

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

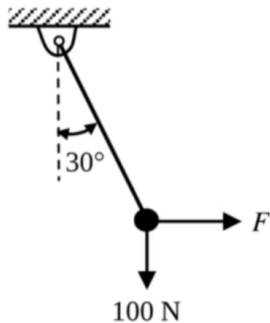


Figure: 1

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 $\mathbf{Ax} = \mathbf{b}$ with $\mathbf{x} = \begin{pmatrix} T \\ F \end{pmatrix}$:

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

Augmented matrix:

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

$$R_1 \rightarrow 2R_1, R_2 \rightarrow 2R_2$$

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

Theoretical Solution

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

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

From the second row

$$2\sqrt{3}F = 200 \quad (9)$$

$$F = \frac{100}{\sqrt{3}}. \quad (10)$$

Thus, the magnitude of force F is:

$$F = \frac{100}{\sqrt{3}} \text{ N}. \quad (11)$$

Numerically, $F \approx 57.7 \text{ N}$.

```
#include <math.h>

// Function to calculate the horizontal force F
// In equilibrium, summing forces in the vertical direction:
//  $T \cdot \cos(\text{angle\_radians}) = \text{weight}$ 
// So, Tension  $T = \text{weight} / \cos(\text{angle\_radians})$ 
// Summing forces in the horizontal direction:
//  $F = T \cdot \sin(\text{angle\_radians})$ 
// Substitute T into the equation for F:
//  $F = (\text{weight} / \cos(\text{angle\_radians})) \cdot \sin(\text{angle\_radians})$ 
//  $F = \text{weight} \cdot \tan(\text{angle\_radians})$ 

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;
```

```
// 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:
    #  $T \cdot \cos(\text{angle\_radians}) = \text{weight}$ 
    # So, Tension  $T = \text{weight} / \cos(\text{angle\_radians})$ 

    # Summing forces in the horizontal direction:
    #  $F = T \cdot \sin(\text{angle\_radians})$ 
    # Substitute T into the equation for F:
    #  $F = (\text{weight} / \cos(\text{angle\_radians})) \cdot \sin(\text{angle\_radians})$ 
    #  $F = \text{weight} \cdot \tan(\text{angle\_radians})$ 
```

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
    })
```