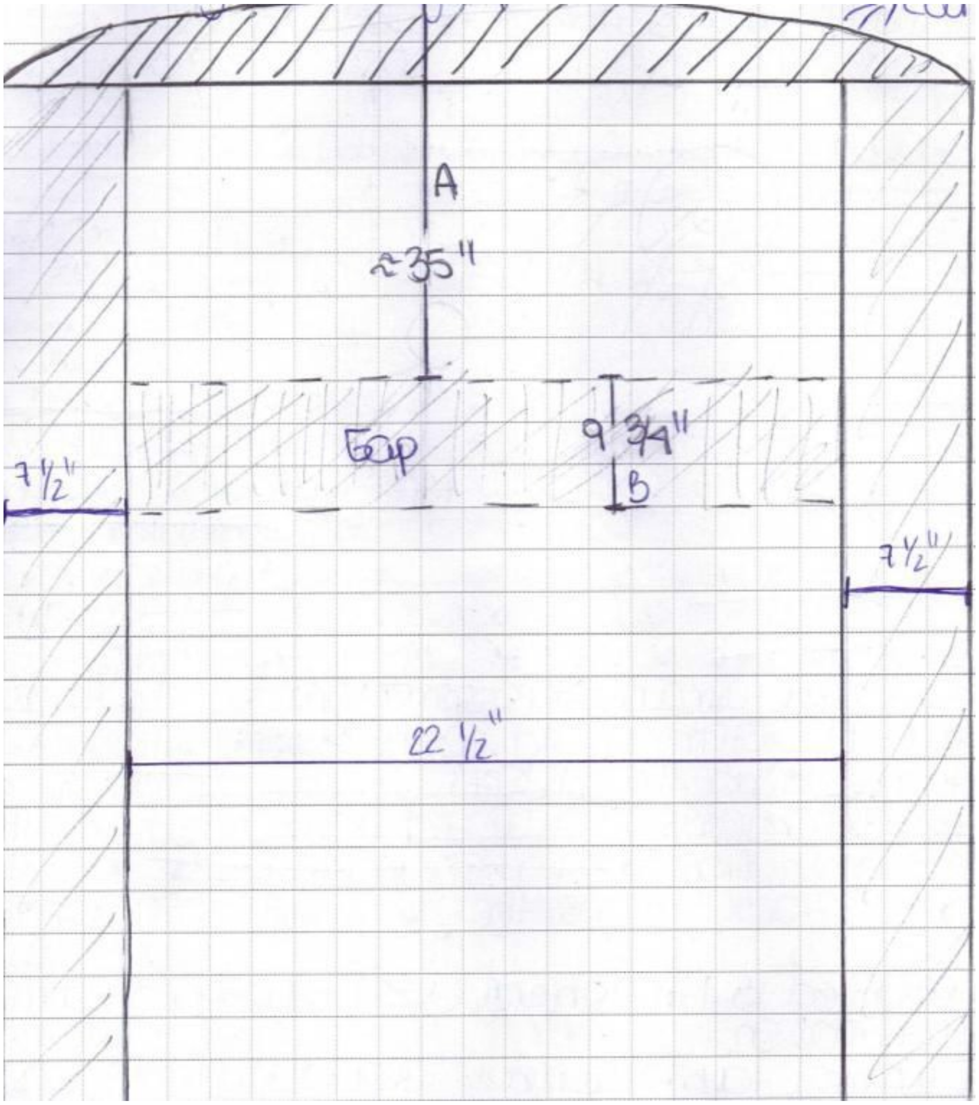
Stability Solution Prototype

To construct a prototype for the stability solution the top two results of the Stability Solution Decision Matrix, the Undermounted Hydraulic Counterweight System and the Undermounted Motor Moving Counterweight System, were modeled using Inventor to visualize the approximate amount of space each would occupy on the bottom of a forklift. The reason why it is important to know the relative shape and dimensions of the solution and the amount of space that it takes up is that there is a limited area of free space on the underside of a forklift, as shown in the following video:

http://youtu.be/GqZpz6EX61Q **(http://youtu.be/GqZpz6EX61Q)** (The video was taken on December 28th 2012. The video shows the underneath of the Toyota 8FGCU20. The video was taken by *[redacted student name]*.)

A simplified version of the space where the design is expected to be installed was sketched for use as a reference.



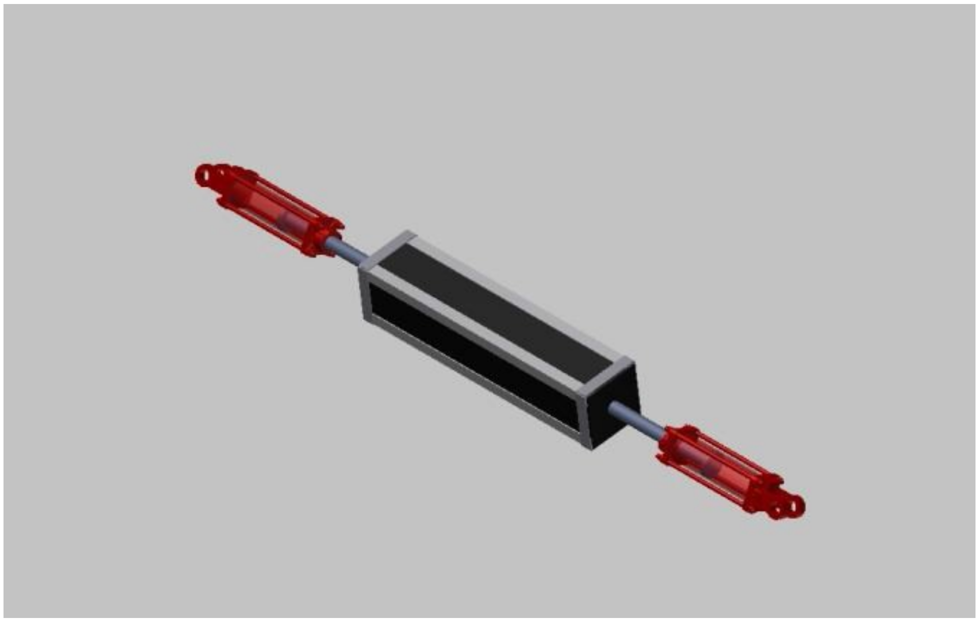
Note: "Gap" is six inches deep across the width of the bottom (not including 7 1/2 " markings)

Sketch from *[redacted student name]* Engineering Notebook entry from 12/28/12

To visualize the Undermounted Hydraulic Counterweight System, the essential parts were constructed in Inventor and then constrained to two opposing hydraulic cylinder parts that were obtained from the following website:

