# 12.330

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# Question

If a weight of $\mathbf{P} = 100N$ is supported by two massless strings connected to the walls as shown in the figure, the value of $T_1$ is _____ N.

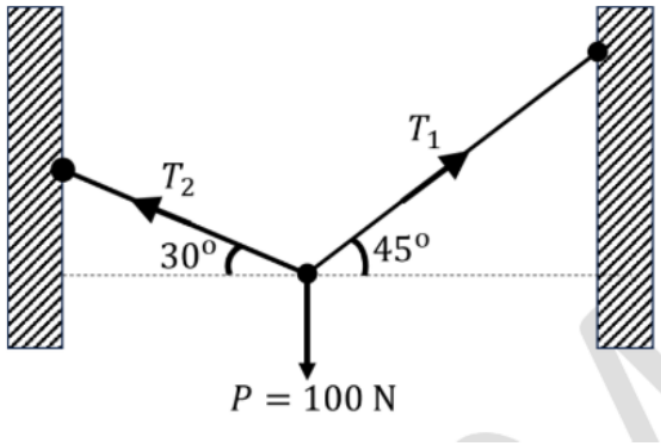


Figure: Figure

# Solution

$$\mathbf{T_1} + \mathbf{T_2} = -\mathbf{P} \tag{1}$$

$$\mathbf{T_1} = \|T_1\| \begin{pmatrix} \cos 45 \\ \sin 45 \end{pmatrix} \tag{2}$$

$$\mathbf{T_2} = \|T_2\| \begin{pmatrix} \cos 180 - 30 \\ \sin 180 - 30 \end{pmatrix} = \|T_2\| \begin{pmatrix} \cos 150 \\ \sin 150 \end{pmatrix} \tag{3}$$

$$\mathbf{P} = -\|P\| \begin{pmatrix} \cos -90 \\ \sin -90 \end{pmatrix} = -100 \begin{pmatrix} \cos(-90) \\ \sin(-90) \end{pmatrix} \tag{4}$$

Therefore:

$$\|T_1\| \begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix} + \|T_2\| \begin{pmatrix} -\frac{\sqrt{3}}{2} \\ \frac{1}{2} \end{pmatrix} = 100 \begin{pmatrix} 0 \\ 1 \end{pmatrix} \tag{5}$$

$$\begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{2} \end{pmatrix} \begin{pmatrix} \|T_1\| \\ \|T_2\| \end{pmatrix} = \begin{pmatrix} 0 \\ 100 \end{pmatrix} \tag{6}$$

Organising the data into an augmented matrix and obtaining RREF:

$$\left(\begin{array}{cc|c} \frac{1}{\sqrt{2}} & -\frac{\sqrt{3}}{2} & 0 \\ \frac{1}{\sqrt{2}} & \frac{1}{2} & 100 \end{array}\right) \xrightarrow{R_2 \to R_2 - R_1} \left(\begin{array}{cc|c} \frac{1}{\sqrt{2}} & -\frac{\sqrt{3}}{2} & 0 \\ 0 & \frac{1}{2} + \frac{\sqrt{3}}{2} & 100 \end{array}\right) \tag{7}$$

# Solution

$$\|T_2\| = \frac{200}{1+\sqrt{3}} = 73.205N \tag{8}$$

$$\|T_1\| = \frac{\sqrt{3}}{\sqrt{2}}\|T_1\| = 89.658N \tag{9}$$

# Code

```
import numpy as np
import numpy.linalg
import matplotlib.pyplot as plt
import math

matrix = np.array([[math.cos(math.pi/4), math.cos(5*math.pi/6)],
                   [math.sin(math.pi/4), math.sin(5*math.pi/6)]])

vec = np.array([0,100])

norms = np.linalg.solve(matrix,vec)

print(norms)

fig = plt.figure(figsize = (10,10))
ax = fig.add_subplot(111)
```

# Code

```
ax.axhline(y=0, color='k')
ax.axvline(x=0, color='k')

ax.quiver(0,0,0,-100, color = 'Blue', label = 'P = 100N', angles=
    'xy', scale_units='xy', scale=1)
ax.quiver(0,0, norms[0]*matrix[0,0], norms[0]*matrix[1,0], color
    = 'green', label = f$T_1 = ${round(norms[0],2)}N, angles='xy'
    , scale_units='xy', scale=1)
ax.quiver(0,0, norms[1]*matrix[0,1], norms[0]*matrix[1,1], color
    = 'orange', label = f$T_2 = ${round(norms[1],2)}N, angles='xy
    ', scale_units='xy', scale=1)


ax.set_xlim(-100, 100)
ax.set_ylim(-100, 100)
ax.legend()
ax.grid(True)
plt.show()
```

# Figure

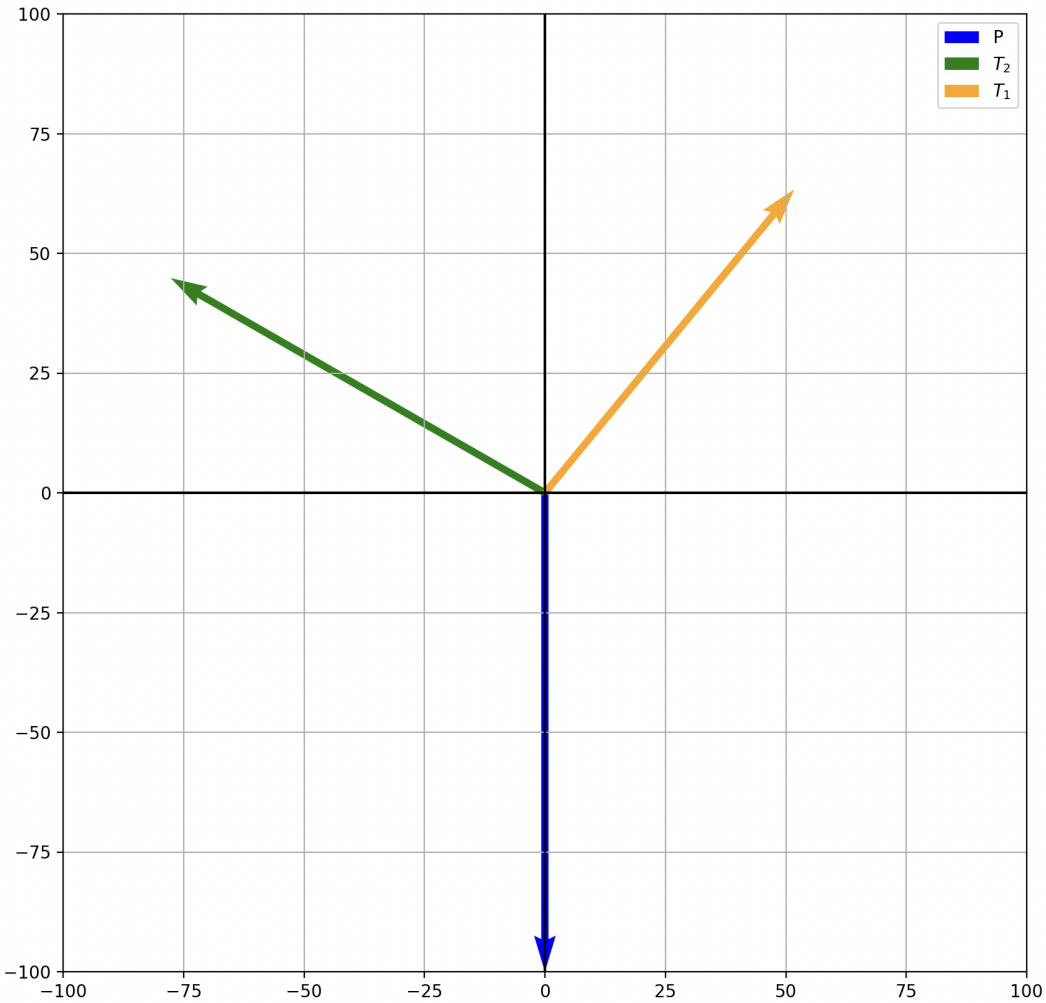


Figure: Plot