3D Printing and Laser Cutting Project

Production Technology - 3901

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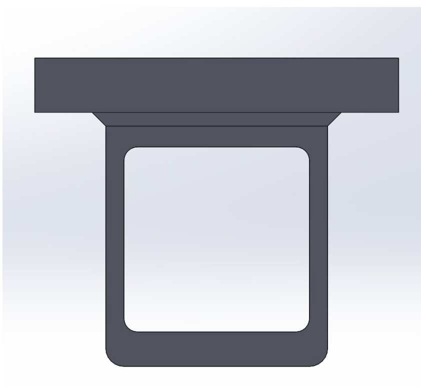
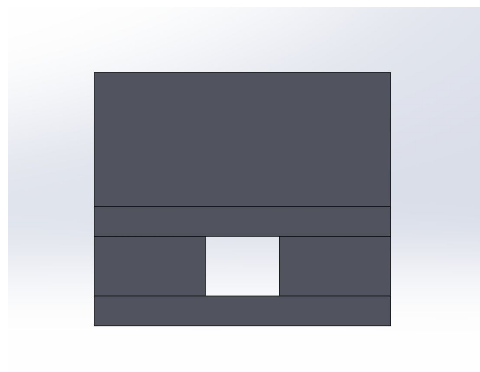
1.0 3D Printing | Part A

1.1 The Design

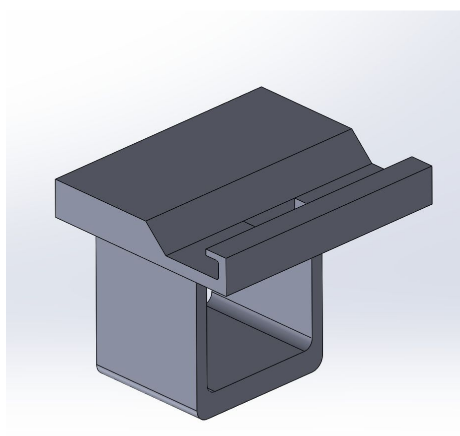
The artifact that our group chose to construct using Memorial University's 3D printing equipment is an iPhone charging station. The charging block is securely fits in a hole in the front of our station, and is plugged into the wall. The phone itself rests on a ledge on the top of the device, with an opening for the charging cord. The purpose of this object is to have a resting place for the user's iPhone while it is charging in the wall outlet.



Front View



Top View



Isometric View

Figure 1: These are screenshots of the final design concept that was submitted to be printed.

Figure 2: Photos showing the final product and its functionality.

1.2 Alternative Concepts

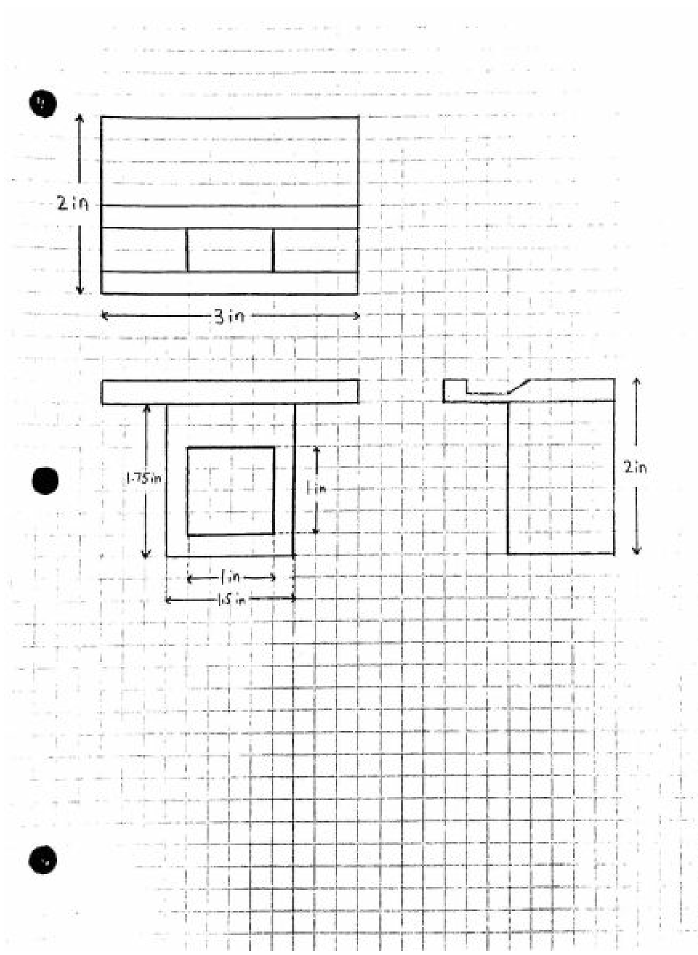


Figure 3: The first design concept that was generated.