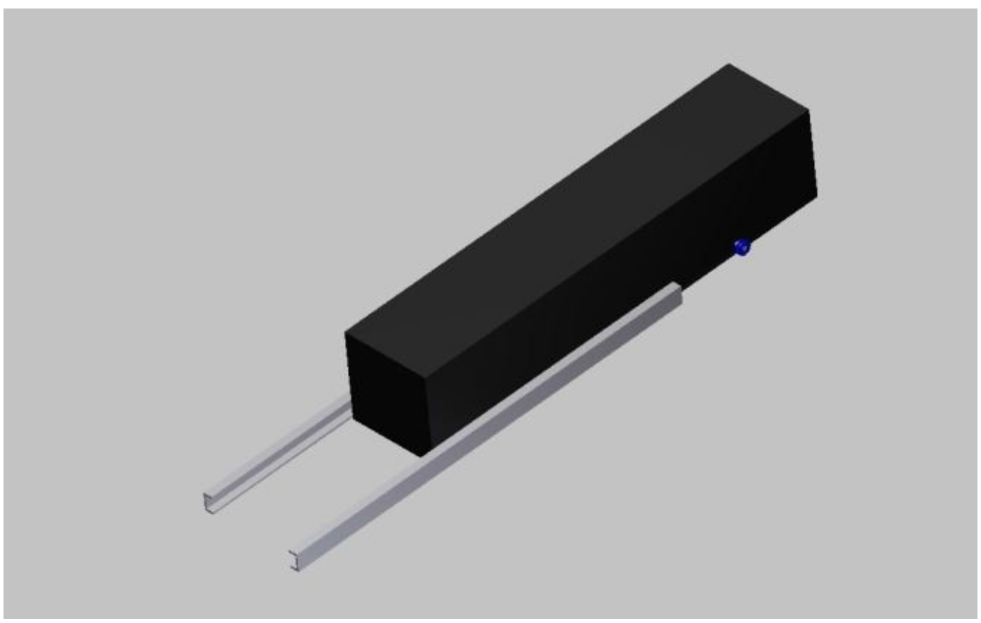
"Cylinders." Fittings. Charles Bliss Web. 01 Jan. 2013 <**http://www.cbliss.com/inventor/Parts/Fittings/index.htm (http://www.cbliss.com/inventor/Parts/Fittings/index.htm)** >

The image below shows a simplified prototype of the "Undermounted Mounted Hydraulic Cylinders." The counterweight would be attached to the hydraulics by some method (a decision matrix still needs to be contucted to detrmine a method of attachment). The corrrespoing forklift would activate when the sensor (which also needs to be tedermined as of this point) activates.



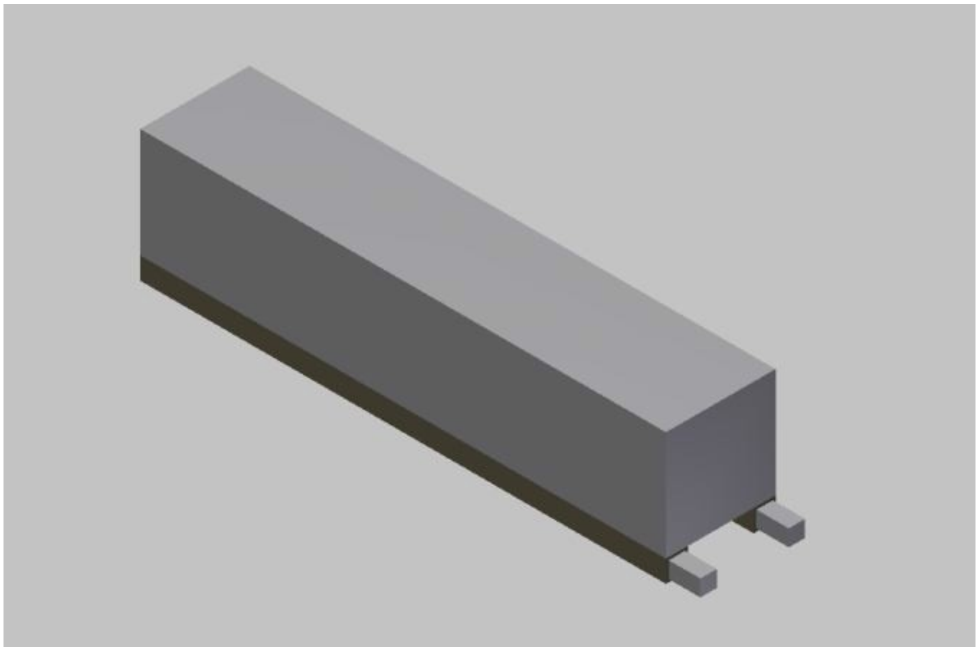
Picture Source: "Hydraulic System Assembly",created by *[redacted student name]* on 1/10/13.

To visualize the Undermounted Motor Counterweight System, several rail systems were designed using arbitrary dimensions which would allow the counterweight to slide from one side of the forklift to the other. These rail concepts were modeled in Inventor to better judge the strengths and weaknesses of each.



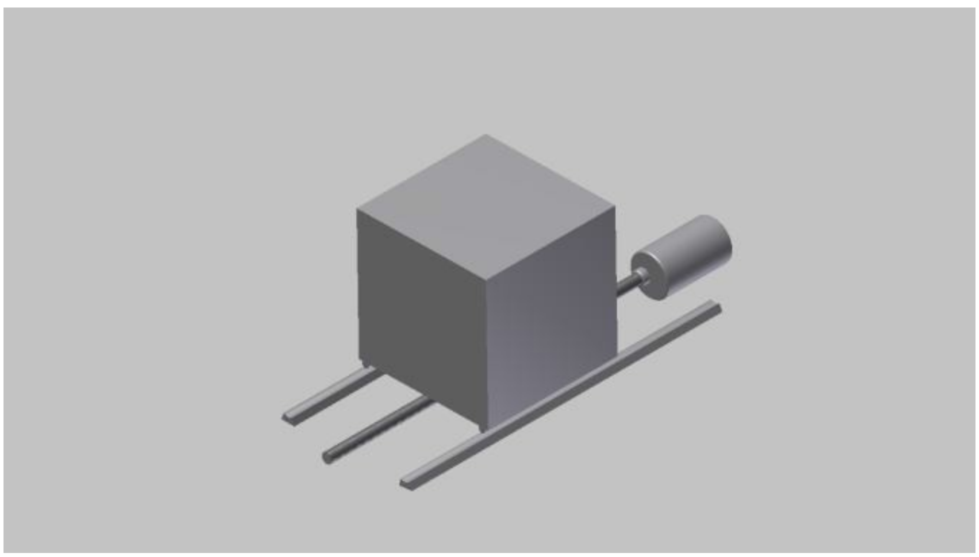
This image depicts one of the possible solutions for the rail system to be used if the "Under mounted Counterweight with Electric Motor" is chosen as the final design. In this design a wheel is contained in a "C" shaped rail. The reason why a rail system such as this one could be used is because if the forklift is in the process of tipping over the wheel might fall out of the rail, if it were not enclosed.

Picture source: "Contained Wheel Assembly",created by *[redacted student name]* on 1/20/13.



