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

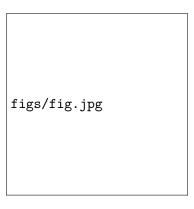


Figure: 1

Theoretical Solution

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

$$T\sin 30^{\circ} - F = 0, \tag{1}$$

$$T\cos 30^{\circ} - 100 = 0. \tag{2}$$

$$\frac{1}{2}T - F = 0, \tag{3}$$

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

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:

$$\begin{pmatrix}
\frac{1}{2} & -1 & 0 \\
\frac{\sqrt{3}}{2} & 0 & 100
\end{pmatrix}$$
(6)

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

$$\begin{pmatrix}
1 & -2 & | & 0 \\
\sqrt{3} & 0 & | & 200
\end{pmatrix}$$
(7)

Theoretical Solution

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

$$\begin{pmatrix}
1 & -2 & | & 0 \\
0 & 2\sqrt{3} & | & 200
\end{pmatrix}$$
(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, $F \approx 57.7 \text{ N}$.

C Code

```
#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
   })
```