Visual Reference

Overall concept: Mirror angles are calibrated for when the sun is at noon (light coming straight down, rays are parallel), and are angled to point the light at focal point which is 1 ft to the right of the rightmost mirrors, 1355 mm up, and centered between the mirrors. See diagrams for where the focal point is in this situation. Note this focal point can be changed in the Angle Calc tab.

Essentially, the mirrors have to be angled in two directions/axes in order to achieve the correct focal point. In the angle calc tab, the sheet takes into account the dimensions of the mirrors and desired focal point, and then calculates the required mirror angle on the two-axis (referred to as front-back and right-left angle). The height tab is specific to this project, and combines the angles on each axis to make corner heights on our the mirror mount cube. This enables us to cut a correctly angled plane into the angled mount in CAD software, by specifying the height down from the top of the block on 3 corners.

Illustration of a model 4 mirror array:

Focal Point

1 ft between edge of front mirrors and focal point x coordinate, 1355mm high.

1-1 (Front Left)	1 -2 (Front Right)
2-1 (Back Left)	2-2 (Back Right)

Point of View

Illustration of mount corner height and corner naming scheme relationship in a four mirror setup:

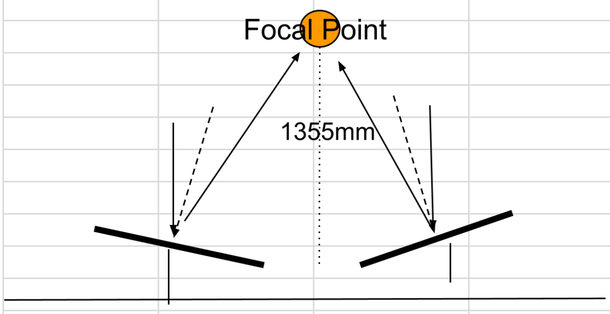
Focal Point

			-3 (Lowest)				-2 (Stp Angle)
4		1		4		1	
	FL				FR		
3		2		3		2	
			-1 (Med Angle)				0 (Highest)
4		1		4		1	
	BL				BR		
3		2		3		2	

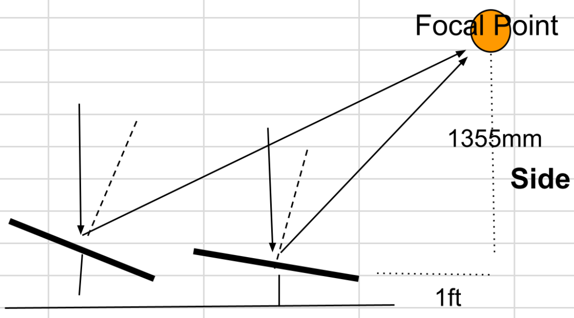
Explanation: 0, -1, -2, and -3 represent the **relative** heights of the angled block/mirror at each corner. For example, in the front right mirror, corner 2 has a height of 0 since it is highest, corner 1 has a height of -2 since the mirror is severely angled forward, corner 3 has a height of -1 since the mirror is angled toward the center., but less steeply than it is angled forward, and corner 4 has a height of -3 since it experiences the cumulative angling effect of the forward and leftward tilt. The numbers 1, 2, 3, 4 are a number system to represent the corners. They do not tell anything about the corner heights.

POV

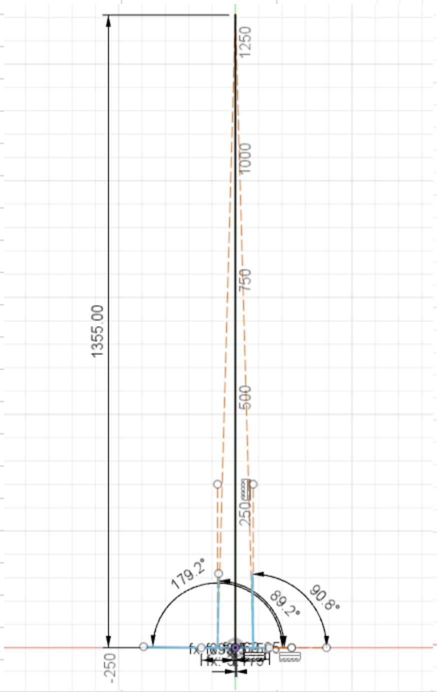
Diagrams of the focal point and mirror angles from different viewpoints:



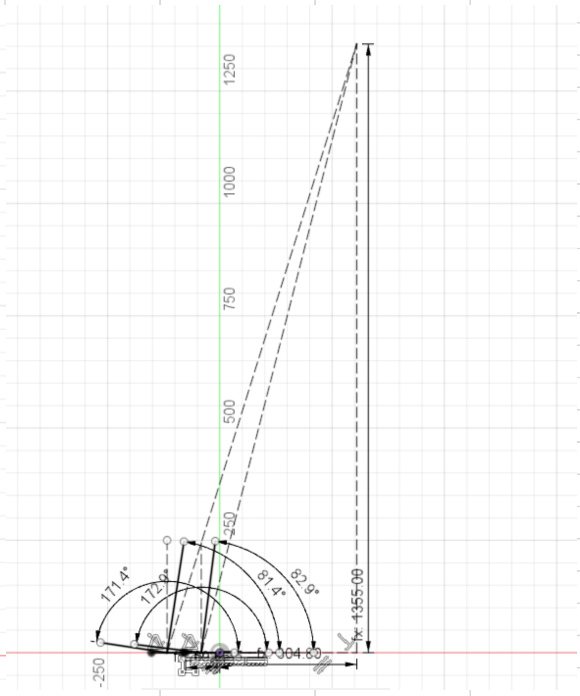
Side View #1



Side View #2



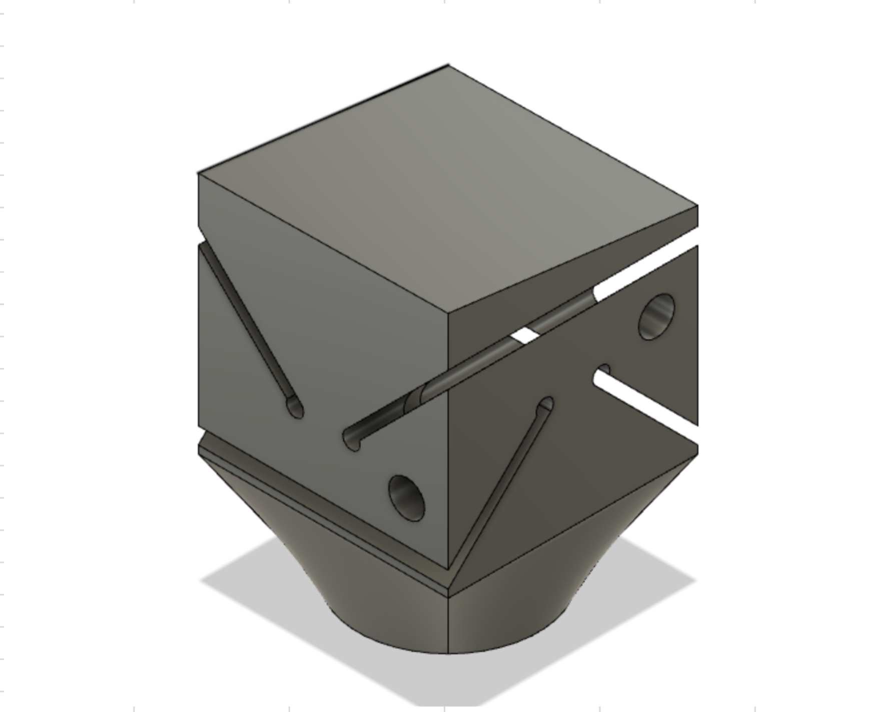
Side View #1



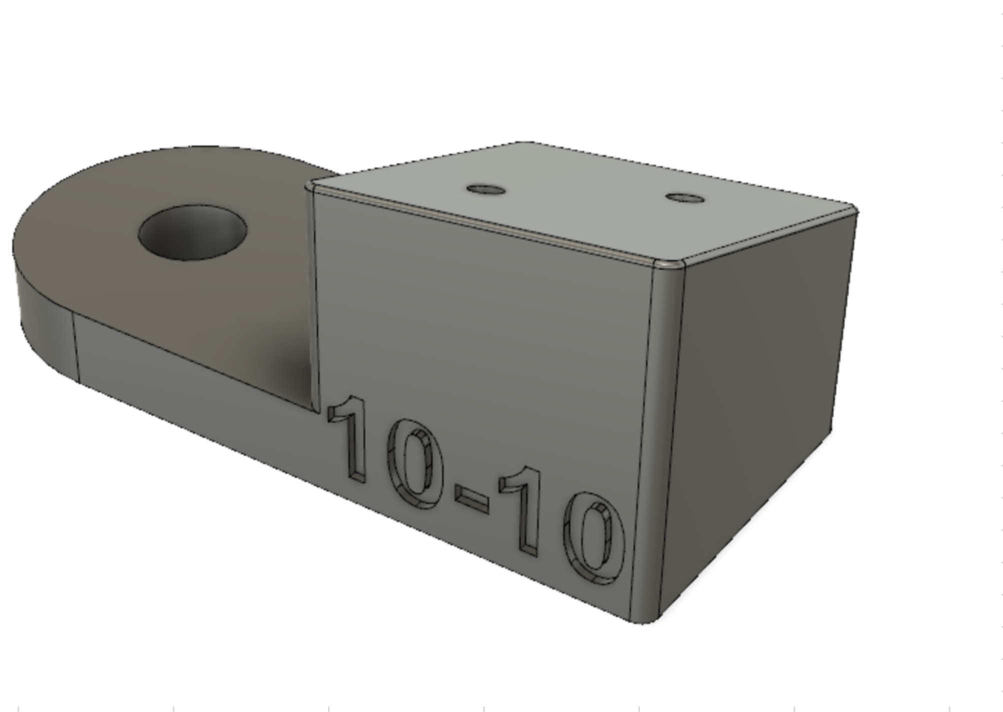
Side View #2

Remember: angle of incidence = angle of reflection across normal line

