# PROTOTYPE DATA

## DLP 3D PRINTER USING LC4500-UV PROJECTOR

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# ABSTRACT

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# 1 INTRODUCTION AND SCOPE

## 1.1 Types of 3D Printers

### 1.1.1 The Filament-Based 3D Printer

A filament-based 3D printer creates an object by melting plastic filament and reforming it into a three-dimensional shape, layer-by-layer. An extruder liquefies the filament by heating it to 230°C. At this high temperature, the filament will not stick to the extruder and can be easily manipulated into any shape. At the bottom of the print bed is the build plate, heated to 80°C to ensure that the filament adheres to it. The extruder moves in the x-y plane, applying the melted filament to the top level of the build. The first layer is applied directly to the build plate; each subsequent layer is drawn on top of its predecessor. As the filament leaves the extruder and comes into contact with the air, it cools almost instantaneously, curing in a matter of microseconds. After each layer is complete, the build plate and the attached build move downwards to prepare for the next layer.

### 1.1.2 The SLA 3D Printer

An SLA 3D printer operates under the same basic premise as filament-based printers: a three-dimensional object is created by curing a source material layer-by-layer, using a baseplate as the build platform. The key difference is the source material and the curing mechanism. An SLA 3D printer uses liquid resin rather than plastic filament as the build material, and the curing agent is not heat but UV light. The resin is stored in a vat which also contains the build plate, submerged in the resin. A UV DLP displays patterns specific to the various layers, curing the resin into precise shapes. After each layer has been cured, the build plate moves away from the projector to prepare for the next layer to form. The specific orientation of the vat, projector, and build plate varies, but SLA 3D printers are typically constructed according to one of two paradigms: top-down or bottom-up. In a top-down printer, the projector is positioned above the vat and shines down onto the baseplate, which starts at the top of the vat and moves downward into the resin. The printed object is submerged in the resin at all times. By contrast, in a bottom-up printer, the projector is positioned below the vat and shines through it to cure against the baseplate on the other side. As the print progresses, the baseplate and attached object rise out of the vat. While the curing time for resin can take several seconds, an entire layer can cure at once, allowing an SLA 3D printer to achieve much faster print times than a filament-based printer, especially for designs with large cross-sectional areas.

## 1.2 Scope

The purpose of this new prototype is to continue to learn about the engineering design process, to modify and improve upon previous design, both our own and others, and to build a functional, repeatable, and a cost-effective DLP 3D printer. The printer will still have the orientation of a bottom-up printer. The main difference in this prototype than in our last one is that now the projector and vat will remain stationary and the baseplate will be moving. The projector will also different than the last prototype. Instead of using the LC4500 projector we will be using a 4K projector. This is so better resolution is achieved.

# 2 BACKGROUND AND PREVIOUS WORK

## 2.1 CONSTRUCTION

The decision to build a bottom-up prototype was based on research into two existing DLP 3D printers: a bottom-up design from the University of Twente and a top-down design from Texas Instruments. In summary, top-down printers are relatively simple to build, but are not cost-effective in terms of the amount of resin used. On the other hand, bottom-up printers are much more mechanically complex, but can vastly reduce the amount of resin used. For this project, the cost was the highest priority, so the bottom-up design was chosen.

This Prototype is a continuation of our last prototype, v1.0 or prototype mini, so any existing data that was gathered from that experiment is being transferred into this prototype to improve our design to make a more efficient printer. All of the information that was gathered from that experiment can be found in the document, DLP printer documentation, and there is a link for it in the APPENDIX.

### 2.1.1 Top-Down Design

In a top-down printer, the projector is positioned above the vat and shines down onto the baseplate, which starts at the top of the vat and moves downward into the resin. When a layer is created, only the resin at the topmost layer of the vat is cured [1]. The first layer cures to the top of the baseplate; each subsequent layer cures to the top of the previous layer. After curing, the hardened resin remains submerged as the build plate descends into the vat. Because the final object is always submerged in the resin, the build dimensions are limited to the size of the vat, which must always be completely filled. After every print, any leftover resin must be discarded because of risk of contamination between prints. The amount of resin wasted can easily exceed the amount of resin used in the actual print, particularly for designs with layers which do not occupy the entire length and width available. Because of the high price of resin, this printer orientation can become very expensive very quickly (Texas Instruments).

