

# ASSIGNMENT 12.11.3.6

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## 1 PROBLEM 1

the augmented matrix is given by,

1. Find the equations of the planes that passes through three points.

$$1) \mathbf{A} = \begin{pmatrix} 1 \\ 1 \\ -1 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 6 \\ 4 \\ -5 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} -4 \\ -2 \\ 3 \end{pmatrix}$$

$$2) \mathbf{A} = \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}, \mathbf{B} = \begin{pmatrix} 1 \\ 2 \\ 1 \end{pmatrix}, \mathbf{C} = \begin{pmatrix} -2 \\ 2 \\ -1 \end{pmatrix}$$

$$\left( \begin{array}{ccc|c} 1 & 6 & -4 & 1 \\ 1 & 4 & -2 & 1 \\ -1 & -5 & 3 & 1 \end{array} \right) \quad (2.0.4)$$

$$\begin{array}{l} \xleftrightarrow{R_2 \leftarrow R_2 - R_1} \\ \xleftrightarrow{R_3 \leftarrow R_3 + R_1} \end{array} \quad (2.0.5)$$

$$\left( \begin{array}{ccc|c} 1 & 6 & -4 & 1 \\ 1 & -2 & 2 & 0 \\ 0 & 1 & -1 & 2 \end{array} \right) \quad (2.0.6)$$

$$\xleftrightarrow{R_2 \leftarrow \frac{-R_2}{2}} \quad (2.0.7)$$

$$\left( \begin{array}{ccc|c} 1 & 6 & -4 & 1 \\ 0 & 1 & -1 & 0 \\ 0 & 1 & -1 & 2 \end{array} \right) \quad (2.0.8)$$

$$\begin{array}{l} \xleftrightarrow{R_3 \leftarrow R_3 - R_2} \\ \xleftrightarrow{R_1 \leftarrow R_1 + 6R_2} \end{array} \quad (2.0.9)$$

$$\left( \begin{array}{ccc|c} 1 & 0 & 2 & 1 \\ 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 2 \end{array} \right) \quad (2.0.10)$$

$$\xleftrightarrow{R_3 \leftarrow \frac{R_3}{2}} \quad (2.0.11)$$

$$\left( \begin{array}{ccc|c} 1 & 0 & 2 & 1 \\ 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) \quad (2.0.12)$$

$$\xleftrightarrow{R_1 \leftarrow R_1 - R_3} \quad (2.0.13)$$

$$\left( \begin{array}{ccc|c} 1 & 0 & 2 & 0 \\ 0 & 1 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{array} \right) \quad (2.0.14)$$

## 2 SOLUTION FOR 1

Equation of plane is given by,

$$\mathbf{n}^T \mathbf{x} = c \quad (2.0.1)$$

$$\Rightarrow \begin{pmatrix} 1 & 1 & -1 \\ 6 & 4 & -5 \\ -4 & -2 & 3 \end{pmatrix}^T \mathbf{n} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \quad (2.0.2)$$

$$\Rightarrow \begin{pmatrix} 1 & 6 & -4 \\ 1 & 4 & -2 \\ -1 & -5 & 3 \end{pmatrix} \mathbf{n} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \quad (2.0.3)$$

Since, all the elements in one of the row is 0. Therefore, there will be no solutions. This signifies that the given points are collinear. The direction vector of the line of collinear points will be,

$$\mathbf{m} = \mathbf{B} - \mathbf{C} = \begin{pmatrix} 10 \\ 6 \\ -8 \end{pmatrix} \quad (2.0.15)$$

Since, the equation of a line is given by,

$$\mathbf{x} = \mathbf{p} + \lambda \mathbf{m} \quad (2.0.16)$$

$$\Rightarrow \mathbf{x} = \begin{pmatrix} 1 \\ 1 \\ -1 \end{pmatrix} + \lambda \begin{pmatrix} 10 \\ 6 \\ -8 \end{pmatrix} \quad (2.0.17)$$

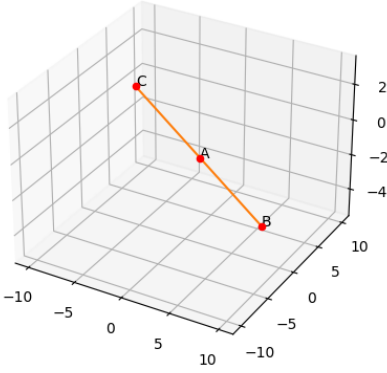


Fig. 2: The figure shows that the given points are collinear

### 3 SOLUTION FOR 2

Equation of plane is given by,

$$\mathbf{n}^T \mathbf{x} = 1 \quad (3.0.1)$$

$$\mathbf{x}^T \mathbf{n} = 1 \quad (3.0.2)$$

Since,  $\mathbf{A}, \mathbf{B}, \mathbf{C}$  satisfies this.