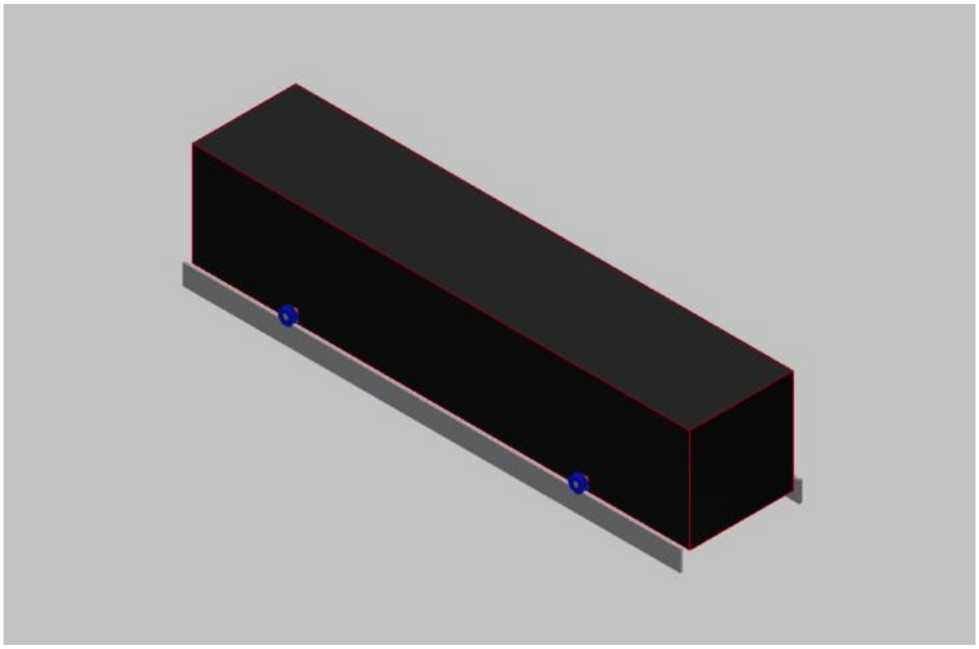
In this system, the counterweight is attached to two hollow rectangular rails.

Picture Source: "Square Rail System",created by *[redacted student name]* on 1/20/13.



In this image, the cylindrical component shown represents a motor. The motor moves the weight through a threaded rod.

Picture Source:"Motor Counterweight System", created by *[redacted student name]* on 1/20/13.

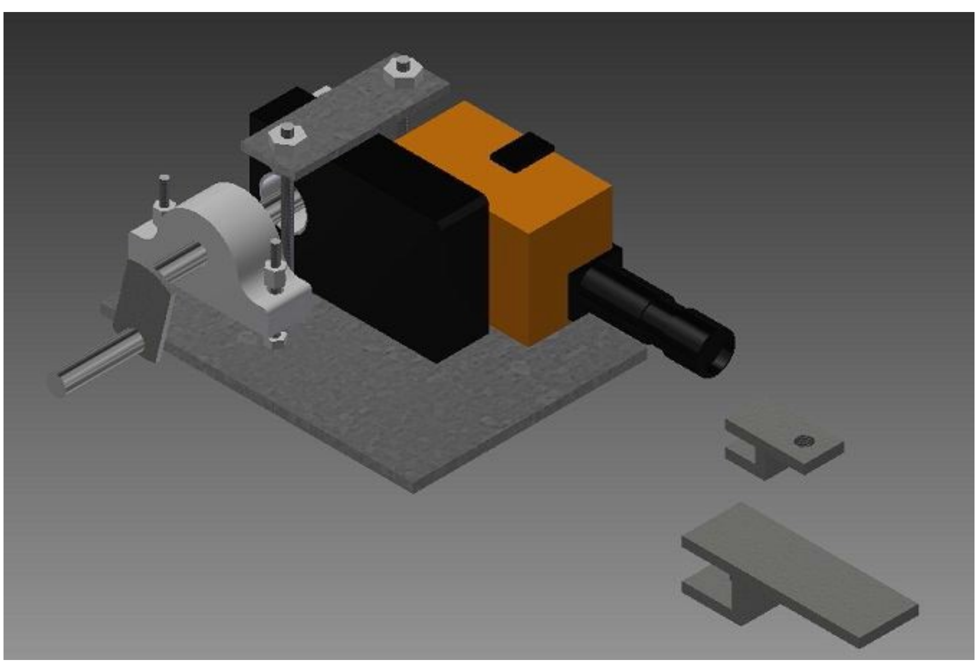


This design works in a similar way to the previously mentioned "Contained Wheel Assembly" except for the different rail structure.

Picture Source: "Wheel Rail System", created by *[redacted student name]*on 1/13/13.

******The "Centripetal Force and Gravitational Force Moments: Determining the Mass of the Moving Counterweight" calculations in Element E showed that the moving counterweight system would not be feasible due to the lack of space in the forklift as well as the significant amount of weight that would be required to counterbalance the tip over. Later the possibility of adding a throttle back was being discussed. The addition of this would slow the forklift down and thereby reduce the amount of weight that would be needed. After careful consideration and brainstorming the team decided to shift directions and use a "speed and turn" detection system instead of using a throttle back and a counterweight system together. Please see Element F: Consideration of Design Viability for more details.***

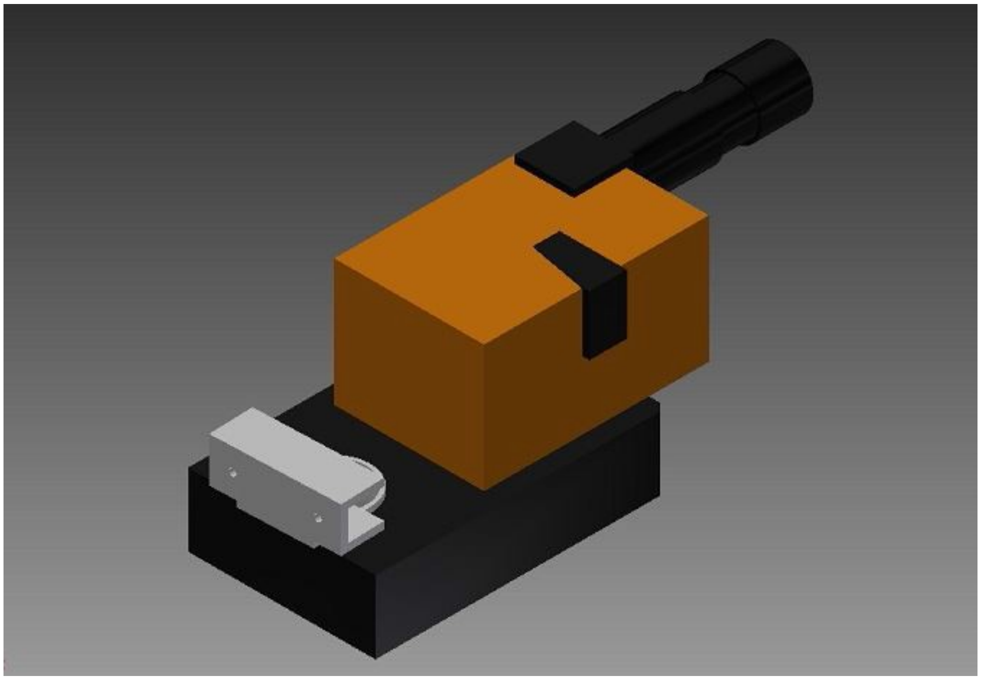
Note that the following design generations pertain to the team's new stability design.***



Picture source: "Stability Solution Assembly." Created by *[redacted student name]* on 5/1/13.