### 2.1.2 Bottom-Up Design

In a bottom-up printer, the projector is positioned below a clear plexiglass vat so that it cures the resin between the build plate and the bottom of the vat. The first layer cures to the underside of the baseplate, which rises out of the vat, allowing more resin to flow in underneath it. This resin is then cured to form the next layer, which adheres to the previous layer. This design offers the significant advantage of requiring only as much resin as is necessary to print the object. Any leftover resin must still be discarded, but the exact amount can be used so that very little is wasted. Thus, the cost per print is significantly less (University of Twente, 23). However, because the resin cure area is the space between the baseplate/build and the bottom of the vat, as the resin cures, it adheres to both the build and to the bottom of the vat. After each layer is created, the object must be peeled off the vat surface, which can prove a rather difficult task due to the vacuum created between the resin and the plexiglass. A special peeling mechanism must be installed to break this seal after each layer is cured. Several such mechanisms have been designed, all of which are difficult to build due to their complexity. Peeling systems are discussed in more detail in Vat Arms and Spring System, Passive Tilt System, Vat and Spring System, and Vat and Arm Construction Information.

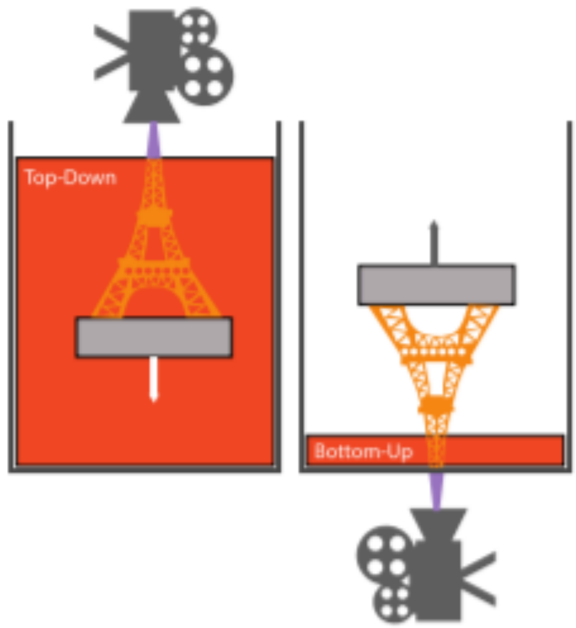


**Figure 1 Top-Down Verses Bottom-Up Printer**

# 3 EXPERIMENT THEORY

## 3.1 DESIGN CHANGE

This printer will continue to be a bottom-up design, but with making the projector and the vat stationary while the baseplate movies up and down. By doing this it allows the projector to be easily changed out and replaced with different lenses and sizes. It also allows for an easier construction process when starting from nothing because less parts are required because the design does not have to adjust to support two different pieces that have multiple precision qualifications, but only one instead. With the baseplate being the only part of the prototype that will be moving then support for the projector is not required, so full attention can be placed onto the peeling system of the vat.

#### 3.1.1 Peeling System

Unlike in the previous prototype where a passive tilt system was used, this prototype will feature a motorized tilt system. This change was made so we could control the force used in the peeling system every time it peels, and nothing is left up to chance. The peeling system will be a 24 teeth gear that is attached to a gear rack which will lifting the vat up and down between curing sessions. Each and every time the vat will lift up and back down which will gently peel the cured resin off of the bottom of the vat while it is still adhered to the baseplate.

# 4 EXPERIMENT METHODOLOGY

## 4.1 MATERIALS USES:

- 1 M6 Bolt 18mm long
- 1 12in x 2 ft Plated Steel Sheet
- 3 3 foot 10M Lead Rod
- 1 AMX3d High Holding Torque 84oz ( 59Ncm ) Bipolar Stepper Motor - Nema 17 frame
- 1 32p 25t 5mm steel gear
- 1 32p gear rack
- 1 100mm M4 bolt, partially threaded (10x)
- 1 Breadboard + Dupont jumper wires
- 1 Driver board (5x) + heat sink (5x) + screwdriver
- 2 L-Bracket for Nema 17 Stepper Motor
- 1 Open beam Nema 17 Stepper Motor Bracket (2x)
- 3 8mm Metric Acme Lead Screw 500mm
- 1 Brass Flange 4 Start Nut (4x)
- 1 Clear Anodized Aluminum Sheet; Thick.: 1/8", Width: 6", Length: 8"
- 3 2" diameter by 2" length aluminum cylinder
- 3 3 foot 10M Lead Rod
- 1 24" x 36" x 1/2" Plastic sheet
- 3 SainSmart NEMA 17 Stepper Motor 1.5A-2.5A
- 2 15, 40, & 45 Series 4 Hole - Inside Corner Bracket with Dual Support
- 84 M8 Slide-in Economy T-Nut - Offset Thread
- 2 M8 x 1.25 mm Thread, 20 mm Long (50x)
- 1 4in x 4in Metal Hinge
- 1 85 x 101mm, 4-6λ Mirror Unprotected Alumium

## 4.2 PROCEDURE

## 4.3 FIGURES AND DIMENSIONS

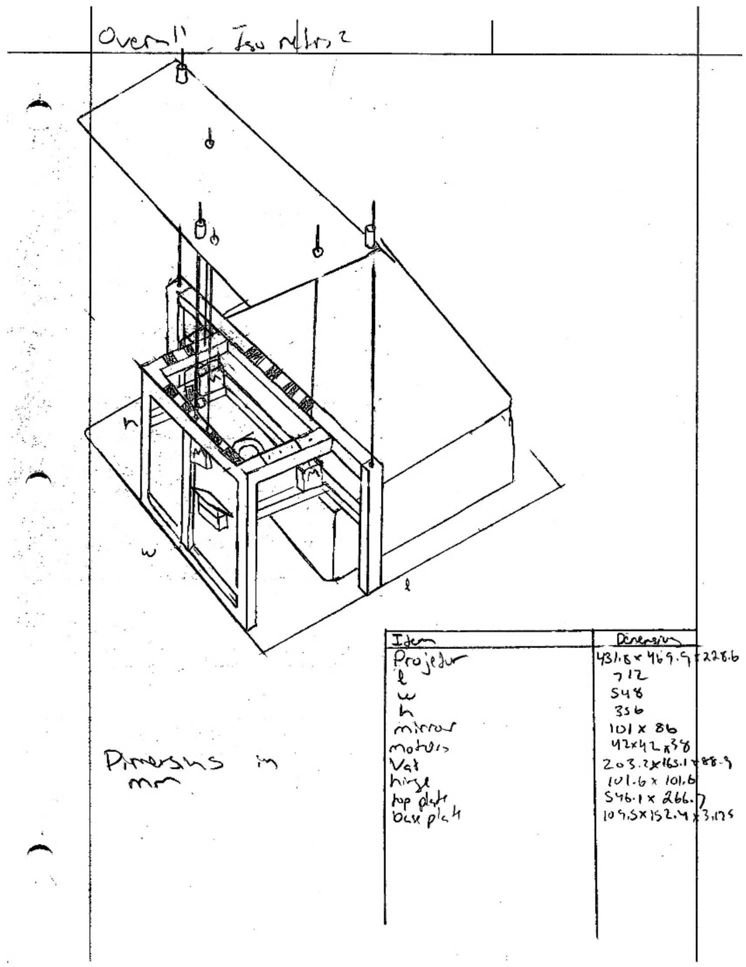


**Figure 2 Overall Isometric**

### 4.3.1 Printer Overview

This new prototype features a completely different design compared to prototype v1.0. The main difference being that the baseplate is the only object to move vertically. The baseplate is connected to the top plate through two sets of extruded aluminum bars of which are 30mm wide. The baseplate will be able to slide in and out of place by a set of screws. The top plate will permanently be attached to the main printer structure by 3 sets of lead screws and lead rods that are positioned in a triangular fashion. The projector is also different than in the last prototype, this time using a 17” x 18” x 13” 4k resolution projector that will connect to the plastic bottom of the printer. This connector system is detailed more in [ ].

