4.13.20

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Question

A ray of light along $x + 3y = 3$ gets reflected upon reaching the X-axis. The equation of the reflected ray is:

$$\text{(a) } y = x + 3 \quad \text{(b) } 3y = x - 3$$

$$\text{(c) } y = 3x - 3 \quad \text{(d) } 3y = x - 1$$

Parametric form of line

The given line in parametric (matrix) form

$$x + 3y = 3.$$

The normal vector is

$$\mathbf{n} = \begin{pmatrix} 1 \\ 3 \end{pmatrix}.$$

A direction vector $\mathbf{d}$ satisfies $\mathbf{n}^\top \mathbf{d} = 0$.

$$\mathbf{d} = \begin{pmatrix} -3 \\ 1 \end{pmatrix},$$

A point on the line is

$$\mathbf{p} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \quad (0 + 3 \cdot 1 = 3).$$

Hence, the parametric form is

$$\mathbf{r}(t) = \mathbf{p} + t\mathbf{d} = \begin{pmatrix} 0 \\ 1 \end{pmatrix} + t \begin{pmatrix} -3 \\ 1 \end{pmatrix}.$$

Point of incidence (intersection with the x-axis)
For incidence with the x-axis, set $y = 0$. From the second component:

$$1 + t = 0 \quad \Rightarrow \quad t = -1.$$

Thus,

$$\mathbf{P} = \mathbf{r}(-1) = \begin{pmatrix} 0 \\ 1 \end{pmatrix} - 1 \begin{pmatrix} -3 \\ 1 \end{pmatrix} = \begin{pmatrix} 3 \\ 0 \end{pmatrix}.$$

Reflection

Reflection in the x-axis is represented by the matrix

$$R = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}.$$

So,

$$\mathbf{d}' = R\mathbf{d} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} -3 \\ 1 \end{pmatrix} = \begin{pmatrix} -3 \\ -1 \end{pmatrix}.$$

(Equivalently, we can take $\mathbf{d}' = (3, 1)$.)

Reflected ray

Equation of the reflected ray
The reflected ray is

$$\mathbf{r}'(s) = \mathbf{P} + s\mathbf{d}' = \begin{pmatrix} 3 \\ 0 \end{pmatrix} + s \begin{pmatrix} 3 \\ 1 \end{pmatrix}.$$

Coordinates:

$$x = 3 + 3s, \quad y = 0 + s.$$

Thus,

$$x - 3 = 3y \quad \Rightarrow \quad 3y = x - 3.$$

Equation of the reflected ray: 3y=x-3

```c
#include <stdio.h>

// Reflect a vector (dx,dy) about the X-axis
void reflect_ray(float dx, float dy, float *rx, float *ry) {
    *rx = dx; // x component unchanged
    *ry = -dy; // y component flipped
}
```

Python Code

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

# --- Load the C library ---
lib_path = os.path.abspath("./reflection.so")
try:
    c_lib = ctypes.CDLL(lib_path)
except OSError:
    print("reflection.so not found. Compile with: gcc -shared -o
        reflection.so -fPIC reflection.c")
    exit()

# Define function signature
c_lib.reflect_ray.argtypes = [ctypes.c_float, ctypes.c_float,
                              ctypes.POINTER(ctypes.c_float),
                              ctypes.POINTER(ctypes.c_float)]
```

Python Code

```
# --- Incident ray direction (line x+3y=3 has direction (-3,1))
    ---
dx, dy = -3.0, 1.0
rx, ry = ctypes.c_float(), ctypes.c_float()

# Call C function
c_lib.reflect_ray(ctypes.c_float(dx), ctypes.c_float(dy),
                  ctypes.byref(rx), ctypes.byref(ry))

print(f"Incident direction = ({dx}, {dy})")
print(f"Reflected direction = ({rx.value}, {ry.value})")

# --- Geometry ---
# Point of incidence (intersection with x-axis)
P = (3, 0)
```

Python Code

```
# Parametric plotting
t = np.linspace(-1, 2, 100)
incident_x = P[0] + dx * t
incident_y = P[1] + dy * t

reflected_x = P[0] + rx.value * t
reflected_y = P[1] + ry.value * t

# --- Plot ---
plt.figure(figsize=(6,6))
plt.plot(incident_x, incident_y, "b", label="Incident Ray")
plt.plot(reflected_x, reflected_y, "r", label="Reflected Ray")
```

Python Code

```
# Mark incidence point
plt.scatter(*P, color="black", s=60, zorder=5)
plt.text(P[0]+0.1, P[1]+0.2, "P(3,0)", fontsize=10)

# Axes formatting
plt.axhline(0, color="black", linewidth=1)
plt.axvline(0, color="black", linewidth=1)
plt.gca().set_aspect("equal")
plt.xlim(-2, 6)
plt.ylim(-3, 3)

plt.title("Reflection of Ray $x+3y=3$ at the X-axis (via C
    function)")
plt.xlabel("x")
plt.ylabel("y")
plt.legend()
plt.grid(True)
plt.show()
```