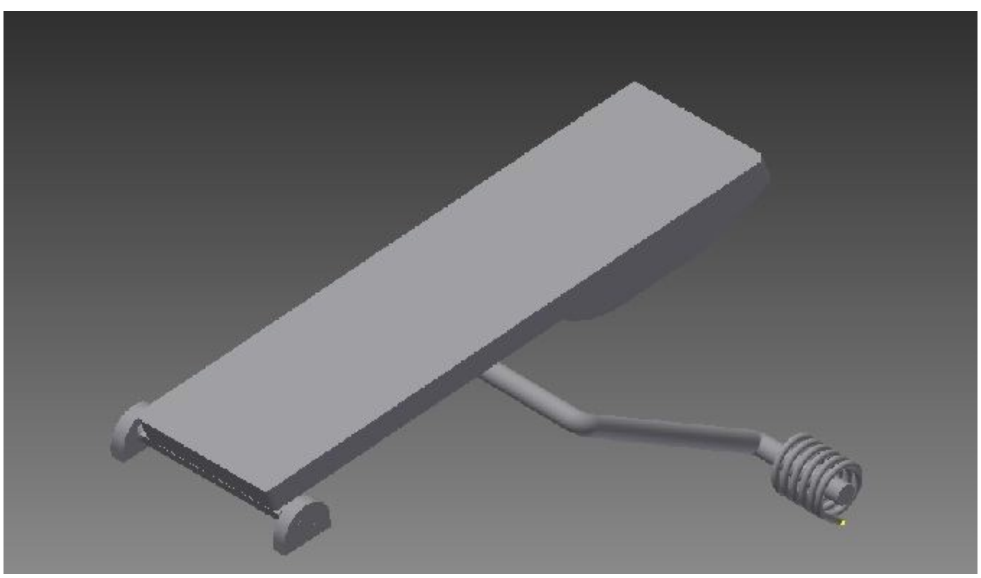
After further consideration and brainstorming, the stability solution was changed to the current form, shown above. Currently the device aids in stabilizing the forklift by slowing down the forklift during turns. A pedal actuator forces the gas pedal up manually when a magnetic switch mounted on the forklift steering assembly detects a break in the circuit. The actuator may be seen in the center-left of the photo, while the clamps used in mounting the switch may be seen in the bottom right.

The Belimo brand damper motor may be viewed below in greater detail.



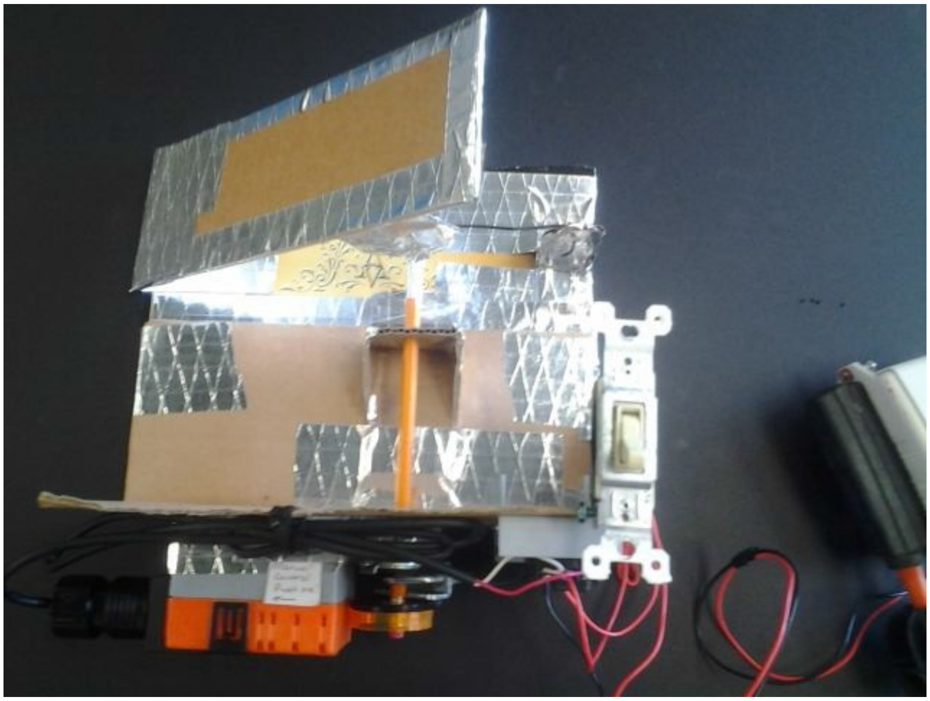
Picture source: "Belimo Motor." Created by *[redacted student name]* on 4/12/13.

Also modeled was the forklift accelerator pedal, used for visualization and modeling the solution in Autodesk Inventor.

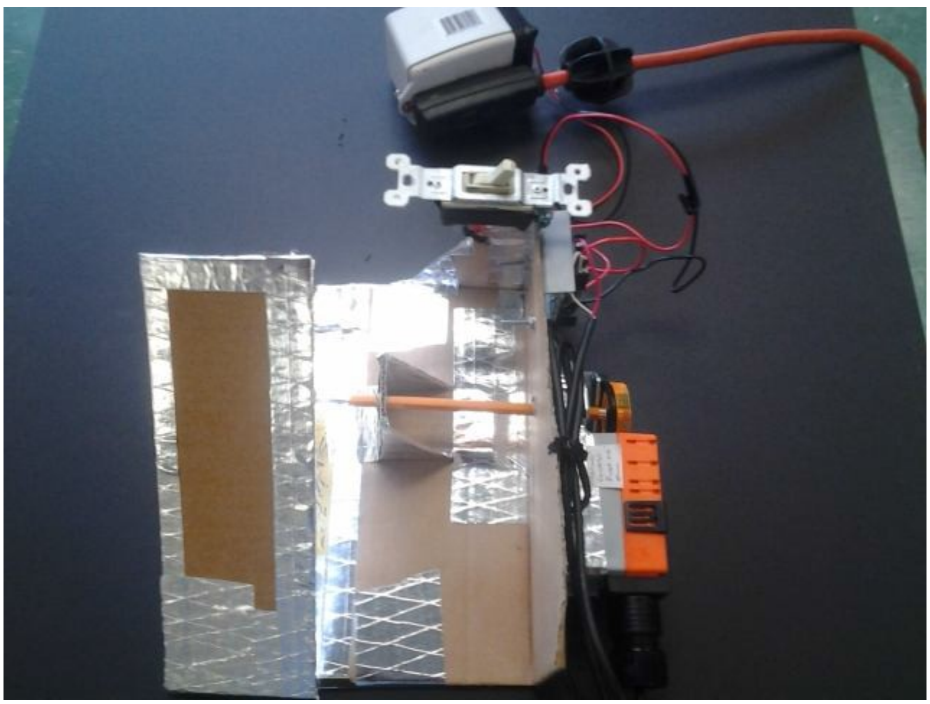


Picture source: "Forklift Accelerator Pedal Assembly." Created by *[redacted student name]* on 4/12/13.

