6.2 Equations of Lines in Three-Space Lesson with solutions

This document was composed and formatted by Annie Bernatchez.

The course material originated from www.jensenmath.ca

www.geogebra.org/3d/aku6q7xs (bonus interactive visualization)

In two-space lines can be represented using: vector equations, parametric equations, scalar equations, or an equation in slope y-intercept form.

A line in three space can be defined by a vector, parametric, or symmetric equation but not a scalar equation. In three-space, a scalar equation defines a plane. A plane is a two-dimensional flat surface that extends infinitely in all directions.

As in two-space, a line in three-space needs a position vector to a known point on the line and a direction vector in order to define it.

Equations of a line in $\mathbb{R}^3$:

i) Vector Equation $\rightarrow \vec{r} = \vec{r_0} + t\vec{m}$ or $[x,\ y,\ z] = [x_0,\ y_0,\ z_0] + t[m_1,\ m_2,\ m_3]$

ii) Parametric Equation $\rightarrow \begin{cases} x = x_0 + tm_1 \\ y = y_0 + tm_2 \\ z = z_0 + tm_3 \end{cases}$

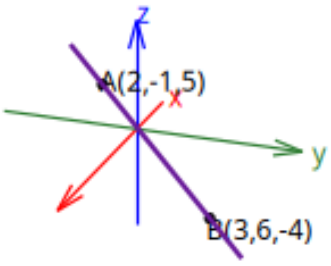
where $\vec{r_0}$ is the position vector and $\vec{m}$ is the direction vector.

iii) Symmetric Equation $\rightarrow \frac{x - x_0}{m_1} = \frac{y - y_0}{m_2} = \frac{z - z_0}{m_3}$

The symmetric equation is derived from the parametric equations and solving for the t parameter in each component.

Example 1: A line passes through points $A(2,\ -1,\ 5)$ and $B(3,\ 6,\ -4)$.

www.geogebra.org/3d/rcnm5ew9 (bonus interactive visualization)



a) Write a vector equation of the line.

$\vec{r_0} = [2,\ -1,\ 5]$

$\vec{m} = \overrightarrow{AB}$

$\vec{m} = [3,\ 6,\ -4] - [2,\ -1,\ 5]$

$\vec{m} = [1,\ 7,\ -9]$

The vector equation is $[x,\ y,\ z] = [2,\ -1,\ 5] + t[1,\ 7,\ -9]$

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b) Write parametric equations for the line.

$$\ell : \begin{cases} x = 2 + t \\ y = -1 + 7t \\ z = 5 - 9t \end{cases}$$

c) Determine if the point $C(0, -15, 9)$ lies on the line.

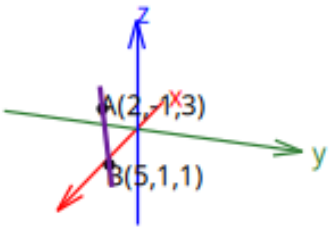
Sub the point into the parametric equations and see if there is a single value of t that makes the equations true:

$0 = 2 + t$ $t = -2$	$-15 = -1 + 7t$ $t = -2$	$9 = 5 - 9t$ $t = \frac{-4}{9}$

Therefore, the point is NOT on the line.

Example 2: Find Vector, Parametric, and Symmetric equations of a line that passes through points $A(2, -1, 3)$ and $B(5, 1, 1)$.

www.geogebra.org/3d/cgk83wun (bonus interactive visualization)



Vector Equation:

$\vec{r_0} = [2, -1, 3]$

$\vec{m} = [5, 1, 1] - [2, -1, 3]$

$\vec{m} = [3, 2, -2]$

Vector equation is $[x, y, z] = [2, -1, 3] + t[3, 2, -2]$

Parametric Equations:

$$\ell : \begin{cases} x = 2 + 3t \\ y = -1 + 2t \\ z = 3 - 2t \end{cases}$$

Symmetric Equations:

$x = 2 + 3t$ $t = \frac{x - 2}{3}$	$y = -1 + 2t$ $t = \frac{y + 1}{2}$	$z = 3 - 2t$ $t = \frac{z - 3}{-2}$

$$\frac{x - 2}{3} = \frac{y + 1}{2} = \frac{z - 3}{-2}$$

Notice that you cannot write a scalar equation of a line in 3-space. This is reserved for defining planes which we will do next lesson.

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