

2. 17 Calculate The Tension In The Cable At B Required To Support The Load Of 200 Kg. The Cable Passes

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Understanding how to calculate the tension in a cable supporting a load is a fundamental concept in physics and engineering, especially in statics and structural analysis. When a cable passes over pulleys or supports, it distributes the load across its length, and calculating the tension at specific points is crucial for ensuring safety, stability, and efficiency of structures such as bridges, cranes, and elevators.

In this article, we delve into the detailed process of calculating the tension in the cable at point B, which is required to support a load of 200 kg. We will explore the underlying principles, assumptions, and step-by-step methods to determine the tension accurately. This comprehensive discussion aims to enhance your understanding of cable mechanics and static equilibrium, whether you are a student, engineer, or enthusiast.

Understanding the Problem Context

Before jumping into calculations, it's essential to understand the typical scenario involving a cable supporting a load. Usually, such problems involve:

- A load of known weight (here, 200 kg)
- A cable passing over pulleys or supports at various points (including point B)
- Inclined or vertical orientations of the cable
- Additional supports or angles influencing tension distribution

Assumptions commonly made in such problems include:

- The cable is massless and inextensible
- The pulleys are frictionless
- The system is in static equilibrium (no acceleration)
- The load is stationary

Converting the Load to Force

Since tension calculations involve forces, the first step is to convert the load's mass into its weight

(force due to gravity):

1. Mass of the load, $m = 200 \text{ kg}$
2. Acceleration due to gravity, $g = 9.81 \text{ m/s}^2$

Calculating the weight (force):

$$W = m \times g = 200 \text{ kg} \times 9.81 \text{ m/s}^2 = 1962 \text{ N}$$

This force (approximately 1962 N) acts vertically downward.

Analyzing the Cable System

The exact calculation depends on the configuration of the cable system. Typically, such a problem involves:

- The load hanging from the cable at point C
- The cable passing over pulleys at points A and B
- The cable being fixed at certain points or passing over an inclined path

Common configurations include:

- A simple inclined cable supporting a load through pulleys
- Multiple segments with different angles
- Symmetrical or asymmetrical arrangements

For illustration, consider the following standard scenario:

- The load of 200 kg is attached at point C
- The cable passes over pulleys at points A and B
- Point B is a pulley or support point where tension needs to be calculated
- The cable segment from B to the load makes an angle θ with the horizontal or vertical

Applying Static Equilibrium Principles

To find the tension at point B, we apply the conditions of static equilibrium:

- Sum of forces in horizontal direction = 0
- Sum of forces in vertical direction = 0

These principles allow us to set up equations based on the geometry and known forces.

Step-by-Step Calculation of Tension at B

Below are the typical steps involved in calculating the tension at point B:

1. Draw a Free-Body Diagram (FBD)

- Indicate all forces acting on the load and the cable segments
- Show tensions T_1 and T_2 in various segments
- Include weights acting downward

2. Resolve Forces Along the Cable Segments

- For inclined segments, resolve tension into horizontal and vertical components
- Use the angles of the cable segments to relate tensions

3. Write Equilibrium Equations

- For the load:

$$\begin{aligned} \sum F_{\text{vertical}} &= T_{\text{vertical}} - W = 0 \end{aligned}$$

- For the segment at B:

$$\begin{aligned} \sum F_{\text{horizontal}} &= T_{\text{horizontal}} = 0 \\ \sum F_{\text{vertical}} &= T_{\text{vertical}} - \text{support reactions} = 0 \end{aligned}$$

4. Express Tensions Using Geometry

- If the cable makes an angle θ with the horizontal, then:

$$T_{\text{vertical}} = T \sin \theta$$

$$T_{\text{horizontal}} = T \cos \theta$$

- Use these relations to express the tensions in terms of known angles and the load force

5. Solve the Equations for Tension at B

- Combine the equilibrium equations to isolate Tension at B (T_B)

Sample Calculation with Assumed Angles

Suppose the cable segments form known angles:

- Angle θ_1 at point B with the horizontal
- The load hangs vertically downward

Given:

- Load weight, $W = 1962 \text{ N}$
- Angle $\theta_1 = 30^\circ$

Calculations:

- Vertical component of tension T_B :

$$T_{B,\text{vertical}} = T_B \sin 30^\circ = 0.5 T_B$$

- The vertical equilibrium condition at the load:

$$T_{B,\text{vertical}} = W$$

$$0.5 T_B = 1962$$

$$T_B = \frac{1962}{0.5} = 3924 \text{ N}$$

This indicates the tension at point B must be approximately 3924 N to support the load, given the

assumed angle.

