<u>Computer Vision Assignment – 5</u>

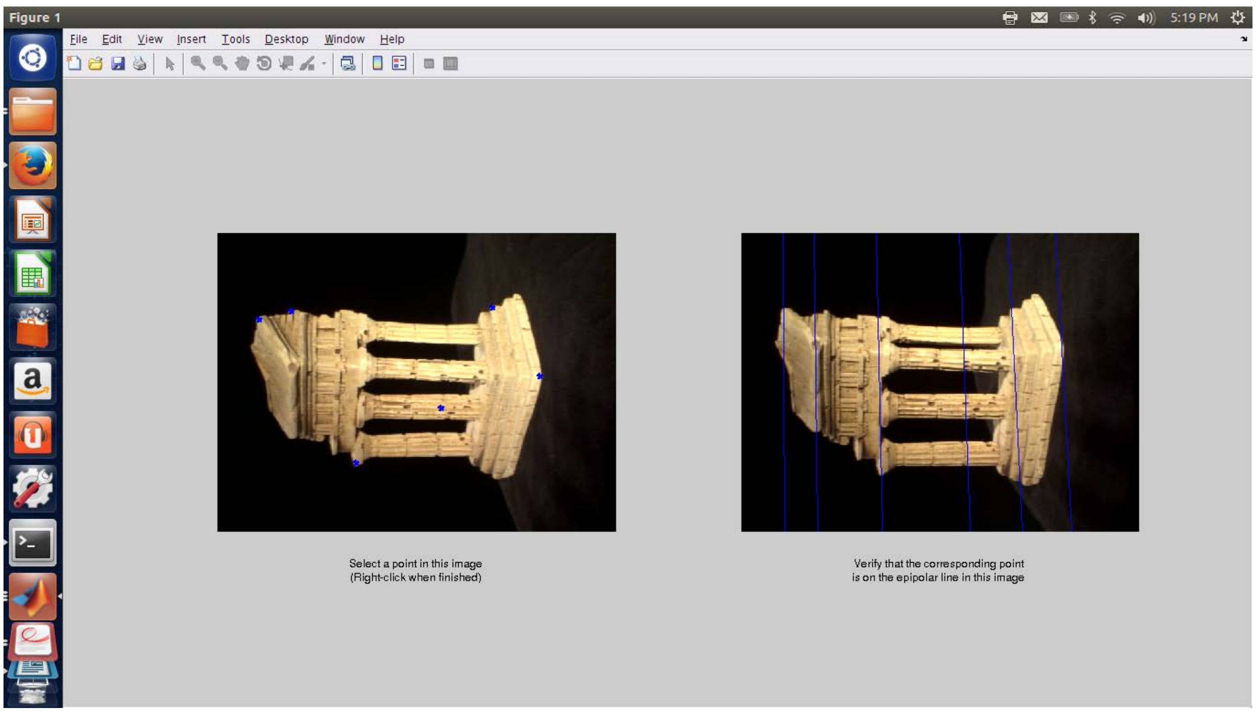
Q1.1

In this question, Eight point algorithm is used to calculate the Fundamental matrix.

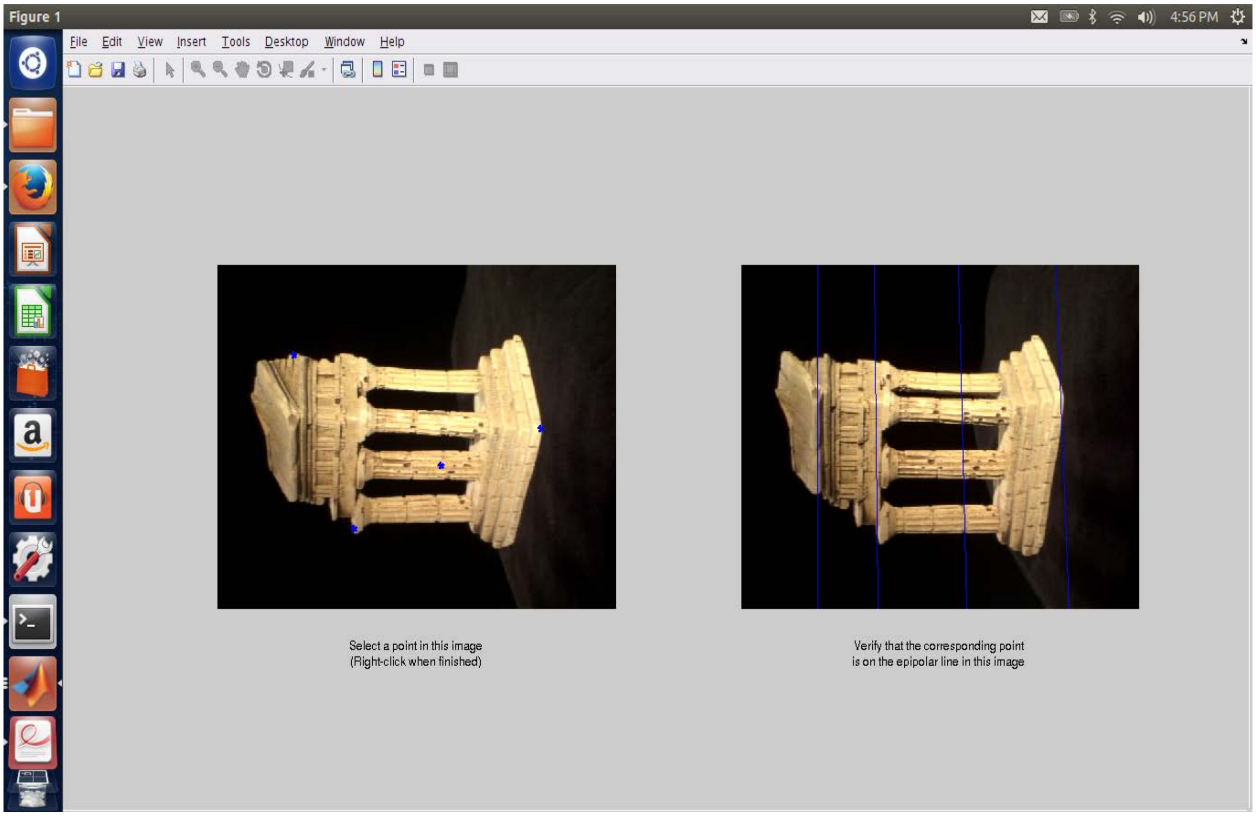
Algorithm:

1. Normalization
2. Apply Linear Least Square.
3. Enforcing Rank 2 constraint.
4. Un-normalizing.

Points and corresponding epipolar line using the given points (some_corresp.mat) :



Points and corresponding epipolar line using hand selected correspondences:



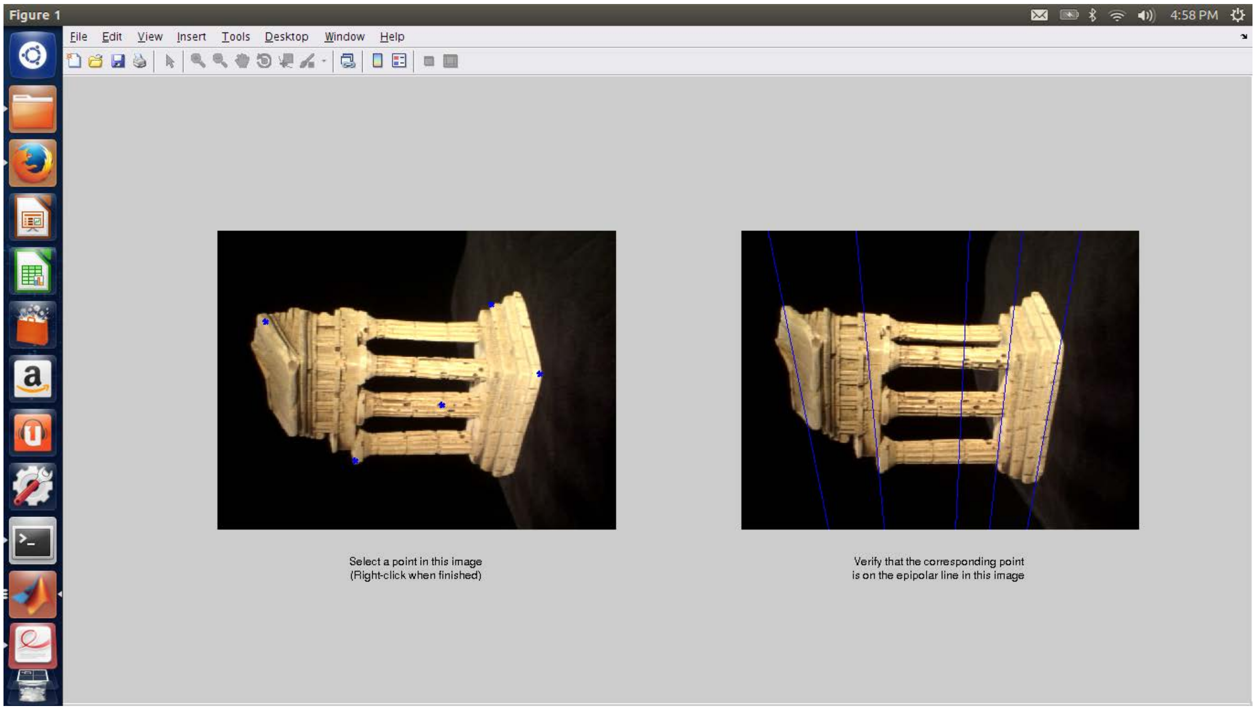
Q1.2

In this question, Seven point algorithm is used to calculate the Fundamental matrix.

Algorithm:

1. Normalization
2. Apply Linear Least Square.
3. Finding roots and then F.
4. Un-normalizing.

Points and corresponding epipolar line using the given points (7pt_corresp.mat) :



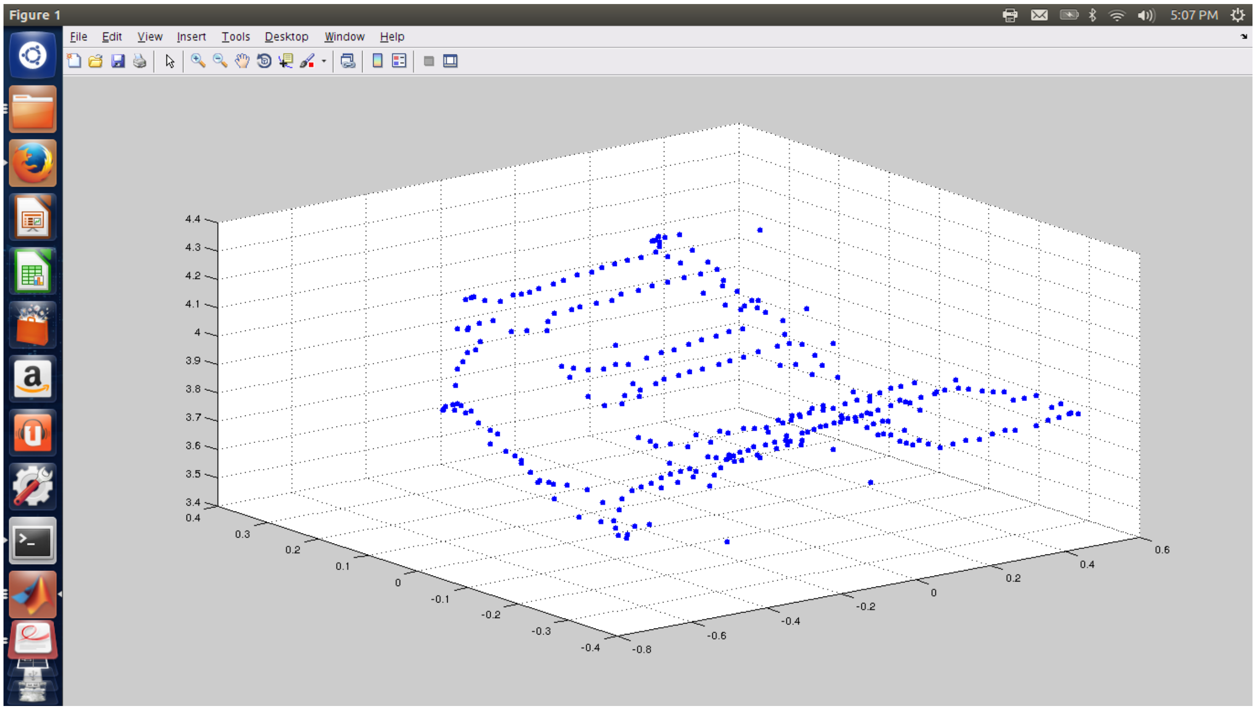
The correct F

```
>> F{2}

ans =

    0.0000   -0.0000    0.0077
    0.0000   -0.0000   -0.0019
   -0.0084    0.0016    0.0999

>>
```

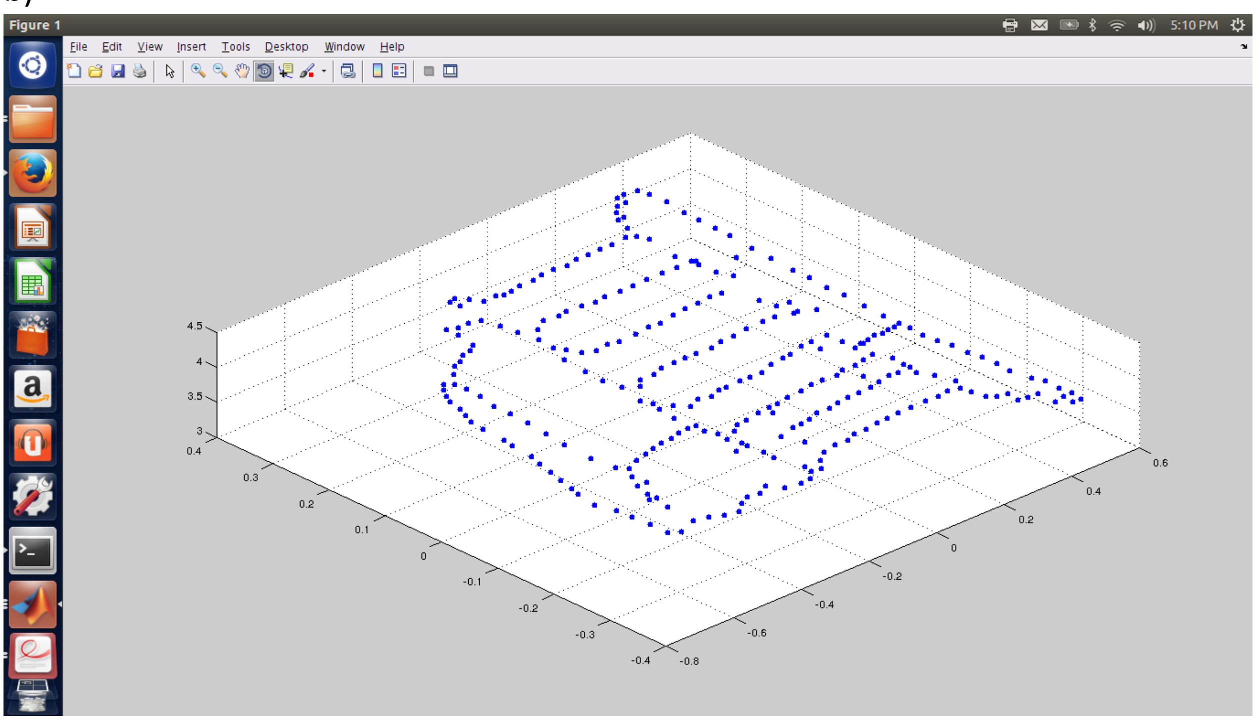
Q2.

In this question, 3D Reconstruction was done.

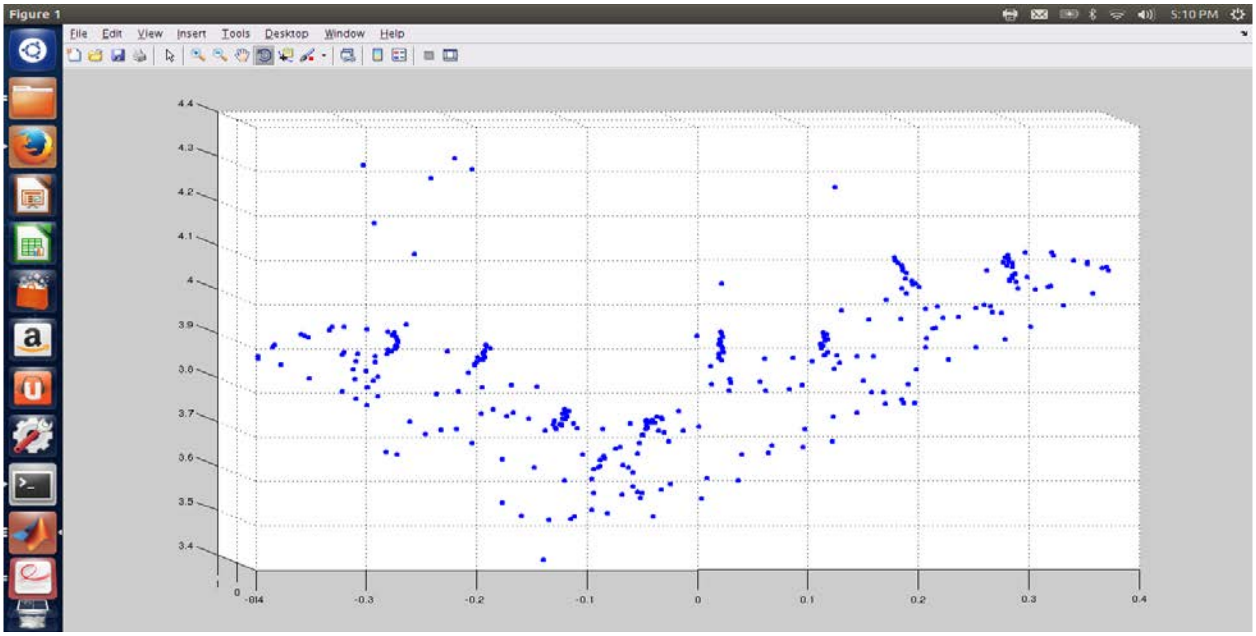
a)



b)



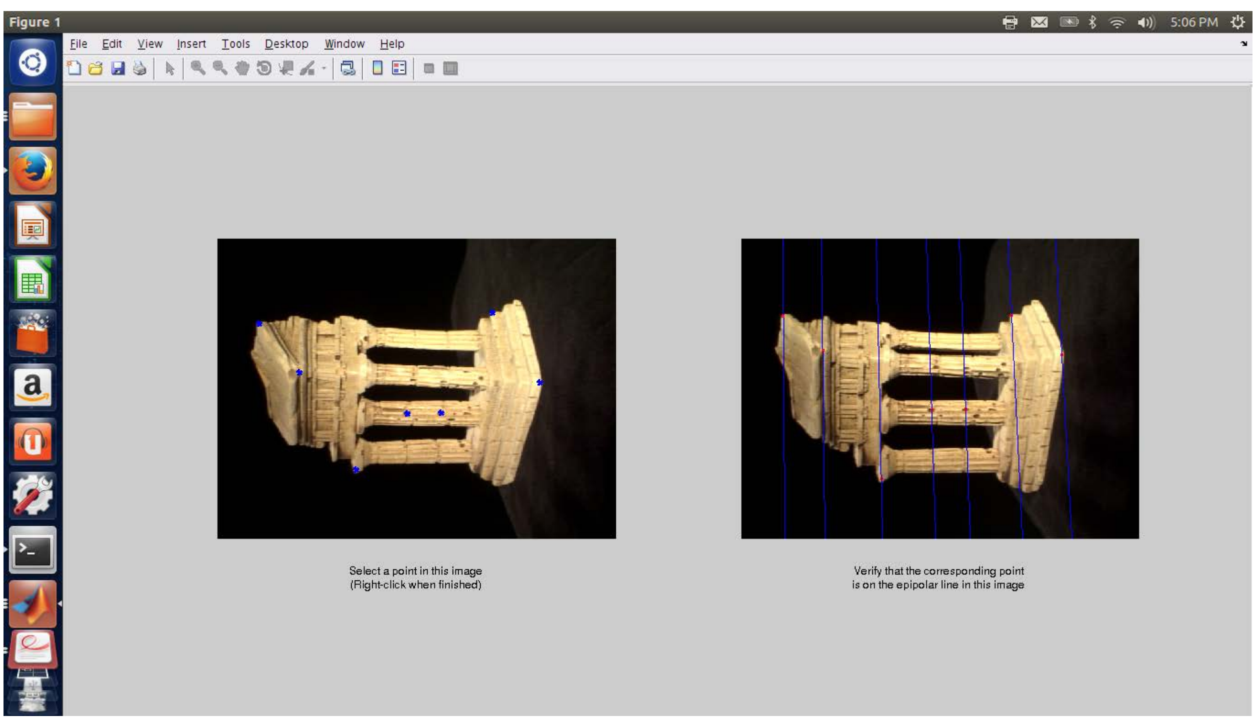
c)



Q3

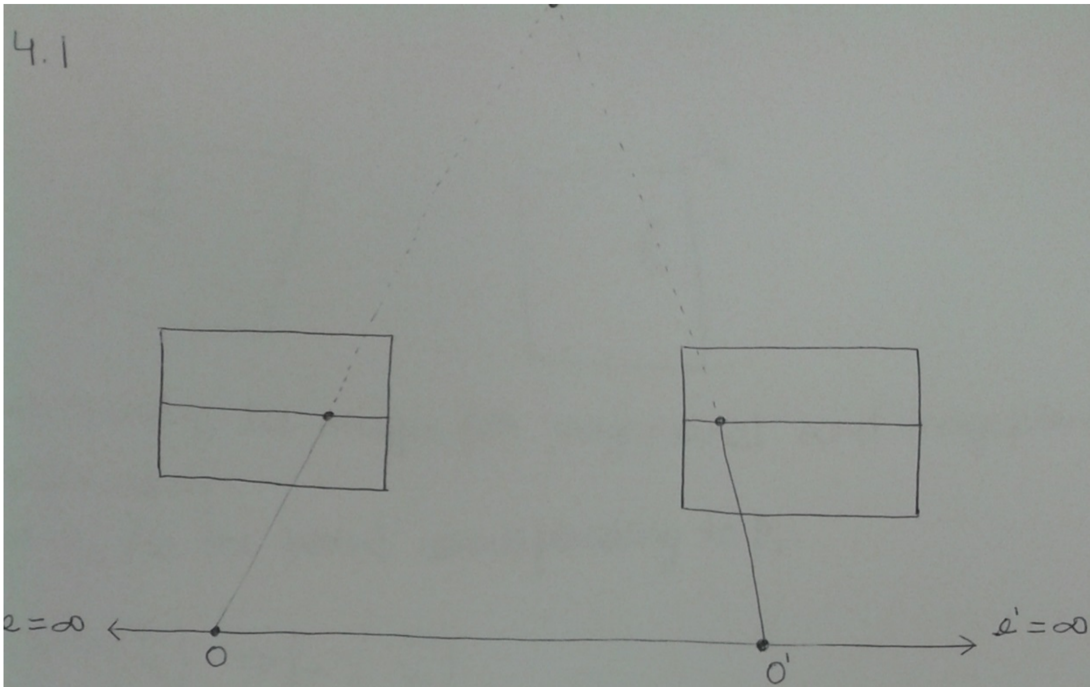
In this question, epipolar correspondences were found.

1. First epipolar line was found, then a window was traced over the line.
2. Point with the minimum intensity difference was selected as the corresponding point.



Q4.1

4.1



) We know that epipolar lines are the intersection of the epipolar plane and the image plane. Here the image planes are parallel to the cameras which differ only by the translation. In this case, the intersection of the image plane and the epipolar plane will give us epipolar lines which are parallel.

