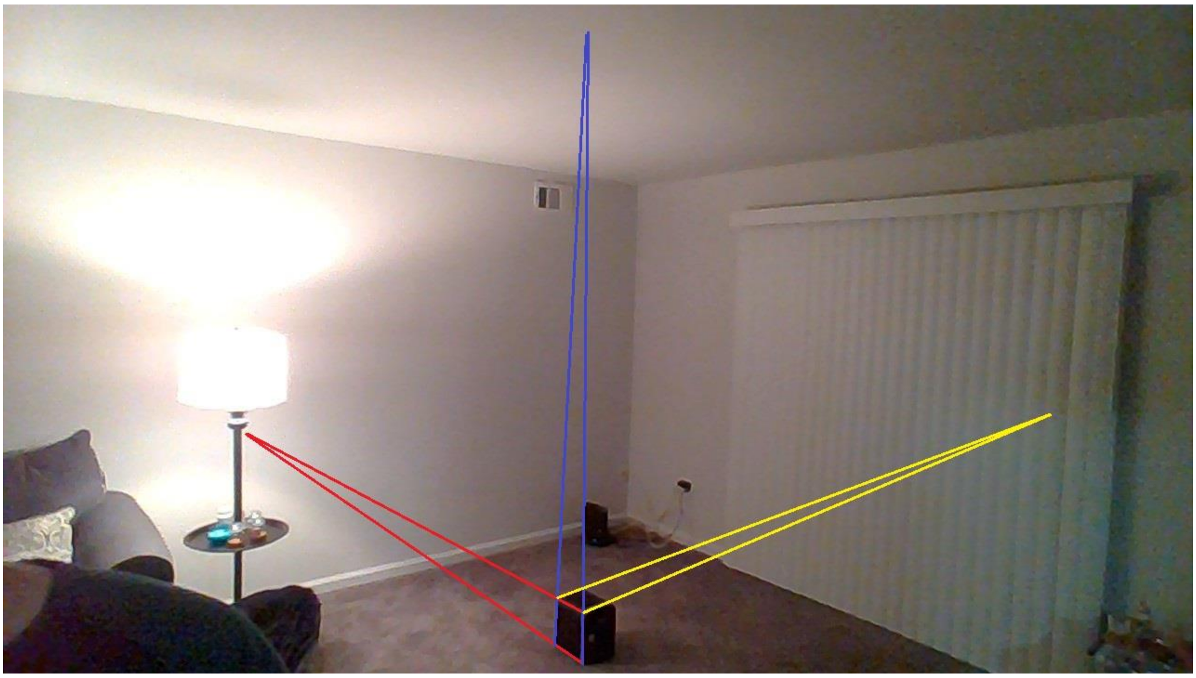
Task 2: Vanishing Points (15 points)

Take an image with your camera so that in the image you can find three orthogonal directions, i.e., 3 vanishing points. **Calculate**, by hand or by code, those three vanishing points and use them to calibrate your camera (focal length f, and principal point position, x0 and y0). **Document** the process, and **visualize** the result.

Solution:

In this Task, firstly I had to click a picture from a Camera in which at least three pairs of parallel lines Ire supposed to be visible. Then I had to find out the Vanishing point from those pairs of parallel lines. Therefore, that makes three Vanishing points. So, when I get those Vanishing points my task becomes simpler. I use the Formula of Vanishing point for Camera Calibration and find out the Focal length, principal point positions x_0 and y_0 of my Camera. I use them to form my Intrinsic Camera K matrix too. In order to solve the problem, I used MS Paint where I could properly draw the lines off the parallel pair of lines and I could see them converging and meeting at the so-called Vanishing Point. I used separate colours for separate pair of lines. Once I found the points, next step was to figure out the coordinates of those points. I could easily do this via MS Paint only, where I could find out the pixel coordinates of the Vanishing Point. These is the result of the mentioned Procedure:



Once I found those coordinates, up next I had to calculate the distance in mm as respect to the picture. Therefore, the conversion ratio is 0.2645833333. Multiplying by this ratio, I get my points in mm. From there onwards, I had to follow the following equations for calibrating my Camera:

$$\mathbf{A}\mathbf{x} = \mathbf{b},$$

$$\mathbf{A} = \begin{bmatrix} u_1 - u_3 & v_1 - v_3 \\ u_2 - u_3 & v_2 - v_3 \end{bmatrix},$$

$$\mathbf{x} = \begin{bmatrix} x_0 \\ y_0 \end{bmatrix},$$

$$\mathbf{b} = \begin{bmatrix} (u_1 - u_3)u_2 + (v_1 - v_3)v_2 \\ (u_2 - u_3)u_1 + (v_2 - v_3)v_1 \end{bmatrix}$$

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

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 Ire:

$$Point\ 1 = (128{,}305)\ Point\ 2 = (314{,}18)\ Point\ 3 = (565{,}292)$$

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 Ire like: