

2.8.37

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Question

If $|\mathbf{a} \times \mathbf{b}|^2 + (\mathbf{a}^T \mathbf{b})^2 = 144$ and $\|\mathbf{a}\| = 4$, then $\|\mathbf{b}\|$ is equal to _____

Equation

$$|\mathbf{a} \times \mathbf{b}|^2 + (\mathbf{a}^T \mathbf{b})^2 = \|\mathbf{a}\|^2 \|\mathbf{b}\|^2.$$

Theoretical Solution

We know that

$$|\mathbf{a} \times \mathbf{b}|^2 + (\mathbf{a}^T \mathbf{b})^2 = \|\mathbf{a}\|^2 \|\mathbf{b}\|^2. \quad (1)$$

Given :

$$|\mathbf{a} \times \mathbf{b}|^2 + (\mathbf{a}^T \mathbf{b})^2 = 144, \quad (2)$$

$$\|\mathbf{a}\| = 4, \quad (3)$$

Theoretical Solution

$$144 = ||\mathbf{a}||^2 ||\mathbf{b}||^2 \quad (4)$$

$$144 = 4^2 ||\mathbf{b}||^2 \quad (5)$$

$$144 = 16 ||\mathbf{b}||^2 \quad (6)$$

$$||\mathbf{b}||^2 = \frac{144}{16} = 9 \quad (7)$$

$$||\mathbf{b}|| = 3. \quad (8)$$

C Code

```
#include <stdio.h>
#include <math.h>

int main() {
    // Given values
    double a = 4.0; // |a| = 4
    double lhs = 144; // |a - b|^2 + (a + b)^2 = 144

    // From identity: |a - b|^2 + (a + b)^2 = |a|^2 * |b|^2
    // => |b|^2 = lhs / (|a|^2)
    double b_squared = lhs / (a * a);
    double b = sqrt(b_squared);

    printf("|b| = %.2f\n", b);

    return 0;
}
```

Python Shared Output

```
import numpy as np
import ctypes
# Local imports
from libs.line.funcs import *
from libs.triangle.funcs import *
from libs.conics.funcs import circ_gen

# Load C math library for sqrt
libm = ctypes.CDLL(libm.so.6)
libm.sqrt.restype = ctypes.c_double
libm.sqrt.argtypes = [ctypes.c_double]
```

Python Shared Output

```
# Given values
a = 4.0 # |a|
lhs = 144.0 # |a - b|^2 + (a + b)^2

# Compute b^2 using NumPy
b_squared = lhs / np.power(a, 2)

# Compute b using C's sqrt via ctypes
b = libm.sqrt(ctypes.c_double(b_squared))

print(f|b| = {b})
```



```
import numpy as np

# Given values
a = 4.0 # |a|
lhs = 144.0 # |a b|^2 + (a b)^2

# Using numpy
b_squared = lhs / np.power(a, 2)
b = np.sqrt(b_squared)

print(f|b| = {b})
```