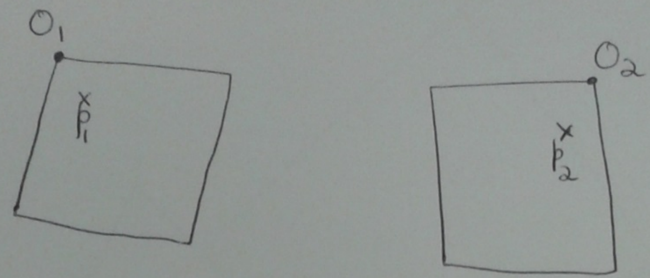
or,

) Also, the projection of camera 1 center in the other view will lie at infinity in this case. That means that epipoles are at infinity.

As epipolar lines intersect at infinity (epipole) ⇒ Epipolar lines are parallel.

Q4.2

Q 4.2



Let O_1 and O_2 be origin for imageplane1 and imageplane2 respectively.
Let p_2 be the point corresponding to p_1.

$$p_1 = \begin{pmatrix} u_1 \\ v_1 \\ 1 \end{pmatrix} \Rightarrow p_2 = \begin{pmatrix} -u_1 \\ v_1 \\ 1 \end{pmatrix}$$

(a)
We know $p_1^T F p_2 = 0 \quad (1 \rightarrow 2)$

$$\begin{pmatrix} u_1 \\ v_1 \\ 1 \end{pmatrix}^T F \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} u_1 \\ v_1 \\ 1 \end{pmatrix} = 0$$

$$\Rightarrow \boxed{p_1^T F \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} p_1 = 0} \quad — ①$$

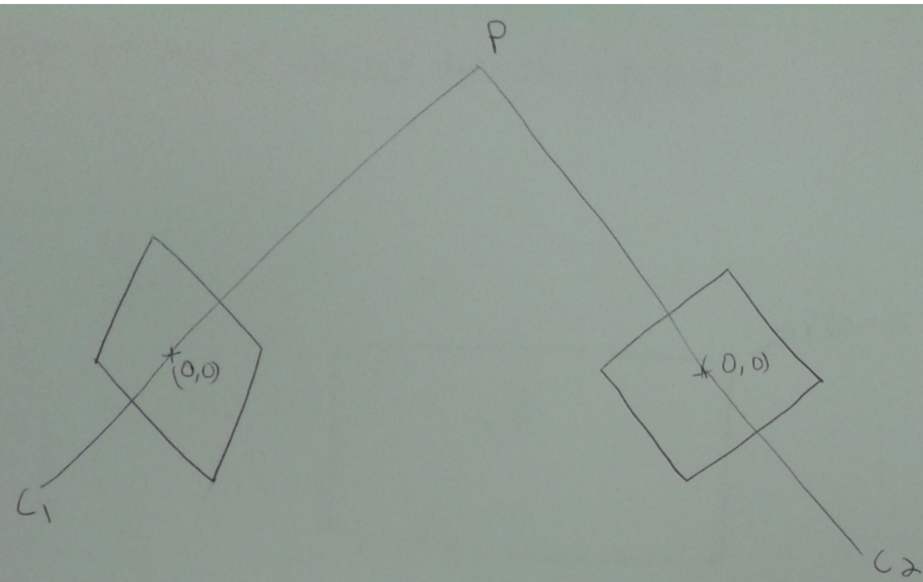
(b)
Also $p_2^T F p_1 = 0 \quad (2 \rightarrow 1)$

$$\Rightarrow \boxed{p_1^T \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} F^T p_1 = 0} \quad — ②$$

From ① and ② $F = -F^T$

Ans.