CAD model of the angled top block to which we are mounting the mirrors:

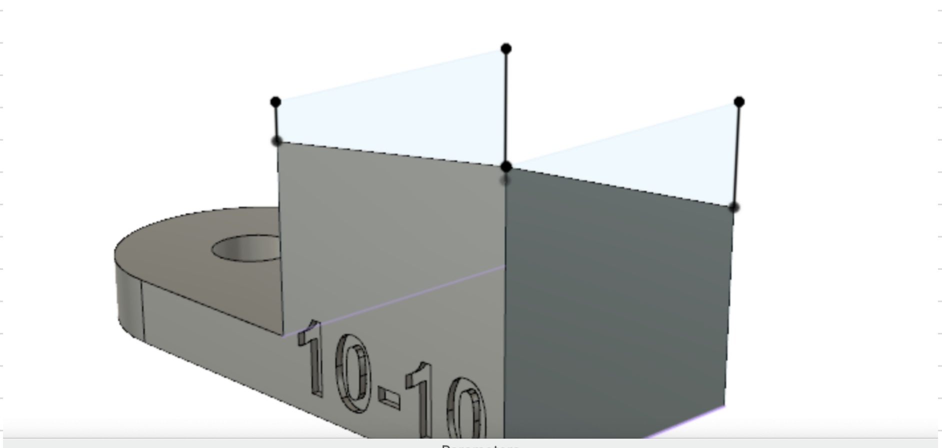


Version 1 - Old



Version 2 - Updated

Illustration of the corner heights, as inputted into the CAD model:



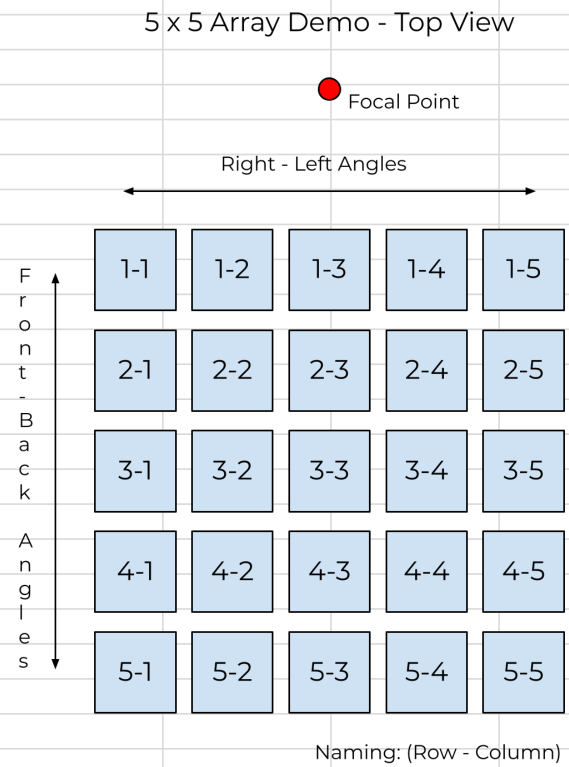
Parameters

Name	Unit	Expression	Value
Corner1	mm	6.698626006910353 mm	6.699
Corner2	mm	0.0 mm	0.00
Corner3	mm	2.4913591178929444 mm	2.491
Corner4	mm	9.189985124803297 mm	9.19

Python Code Reference

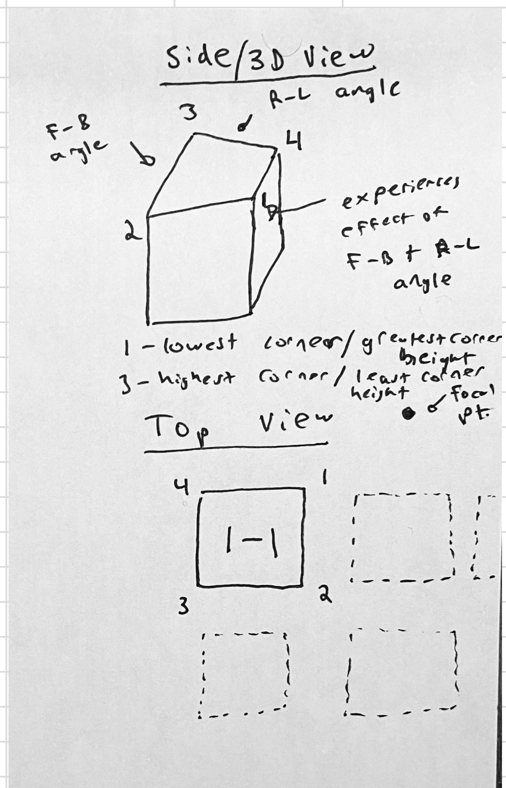
All of the mirror array calculations are now done in a Python code! You input the array dimension, focal position, and mirror specifications, and it calculates the angles on each axis and the corner heights. It produces a .csv file with the corner heights for each mount, which you can use to modify the mirror mount parametric design in Fusion 360 (there is another piece of code to automatically import the parameters and export the unique .stl files)

Mirror array naming scheme visual reference:



Individual mirror mount block angle/corner-height reference:

Remember, the angles calculated by the python script are from the mirror plane up to the focal point, on two axis, and the corner heights are from the top of the mounting block downward.



Old - Angle Calc

This is now done in Python!

