Tutorial: Using SolidWorks to assemble an off-the-shelf lens system

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November 29, 2010

Introduction

When designing an optical system, significant considerations must be made for the mechanical mounting of the lens elements. Many times these mechanical mounts can be purchased from a vendor, such as ThorLabs[1] or Edmund Optics, rather than designed from scratch. The systems can be complex and can include components from multiple vendors, so it is convenient to view the assembled system to ensure all parts fit together before the components are purchased. This can save time and help minimize the footprint of the optical system.

SolidWorks[2] is a computer software program that can help visualize the designed optical system. Many vendors have SolidWorks files for each component that can be downloaded and manipulated with respect to other parts. This tutorial walks through the process from finding a part online, downloading its SolidWorks file and assembling that part in conjunction with others found at the same vendor, ThorLabs. Although this tutorial exclusively uses elements from ThorLabs, parts from any vendor that provides a SolidWorks file will work. Once the parts are collected, this tutorial will walk through the assembly and mating process in order to mimic the actual optical system.

This tutorial will build and assemble the application idea found on the precision rotary stage, part number CRM1P, webpage at ThorLabs as shown below in Fig. 1. This system was chosen to illustrate the skills necessary to build an optical system from the ground up, including fasteners, lens posts, as well as cascading parts on a single mount.

Reference	Part Number	Part Name
A	MB4	Aluminum Breadboard
B	RS1.5P8E	Pedistal Pillar Post
C	CF125	Small Clamping Fork
D	CP02	Threaded Cage Lens Mount
E	CRM1P	Precision Cage Rotation Mount
F	ER4	Connection Rods
		#8-32 Set Screw
		¼”-20 Socket Head Screw

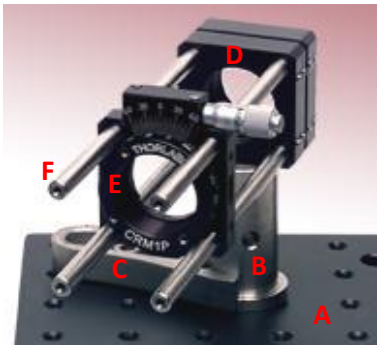

Figure 1: Desired assembly and associated part list

Importing Elements from Vendor

The first step to assembling the desired lens system is to gather the necessary elements from the desired vendors.

1. Locate each part on ThorLabs website, click on the SolidWorks symbol to download the file. Then click Save File, as shown below. Make sure to locate where the files are being saved to.

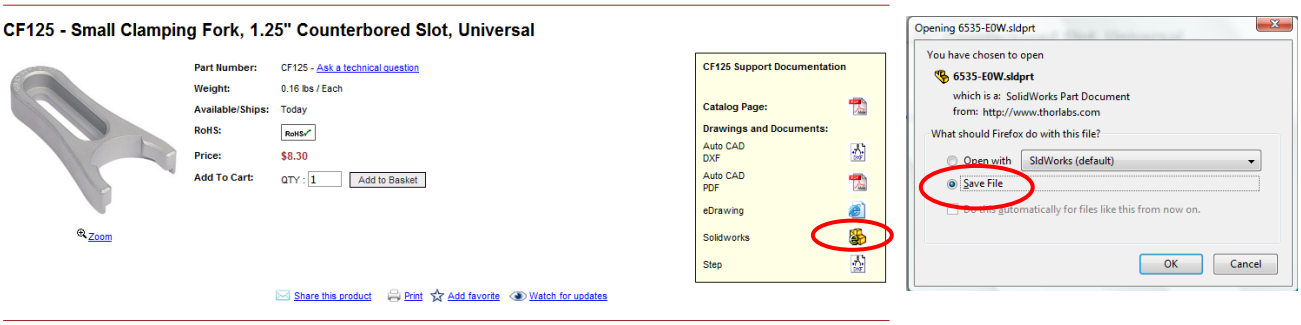

Figure 2: Find element files and save associated SolidWorks file.
http://thorlabs.com/thorProduct.cfm?partNumber=CF125

2. Repeat this process for all elements within the assembly.
3. Open SolidWorks program.
   NOTE: For student access, the VPN Client must be activated. If you have not downloaded the VPN Client, it can be found at https://sitelicense.arizona.edu/vpn/
4. Use File → Open to open the saved .sldprt files that were just downloaded.
5. Resave this file to the desired file location. Do this for each part of the assembly. Figure 3 shows the opened SolidWorks file for just one of the elements listed above in Fig. 1. There will be a separate SolidWorks part file for each element.

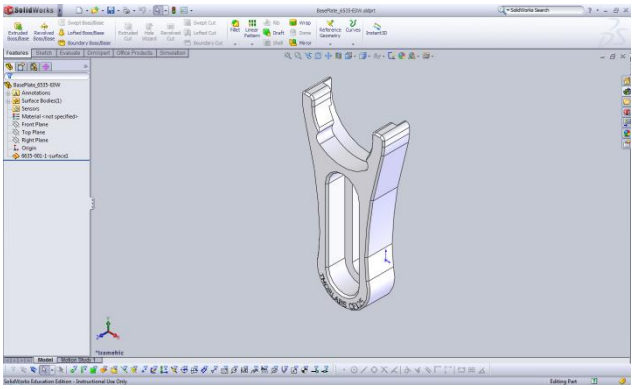

Figure 3: Part file for small clamping fork

Creating Lens Assembly

Once all parts have been collected from ThorLabs, a SolidWorks assembly file will be created. This is the file that can incorporate and assemble all parts into a complete lens system.

1. Open a new Solidworks assembly file. Click File → New. Choose Assembly, a 3D arrangement of parts and/or other assemblies.

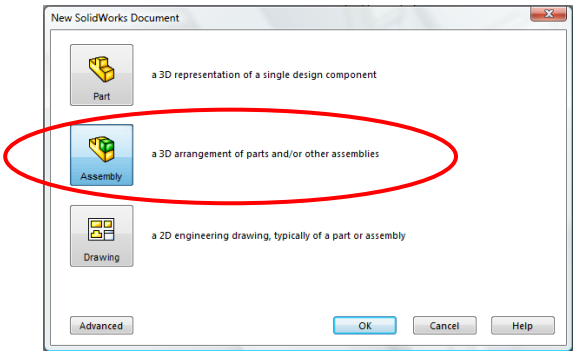

Figure 4: Opening a new assembly file.

2. Insert each component into the assembly file. Click Insert → Component → Existing Part/Assembly.

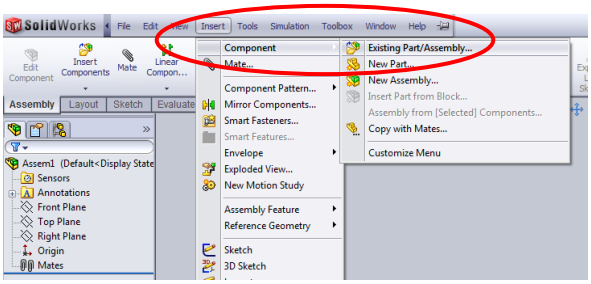

Figure 5: Insert component into assembly file

3. Choose a file to import the desired part into the assembly file. Choose Browse from the far left column. Then choose the part file. Repeat until all components are imported to the assembly file.