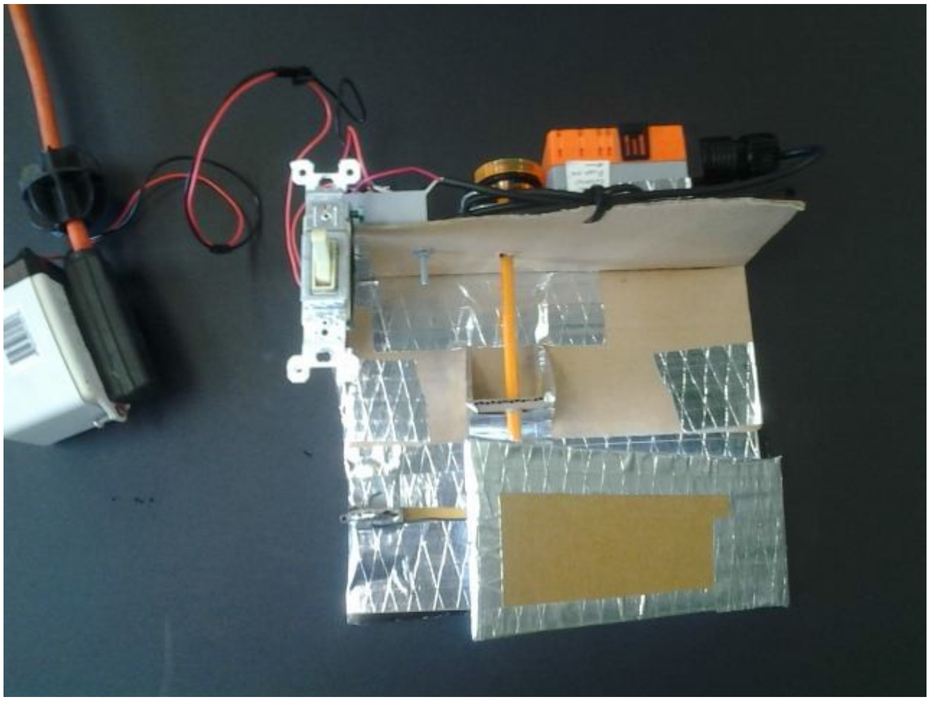
Before building a prototype the team built a "mock up" based on the CAD drawings:



"Mock up Top View" Picture Source: taken by *[redacted student name]* on 03/25/13

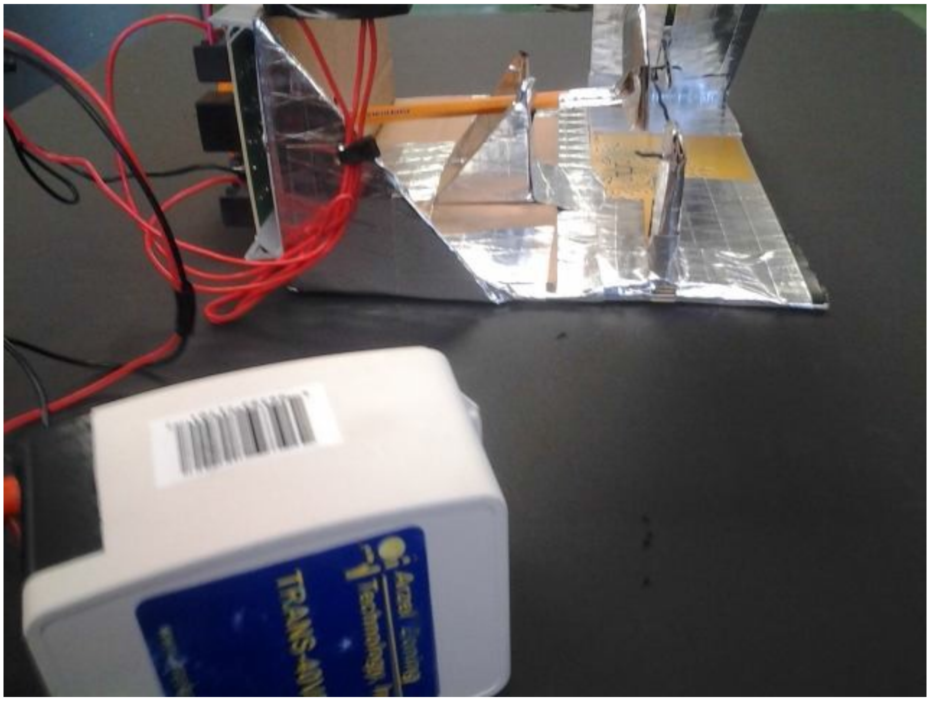


"Mock up 2" Picture Source: taken by*[redacted student name]* on 03/25/13

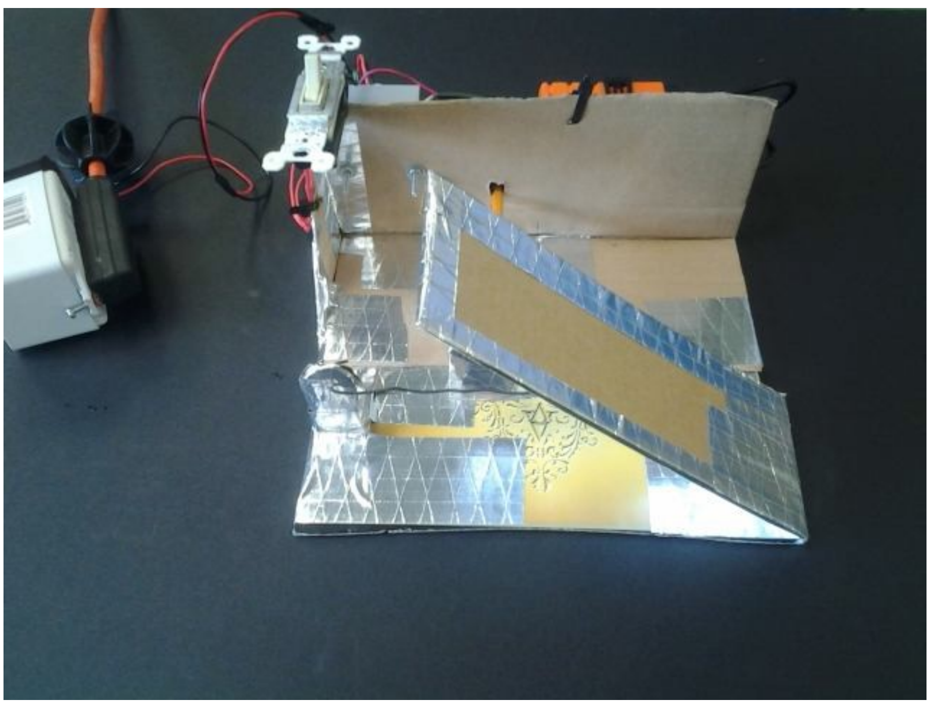


"Mock up 3" Picture Source: taken by *[redacted student name]* on 03/25/13

"Mock up 4" Picture Source: taken by *[redacted student name]* on 03/25/13



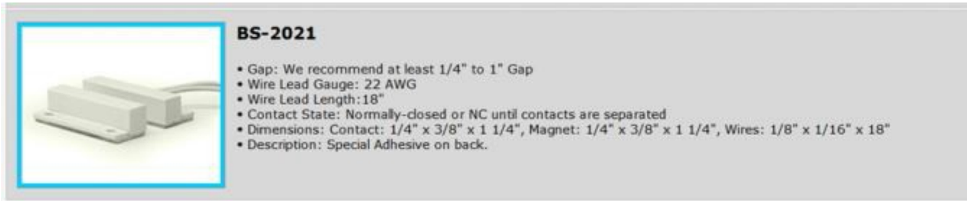
"Mock up 5" Picture Source: taken by *[redacted student name]* on 03/25/13



