12.472

EE25BTECH11043 - Nishid Khandagre

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Question

A rigid ball of weight 100 N is suspended with the help of a string. The ball is pulled by a horizontal force F such that the string makes an angle of 30° with the vertical. The magnitude of force F (in N) is

Diagram

figs/fig.jpg

Figure: 1

Theoretical Solution

Let T be the tension in the string and F the horizontal force. Equilibrium of the ball gives the linear system:

$$T \sin 30^\circ - F = 0, \quad (1)$$

$$T \cos 30^\circ - 100 = 0. \quad (2)$$

$$\frac{1}{2} T - F = 0, \quad (3)$$

$$\frac{\sqrt{3}}{2} T = 100. \quad (4)$$

Theoretical Solution

Writing this in matrix form $\mathbf{A}\mathbf{x} = \mathbf{b}$ with $\mathbf{x} = \begin{pmatrix} T \\ F \end{pmatrix}$:

$$\begin{pmatrix} \frac{1}{2} & -1 \\ \frac{\sqrt{3}}{2} & 0 \end{pmatrix} \begin{pmatrix} T \\ F \end{pmatrix} = \begin{pmatrix} 0 \\ 100 \end{pmatrix} \tag{5}$$

Augmented matrix:

$$\left(\begin{array}{cc|c} \frac{1}{2} & -1 & 0 \\ \frac{\sqrt{3}}{2} & 0 & 100 \end{array}\right) \tag{6}$$

$R_1 \to 2R_1, R_2 \to 2R_2$

$$\left(\begin{array}{cc|c} 1 & -2 & 0 \\ \sqrt{3} & 0 & 200 \end{array}\right) \tag{7}$$

Theoretical Solution

Perform row operation $R_2 \to R_2 - \sqrt{3}R_1$:

$$\left(\begin{array}{cc|c} 1 & -2 & 0 \\ 0 & 2\sqrt{3} & 200 \end{array}\right) \tag{8}$$

From the second row

$$2\sqrt{3}F = 200 \tag{9}$$

$$F = \frac{100}{\sqrt{3}}. \tag{10}$$

Thus, the magnitude of force F is:

$$F = \frac{100}{\sqrt{3}} \text{ N}. \tag{11}$$

Numerically, $F \approx 57.7$ N.

C Code

```c
#include <math.h>

// Function to calculate the horizontal force F
// In equilibrium, summing forces in the vertical direction:
// T * cos(angle_radians) = weight
// So, Tension T = weight / cos(angle_radians)
// Summing forces in the horizontal direction:
// F = T * sin(angle_radians)
// Substitute T into the equation for F:
// F = (weight / cos(angle_radians)) * sin(angle_radians)
// F = weight * tan(angle_radians)

double calculate_horizontal_force(double weight, double
    angle_degrees) {
    // Convert angle from degrees to radians for trigonometric
        functions
    double angle_radians = angle_degrees * M_PI / 180.0;
```

C Code

```

    // F = W * tan(angle)
    double force_F = weight * tan(angle_radians);

    return force_F;
}
```

Python Code using C Shared Library

```
import ctypes

# Load the shared library
lib_code = ctypes.CDLL(./code23.so)

# Define the argument types and return type for the C function
lib_code.calculate_horizontal_force.argtypes = [
    ctypes.c_double, # weight
    ctypes.c_double # angle_degrees
]
lib_code.calculate_horizontal_force.restype = ctypes.c_double
# Given values from the problem
weight = 100.0 # N
angle_degrees = 30.0 # degrees
# Call the C function
force_F = lib_code.calculate_horizontal_force(weight,
    angle_degrees)
print(fThe magnitude of force F is (in N): {force_F:.3f})
```

Pure Python Code

```
import math

def calculate_horizontal_force_pure_python(weight, angle_degrees)
    :
    # Convert angle from degrees to radians for trigonometric
        functions

    angle_radians = math.radians(angle_degrees)

    # In equilibrium, summing forces in the vertical direction:
    # T * cos(angle_radians) = weight
    # So, Tension T = weight / cos(angle_radians)

    # Summing forces in the horizontal direction:
    # F = T * sin(angle_radians)
    # Substitute T into the equation for F:
    # F = (weight / cos(angle_radians)) * sin(angle_radians)
    # F = weight * tan(angle_radians)
```

Pure Python Code

```
force_F = weight * math.tan(angle_radians)
return force_F

# Given values from the problem
weight_ball = 100.0 # N
angle_string_vertical = 30.0 # degrees

# Calculate the force using the pure Python function
force_F_magnitude = calculate_horizontal_force_pure_python(
    weight_ball, angle_string_vertical)

print(fThe magnitude of force F is (in N): {force_F_magnitude:.3f
    })
```