

$$f = \sqrt{-(u_1 - x_0)(u_2 - x_0) - (v_1 - y_0)(v_2 - y_0)}$$

From these equations implemented in Python, I can figure out the values of Focal length, y_0 and x_0 values. The points I got as my Vanishing points in pixels are:

Point 1 = (128,305) Point 2 = (314,18) Point 3 = (565,292)

My Results are as such:

```
*Output Task 2.txt - Notepad
File Edit Format View Help
A=[[-115.62291665  3.43958333]
   [-66.41041666 -72.49583332]]

b=[[-9589.47454619]
   [-8099.36215942]]

x=[[83.97266806]
   [34.79789347]]
|
f=(36.52198617277163+0j)
```

Task 3: Camera Calibration (10 points)

Use the pyAprilTag package provided in the class or other free packages (e.g., OpenCV's camera calibration toolkit) that you may be aware of, to calibrate your camera (full K matrix, with the top two-distortion parameters K1 and K2). **Compare** this calibration result with the one you obtain above and **discuss** the pros and cons of the two methods.

Solution:

For this problem, first I need to take different images of the April Tags provided in the GitHub website from my Camera, which I used in Task 2. Then after, I have used the pyAprilTag Package provided by Prof. Chen Feng and calibrated my Camera matrix using the pictures clicked by it. I used the python demo_calib_by_photo.py function to get my K Matrix and distortion parameters. For this, I just had to store my Pictures in the '...site-packages\pyAprilTag\data\calib\' folder as per the pyAprilTag package. The calibration was performed using all 40 Tags.

The pictures used are like:



This was my result:

```
*Output Task 3.txt - Notepad
File Edit Format View Help
Last log: calib_log.AprilCalib_log_00017
camera intrinsic matrix:
[[788.53833244    0.          641.3123704 ]
 [ 0.          788.48461472 358.01028946]
 [ 0.           0.           1.          ]]
camera distortion parameters:
[-0.12572225  0.23407207  0.00346949  0.00183746  0.          ]
```

As I can see here, this result is different from the results obtained in Task 2. This is because two separate procedures I've followed to solve this task. The more accurate method is the one of Task 3 as the Vanishing point coordinates are calculated with a lot more precision and multiple images can be considered and iterated upon to conclude. The following are some of the major Pros and Cons of the two methods producing different results.

	Pros	Cons
Task 2	<ul style="list-style-type: none"> Calibration did not require April Tag. Calibration can be performed in a single picture's three Vanishing points. 	<ul style="list-style-type: none"> One needs to find a picture where there are three pairs of parallel lines. Correct Vanishing points is extremely hard to plot. Approximations lead to incorrect results. Pixel Sizes are also approximated. One cannot iterate and correct our results with multiple pictures. I do not check for distortion parameters and cannot achieve accurate results.
Task 3	<ul style="list-style-type: none"> Pixel Size is taken into consideration, helping in increasing accuracy. One does not need to find real life structures with parallel lines to derive Vanishing points. April Tags take care of that part. Multiple images provides the way for error management. I check for distortion parameters. 	<ul style="list-style-type: none"> One requires April Tags for Calibration purpose. Need to click multiple images with varying angles for iteration purpose.