$$\mathbf{A}^T \mathbf{n} = 1 \quad (3.0.3)$$

$$\mathbf{B}^T \mathbf{n} = 1 \quad (3.0.4)$$

$$\mathbf{C}^T \mathbf{n} = 1 \quad (3.0.5)$$

$$\Rightarrow \begin{pmatrix} \mathbf{A}^T \\ \mathbf{B}^T \\ \mathbf{C}^T \end{pmatrix} \mathbf{n} = 1 \quad (3.0.6)$$

$$\Rightarrow \begin{pmatrix} \mathbf{A} & \mathbf{B} & \mathbf{C} \end{pmatrix}^T \mathbf{n} = 1 \quad (3.0.7)$$

$$\Rightarrow \begin{pmatrix} 1 & 1 & 0 \\ 1 & 2 & 1 \\ -2 & 2 & -1 \end{pmatrix}^T \mathbf{n} = 1 \quad (3.0.8)$$

$$\Rightarrow \begin{pmatrix} 1 & 1 & -2 \\ 1 & 2 & 2 \\ 0 & 1 & -1 \end{pmatrix} \mathbf{n} = 1 \quad (3.0.9)$$

the augmented matrix is given by,

$$\left( \begin{array}{ccc|c} 1 & 1 & -2 & 1 \\ 1 & 2 & 2 & 1 \\ 0 & 1 & -1 & 1 \end{array} \right) \quad (3.0.10)$$

$$\begin{array}{l} R_2 \leftarrow R_2 - R_1 \\ R_3 \leftarrow R_3 - R_2 \end{array} \quad (3.0.11)$$

$$\left( \begin{array}{ccc|c} 1 & 1 & -2 & 1 \\ 0 & 1 & 4 & 0 \\ 0 & 0 & -5 & 1 \end{array} \right) \quad (3.0.12)$$

$$\begin{array}{l} \xleftrightarrow{R_2 \leftarrow -5R_2 + 4R_3} \\ \xleftrightarrow{R_1 \leftarrow -5R_1 - 2R_3} \end{array} \quad (3.0.13)$$

$$\left( \begin{array}{ccc|c} 5 & 5 & 0 & 3 \\ 0 & 5 & 0 & 4 \\ 0 & 0 & -5 & 1 \end{array} \right) \quad (3.0.14)$$

$$\xleftrightarrow{R_1 \leftarrow R_1 - R_2} \quad (3.0.15)$$

$$\left( \begin{array}{ccc|c} 5 & 0 & 0 & -1 \\ 0 & 5 & 0 & 4 \\ 0 & 0 & -5 & 1 \end{array} \right) \quad (3.0.16)$$

$$R_1 \leftarrow \frac{R_1}{5}; R_2 \leftarrow \frac{R_1}{5}; R_3 \leftarrow \frac{-R_3}{5} \quad (3.0.17)$$

$$\left( \begin{array}{ccc|c} 1 & 0 & 0 & \frac{-1}{5} \\ 0 & 1 & 0 & \frac{4}{5} \\ 0 & 0 & 1 & \frac{-1}{5} \end{array} \right) \quad (3.0.18)$$

Now, the equation of the plane will be,

$$\left( \frac{-1}{5} \quad \frac{4}{5} \quad \frac{-1}{5} \right) \mathbf{x} = 1 \quad (3.0.19)$$

multiplying both sides by 5, we get,

$$\left( -1 \quad 4 \quad -1 \right) \mathbf{x} = 5 \quad (3.0.20)$$

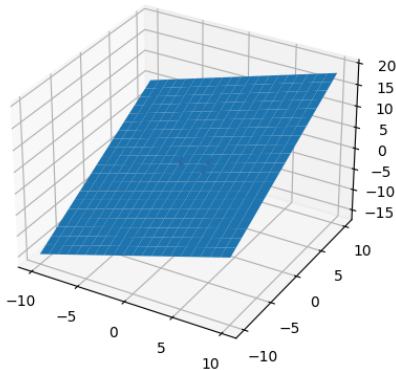


Fig. 2: Plane passing through the given points