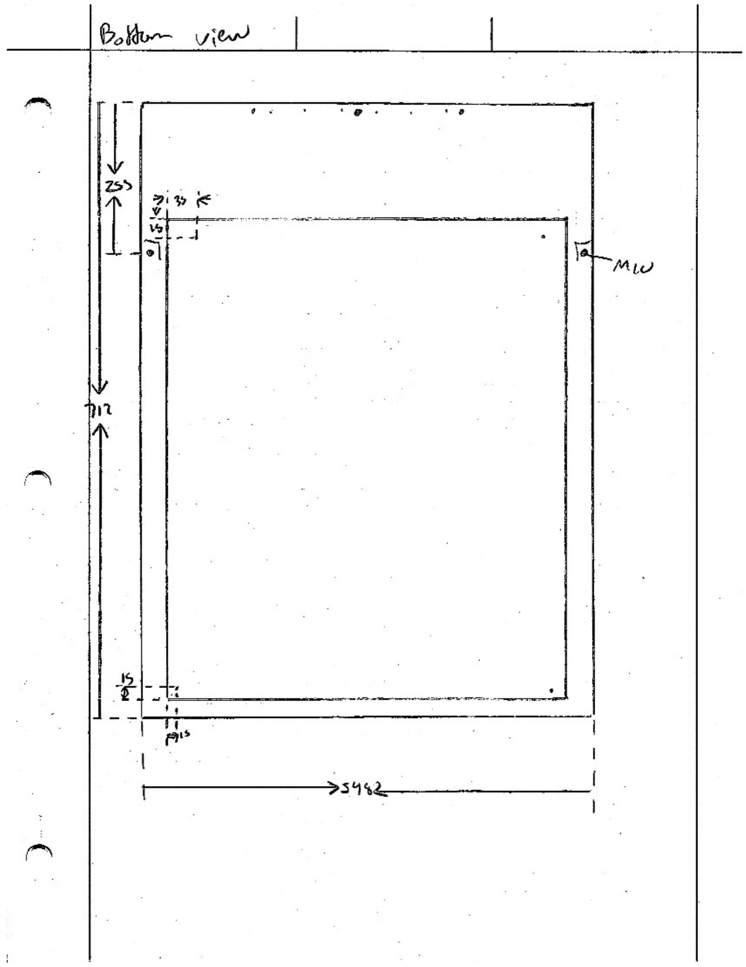


**Figure 3 Bottom Viewpoint**

### 4.3.2 Projector Mounting

The projector and the printing frame will mount to the ½" plastic bottom with counter sunk mounting screw, so that the bottom remains flesh with the surface it is sitting on. There are four holes on the bottom of the projector where the frame of the projector connects that are located on the four corners, and that is where the holes will be located. This mounting system is designed for the projector to not be able to move to either side when printing, but then able to be taken on after if necessary. The frame will be connected by a similar process. There will be nuts inside the extruded aluminum frame where the bolts will go up into to connect, and then for the vertical pieces they will be connected by a triangular side bracket that will connect to the side of the piece and to the plastic. The printer frame is not be removed once attached.

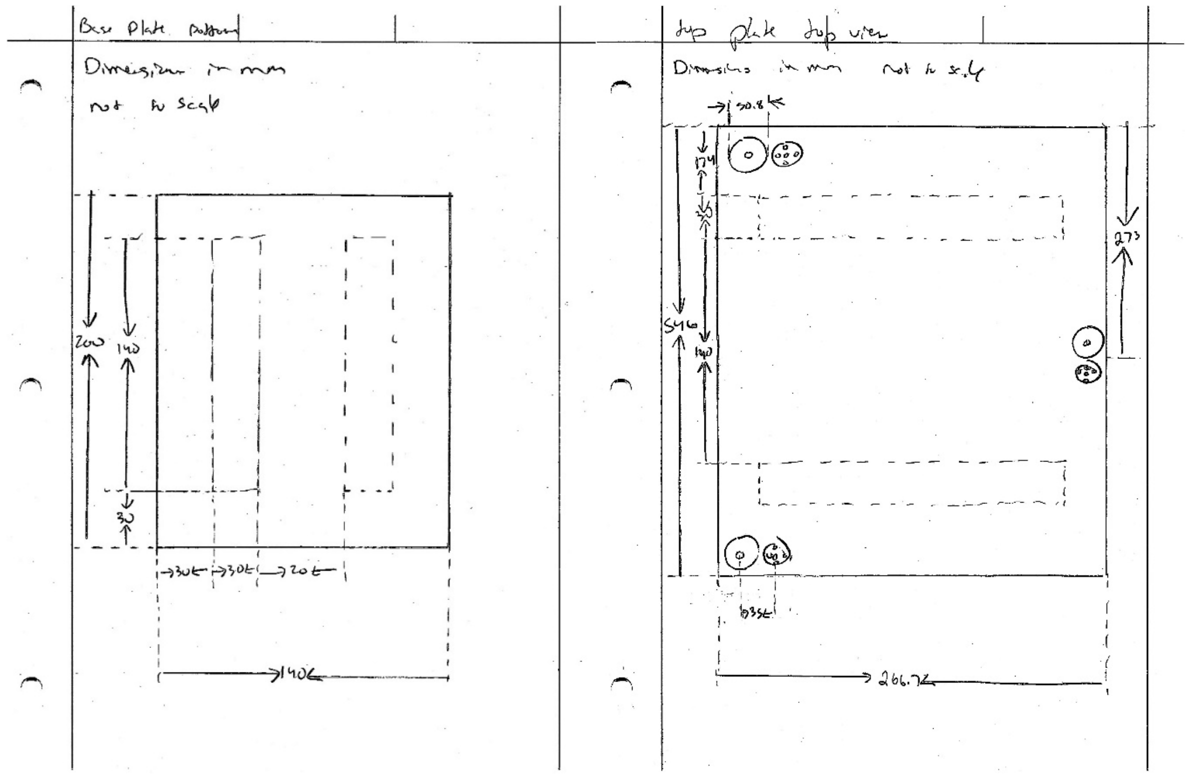


**Figure 4 Baseplate and Top Plate**

### 4.3.3 Baseplate and Top Plate

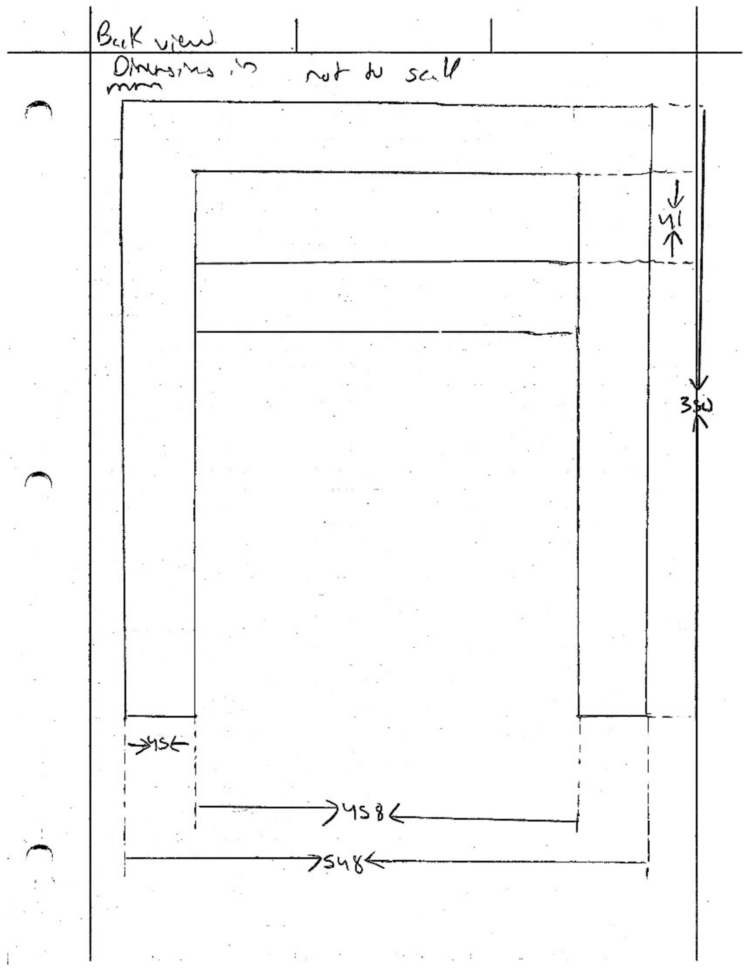


**Figure 5 Back Viewpoint**

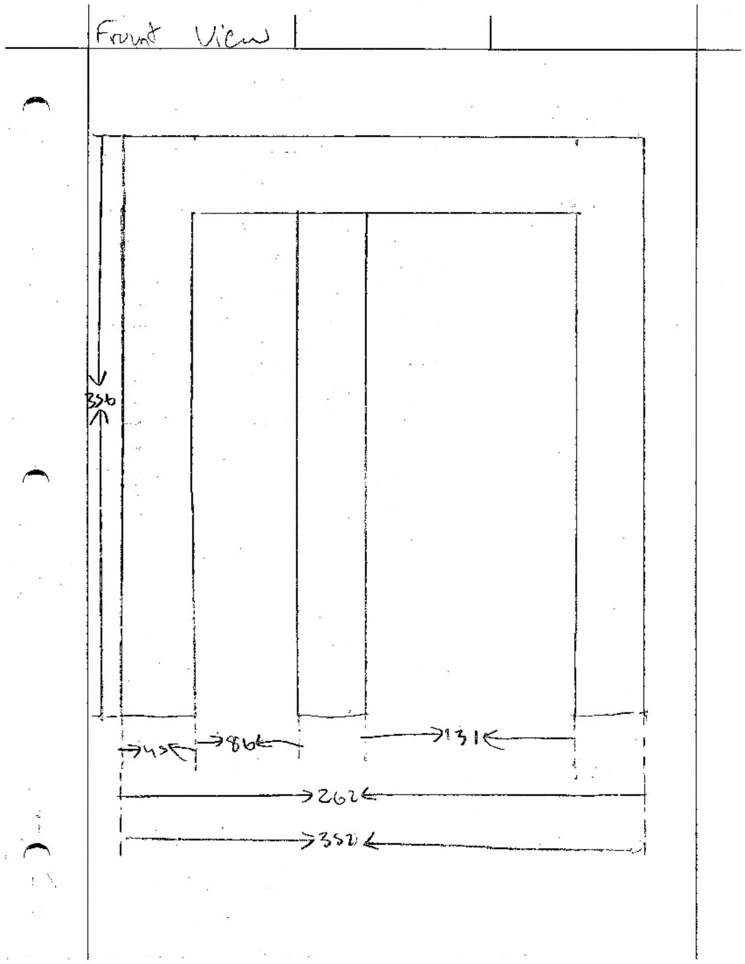


**Figure 6 Front View**

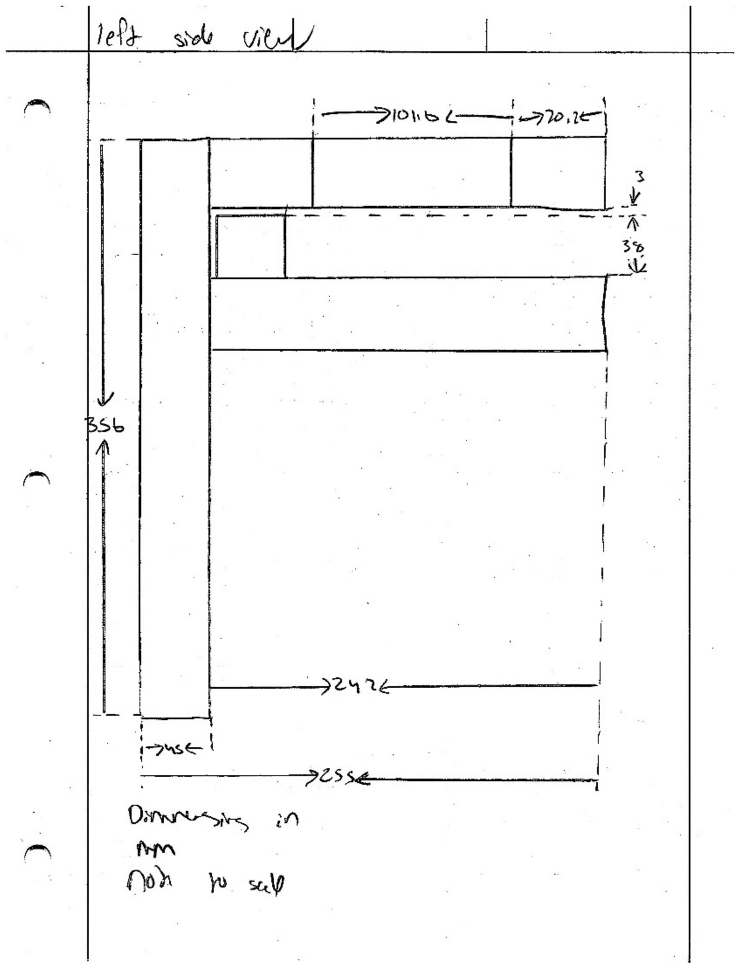


**Figure 7 Left Viewpoint**

