific orientation of a mechanism. Examples would be: the start and end orientations of a mechanism, the open and closed positions. Any time you would like to return to a previously defined position, you should create a snapshot.*

Time Domain: *The specified duration of a motion run. When using multiple drivers, you can stagger drivers to occur at specific points and even have them overlap for sequential motion.*

Definition of Connection Types:

Connection Type	DOF		Description
	Rotation	Translation	
Pin	1	0	Rotates about an axis.
Bearing	3	1	Combination of a ball joint and a slider joint.
Cylinder	1	1	Translation along and rotation about a specific axis.
Planar	1	2	Bodies connected by a planar joint move in a plane with respect to each other. Rotation is about an axis perpendicular to the plane.
Ball	3	0	A "ball-in-spherical-cup" joint allows rotation in any direction.
Weld	0	0	Glues two parts together.
Rigid	0	0	Glues two parts together while changing the underlying body definition. Parts constrained by a rigid connection constitute a single body.
Slider	0	1	Translates along an axis.



Tutorial Evaluation:

Title:	<input type="checkbox"/> Engineer <input type="checkbox"/> Designer <input type="checkbox"/> Draftsmen <input type="checkbox"/> Mfg. Engr. <input type="checkbox"/> Tech. Pubs. <input type="checkbox"/> Analyst					
PTC Products Used:	<input type="checkbox"/> Foundation <input type="checkbox"/> Advanced Assembly Extension <input type="checkbox"/> Advanced Surface Extension <input type="checkbox"/> Behavioral Modeling <input type="checkbox"/> Intralink <input type="checkbox"/> Modelcheck <input type="checkbox"/> All					
Time using Pro/E:	<input type="checkbox"/> 0-6 months <input type="checkbox"/> 6-12 months <input type="checkbox"/> 1-2 years <input type="checkbox"/> 2-5 years <input type="checkbox"/> 5+ years					
1 – Strongly Disagree 3 – Agree 5 – Strongly Agree						
1. This tutorial content met my expectations:	1	2	3	4	5
2. The exercise was easy to understand:	1	2	3	4	5
3. This tutorial will help me on current projects:	1	2	3	4	5
4. These techniques make Pro/E a more effective tool:	1	2	3	4	5
5. These techniques will increase my speed using Pro/E:	1	2	3	4	5
What concepts/techniques learned from this tutorial will you apply on the job?						
1)						
2)						
3)						
What would you like to see as a future tutorial at your company?						
1)						
2)						
3)						
What can be done to improve these tutorials for your company?						
1)						
2)						
3)						

Additional Comments: