ENGR 1182 | SolidWorks 7: Assemblies
SW07 – EXTRA CREDIT OUT of CLASS Assignment

- Assignment Description
- Grading Rubric
- Discipline Guides
Assignment Objectives:
Improve modeling skills through build and assemble assignment and see applications of solid modeling in different majors.

Instructions
Choose one of the multi-disciplinary assemblies and model all of the parts in SolidWorks. The assemblies are similar in difficulty and represent a variety of majors and applications. For each advanced assembly there is a guide included as appendices of this document.

Deliverables
1. Final assembly isometric for cover page with name.
2. Individual part isometrics – one isometric per part used

RealView Graphics
This option in your viewing options will allow you to see the difference in materials appearances.
## Grading Rubric

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### List of Construction Guides in order:

1. Aerospace p.4
2. Biomedical p.15
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Appendix 1: Aerospace Engineering

Landing Gear

Dimension: Inches

An important part of airplane design entails safety and this activity includes landing gear design. Aerospace engineers and mechanical engineers interface to design these parts for the hardest of landing situations. Aerospace engineers can use lift and thrust information to determine how much force is imparted on this structure. The following assembly is for a simple landing gear design that folds up as most do into the aircraft.

The total assembly consists of six main components: the fixed support, slider, upper shock, lower shock, wheel hub and wheel. A brief tutorial will be given to identify the steps needed to successfully complete the parts.
Materials
Ti – 5Al – 2.5Sn Annealed (SS) – Lower shock, Cast Alloy Steel – Upper shock, AISI 1020 – Wheel hub, Natural Rubber – Wheel, 1023 Carbon Steel Sheet (SS) – Fixed support, 1060 Alloy – slider

Fixed Support (base of assembly)
The fixed support was completed in four main steps. These steps are outlined below.

1. The first extrusion was done using the sketch below. Appropriate dimensions and relationships are shown and the midplane extrusion thickness was 6.0 in.

2. Two sets of fillets were made on the resulting structure. These fillets and their sizes are shown below.
3. An extruded cut was created on the front plane using the sketch shown below. The box creating the cut should be tangent to the arc on the bottom and intersect the upper boundary of the feature. The extruded cut was done midplane at a distance of 5.0 in.

![Sketch of extruded cut](image1.png)

4. The symmetric sketch shown below was finally used to make an extruded cut through the part for the slider slot.

![Symmetric sketch](image2.png)
**Slider**
The slider was completed in three main steps. These steps are outlined below.

1. The first extrusion was done using the sketch below. Appropriate dimensions and relationships are shown and the extrusion thickness was **1.0 in.**

![Step 1 Sketch](image1)

2. Two circles concentric to the outer arcs were then sketched of diameter **0.50 in.** and the sketch was extruded **8.0 in** as shown below.

![Step 2 Sketch](image2)

3. The sketch shown in step 1 was completed again on the new peg faces to make the part symmetric. The result is shown below.

![Step 3 Sketch](image3)
Upper Shock
The upper shock was completed in four main steps. These steps are outlined below.

1. The first extrusion was done using the sketch below. Appropriate dimensions and relationships are shown and the midplane extrusion thickness was 5.0 in.

![Sketch of first extrusion](image1)

2. A circular sketch on top of the resulting feature was created as shown in the sketch below. The extrusion distance was 32.0 in. with a 1.0 degree draft.

![Sketch of circular extrusion](image2)
3. A through thickness extruded cut was created according to the sketch shown below on the resulting feature from step 2. The concentric circle is of diameter **3.0 in.**

4. The final extruded cut was created according to the sketch shown below.

**Lower Shock**
The lower shock was completed in seven main steps. These steps are outlined below.

1. The first extrusion was done using the sketch below. Appropriate dimensions and relationships are shown and the extrusion thickness was **32.0 in.**
2. On the bottom of the shaft just created, the following sketch was extruded **1.0 in.** The sketch is a co-radial circle on the outside of the pipe.

3. The following sketch was created on the bottom of the previous feature and extruded **3.0 in.**

4. The following sketch was created on the front plane to be coincident to the outer radius of the cylinder and extruded **5.0 in.**
5. A fillet of radius **1.0 in.** was created between the last two features and the shaft as shown below.

6. The following circular sketch was created on the front face of the feature created in step 5. The feature was extruded a distance of **12.0 in.**

7. A fillet of radius **1.4 in.** was created on the front face of the feature from step 5. The feature is shown below on the left. The final fillet was created of radius **0.25 in.** as shown in the second picture below.
Wheel Hub
The wheel hub was completed in four main steps. These steps are outlined below.

1. The first feature was a revolved feature about the horizontal axis of the hub. The 360 degree revolution was created from the sketch on the right plane shown below.

2. The created feature was mirrored on the front plane to create the full hub as shown below.

3. A 3.0 in. diameter hole was created as an extruded cut through the center of the hub.
4. A 2.0 in. offset (or 5 in. total) diameter hole was extruded cut through the front face of the hub to a distance of 2.0 in. as shown in the picture below.
Wheel
The wheel was completed in two main steps. These steps are outlined below.

1. The first feature was a revolved feature about the horizontal axis of the wheel. The 360 degree revolution was created from the sketch on the right plane shown below. The sketch was divided into two parts for clarity. The upper part of the sketch is on the right.

2. The resulting feature was mirrored about its front face to create the full wheel. The result after applying rubber as the material and changing the color to black is shown below. Help on changing the color can be found in the shock absorber assembly for the bottom cylinder part of the assembly.
Assembly

Refer to the class presentation on creating assemblies to assemble the six parts together. Students should use this part of the assignment as an opportunity to explore different ways to constrain the assembly. The final assembly should be able to fold up as if it folds up into the cargo area of an airplane. Below is a potentially helpful mate technique (under advanced mates) to constrain rotation of the assembly to a certain angle. It’s also suggested to constrain the bottom of the upper shock to the top of the base of the lower shock within a certain distance. This simulates the resistance the real shock assembly would have to compression between these two components.

The first box is the starting angle, and the second two boxes are maximum and minimum angles of rotation.

The sample assembly constrained the shock to within six inches of the highlighted surfaces.
Appendix 2: Biomedical Engineering

Replacement Hip

Dimension: Inches

An important field within biomedical engineering is biomechanics. Biomechanics is the study of the mechanical functions that organs and systems play in the human body. Prosthetics are an important aspect of biomechanics in their design against mechanical failure and for biological acceptance by the surrounding tissues. The pictorial below gives an overview of the parts to be completed in Solidworks.

The total assembly consists of four main components: the hip stud, the ball joint, the socket joint, and the socket cap. A brief tutorial will be given to identify the steps needed to successfully complete the parts.
Materials
Commercially Pure Cp-Ti UNS R50400 (SS) – Stud, Socket joint, Stainless Steel – Ball joint, Polyester Resin – Socket joint cap

Replacement Hip Stud (base of assembly)
The hip stud can be modeled in four main steps. These are outlined below.

1. The base of the stud was made with a revolution about a central axis using the sketch shown below.

![Sketch of hip stud base](image1)

2. The top face of the resulting feature must be revolved in a clockwise fashion 30 degrees as shown below. The axis of revolution can be placed near the right edge of the top face. The exact distance is not critical. A fillet underneath the revolved feature of 1 inch was selected and applied.

![Revolution of top face](image2)
3. A drafted extrusion is made next off of the revolved face. The angle of **draft was chosen to be 30 degrees at a distance of 2 inches**. This value is important for the remaining assembly.

4. The top face of the drafted extrusion was extruded a distance of **3 inches** as shown in the picture below. A fillet of **2 inches** was also applied between the drafted extrusion and regular extrusion as shown.
**Ball Joint**
The ball part of the ball and socket joint was created in one step with a revolved feature. The necessary sketch is provided below. One key thing to note about the sketch is that the circular arc is constrained to be tangent with a horizontal construction line perpendicular to the vertical axis and is coincident the top of the curve.
**Socket Joint**
The metallic socket portion of the joint was also created in one step with a revolved feature. The necessary sketch is provided below. Similarly to the ball joint, the **circular arcs are constrained to be perpendicular to the vertical line at the top.**

![Socket Joint Diagram](image)

**Socket Joint Cap**
The plastic socket portion of the joint was also created in one step with a revolved feature. The necessary sketch is provided below. Similarly to the ball joint, the **circular arcs are constrained to be perpendicular to the vertical line at the top.**

![Socket Joint Cap Diagram](image)
Assembly
Refer to the class presentation on creating assemblies to assemble the four parts together. Students should use this part of the assignment as an opportunity to explore different ways to constrain the assembly. The ball and socket joint should be free to rotate as a real joint would.
Appendix 3: Civil Engineering

Monorail Support

Dimension: Inches

Civil Engineers are involved heavily in the design and support of structures as they relate to buildings and infrastructure. One mode of transportation commonly used in metropolitan communities or airport applications is a monorail system. The AEV project during ENGR 1182 will relate to a type of monorail vehicle but this assembly will focus on the support structure of the monorail itself. This guide outlines how to model the parts necessary for the assembly.

The total assembly consists of four main components: the support column, the brackets, the rail tray, and the rail component. A brief tutorial will be given to identify the steps needed to successfully complete the parts.
**Materials**

Ductile Iron (in reality would be reinforced concrete) – Support column, TIMETAL 35A CP Titanium (ASTM Grade 1) 99.1 Ti – Bracket, Cast Carbon Steel – Rail Tray, Aluminum 1060 Alloy – Monorail

**Support Column (base of assembly)**

The support column was made in six steps. Most of the steps are extrusions with a final bolt hole extruded cut. These steps are outlined below.

1. The first step of creating the support column was an extruded circle of diameter 36.0 in. at a distance of 120 in.
2. The top face was then used to create an oval sketch with two circular arced ends. The arcs at each side of the sketch are perfect circles of diameter 24.0 in. The length of the oval in between is 96.0 in. Tangent constraints can be used to constrain the arc ends to the oval pieces on top and bottom. The sketch should also be constrained to be horizontal which can be done with a construction line through the center as shown. Once the Circles are tangent to the oval then the trimming tool can be used to remove all unnecessary lines.

3. This sketch was extruded 30.0 in.
4. An extruded cut was done on the bottom of the previous extrusion by sketching on the mid plane of the part (could be front or right plane based on how an individual models the part). The vertical constraint is midpoint of the previous extrusion. The necessary sketch is provided below.

5. A fillet of radius 5.0 in. was completed on the bottom of the top extrusion as shown below.

6. Two circles of radius 24.0 in. were then extruded a distance of 6.0 in. on each side of the oval to be tangential to the top face. This feature is shown below.
7. A four-hole bolt pattern was made on each of the circular extrusions from step 5. The necessary dimensions are shown in the sketch provided. The extruded cut was completed as “through-all”.

**Bracket**

The bracket was made in three main steps. The steps to complete the bracket are outlined below.

1. The sketch provided below is symmetric about the horizontal and vertical axes. This sketch was extruded 1.0 in. All hole diameters are 2.0 in.
2. A circle of **16.0 in.** was then drawn on the top face and the holes were sketched again with the convert entities tool using the existing hole features. This completed sketch was extruded upward a distance of **2.0 in.**

3. A fillet and chamfer were added to the part. The inside edge of the part was rounded with a fillet of radius **0.5 in.** The chamfer on the top edge of the part was added of **0.25 in. at an angle of 45 degrees.**
Rail Tray
The rail tray was made in two main steps. The steps to complete the rail tray are outlined below.

1. A mid-plane extrusion was completed to create the bulk solid for the rail tray. This is the base for which the rail sits on. The necessary dimensions for the sketch were provided in the picture below. **Note that the part is symmetrical about the vertical axis. The depth of the extrusion was 240.0 in.**

![Diagram 1](image1.png)

2. Bolt holes for the anchors to which the rail structure is attached were created with an extruded cut. The bolt hole pattern is the same as provided in the bracket sketches with a **2.0 in. diameter hole and 8 in. by 10 in. horizontal and vertical spacing**. The necessary sketch to create each set of bolt holes along the horizontal and vertical axes is shown below. **Note that the horizontal spacing from the centerline to the nearest bolt hole on either side is 30.0 inches (to the hole’s center). The vertical spacing is 55 in. in the same way. Construction lines can be used to mirror one bolt hole in each direction to create all six sets.**

![Diagram 2](image2.png)
Monorail
The monorail was made in five main steps. The steps to complete the monorail are outlined below.

1. A mid-plane extrusion was completed to create the bulk solid for the monorail. The necessary sketch is provided below. **The depth of the mid-plane extrusion was 240.0 in.**

![Mid-plane extrusion sketch](image1)

2. The following sketch was created on the symmetry plane from step 1. This sketch was extruded mid-plane as well at a distance of **18.0 in.**

![Symmetry plane sketch](image2)
3. The created feature was mirrored about the other side of the monorail by using the front plane in this case. These two legs of the monorail will be used in step 4 again. A supporting picture is shown below.

4. A linear feature pattern was used to create two more legs on either side at a distance of 60 in. from the middle legs. The result is shown below. **Note that either end of the monorail circular face can be used as the direction in the linear feature pattern.**
5. The final step was to make extruded cuts on each leg for the bolt hole patterns to match up with the rail tray. The sketch in step 2 of the rail tray is the same as the one used for the monorail and provided below. The sketch is again symmetric about the horizontal and vertical axes.

![Sketch of rail tray]

**Assembly**
Refer to the class presentation on creating assemblies to assemble the five total parts together. Students should use this part of the assignment as an opportunity to explore different ways to constrain the assembly. **Note that the brackets are assembled on top of the support column below the rail tray. The holes should be concentric from top to bottom through the whole assembly.**

![Assembly diagram]
Appendix 4: Electrical Engineering

Electromagnetic Brake

Dimension: Inches

Many amusement park rides have strict safety requirements for the vehicles, restraints and mechanical systems controlling the ride. One such system is a technology called electromagnetic braking. This uses the science of eddy currents which are electrical currents generated by a changing magnetic field to slow down rotation of an object. These are often used in amusement park rides such as the “Top Thrill Dragster” at Cedar Point where the cars need to be quickly braked from a high speed. The science behind these can be researched on in further detail but involves many aspects of electrical engineering. This technology will be the focus of this assembly.

The total assembly consists of six main components: the housing, the wire coil, the impeller, the drag ring, the bushings and the shaft. A brief tutorial will be given to identify the steps needed to successfully complete the parts.
Materials

Housing (base of assembly)

The housing of the electromagnetic brake was made in two steps. The first step is a fairly complex revolution but the second step is a simple chamfer applied to the right and left sides. These steps are outlined below.

1. The sketch shown below was revolved about the horizontal axis to create the bulk housing shape. It should be noted that the origin was aligned symmetrically with the middle of the sketch.

2. A ¼ in. chamfer of 45 degrees was placed around the right and left edges of the housing as shown in the picture below.
**Wire Coil**
The wire coil component of the assembly was created in one step with a revolved sketch. This sketch is shown below. Note that the sketch was not fully defined for visibility in this guide however a fully defined sketch should be the goal. The circles are all touching in the horizontal and vertical directions.

**Impeller**
The impeller component of the assembly was created in five steps. These steps are outlined below.

1. A circle of diameter **5 in.** was extruded **0.5 in.** as shown with the sketch below.
2. The impeller fins were extruded off of the front of the first extrusion at a distance of 1.0 in. with the dimensions on the sketch below. Note that ten fins were created in a circle with a circular pattern of equal spacing. These can also be placed manually with an angular difference of 36 degrees.

3. Fillets were placed between the fins along the edges aligned with the axis of rotation. The radius of the fillet was 0.25 in. The necessary picture is provided below.
4. The central axis hole was sketched and an extruded cut was created through the depth of the part according to the sketch below.

![Central axis hole sketch](image)

5. The slot on the back of the impeller was cut with two concentric circles to create a place to attach the drag ring. This sketch and extruded cut was created as shown below. **Note that the depth of the cut was 0.25 in.**

![Slot on back of impeller](image)
**Drag Ring**
The drag ring was created in one step. The extrusion of length 2.0 in. was created from the concentric circles of dimensions as shown below.

![Drag Ring Diagram](image1)

**Bushings**
The bushings were created in one step. The extrusion of length 0.5 in. was created from the concentric circles of dimensions as shown below. A chamfer was then applied to the inside hole on one side of the bushing of 1/16 in. at an angle of 45 degrees.

![Bushings Diagram](image2)
Shaft
The shaft was created in one step. The extrusion of length **12.0 in.** was created from the circle of diameter **1.5 in.** A chamfer was then applied to each edge of dimension **1/8 in. at an angle of 45 degrees.**

Assembly
Refer to the class presentation on creating assemblies to assemble the four parts together. Students should use this part of the assignment as an opportunity to explore different ways to constrain the assembly. **Note that the impeller, drag ring and shaft should rotate together.** This locked concentric constraint can be created by checking the “lock rotation” option under the concentric constraint. The shaft can be dimensioned a distance symmetric from each side of the housing. See the picture below for a cross sectional picture.
Appendix 5: Mechanical Engineering

Shock Absorber

Dimension: Inches

Mechanical engineers at companies like Trek work on designing bicycle components to protect riders and the frame of the bike during a tough ride. Shock absorbers are critical components in bike stability; in other applications such as cars, shock absorbers protect occupants of vehicles from feeling a bumpy road. You will create such a device for this assignment.

The total assembly consists of five components: the bottom cylinder, the tightening rings, the spring, the piston and the top cap.
Materials
Aluminum 1060 Alloy – Bottom cylinder assembly, Top component, Tightening ring, Gray Cast Iron – Spring, Aluminum Bronze – Piston

Bottom Cylinder Assembly
The bottom cylinder assembly can be modeled in five main steps (six including fillets) as shown below.

1. The connector portion of the cylinder was created with a circular extrusion with dimensions as shown in the sketch below.

2. The connector tip was done with a mid-plane extrusion on the right plane of the part of dimensions as shown below. Note that this feature is centrally located on the front face vertically and horizontally.

3. A hole through the connector tip was cut out using a 0.25 in. diameter circle. This feature is concentric with the outer arc.
4. The next step is to fillet the connector tip. The fillets around the tip are of radius $1/16$ in. The fillets around the base of the connector are $1/16$ in as well. The reference pictures are shown below.

5. The cylinder was extruded off of the back of the connector with outside diameter $0.875$ in. and length $3$ in. Note that the cylinder is concentric with the connector’s circular feature.
Note, to change the color of this face, right click on the extrude feature in the modeling tree and select the multi-colored ball. Click again on the top item in the list which is the feature name and select the color of your choosing.

6. The inside of the cylinder was cut out leaving a cylinder thickness of 0.125 in. Note that the hole is concentric with the connector’s circular feature. The extruded cut also goes to the edge of the connector.
Tightening Ring
The tightening ring was made in three simple steps as shown below.

1. The first step in creating the tightening ring is the ring extrusion with dimensions as shown below.

2. A chamfer of 1/16 in. at 45 degrees was created on the front edge of the tightening ring.
3. A slot on the back side of the tightening ring was created to create a place for the spring to rest in the assembly. This was created according to the sketch below. The slot was created concentric to the circular ring feature. The slot is 0.125 in. in diameter at a distance of 1/32 in. from the inside edge. The depth of the cut was 1/8 in.
Spring Tutorial

First, create a sketch of the cross section (circle of diameter **0.125 in.** of the spring at a distance of **0.53125 in.** from a centerline. (This centerline should preferably go through the origin)

Sketch 1 (profile for sweep)

On the Front plane draw a circle on the horizontal axis with the following dimensions.

End Sketch
Sketch 2 (path for sweep)

Second, create a helical sketch by going to **Insert -> Curve -> Helix/Spiral**. Draw a circle of **diameter 1.0625 in.** on the top plane where the circle goes through the first circle drawn in step a.

On the Top plane draw a circle with its center at the origin. This will be the basis for the helix.

Follow the information listed on the left hand side for the values to create the correct pathway.
Sweep

Select the first sketch as the profile and the second sketch with the helix as the path.
1. Next, the top circular edge of the spring was created. The cross section was revolved around the central axis to create a feature as shown below.

2. Finally, the bottom circular edge of the spring was created similarly to the top edge. The cross section was revolved around the central axis to create a feature as shown below.

3. If the central axis has not been sketched yet, it is recommended to sketch a line through the spring for assembly purposes to align the spring.

Note that at this point, the total length of the spring from top ring to bottom ring should be approximately 3.063 in.
Piston
The piston was created in three steps. Three circular extrusions were created with the pertinent sketches provided below. **The first sketch shows a circle of diameter 0.875 in. extruded a depth of 1/8 in. The second sketch is a circle of ¼ in. extruded 3.0 in. The final sketch is a circle of 5/8 in. extruded a depth of 0.5 in.**

Top Connector
To create the other connector, repeat steps 1 – 4 of the bottom cylinder assembly tutorial to get the result provided below.

Assembly
Refer to the class presentation on creating assemblies to assemble the six parts together. Students should use this part of the assignment as an opportunity to explore different ways to constrain the assembly.