Units: mm, deg

Angle Calculation

Inputs:		
Focal Point X	304.8	
Focal Point Y	1355	
Number of Mirrors X	2	
Number of Mirrors Y	2	
Mirror Length X	69.85	2.5"
Mirror Width Y	69.85	2.5"
Mirror Spacing	6.35	0.5"

Output:	Front-Back Direction Angle	Right-Left Direction Angle
Back Left Mirror	171.3453845	179.1946885
Back Right Mirror	171.3453845	0.805311501
Front Left Mirror	172.836	179.1946885
Front Right Mirror	172.836	0.805311501

Calculations:

Remember, the angle goes all the way through the set of mirrors in each direction. Ex: the front mirrors angle, apples in that direction to the right and left mirrors. Same with the left mirror angle -- it applies to the front and back mirrors, just in its axis/plane

<u>Front-Back Angle Calculation (Side View #2 in Visual Reference)</u>

<u>Front Mirrors:</u>	
Triangle X Length from front mirr	346.075
Triangle Y length (basically height	1355.000
Angle from Front mirror center to	75.673
Difference Between Above Angle	14.327
Normal Line Angle	82.836
Angle of Mirror from flat plane	**172.836**
<u>Back Mirrors:</u>	
Triangle X Length from back mirr	422.275
Triangle Y length (basically height	1355
Angle from back mirror center to	72.69076896
Difference Between Above Angle	17.30923104
Normal Line Angle	81.34538448
Angle of Mirror	**171.3453845**

<u>Right-Left Angle Calculation (Side View #1 in Visual Reference)</u>

<u>Left Mirrors:</u>	
Triangle x length from center of m	38.1
Triangle y length (basically height	1355
Angle from left mirror center to to	88.389377
Difference between above angle a	1.610623002
Normal line angle	89.1946885
Angle of mirror	**179.1946885**

<u>Right Mirrors</u>

Since this focal point in centered between the mirror and not off to the side, the right angle is just the left angle mirrored across the center line

Degrees that the left angle is to th	89.1946885
Angle of mirror	**0.805311501**

Old - Height Calc

This is now done in Python!

Units: mm, deg

Heights Calculation (Adjusted to Keep Center Heights The Same)

This gives the heights of each corner of the mirror-mount cube, adjusted up/down to keep the center heights the same.

Context: We have four mirrors, with a focal point that is to one side in the front-back direction, and centered in the right-left direction. Specifically this is 1' out from the frontmost mirror, and 1355 mm high. The previous angle calc tab calculated the angle in each axis that the mirror needed to be at. Now, since we need to cut this angle into the 3D printed cube that is a mount for the mirror, this tab takes these angles and turns them into corner heights. Corner heights refer to the amount we need to cut down from each corner of our mounting cube, in order to achieve the desired angle. In the CAD software, we use three of these corner heights to create a plane angled on two axis, and cut the body with this plane. An added complication is that we need the height at the center of each of the mounted mirrors to be the same so that that the focal point calculations remain correct. We achieve this by calculating the corner heights, then calculating the center height, and then adjusting all of the corner heights up/down to make each center height the same.

Concept: We are cutting a box along two planes/in two dimensions and need to know the change in center height for each box so we add it to the initial box height, since the center height needs to remain the same for each box in the array. We achieve this by calculating the height change along the first axis and adding in the height change along the second axis, relative to their impacts on the different corner of the square. Cutting a box with angled part, also adjusting for the center height.

See visual reference for location of each point.

			FR	BR	FL	BL	
Constants							
Length of 3D Printed Box	20	LR Angle	0.81	0.81	Doesn't Matter	Doesn't Matter	Since we are mirroring fronts and backs
		FB Angle	172.84	171.35	Doesn't Matter	Doesn't Matter	
		Initial Heights					
		1	2.514	3.044	2.795	3.325	
		2	0	0	0.281	0.281	
		3	0.281	0.281	0	0	
		4	2.795	3.325	2.514	3.044	
		Center Height	1.397	1.663	1.397	1.663	Later: Write a function to compare the center heights and adjust accordingly
		Adjusted Heights					Assumes BR and BL have the largest center angle
		1	2.779	3.044	3.060	3.325	
		2	0.265	0	0.546	0.281	
		3	0.546	0.281	0.265	0	
		4	3.060	3.325	2.779	3.044	

The mirror with the lowest center height stays the same, but then the others are adjusted down in all four corners so that the center heights are all the same while keeping the correct angles