

# Direction and Normal Vectors

EE25BTECH11008 - Anirudh M Abhilash

September 30, 2025

# Problem Statement

Find the equation of the line passing through the point  $(1, 2, 3)$  and parallel to the vector  $3\hat{i} + 2\hat{j} - 2\hat{k}$

## Solution

Let the point  $\mathbf{h}$  and direction vector  $\mathbf{m}$  be

$$\mathbf{h} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}, \quad \mathbf{m} = \begin{pmatrix} 3 \\ 2 \\ -2 \end{pmatrix}.$$

The vector equation of the line is given by

$$\mathbf{x} = \mathbf{h} + \kappa \mathbf{m}, \quad \kappa \in \mathbb{R}.$$

## Solution (cont..)

Expanding,

$$\mathbf{x} = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix} + \kappa \begin{pmatrix} 3 \\ 2 \\ -2 \end{pmatrix} \quad (1)$$

$$= \begin{pmatrix} 1 + 3\kappa \\ 2 + 2\kappa \\ 3 - 2\kappa \end{pmatrix}. \quad (2)$$

Hence the parametric equations of the line are

$$x = 1 + 3\kappa, \quad (3)$$

$$y = 2 + 2\kappa, \quad (4)$$

$$z = 3 - 2\kappa, \quad \kappa \in \mathbb{R}. \quad (5)$$

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

## Python Code (Plotting Line and Vectors)

```
import numpy as np
import matplotlib.pyplot as plt

h = np.array([1, 2, 3])
m = np.array([3, 2, -2])
kappa = np.linspace(-2, 2, 100)

x = h[0] + kappa*m[0]
y = h[1] + kappa*m[1]
z = h[2] + kappa*m[2]
```

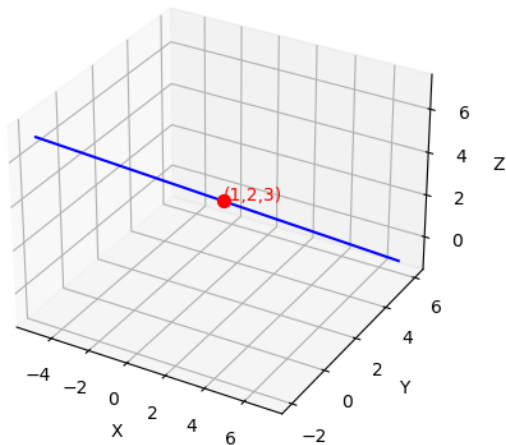
## Python Code (cont..)

```
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.plot(x, y, z, color='blue')
ax.scatter(h[0], h[1], h[2], color='red', s=50)
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title('Line through (1,2,3) parallel to  $[3, 2, -2]$ ')
ax.text(h[0], h[1], h[2], '(1,2,3)', color='red')

plt.show()
```

# Plot

Line through  $(1,2,3)$  parallel to  $[3,2,-2]$



## C Code (Computations)

```
#include <stdio.h>

void line_point(double kappa, double h[3], double m[3], double
    out[3]) {
    out[0] = h[0] + kappa * m[0];
    out[1] = h[1] + kappa * m[1];
    out[2] = h[2] + kappa * m[2];
}
```



## Python Code (Calling C)

```
import numpy as np
import ctypes
import matplotlib.pyplot as plt

lib = ctypes.CDLL("./pts.so")

lib.line_point.argtypes = [ctypes.c_double,
                           ctypes.POINTER(ctypes.c_double),
                           ctypes.POINTER(ctypes.c_double),
                           ctypes.POINTER(ctypes.c_double)]

h = np.array([1.0, 2.0, 3.0], dtype=np.float64)
m = np.array([3.0, 2.0, -2.0], dtype=np.float64)
```

## Python Code (cont..)

```
kappa_values = np.linspace(-2, 2, 100)

points = np.zeros((len(kappa_values), 3), dtype=np.float64)

for i, k in enumerate(kappa_values):
    lib.line_point(ctypes.c_double(k),
                   h.ctypes.data_as(ctypes.POINTER(ctypes.
                                                       c_double))),
                   m.ctypes.data_as(ctypes.POINTER(ctypes.
                                                       c_double))),
                   points[i].ctypes.data_as(ctypes.POINTER(
                                                       ctypes.c_double))))
```

## Python Code (cont..)

```
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.plot(points[:,0], points[:,1], points[:,2], color='blue')
ax.scatter(h[0], h[1], h[2], color='red', s=50)
ax.text(h[0], h[1], h[2], '(1,2,3)', color='red')
ax.set_xlabel('X')
ax.set_ylabel('Y')
ax.set_zlabel('Z')
ax.set_title('3D-Line-through-(1,2,3)-parallel-to-[3,2,-2]')

plt.show()
```