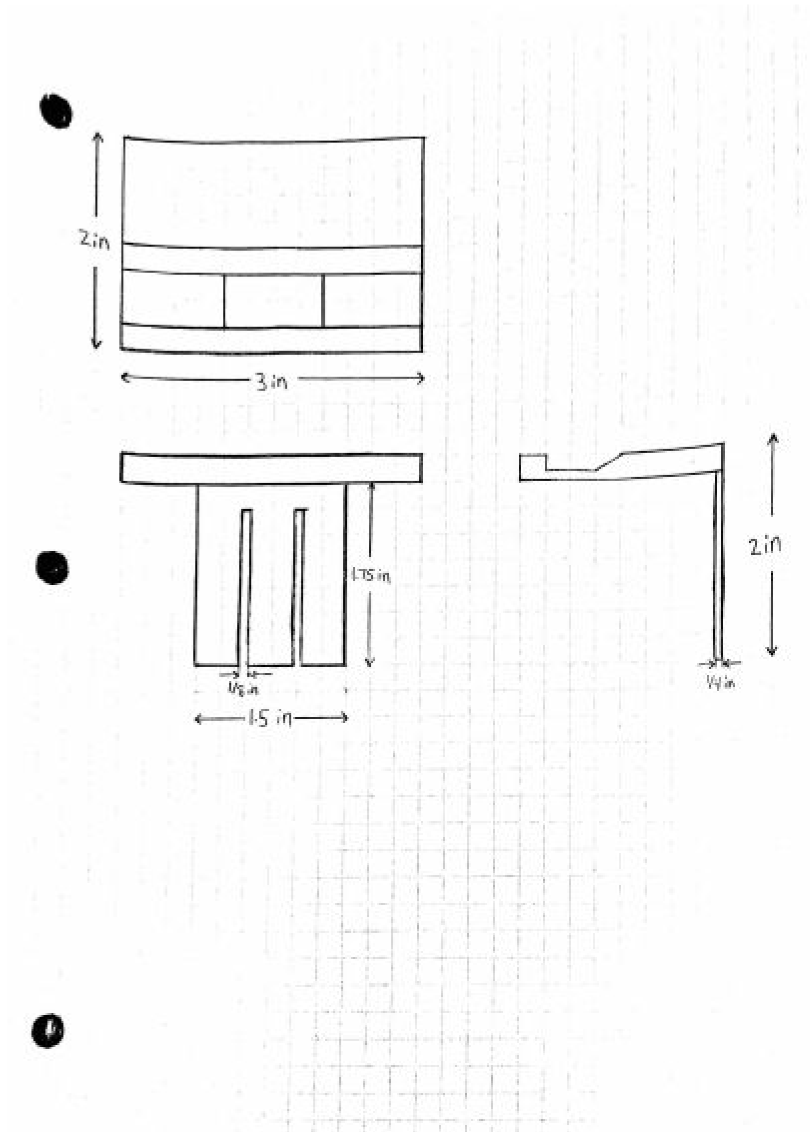


Figure 4: The second design concept that was generated.

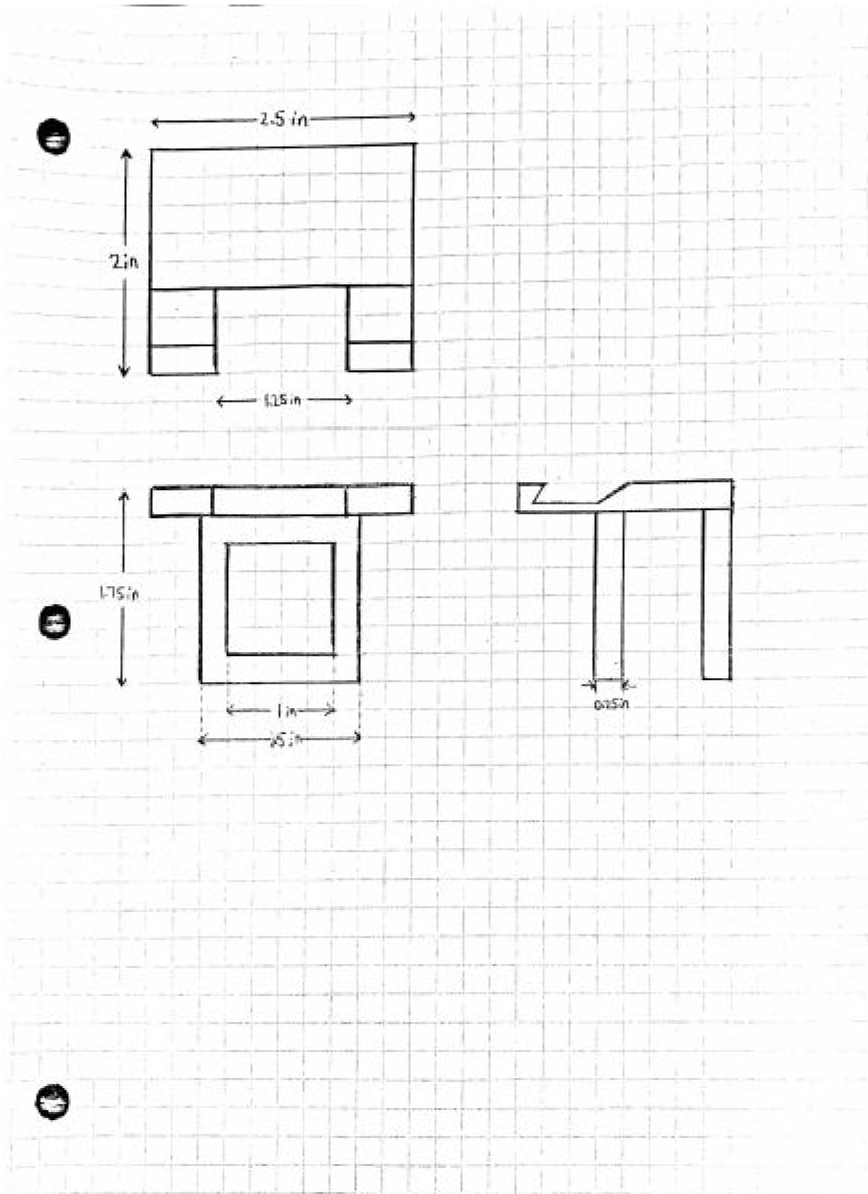


Figure 5: The third concept that was generated.

1.3 Design Process

By going through each design concept we were able to take a step back and evaluate the pros and cons while ensuring we did not violate any of the design constraints. The concept depicted in Figure 3 was our original design. During the development of this prototype in SolidWorks we did not frequently check the volume of the part. Once it was done, we realized we were well over the allowed volume of 1.50 cubic inches.