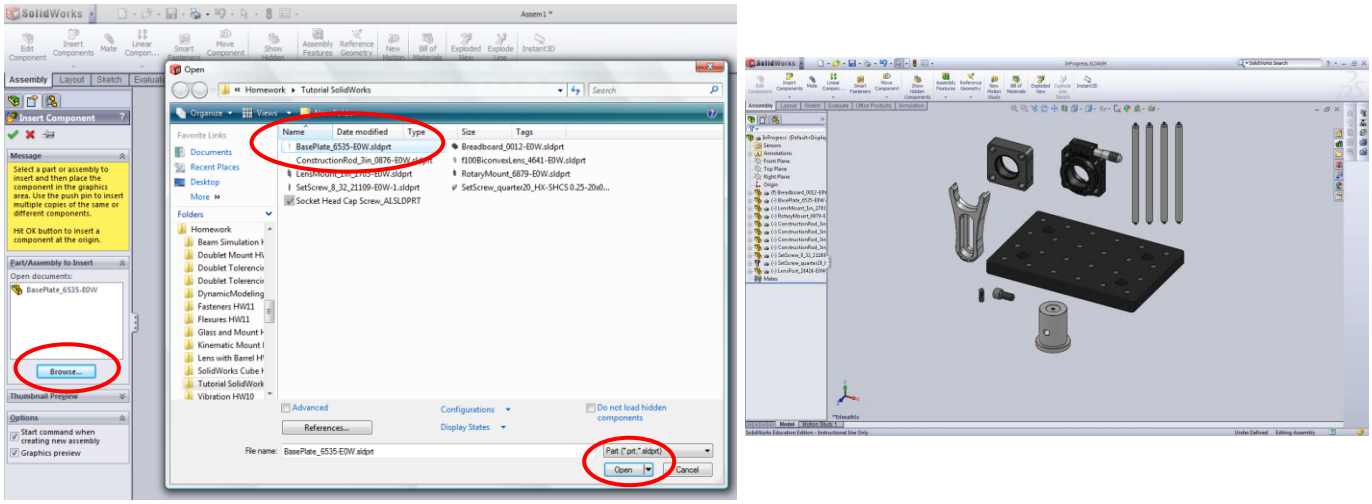

Figure 6: Inserting a component into the assembly file and an illustration of all parts of the assembly.

Final Mating and Assembly

The final steps of assembly include specifying constraints, known as mates in the SolidWorks program, in order to confine the motion of each element in the same way it would be confined on the optical bench. This is the most difficult part of the alignment process. It is also the most critical component to ensure that the components of interest fit together on the optical bench. This tutorial will build the optical mount from the ground up, attaching the post to the aluminum breadboard first.

1. Make the top plane of the breadboard coincident with the bottom surface of the lens post. This allows the post to move anywhere on the plane of the breadboard while maintaining contact. To do this, first choose the mate option from the Assembly toolbar.

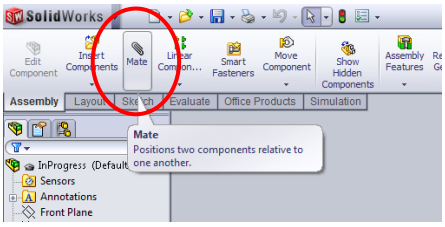

Figure 7: Mate option found on assembly toolbar

2. Select the top plane of the breadboard and the bottom surface of the lens post. Choose coincident mating. Click green checkmark along left column to accept mating condition.

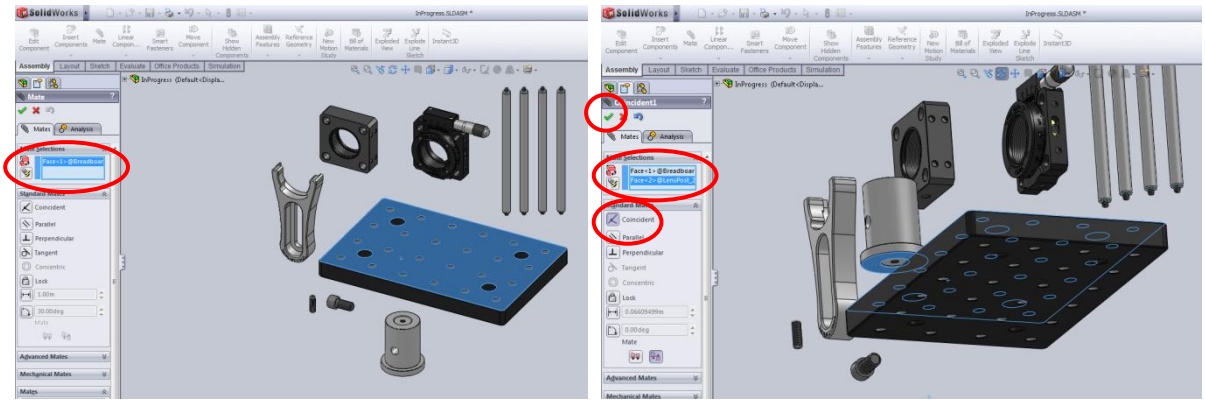

Figure 8: Coincident mating of top plane of breadboard and bottom plane of lens post. Plane of view is rotated to visualize mate.

3. Mate the ledge surface of the lens mount with that of the small clamping fork using the coincident mating condition. This will allow the post to be mounted to the breadboard while being tightened down with the socket head ¼”-20 screw.

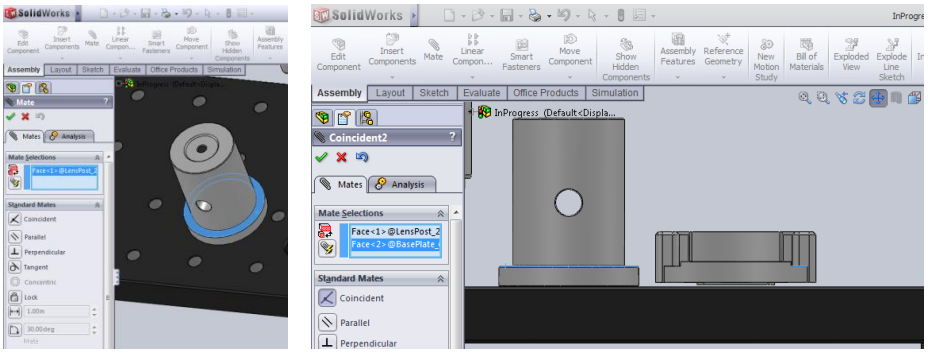

Figure 9: Coincident mating condition for clamping fork and lens post

4. An additional mating condition is needed for the small clamping fork. Not only does the plane of contact need to be made, but also the cylinder of the lens post must be concentric with the cylinder of the small clamping fork. These two mating conditions fully constrain the lens post. Notice the small clamping fork is still free to rotate about the lens post as it would be on the physical optical bench.

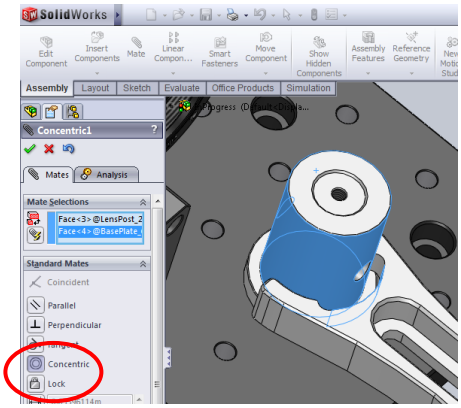

Figure 10: Additional concentric constraint to position clamping fork

5. The next step is to mount the lens barrel to the lens post. A #8-32 set screw is used to secure these components together. Make a concentric mating condition with the outer cylinder of the set screw and the inner cylinder of the top of the lens post. Repeat this mating condition with the outer cylinder of the set screw and the inner cylinder of the bottom of the lens mount.

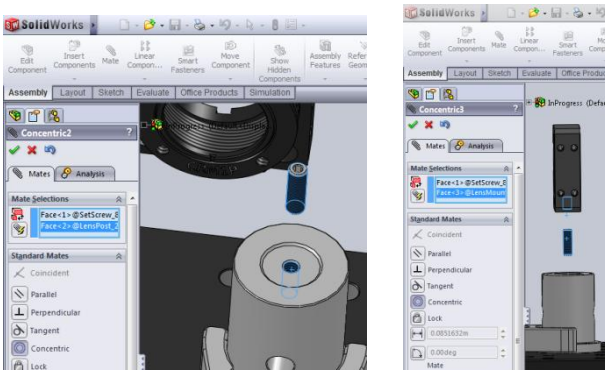

Figure 11: Concentric mating conditions used to attach the lens mount to the lens post

6. Position the set screw so that half of it is inserted into the lens post. Then apply a coincident mating condition to the top plane of the lens post and the bottom plane of the lens mount. This simulates the tightening of the set screw and correct position of the lens mount relative to the lens post.

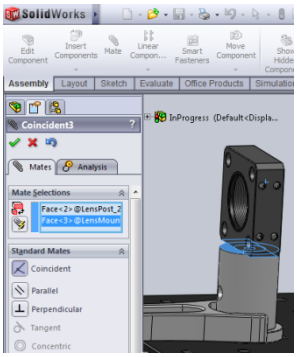

Figure 12: Additional coincident constraint to attach lens mount

7. At this point the cage connection bars must be assembled in order to mount the precision rotation mount. Each connection bar must be mounted with a concentric mating condition between its outer cylinder and the inner cylinders of the corners of the lens mount. Repeat for all four connection bars.

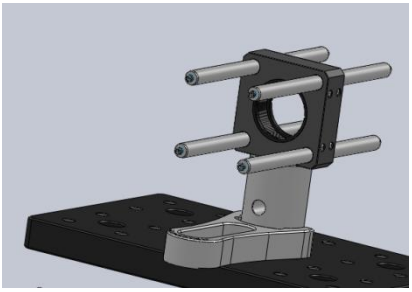

Figure 13: Cage connection Bars attached to lens mount

8. The precision rotation mount can now be assembled onto the cage mount connection bars. Repeat step 7 for the concentric mating condition for the top two cylinder bars. Only two bars need to be constrained in this case because they will constrain the rotation degrees of freedom and allow the rotation mount to translate along the connection bars.

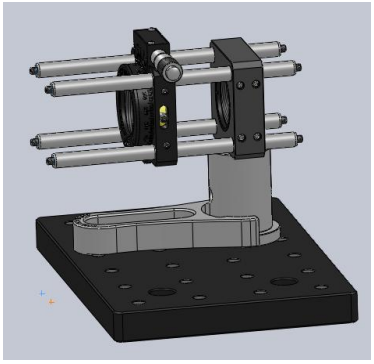

Figure 14: Slide on precision rotation mount

9. The final step of the assembly is to screw down the lens post to the breadboard with a ¼”-20 socket head screw. A coincident mating condition between the bottom surface of the socket head and the top surface of the extruded cut in the clamping fork.

10. Finally, the socket head screw needs to have a concentric mating condition between its threaded cylinder and the inner cylinder of the desired hole on the breadboard.

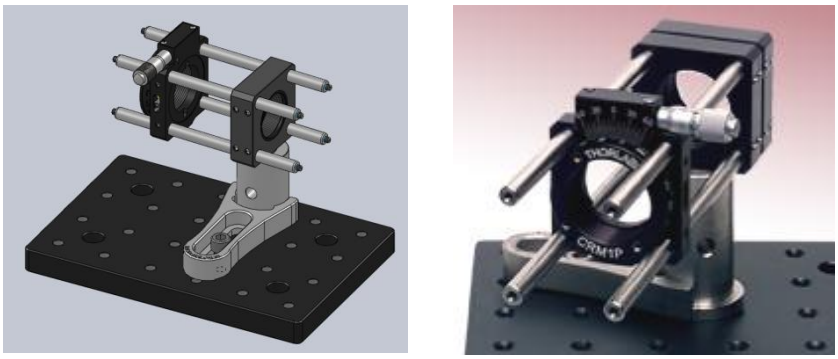

Figure 15: Final SolidWorks assembly and comparison to ThorLabs actual lens assembly

Conclusion

This assembly is a complete mock-up, including degrees of freedom, for an off-the-shelf lens system that would be mounted onto a breadboard. Once assembled, SolidWorks is capable of analyzing the assembly in more detail. A parts list can be generated as well as a mechanical drawing to ensure the distances between the rotation mount and the lens mount are set or the positions of the connection bars. Also, static and dynamic simulations can be run to analyze performance and stress characteristics under operational environments, both statically and dynamically. Information for these studies can be found on the SolidWorks website or in the Optics 521 Lecture Notes[3] found online.

References

[1] www.thorlabs.com
[2] www.solidworks.com
[3] http://www.optics.arizona.edu/optomech/Fall10/Fall10.htm