4.3.47

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September 14, 2025

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Problem Statement

Question : Find the equation of the line through (-2,3) with slope -4.

Equation of Line in Slope form

Solution : Given point is

$$\mathbf{h} = \begin{pmatrix} -2 \\ 3 \end{pmatrix}, Slope = m = -4 \tag{3.1}$$

The equation of the line is given by

$$y = mx + c \tag{3.2}$$

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} x \\ mx + c \end{pmatrix} = \begin{pmatrix} 0 \\ c \end{pmatrix} + x \begin{pmatrix} 1 \\ m \end{pmatrix} \tag{3.3}$$

So

$$\mathbf{n}^\top \mathbf{x} = \mathbf{n}^\top \mathbf{h} = c \tag{3.4}$$

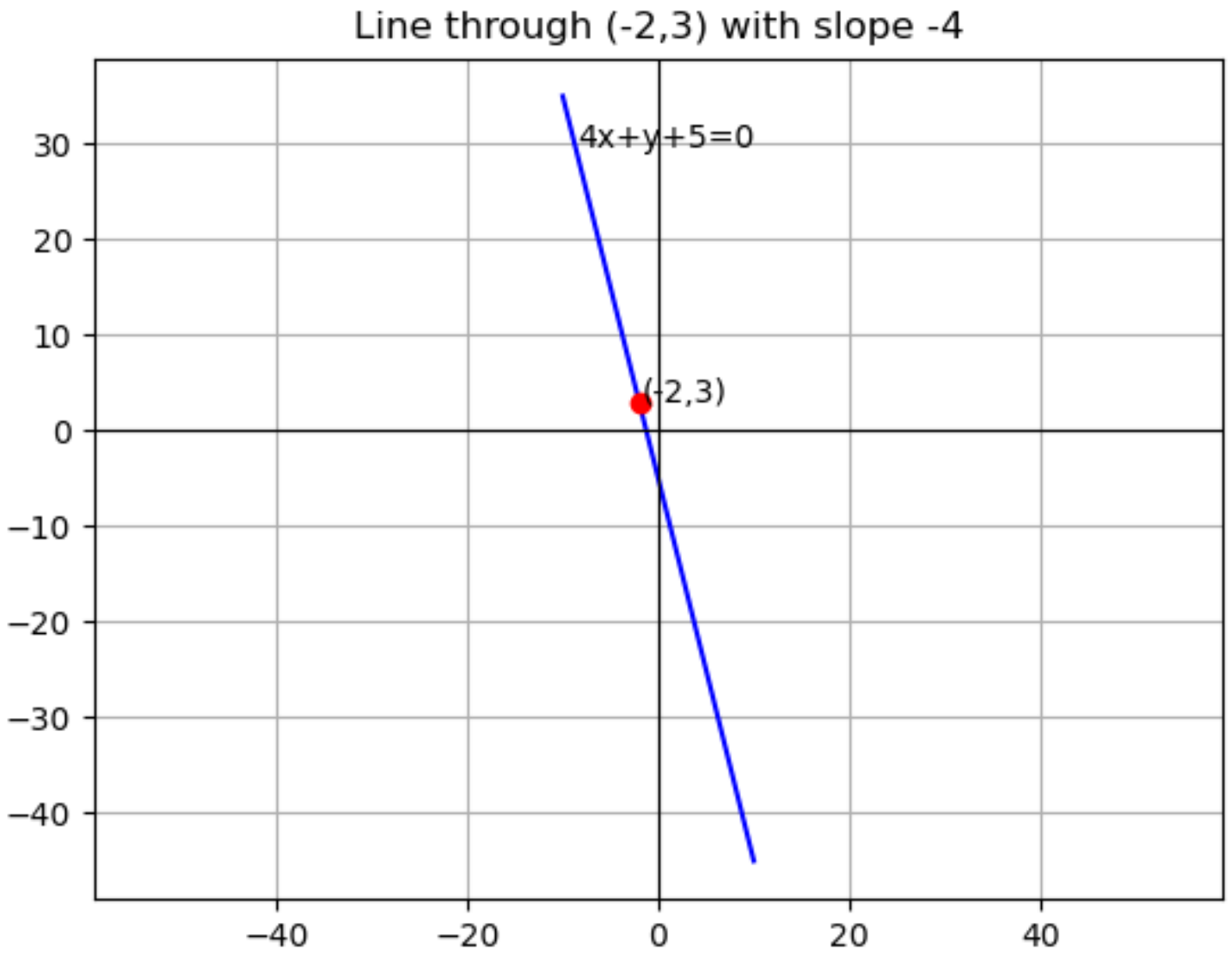
where $\mathbf{h}$ is any point on the line and $\mathbf{n} = \begin{pmatrix} -m \\ 1 \end{pmatrix}$