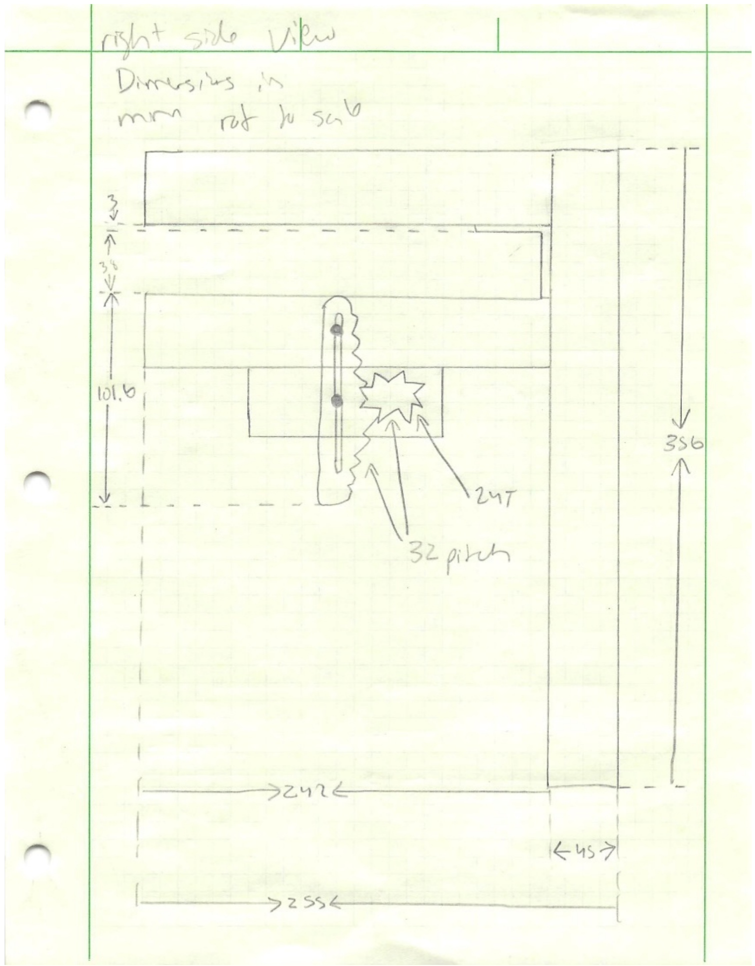


**Figure 8 Peeling System and Right Viewpoint**

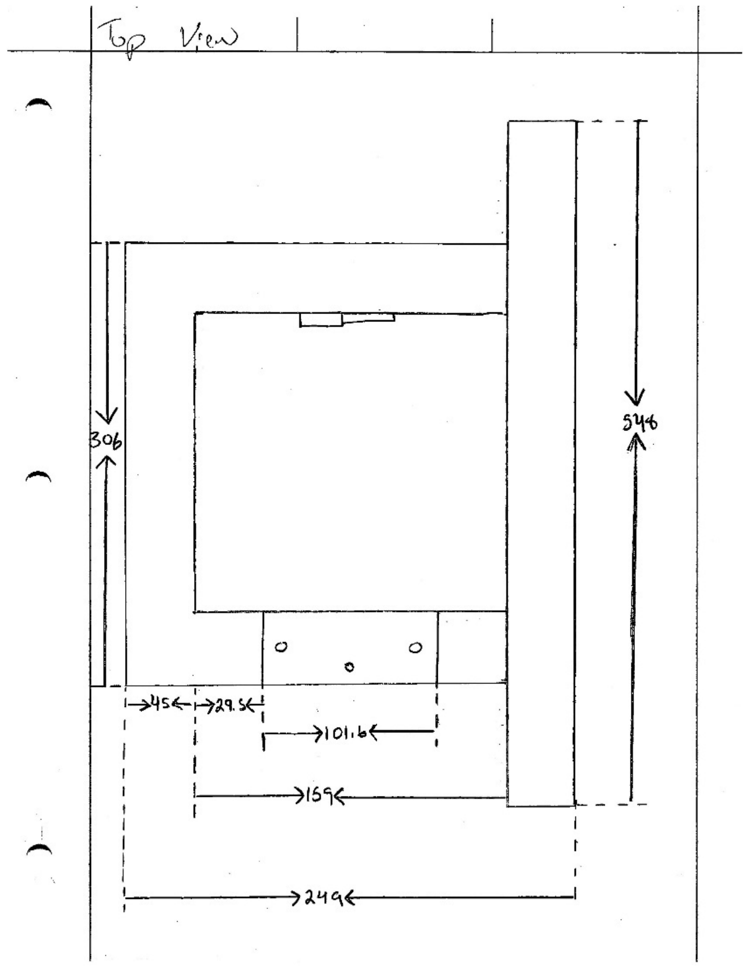


**Figure 9 Top Viewpoint**