MATHEMATICS · GRADES 10-12

Lines and planes in three dimensions

Difficulty level: Advanced

Mathematics: Grades 10-12

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Overview of the concept

This is how you describe directions and flat surfaces in real space, like a flight path through the sky or a wall meeting a floor in a room. In three dimensions, a line can head in any direction and a plane can tilt any way, and naming them properly is how engineers and builders talk about real space. You use it when a pilot plans a flight path, a builder checks that a wall meets a floor squarely, or an architect draws a room that has to work in three dimensions, not just on paper.

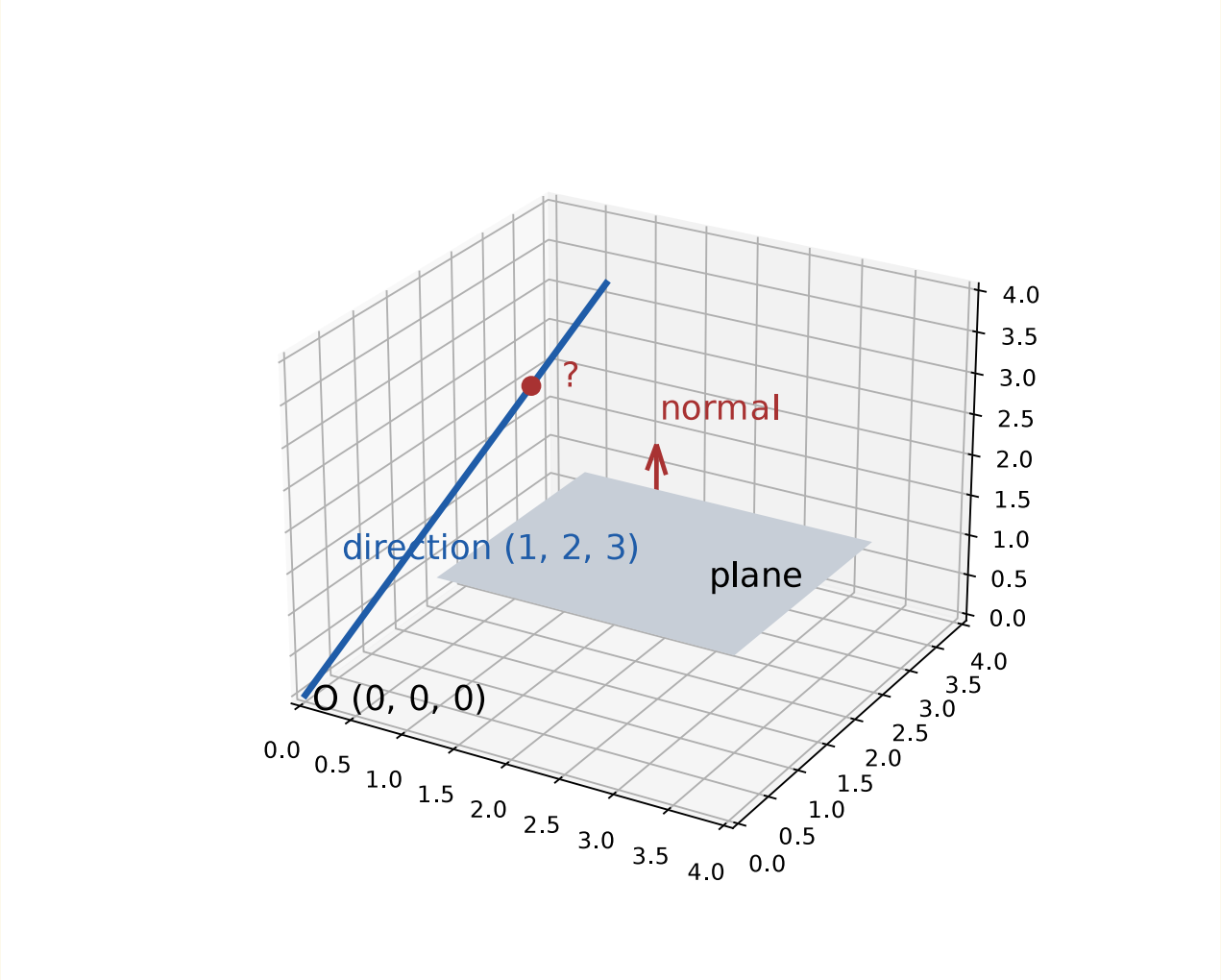


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Worked examples

EXAMPLE 1

Q Write a point on the line through (0, 0, 0) in direction (1, 2, 3).



SOLUTION

A line is a starting point plus a multiple of its direction.