"Mock up 6" Picture Source: taken by *[redacted student name]* on 03/25/13

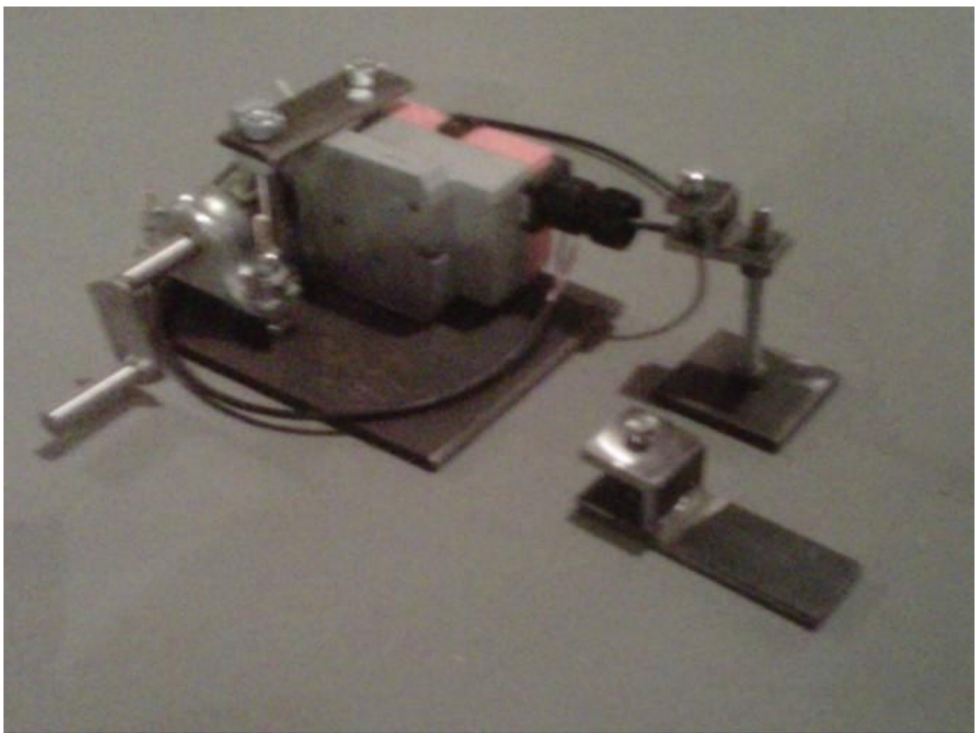
Switch:

From the “Deciding on a Sensor” matrix located in Element D: Design concept generation, analysis, and selection, it was decided that a magnetic door switch was going to be used for the initial prototype. Please note that this is NOT the intended switch to be used if the prototype were to be completed used all of the required parts. As the defense of this matrix included, ideally limit switches would be used, please see Element L for further information on the limit switch. The limit switches were not used in the prototype due to lack of budget. The team included the magnetic door switch in this element since it is what the prototype will contain on the day of the final presentation.



Picture Source: "BR-2021" WINN Security Products. WINN. Web 27 Mar. 20130< http://www.winnsecurityproducts.com /secu rity_co ntacts.htm> (http://www.winnsecuritypr oducts.com/security_contacts.htm>)

Pictured below is the physical assembly of the stability solution, currently reflecting building progress as of 5/2/2013.



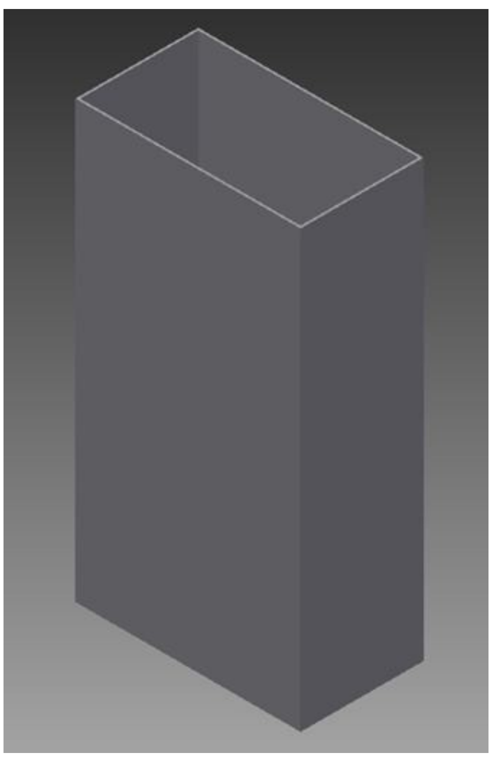
Picture Source: "Stability Solution Physical Assembly" taken by *[redacted student name]* on 5/2/2013.

Visibility Solution Prototype

To construct a prototype for the visibility solution, the Swinging Periscopic Viewport, the construction of a forklift overhead guard was necessary to visualize how the solution would interface with the overhead guard part that it is designed to attach to. The overhead guard was constructed in Inventor according to the dimensions of the actual overhead guard loaned to the team by Thompson & Johnson Equipment Co., Inc.

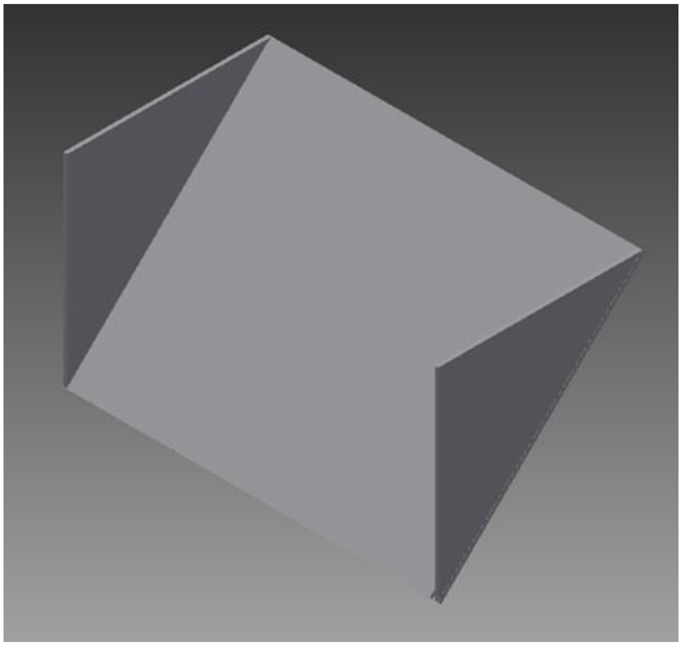
Picture Source: "Overhead Guard Assembly" created by *[redacted student name]* in Inventor on 1/9/13

To construct the prototype device, the core box of the device was constructed in Inventor.



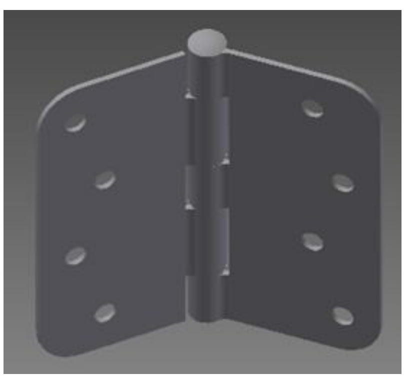
Picture Source: "Box Assembly" created by *[redacted student name]* on 1/10/13

The mirror sections were also constructed in Inventor and then constrained to the device box in Inventor. The Mirror Section sub-assembly holds the mirror parts in place at the correct angle.