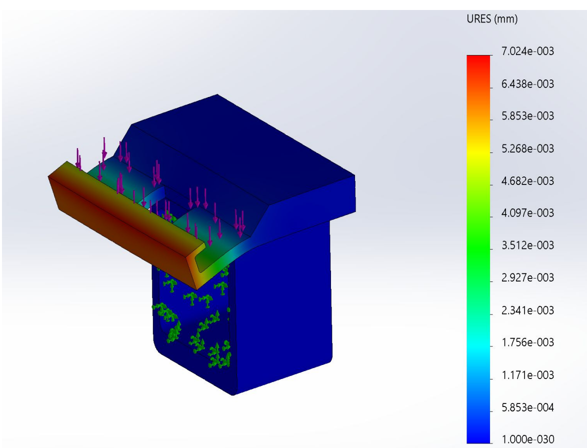
We then took a step back and decided we should try reducing the volume. To do this we changed the way in which the platform would stay in place during charging. As you can see in Figure 4 we decided to fix the platform by using the force that is applied from plugging in the charging block to the wall. This design however may cause a weaker connection of the charging block with the wall outlet and therefore we decided to try another design.

In Figure 5, a sketch of our second attempt at reducing the volume is shown. We removed a significant amount of material from the bottom portion in which the charging block rests, and removed part of the front support of the platform which now includes a slight modification. This concept eventually seemed to not be functional as it provides much less support for the phone, causing it to fall. We decided to keep the addition of the overhanging section and include it in our final design concept to further decrease the risk of the phone falling over while charging.

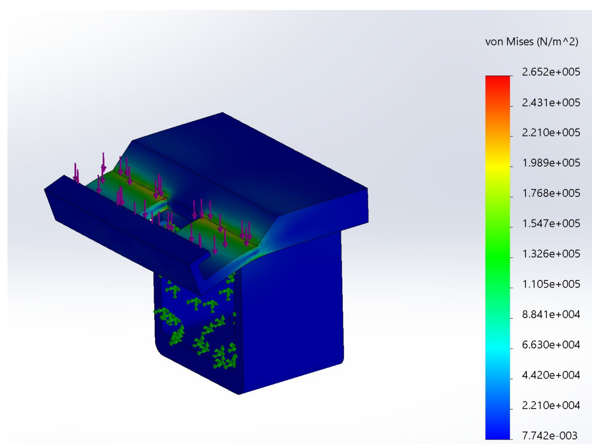
Essentially we combined the design of the first and second concepts which yielded the images seen in Figure 1 and this was the design that both fit the 1.50 cubic inch volume and had the highest potential to complete its required task.

1.4 Design Analysis

After coming to the final design which essentially was a mix between concept 1 (Figure 3) and concept 2 (Figure 5). To ensure it would be strong enough to support the weight of the Iphone we ran finite element analysis (FEA) to simulate the load scenario that the charging station would undergo.



Displacement plot when the charging station experiences the force of an iphone resting on it.



Stress plot when the charging station experiences the force of an iphone resting on it.

Figure 6: The displacement and stress plots of the charging station undergoing an Iphone being charged.

To correctly simulate the forces that the charging station would undergo we fixed the inside of the station where the charging block is placed and applied the force of gravity.

$m_{iphone} = 0.174\ kg$
$g = 9.81\ m/s^2$
$F_g = mg = (0.174kg)(9.81m/s^2) = 1.71N$

By doing this the largest displacement the charging station underwent was 0.007024 mm and did not surpass the plastic deformation threshold.

1.5 3D Printing Process

After our design was completed, it had to be 3D printed. The computer aided design (CAD) file of our design had to be converted to a .stl file format that is specified for the printer. Once the printing had started, our design was being built layer by layer from the bottom up. It is fabricated in the orientation it has been input in the CAD file, starting from the very bottom to ensure a sturdy base for the charging station. Once it is fully printed, the object must be soaked in a solution to assure that it is clean and completely hardened.

1.6 Prototyping Problems

When the charging station was printed and soaked we went to prototype the product. When we went to test it the standard charging block made by Apple was slightly too large in the vertical dimension. Due to this we were forced to sand down the inside of the mounting hole slightly to accommodate the charging block. We believe this happened due to the combination of multiple factors such as variances between different charging blocks, incorrect dimensions online and dimensions that were measured by us. Prior to mass production this would have to be fixed to ensure it fit correctly.

1.7 Mass Production of Our Product

In terms of mass production for our object, there are various options that we have. The most important variable to think about is the material of the product. The ideal material must be easy to manufacture, strong so it does not break, and cost efficient. Upon researching some inexpensive plastics, our possibilities were High Impact Polystyrene, Polyoxymethylene, and CE Canvas Phenolic. All three plastics are known to be strong and easily machinable. To determine which one of these plastics would be the best choice, the cost of material required to produce 125 000 iPhone charging stations per year was calculated for each one. Our final product ended up being 1.44 cubic inches, so 180 000 cubic inches of material is required each year. The cost of this amount of High Impact Polystyrene is $18 671.88, while Polyoxymethylene costs $100 806.45, and CE Canvas Phenolic costs $574 572.13. The cost of High Impact Polystyrene is significantly smaller than that of the other materials, making it the optimal material for mass production. The 3D printing process that would be most efficient for this production is fused deposition modeling (FDM). FDM is the only 3D printing technology that builds parts with production-grade thermoplastics, resulting in products with high quality mechanical properties.

2.0 Laser Cutting | Part B

2.1 Overview

To become familiar with laser cutting processes we designed a geneva drive mechanism. Geneva drive mechanisms are used in clocks with the purpose to avoid springs being wound too tight. This mechanism works by the drive wheel turning continuously, the pin on the drive wheel then turns the cross shaped piece a quarter turn for each revolution of the drive wheel.

2.2 The Design

Our group was given free will to design a geneva drive mechanism that's parts were laser cut from a 1’x2’x1/8” piece of plywood.

The final product is depicted below in Figure 7. As you may notice there is a ¾” dowel that is used as the handle that allows the geneva mechanism to be sampled by the user. This part was not laser cut along with bolts, nuts and washer. These were purchased to assemble the mechanism.

The design of the individual pieces was done with SolidWorks due to the group's familiarity with the software along with the experience of developing water jet and laser cut drawings from previous projects.

Isometric View

Top View

Figure 7: An isometric and top view of our final design fully assembled.

2.3 Fabrication

2.3.1 Cutting

In order to get the part ready for the laser cutting it is required that a drawing of the specific sheet size is developed and the correct drawing view of each part is strategically placed onto the sheet without any of the parts touching each other. Once this is done the file is then converted to a .dxf or .ai file and lines are coloured depending on if they are suppose to be cut through all or blindly engraved.

2.3.2 Fabrication

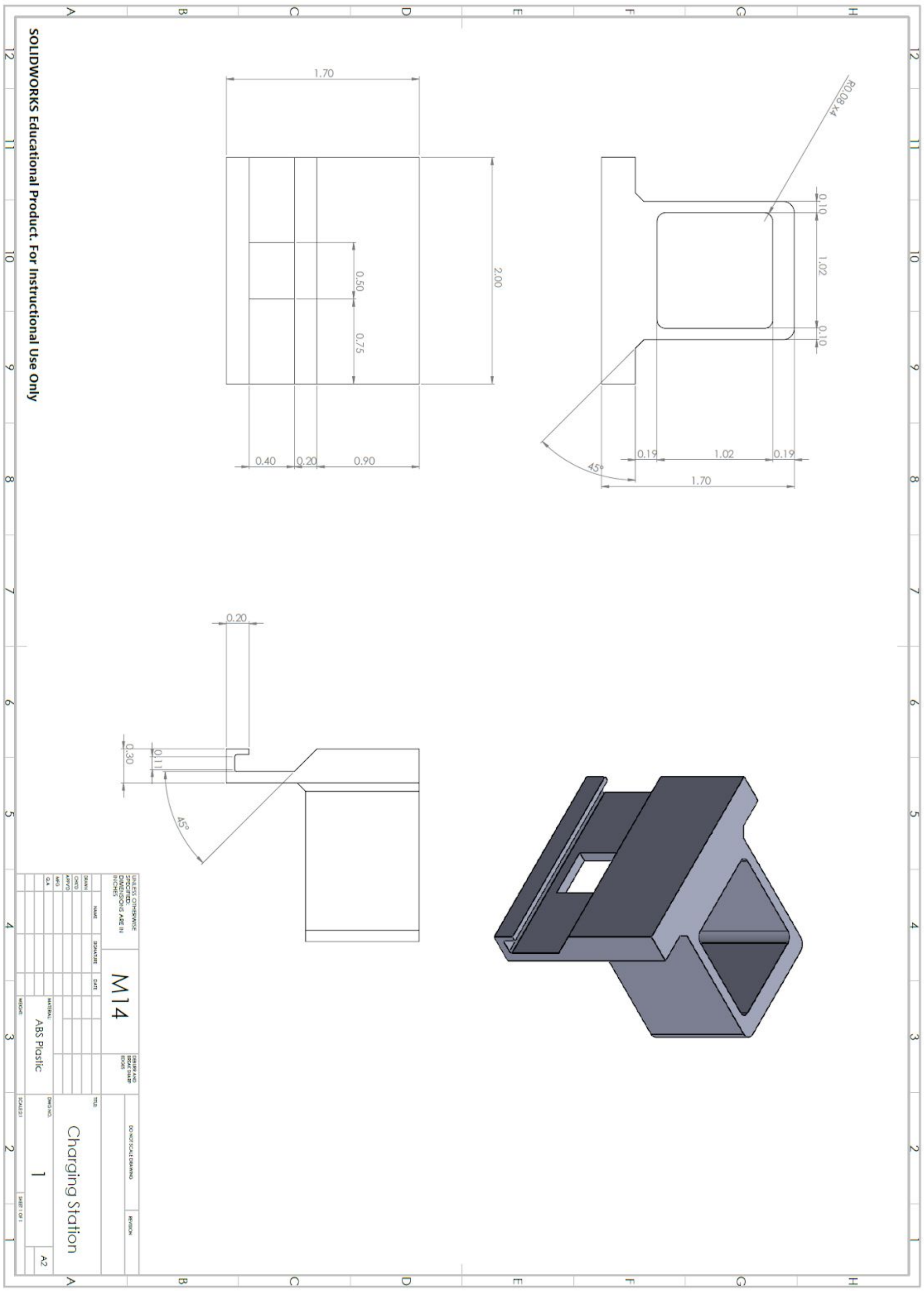
Once each piece was cut from the plywood our group used nuts, bolts, washers, would glue and a dowel to fabricate the mechanism. All these individual parts and final assembly can be seen in Appendix 3.2 or in Figure 7.

2.4 Testing

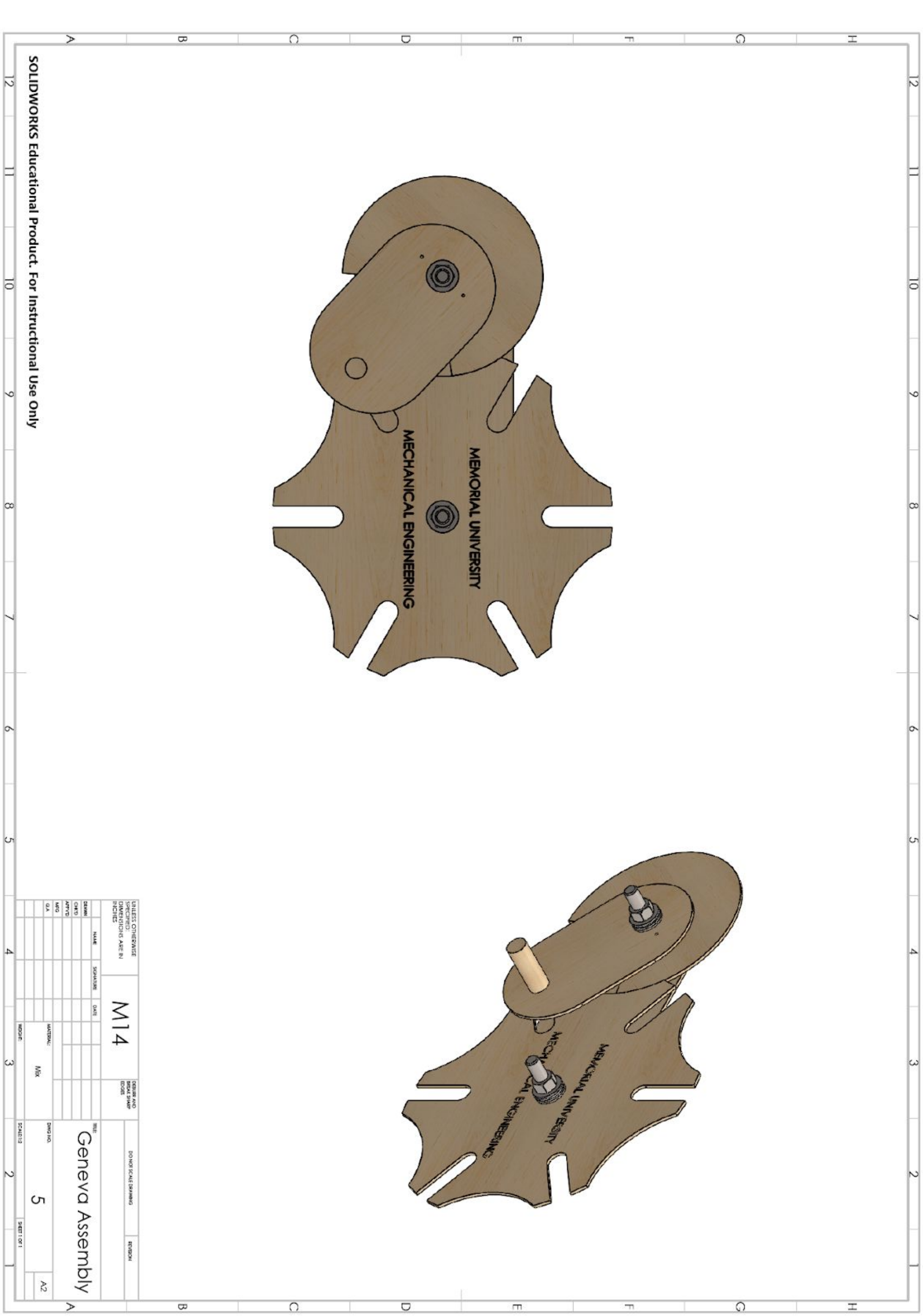
When the fabrication was completed we went to test the mechanism. It appeared to work well except for the fact that we had screws that interfered with the base of the mechanism which caused difficulty turning the mechanism. To solve this issue we used washers between the base and the rest of the mechanism. By adding in washers the mechanism became off balance and when the crank completed a 360 degree turn the mechanism would begin to overlap and therefore required slow movements in order to maintain constant and smooth motion. To correct this if the group was to redesign we would ensure that the drive mechanism did not require screws to fix objects to one another.

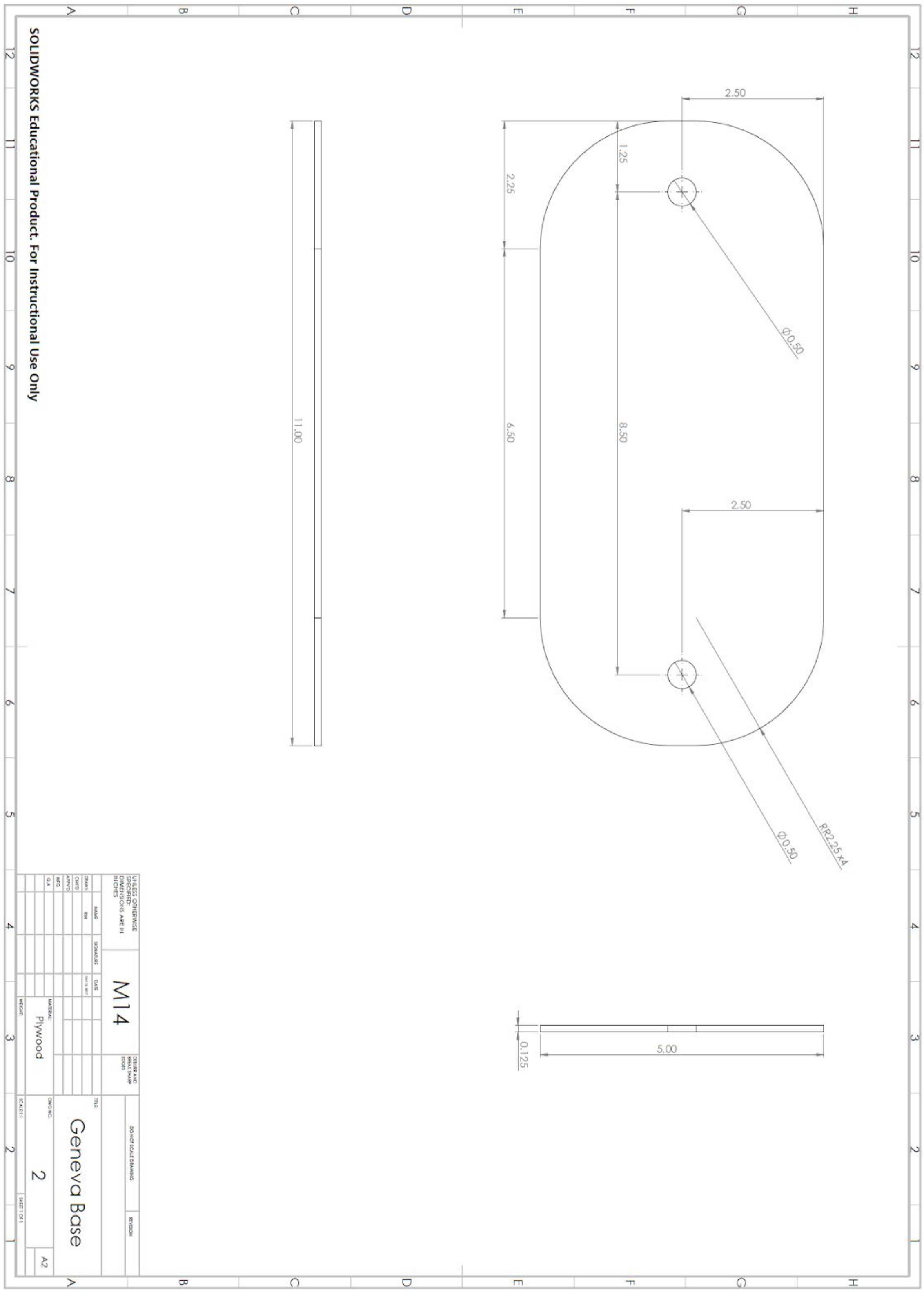
3.0 Appendices

3.1 3D Printed Charging Station - Drawing Package



3.2 Laser Cut Geneva Mechanism - Drawing Package

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2.25
Ø0.50
6.50
8.50
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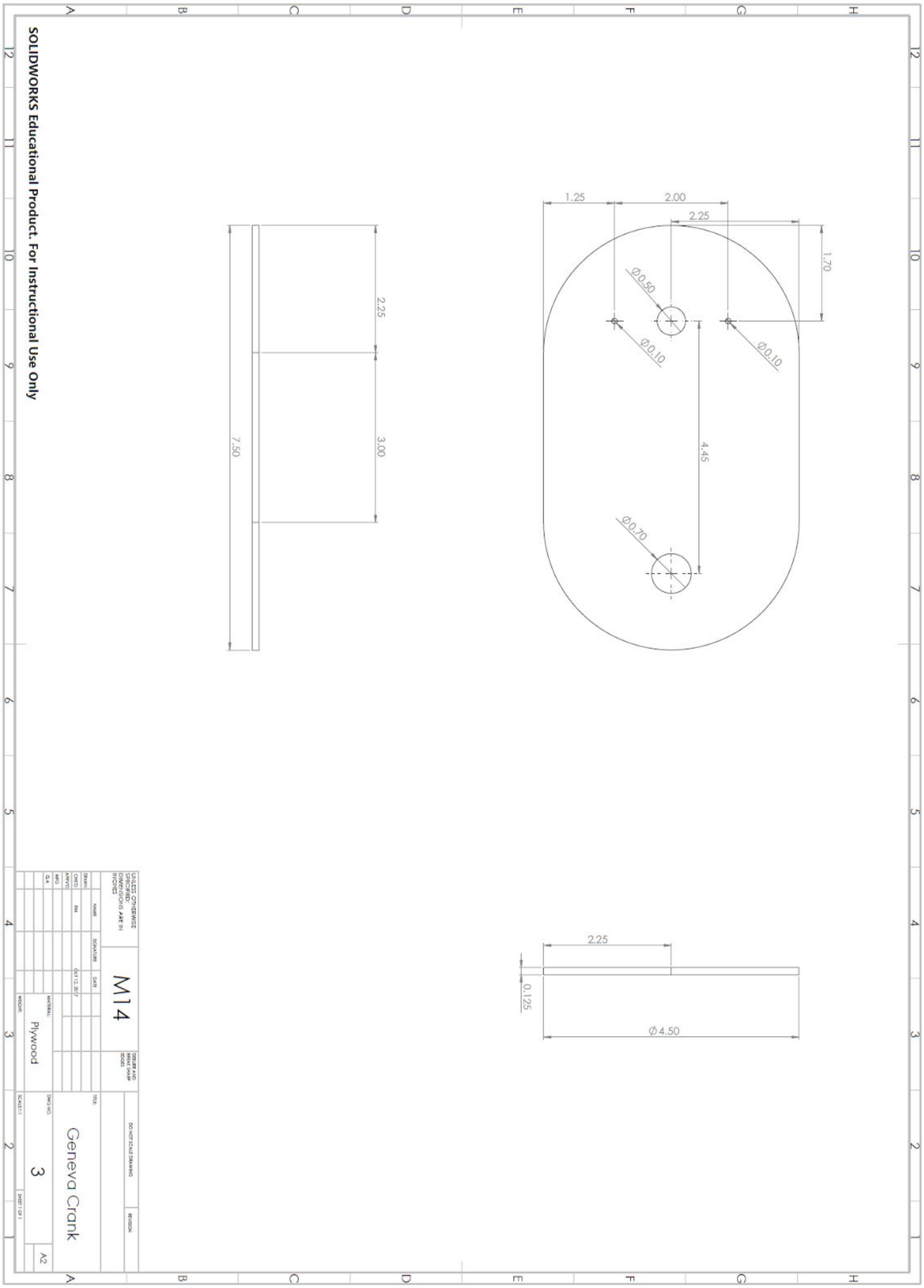
R2.25 X4
0.125
5.00
M14
Geneva Base
Plywood
2
A2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2.25
3.00
7.50
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0.125
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UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES
M14