With multiple 1, the point is (0, 0, 0) + (1, 2, 3)

One point on the line: (1, 2, 3)

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EXAMPLE 2

Q Does the point (2, 4, 6) lie on that line?

SOLUTION

Check if (2, 4, 6) is a multiple of (1, 2, 3).

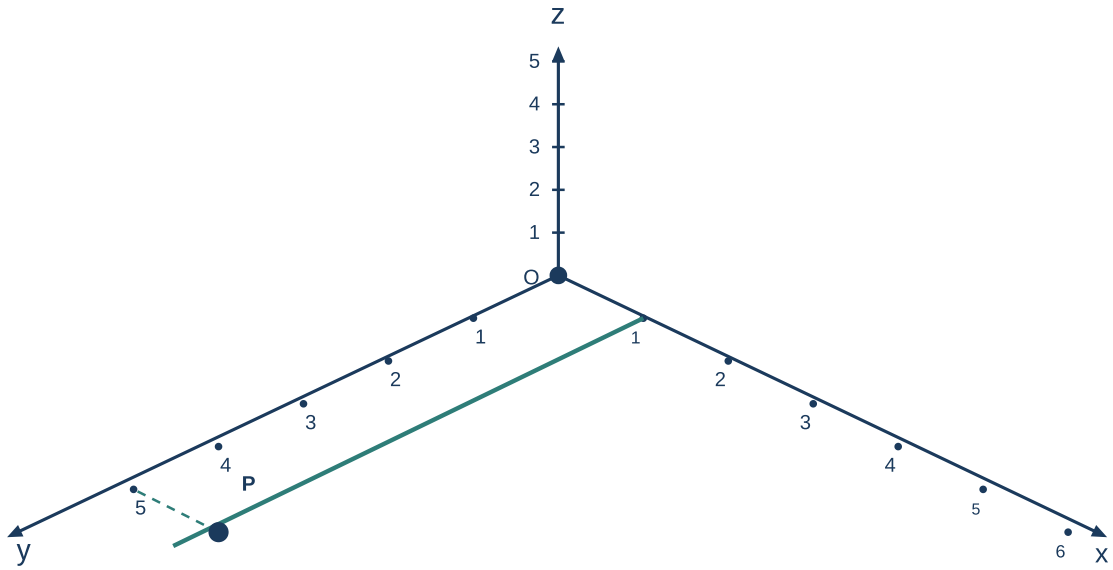
It is 2 × (1, 2, 3)

Yes, it lies on the line.

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Practice questions

1 A drone flies along a straight path through (1, 0, 0) in the direction (0, 1, 0). Point P is marked on its path. Read the coordinates of P from the axes.



- **A** (1, 0, 0)
- **B** (0, 5, 0)
- **C** (1, 5, 0)
- **D** (1, 5, 5)

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2

A lift shaft runs straight up the y-axis from the origin. Does (0, 3, 0) lie on this line?

A Yes

B No

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3

What two things define a line in space?

A Two points on the line

B A point and a direction vector

C A point and a normal vector

D A direction vector only

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4 What defines a plane in space?

- **A** A point and a direction vector
- **B** Two intersecting lines
- **C** A point and a normal vector
- **D** A normal vector only

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5 A crane rail runs along the x-axis from the origin in the direction (2, 0, 0). What point is on the rail when the multiple is 3?

- **A** (2, 0, 0)
- **B** (6, 0, 0)
- **C** (3, 0, 0)
- **D** (0, 6, 0)

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6 **A flight path leaves the origin in the direction (1, 2, 3). Does (1, 1, 1) lie on this line?**

- A Yes
- B No

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7 **What is a direction vector?**

- A A vector pointing along the line
- B A vector at right angles to the plane
- C A point on the line
- D A vector pointing away from the line

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8

What is a normal vector to a plane?

A A vector pointing along the line

B A point on the plane

C A vector lying flat in the plane

D A vector at right angles to the plane

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9

A cable runs through (1, 1, 1) in the direction (1, 0, 0). Which point is NOT on the cable?

A (5, 1, 1)

B (1, 2, 1)

C (0, 1, 1)

D (2, 1, 1)

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10 **An elevator shaft runs straight up the z-axis from the origin. Does $(0, 5, 0)$ lie on this line?**

A Yes

B No

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ANSWER KEY

1. (1, 5, 0)

2. Yes

3. A point and a direction vector

4. A point and a normal vector

5. (6, 0, 0)

6. No

7. A vector pointing along the line

8. A vector at right angles to the plane

9. (1, 2, 1)

10. No

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