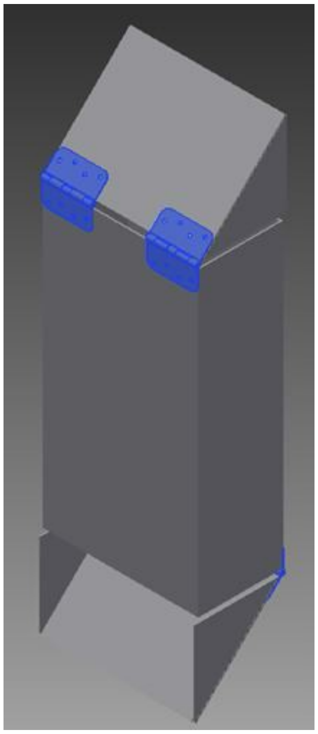


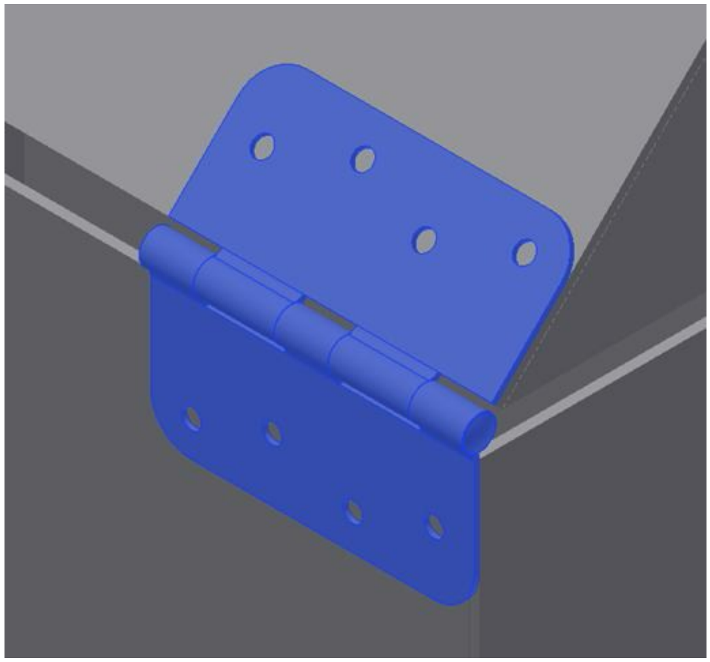
Picture Source: "Mirror Section Assembly" created by *[redacted student name]* on 01/14/13

To visualize the functionality of the Mirror Section Hinge System brainstormed idea and how it interfaces with both the device box and the two mirror sections, a sample hinge was modeled in Inventor using dimensions from a door hinge. This system is a method of attachment of the device box to the two mirror sections that allows someone to easily access the mirrors in the mirror sections for cleaning and maintenance without having to remove the device or the mirror section.



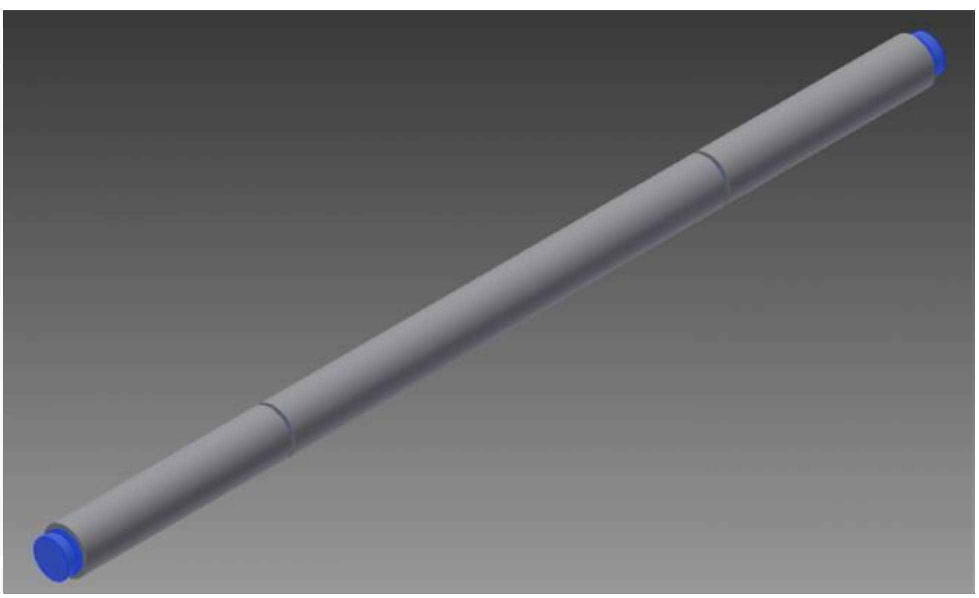
Picture Source: "Mirror Section Hinge Assemby" created by *[redacted student name]* on 1/18/13



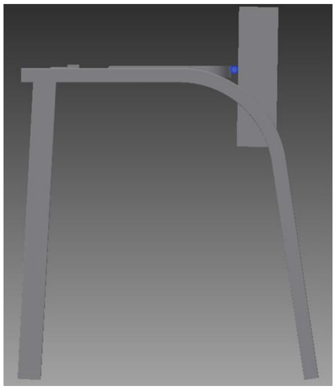


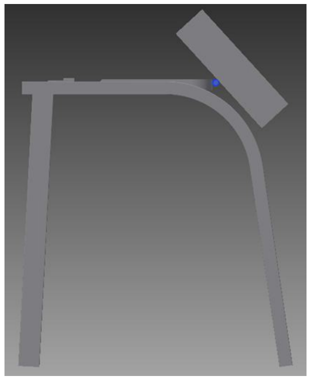
Pictures Source: "Device Assembly" created by *[redacted student name]*on 1/18/13

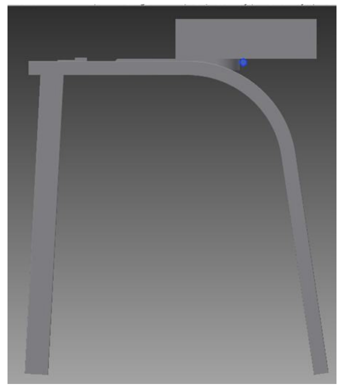
To visualize the functionality of the Device Hinge System brainstormed idea and how it interfaces with both the overhead guard and the device, the idea was modeled using arbitrary dimensions in Inventor. This system is a method of attachment of the device to the overhead guard that allows the device limited rotational freedom of movement to allow it to be positioned in the "in use" position and the "not in use" position.



Picture Source: "Device Hinge System Assembly" created by *[redacted student name]*on 1/10/13



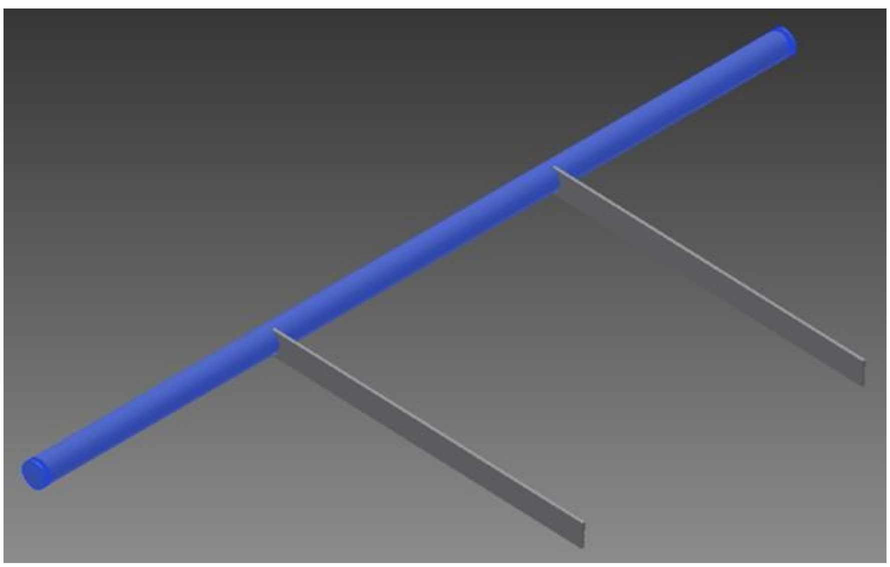




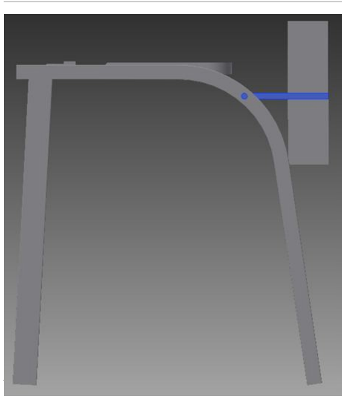
Device in "In Use" position	Device transitioning from "In Use" to "Not In Use" position	Device in "Not in Use" position

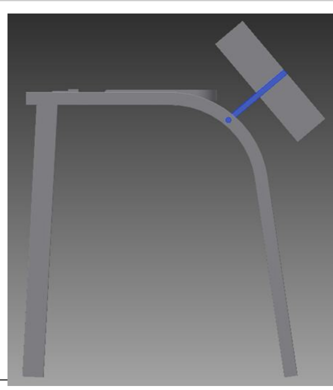
Pictures Source: "Attached Device Hinge System Assembly" created by *[redacted student name]* on 1/10/13

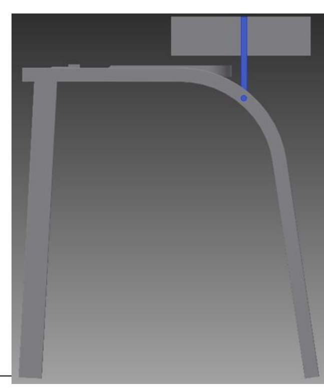
To visualize the functionality of the Overhead Guard Hole System brainstormed idea and how it interfaces with both the overhead guard and the device, the idea was modeled using arbitrary dimensions in Inventor. This system is also a method of attachment of the device to the overhead guard that allows the device limited rotational freedom of movement to allow it to be positioned in the "in use" position and the "not in use" position.



Picture Source: "OHG Hole System Assembly" created by*[redacted student name]* on 1/17/13







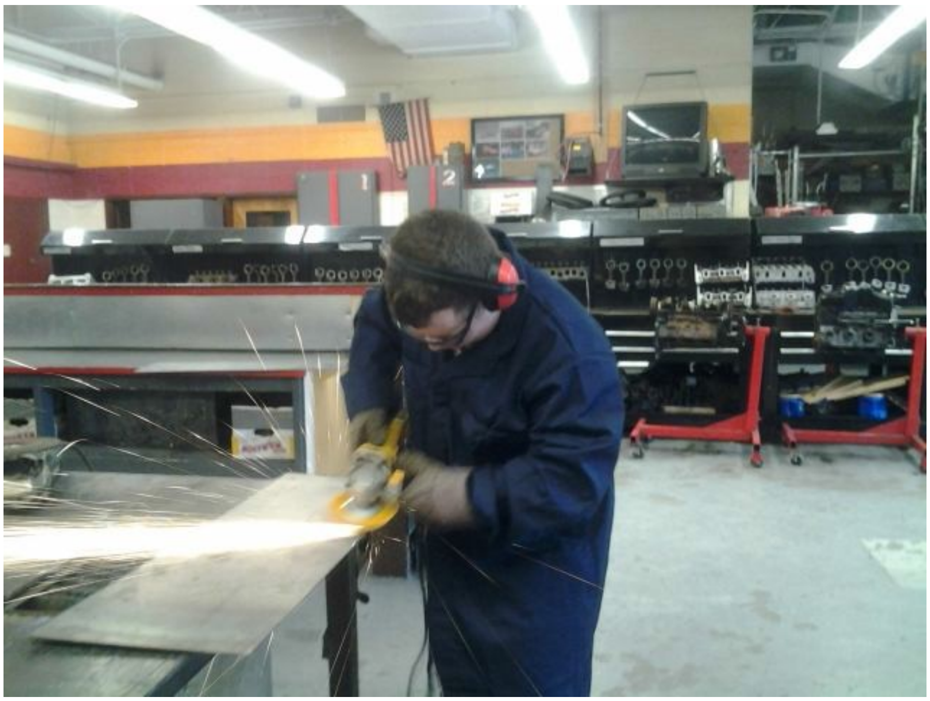
Device in "In Use" position	Device transitioning from "In Use" to "Not In Use" position	Device in "Not in Use" position

Picture Source: "Attached OHG Hole System Assembly" created by *[redacted student name]* on 1/17/13

NOTE: To determine which out of the many solutions for the variety of different aspects of each design is the most viable, (such as the decision between the different rail systems for Stability, and the decision between the different methods of attachment of the device to the overhead guard for Visibility) the team will complete decision matrices. It is not premature to make Inventor files of these various systems before actually deciding which one will be incorporated into the solution because Inventor has actually aided the team in making the decisions.

After several decision matrices determined the design, physical construction was started on the visibility device prototype. Building primarily included tasks such as welding.

The box and mirror sections of the device were first cut from 1/8in steel plate with a plasma cutter. The cut edges of the plates were smoothed with a grinder and then welded together by Ian Crell.



Picture taken by *[redacted student name]* on 3/25/13

Picture taken by *[redacted student name]* on 3/25/13

Hinges and various other parts were acquired and these components were added to the device. The mirror sections were attached to the device box with hinges that were welded onto the device.

After the polycarbonate mirrors were obtained, they were attached to the inside of the mirror sections with velcro.

Mirror attached to Mirror Section

Picture taken by *[redacted student name]* on 5/2/13

Before being welded onto the sides of the device, 1/2in diameter holes were drilled through the two eyebolt attachment parts to allow the eyebolts to attach to them with hex bolts as shown in the following pictures:

Eyebolt Attachment part

The holes in the edges of the device dox were filled with Bondo which was allowed to harden before being sanded smooth. The device was then coated with primer and painted.