Q4.3



$$p_1 = \begin{pmatrix}0\\0\\1\end{pmatrix}\begin{pmatrix}u_j\\v_j\\1\end{pmatrix} \quad p_2 = \begin{pmatrix}0\\0\\1\end{pmatrix}\begin{pmatrix}u'_j\\v'_j\\1\end{pmatrix} \text{ and } = F = \begin{bmatrix} F_{11} & F_{12} & F_{13} \\ F_{21} & F_{22} & F_{23} \\ F_{31} & F_{32} & F_{33} \end{bmatrix}$$

and $UF = 0$ where

$$U = \begin{bmatrix} u_j u'_j & u_j v'_j & u_j & \cdots \\ & \vdots & & \end{bmatrix}$$

$u_j = 0 \quad u'_j = 0$

$v_j = 0 \quad v'_j = 0$

$$\Rightarrow \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ & & & & \vdots & & & & \end{bmatrix} \begin{bmatrix} F_{11} \\ F_{12} \\ F_{13} \\ \vdots \\ F_{33} \end{bmatrix} = \begin{bmatrix} 0 \\ \vdots \end{bmatrix}$$

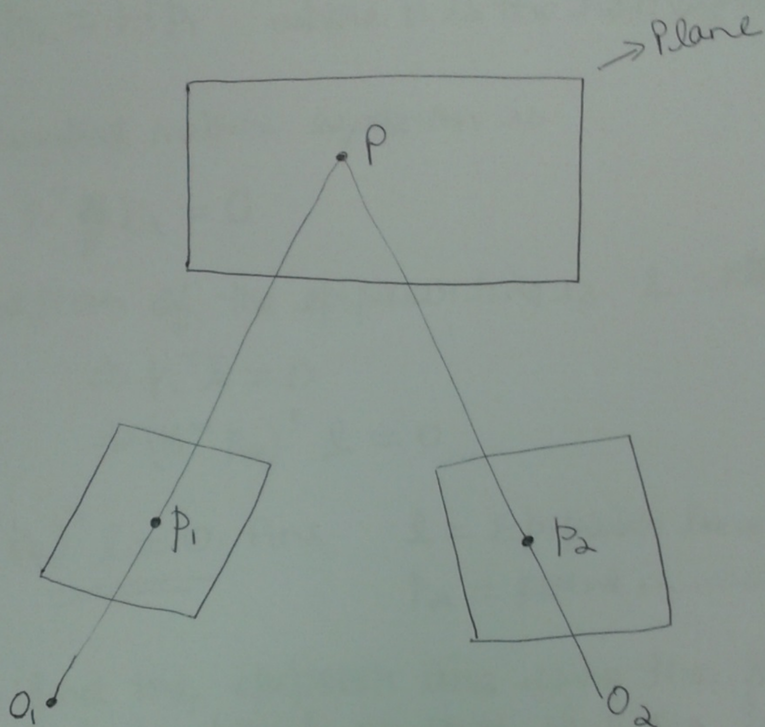
First row will be $0 \times F_{11} + \ldots + 1 \times F_{33} = 0$

$\Rightarrow \underline{\underline{F_{33} = 0}}$ Ans.

Q4.4

Q4.4

1) All points of interest lie on a plane.



⇒ 1. In the planar case, Yes it is possible to find an epipolar line in the second image that corresponds to a point in first image.

2. We know that point in the world space is restricted to a plane, therefore we can find P corresponding to p_1 by intersecting the ray $O_1 p_1$ and the plane to get P.

$$p_1 = M_1 P$$

3. Now, we know the world point, so the corresponding point in Imageplane2 will be p_2

$$p_2 = M_2 P.$$

Also

$p_2 = H p_1$ where H is the homography matrix.

4. The essential matrix equation is

$$p_1^T F p_2 = 0$$

The equation of the epipolar line is $l = F p_2$

$$\Rightarrow p_1^T l = 0$$

$$\Rightarrow (H^{-1} p_2)^T l = 0$$

$\Rightarrow (H^{-1} p_2)^T l = 0$ Ans l = Epipolar line
p_2 = point in image plane 2

5. We can find the epipolar line using the fundamental matrix and the point on that epipolar line can be given by homography ($p_2 = H p_1$).

Q4.4

2) a) In the rotational case, it is NOT possible to find an epipolar line in the second image that corresponds to a point in the first image.

b) By definition, epipolar line is given by the intersection of the image plane and the epipolar plane.

But the epipolar plane is formed using the baseline which is the line joining the centers of the two cameras.

c) Here, O_1 and O_2 coincides, therefore baseline does not exist. or $O_1O_2 = 0$.

d) Therefore, we will not get any epipolar lines by intersecting the epipolar plane and the image plane.