$$c = \mathbf{n}^\top \mathbf{h} = \begin{pmatrix} 4 & 1 \end{pmatrix} \begin{pmatrix} -2 \\ 3 \end{pmatrix} = -5 \tag{3.5}$$

so equation of line is

$$y = -4x - 5 \tag{3.6}$$

Plots


Line through (-2,3) with slope -4
4x+y+5=0
(-2,3)
30
20
10
0
−10
−20
−30
−40
−40
−20
0
20
40

C Code

```c
#include <stdio.h>
// Function to print line equation given point (x0,y0) and slope
void line_equation(double x0, double y0, double slope) {
    // direction vector from slope
    double dx = 1.0;
    double dy = slope;
    // normal vector = (dy, -dx)
    double a = dy;
    double b = -dx;
    double c = -(a * x0 + b * y0);

    printf("Point on line: (%.2f, %.2f)\n", x0, y0);
    printf("Slope: %.2f\n", slope);
    printf("Cartesian form: %.2fx + %.2fy + %.2f = 0\n", a, b, c);
    printf("Vector form: r = (%.2f, %.2f) + t(%.2f, %.2f)\n",
           x0, y0, dx, dy);
}
```

```
// Function exposed for Python (shared object)
const char* get_line_equation() {
    static char result[200];
    double x0 = -2, y0 = 3, slope = -4;
    double dx = 1.0, dy = slope;
    double a = dy, b = -dx, c = -(a * x0 + b * y0);

    snprintf(result, sizeof(result),
             "Equation: %.2fx + %.2fy + %.2f = 0; Vector: r = (%.2f,
                 %.2f) + t(%.2f, %.2f)",
             a, b, c, x0, y0, dx, dy);
    return result;}
int main() {
    // Example: line through (-2,3) with slope -4
    line_equation(-2, 3, -4);
    return 0;
}
```

Python : call_c.py

```
import ctypes
import os

# Part 1: Call the C shared object
# Path to shared object (must be in same directory)
lib_path = os.path.abspath("./libline.so")

# Load the shared library
lib = ctypes.CDLL(lib_path)

# Tell Python return type of the function
lib.get_line_equation.restype = ctypes.c_char_p
# Call the function
c_result = lib.get_line_equation().decode("utf-8")
print("=== Result from C shared library ===")
print(c_result)
```

```
print()
# Part 2: Direct computation in Python

def line_equation(x0, y0, slope):
    dx, dy = 1.0, slope
    a, b = dy, -dx
    c = -(a * x0 + b * y0)
    print("=== Direct Python Computation ===")
    print(f"Point on line: ({x0}, {y0})")
    print(f"Slope: {slope}")
    print(f"Cartesian form: {a:.2f}x + {b:.2f}y + {c:.2f} = 0")
    print(f"Vector form: r = ({x0}, {y0}) + t({dx}, {dy})")
    print()

line_equation(-2, 3, -4)

# Part 3: Row reduction (manual)
def row_reduction():
```

```
    print("=== Row Reduction Verification ===")
    # Equations: a − 4b = 0, −2a + 3b + c = 0
    print("System of equations:")
    print("1) a − 4b = 0")
    print("2) −2a + 3b + c = 0")

    # From (1): a = 4b
    # Substitute into (2): −8b + 3b + c = 0 => −5b + c = 0 => c =
          5b
    a = 4
    b = 1
    c = 5
    print(f"Solution (up to scale): (a, b, c) = ({a}, {b}, {c})")
    print(f"Equation: {a}x + {b}y + {c} = 0")
    print()

row_reduction()
```

Python Code for Plotting

```
import numpy as np
import matplotlib.pyplot as plt
x=np.linspace(−10, 10, 100)
y=(−4∗x)−5

plt.plot(x, y, '−b')
plt.plot(−2, 3, 'ro')
plt.text(−8.6, 29.6, "4x+y+5=0", fontsize=10, color="black")
plt.text(−1.8, 2.9, "(−2,3)", fontsize=10, color="black")
plt.axhline(0, color="black", linewidth=0.8)
plt.axvline(0, color="black", linewidth=0.8)
plt.title("Line through (−2,3) with slope −4")
plt.grid(True)
plt.axis("equal")
plt.savefig("../figs/fig6.png")
plt.show()
```