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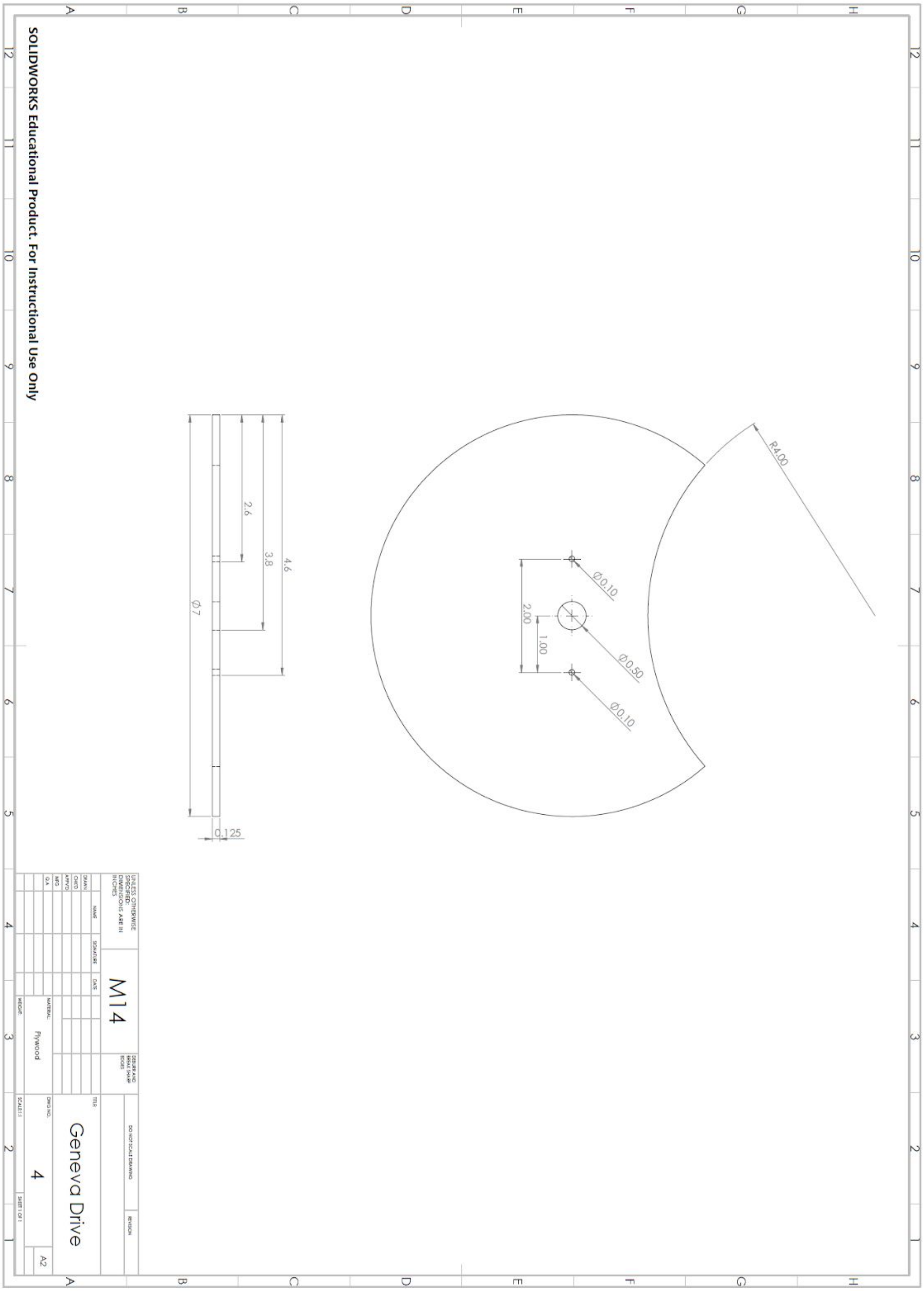
DWG NO.
3
A2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Plywood
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DWG NO.
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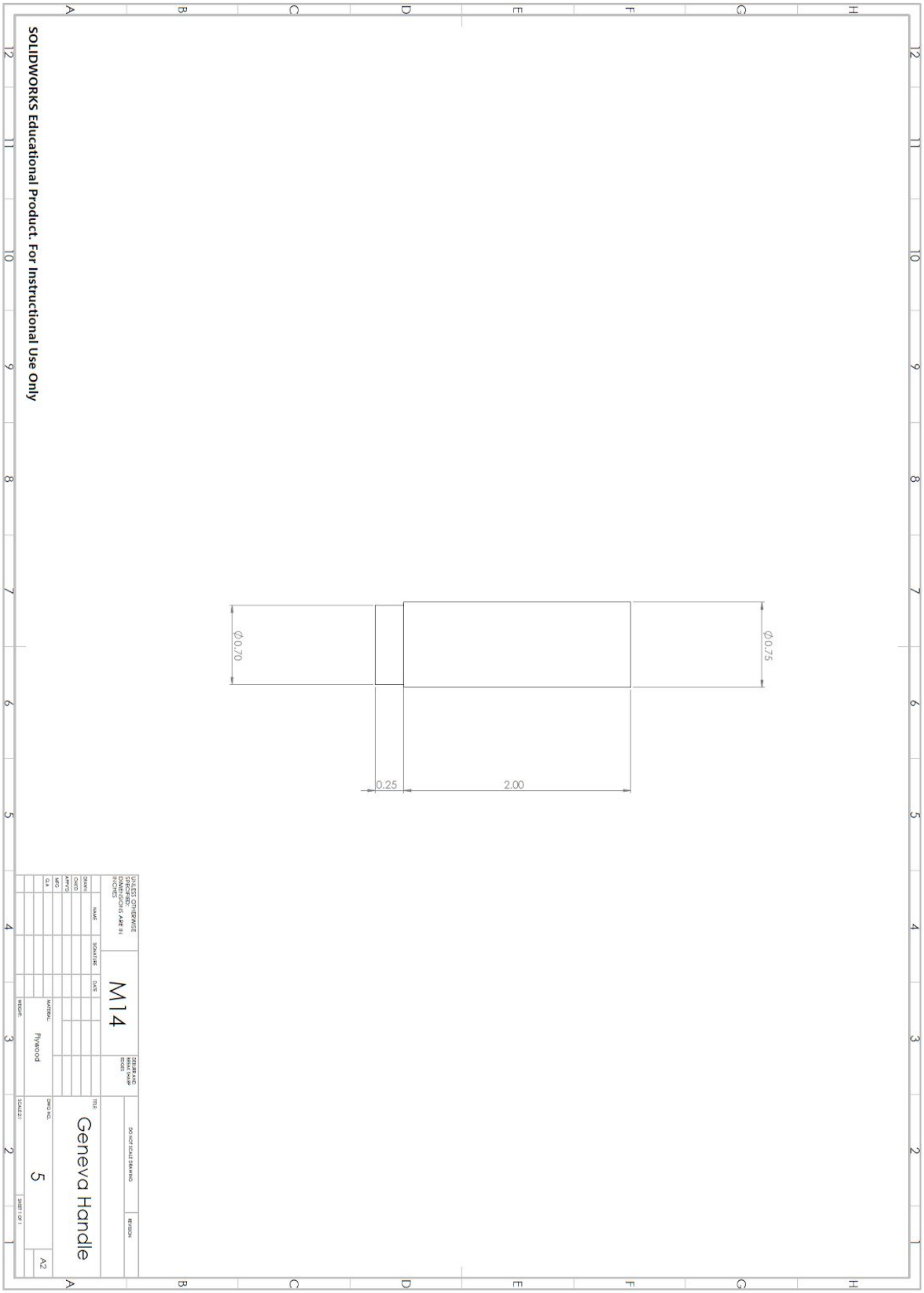
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Geneva Handle
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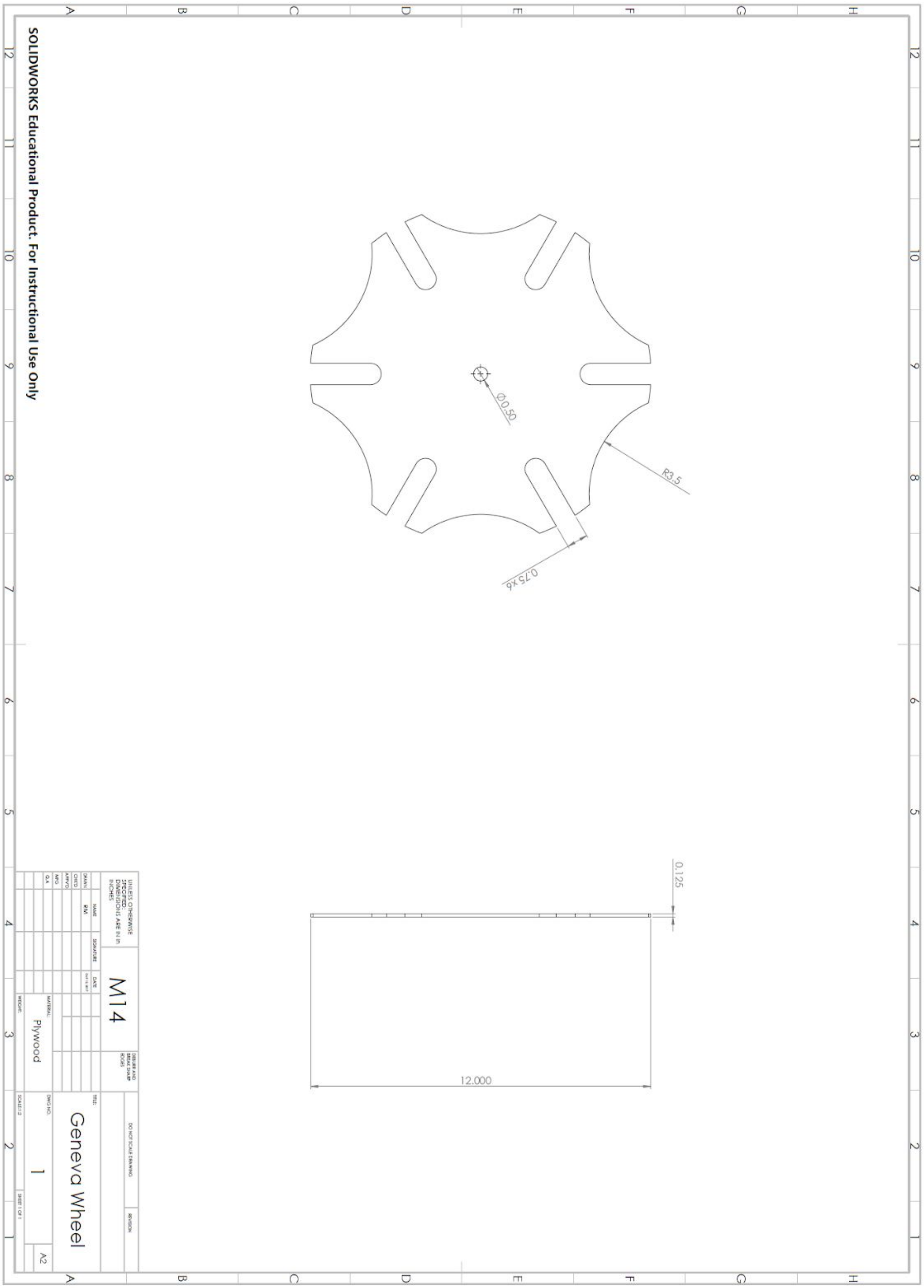
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12.000
M14
Plywood
Geneva Wheel
1
A2

4.0 Citations

1) Rob Ives. (2017). *Geneva Drive Mechanism*. [online] Available at: https://www.robives.com/blog/geneva-drive-mechanism/ [Accessed 13 Oct. 2017].

2) Anon, (2017). [online] Available at: https://www.curbellplastics.com/Shop-Materials/All-Materials/High-Impact-Polystyrene/High-Impact-Polystyrene-Sheet#?Shape=CRBL.SkuSheet [Accessed 13 Oct. 2017].

3) Professional Plastics.com. (2017). *Professional Plastics*. [online] Available at: https://www.professionalplastics.com/ACETAL-POMSHEET-RODS [Accessed 13 Oct. 2017].

4) Curbell Plastics.com. (2017). *CE Canvas Phenolic Rod | Buy Online at Curbell Plastics*. [online] Available at: https://www.curbellplastics.com/Shop-Materials/All-Materials/CE-Canvas-Phenolic/CE-Canvas-Phenolic-Rod#?Shape=CRBL.SkuRod [Accessed 16 Oct. 2017].