Note: Actual angles and system configurations can significantly affect the tension calculations, so precise measurements or diagrams are essential.

Factors Affecting Tension Calculations

Several factors influence the tension in the cable at point B:

- Angles of the cable segments: Steeper angles generally increase tension.
- Number of supports and pulleys: More supports can distribute load differently.
- Mass of the cable: If cable mass is significant, it adds to the load.
- Friction in pulleys: Frictional forces can alter tension.
- Additional loads or forces: Wind, dynamic forces, or other loads impact tension.

Practical Considerations and Safety Factors

In engineering practice, it's crucial to incorporate safety factors into tension calculations to account for uncertainties, material fatigue, and dynamic effects.

- Typical safety factor: 1.5 to 3 times the calculated tension
- Material strength: Ensure the cable's maximum tensile strength exceeds the maximum expected tension
- Inspection and maintenance: Regularly check for wear and tear

Conclusion

Calculating the tension in a cable supporting a 200 kg load involves understanding the system's geometry, applying static equilibrium principles, and accurately resolving forces. The key steps include converting the load to force, analyzing the cable configuration, resolving tensions into components based on angles, and solving the resulting equations.

While simplified assumptions help illustrate the process, real-world applications require precise measurements, consideration of additional factors, and safety margins. Mastery of these calculations is essential for designing safe and efficient structural systems in civil, mechanical, and electrical engineering.

Keywords: tension in cable, static equilibrium, load support, cable mechanics, pulley system, tension calculation, structural analysis, engineering safety, cable angles, load support calculations

Frequently Asked Questions

How do you calculate the tension in a cable supporting a 200 kg load?

To calculate the tension, you need to analyze the forces acting on the cable, typically using static equilibrium equations, considering the weight (mass $\times$ gravity) and the angles involved.

What is the formula to find the tension in a cable supporting a load?

The tension T can be found using $T = W / (2 \times \sin\theta)$, where W is the weight of the load and θ is the angle the cable makes with the horizontal.

How does the angle of the cable affect the tension needed to support a load?

As the angle increases (the cable becomes more vertical), the tension decreases; at smaller angles (more horizontal), tension increases significantly to support the same load.

What is the weight of a 200 kg load that the cable supports?

The weight W is calculated as $W = \text{mass} \times \text{gravity} = 200 \text{ kg} \times 9.81 \text{ m/s}^2 = 1962 \text{ N}$.

If the cable passes over a pulley at point B, how does that influence tension calculation?

The pulley redirects the cable but ideally doesn't change the tension in an ideal frictionless scenario; the tension depends on the load and the cable's angle relative to the support.

What assumptions are made when calculating cable tension in such problems?

Assumptions typically include neglecting cable weight, friction, and deformation, and assuming the system is in static equilibrium.

How do you determine the angle at which the cable passes in this problem?

The angle can be determined from the geometry of the setup, such as the height of support points and the horizontal distance between them, using trigonometry.

What units should be used for calculating tension in this scenario?

Force should be calculated in Newtons (N), mass in kilograms (kg), and angles in degrees or radians, ensuring consistency throughout calculations.

Can the tension in the cable exceed the weight of the load?

Yes, especially if the cable angle is small, the tension can be several times the load's weight due to geometric effects and the need to balance forces.

What safety factors should be considered when designing a cable support system for 200 kg load?

A safety factor (often 4 to 6 times the calculated tension) should be included to account for dynamic loads, material imperfections, and unforeseen stresses to ensure safety and durability.

Additional Resources

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Introduction

In the realm of engineering and physics, understanding the forces acting on a system is critical for ensuring safety, stability, and efficiency. One common problem involves calculating the tension in a cable supporting a load, especially when the cable system involves multiple segments passing over pulleys or anchoring points. The specific problem—"Calculate the tension in the cable at B required to support the load of 200 kg, where the cable passes"—serves as a classic example illustrating the principles of static equilibrium, force resolution, and tension distribution.

This article undertakes a comprehensive investigation into this problem, dissecting the underlying mechanics, exploring various configurations, and providing step-by-step methodologies for calculating the tension. The goal is to clarify the principles involved, analyze typical scenarios, and offer insight into practical applications.

Understanding the Problem Context

Before diving into calculations, it is essential to clarify the problem's scope and assumptions:

- Load: 200 kg, which translates to a weight (force due to gravity) of approximately 1960 N (assuming $g = 9.8 \text{ m/s}^2$).
- Cable: Assumed to be massless and inextensible for simplicity.
- Support Points: The cable passes over pulley(s) or fixed points, with point B being a critical point

where tension is to be calculated.

- Configuration: The specific pathway of the cable is not fully specified, but typically involves a load suspended via a cable passing over pulleys, with segments passing through multiple points like A, B, etc.

Fundamental Principles of Tension Calculation

The core principles involved are:

1. Static Equilibrium

For the loaded cable system to be in equilibrium:

- The sum of forces in any direction must be zero.
- The sum of moments about any point must be zero.

2. Force Resolution in Inclined Cables

When cables are inclined, tension components resolve into horizontal and vertical parts, contributing to equilibrium.

3. Symmetry and Load Distribution

Depending on the configuration, tension may be distributed equally or unequally, especially when pulleys are frictionless and massless.

Typical Configurations and Their Analysis

To illustrate the calculation process, consider two common configurations:

Configuration 1: Single Load with Vertical Support

Imagine a load of 200 kg hanging from a cable passing over a pulley at point B, which is connected to supports or other anchors.

Assumptions:

- The cable from B passes over a pulley at B and supports the load directly.
- The tension in the cable at B supports the entire load.

Calculation:

- Weight (W) = $200 \text{ kg} \times 9.8 \text{ m/s}^2 = 1960 \text{ N}$
- Tension (T) at B = $W = 1960 \text{ N}$

In this straightforward case, the tension in the cable at B equals the load's weight, assuming no other forces or angles.

Configuration 2: Inclined Cable with Multiple Pulleys

A more complex scenario involves a load suspended by a cable passing over pulleys at points A and B, with the cable inclined at certain angles.

Diagram:

...
Load (200 kg)
|
|
/\
/\
A B
| |
Supports
...

Assumptions:

- The cable segments form angles θ_1 at A and θ_2 at B.
- The load is suspended at a point between A and B.
- The pulleys are frictionless.

Step-by-Step Calculation:

Step 1: Resolve forces at the load

Let T_1 and T_2 be the tensions in the segments passing over pulleys at A and B, respectively.

- Vertical equilibrium:

$$T_1 \sin \theta_1 + T_2 \sin \theta_2 = W$$

- Horizontal equilibrium (if applicable):

$$T_1 \cos \theta_1 = T_2 \cos \theta_2$$

If the cable is symmetric and angles are equal (θ), then:

$$T_1 = T_2 = T$$

$$\text{- Vertical component: } 2 T \sin \theta = W$$

- Therefore,

$$T = W / (2 \sin \theta)$$

Step 2: Calculate Tension at B

- If $T_2 = T$, then the tension in the cable passing over pulley B (at point B) is T_2 .

- From above:

$$T = W / (2 \sin \theta)$$

Example:

Suppose $\theta = 30^\circ$, then:

$$\sin 30^\circ = 0.5$$

$$T = 1960 \text{ N} / (2 \times 0.5) = 1960 \text{ N} / 1 = 1960 \text{ N}$$

Thus, the tension at B, T_2 , is approximately 1960 N.

Advanced Considerations

While the above models assume ideal conditions, real-world scenarios involve additional factors:

1. Friction in Pulleys

Friction reduces the tension transmitted and may require higher tension calculations.

2. Mass of the Cable and Pulley

Massive cables or pulleys introduce additional forces and may necessitate dynamic analysis.

3. Multiple Loads and Dynamic Loads

Multiple loads or moving loads involve complex force distributions and potentially dynamic analysis.

Practical Applications and Safety Margins

In engineering practice, safety factors are incorporated. For example, if the calculated tension is T , engineers often select cable ratings exceeding T by a safety margin (e.g., 1.5 to 2 times T).

Summary of Calculation Methodology

Step	Action	Notes
1	Determine load force (W)	Convert kg to N
2	Identify cable configuration	Geometry and angles
3	Resolve forces	Use equilibrium equations
4	Calculate tension T	Based on geometry and load
5	Consider real-world factors	Friction, mass, safety margins

Concluding Remarks

Calculating the tension in a supporting cable, especially at a specific point like B supporting a load of 200 kg, involves understanding the system's geometry, applying static equilibrium principles, and considering real-world effects. While straightforward in simple cases—where tension equals the load weight in vertical, direct suspensions—in more complex arrangements, angles, pulley arrangements, and additional forces significantly influence the tension.

Engineers must carefully analyze each scenario, often employing free-body diagrams and resolving components systematically. Proper calculation ensures the safety and reliability of lifting systems, bridges, cranes, and various structural applications.

This investigation underscores the importance of a thorough understanding of mechanics fundamentals, meticulous analysis, and prudent safety considerations in all cable-supported structures.

References

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Note: For precise calculations tailored to specific configurations, detailed diagrams and exact angles are necessary. The above analysis provides a foundational understanding applicable to common scenarios.

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