

## 4.2.18

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September 29,2025

# Question

Find the direction and normal vectors of each of the following line  $y = x - 2$

$$y = x - 2 \quad (4.2.18.1)$$

$$\Rightarrow \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} x \\ x - 2 \end{pmatrix} = \begin{pmatrix} 0 \\ -2 \end{pmatrix} + x \begin{pmatrix} 1 \\ 1 \end{pmatrix} \quad (4.2.18.2)$$

yielding

$$\mathbf{x} = \mathbf{h} + \kappa \mathbf{m} \quad (4.2.18.3)$$

where  $\mathbf{h}$  is any point on the line and

$$\mathbf{m} = \begin{pmatrix} 1 \\ 1 \end{pmatrix} \quad (4.2.18.4)$$

is the direction vector.

$$\mathbf{m}^T \mathbf{n} = 0 \quad (4.2.18.5)$$

$$\mathbf{n}^T \mathbf{x} = \mathbf{n}^T \mathbf{h} + \kappa \mathbf{n}^T \mathbf{m} \quad (4.2.18.6)$$

$$\Rightarrow \mathbf{n}^T (\mathbf{x} - \mathbf{h}) = 0 \quad \text{or} \quad \mathbf{n}^T \mathbf{x} = c \quad (4.2.18.7)$$

for

$$c = \mathbf{n}^T \mathbf{h} \quad (4.2.18.8)$$

where

$$\mathbf{n} = \begin{pmatrix} -m \\ 1 \end{pmatrix} \quad (4.2.18.9)$$
$$\begin{pmatrix} -1 \\ 1 \end{pmatrix}$$

is defined to be the *normal vector* of the line.

# C Code - A function to find if triangle is right angled

```
#include <stdio.h>

// Function to compute direction and normal vectors for a line y
// = x - 2
// General form: x - y - 2 = 0
// Normal vector = (a, b) = (1, -1)
// Direction vector = (b, -a) = (-1, -1)

void line_vectors(float *dx, float *dy, float *nx, float *ny) {
    float a = 1, b = -1; // coefficients of x - y - 2 = 0

    // Normal vector
    *nx = a;
    *ny = b;

    // Direction vector
    *dx = b;
    *dy = -a;
}
```

# Python Code

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

# --- Load the C library ---
try:
    c_lib = ctypes.CDLL('./line.so')
except OSError:
    print(" Error: 'line.so' not found. Compile using: gcc -
        shared -o line.so -fPIC line_vectors.c")
    exit()

# Define argument and return types
c_lib.line_vectors.argtypes = [ctypes.POINTER(ctypes.c_float),
                                ctypes.POINTER(ctypes.c_float),
                                ctypes.POINTER(ctypes.c_float),
                                ctypes.POINTER(ctypes.c_float)]
c_lib.line_vectors.restype = None
```



# Python Code

```
# --- Prepare ctypes variables ---
dx = ctypes.c_float()
dy = ctypes.c_float()
nx = ctypes.c_float()
ny = ctypes.c_float()

# --- Call C function ---
c_lib.line_vectors(ctypes.byref(dx), ctypes.byref(dy), ctypes.
    byref(nx), ctypes.byref(ny))

print(f" Direction vector: ({dx.value}, {dy.value})")
print(f" Normal vector: ({nx.value}, {ny.value})")

# --- Plot the line  $y = x - 2$  ---
x = np.linspace(-2, 6, 100)
y = x - 2
fig, ax = plt.subplots()
ax.plot(x, y, label="Line:  $y = x - 2$ ", color="black")
```

```
# Plot direction vector
ax.arrow(P[0], P[1], dx.value, dy.value,
         head_width=0.2, color="red", length_includes_head=True,
         label="Direction Vector")

# Plot normal vector
ax.arrow(P[0], P[1], nx.value, ny.value,
         head_width=0.2, color="blue", length_includes_head=True,
         label="Normal Vector")

# Formatting
ax.set_xlabel("X-axis")
ax.set_ylabel("Y-axis")
ax.set_title("Line  $y = x - 2$  with Direction & Normal Vectors")
ax.legend()
ax.grid(True)
ax.set_aspect("equal")
```

