# A 10-fit Chain Weighs 25 Lb And Hangs From A Celing. Find The Work Done In Lifting The Lower End Of The

**A 10-fit Chain Weighs 25 Lb And Hangs From A Celing. Find The Work Done In Lifting The Lower End Of The** chain to a certain height is a classic problem in physics and engineering that involves calculating the work required to lift an object against gravity. This scenario is commonly encountered when analyzing the energy needed to lift chains, ropes, or cables, especially when their weight distribution varies along their length. Understanding how to approach such problems involves applying principles of calculus, specifically integration, to account for the changing weight as you lift different segments of the chain. In this article, we will explore the problem in detail, discuss the underlying concepts, and walk through the step-by-step process to find the work done in lifting the lower end of a chain hanging from the ceiling.

## Understanding the Problem: Chain Hanging from the Ceiling

### Details of the Chain

The problem provides specific measurements:

- Length of the chain: 10 feet
- Weight of the chain: 25 pounds

This indicates that the chain's weight per unit length is constant, which simplifies calculations since the chain is uniform.

### What Is Being Asked?

The goal is to find the total work done in lifting the lower end of the chain to a certain height—often to the ceiling level or a specified height. For the purpose of this problem, we assume the chain is lifted to the ceiling, which is at the same level as where the chain hangs from.

# Fundamental Concepts: Work, Force, and Weight Distribution

## Work Done Against Gravity

Work is defined as the energy transferred when a force moves an object over a distance. When lifting an object against gravity, the work done (W) can be calculated as:

- W = Force × Distance

However, since the chain's weight varies along its length during lifting, the calculation involves integrating the incremental work over the chain's length.

## Uniform Chain and Weight Distribution

Because the chain is uniform:

- Weight per unit length (w) = Total weight / Length
- w = 25 lb / 10 ft = 2.5 lb/ft

This uniformity allows us to analyze the problem in a straightforward manner, considering small segments of the chain.

# Calculating the Work Done in Lifting the Chain

## Setting Up the Coordinate System

To analyze the problem:

- Let y be the vertical coordinate, with y = 0 at the ceiling and y increasing downward.
- The chain initially hangs from the ceiling, with its lower end at y = 10 ft.
- When lifting, we lift the lower end from y = 10 ft to y = 0 ft (the ceiling level).

## Modeling the Chain During Lifting

As we lift the chain:

- The length of the chain remaining hanging decreases from 10 ft to 0 ft.
- The weight of the chain segments at different stages varies, so we consider a differential element of the chain at position y.

## Calculating the Differential Work

At a particular stage:

- Consider a small segment of the chain at position y, with length dy.
- The weight of this segment is w × dy = 2.5 lb/ft × dy.
- This segment must be lifted a distance of y to reach the ceiling.

Therefore, the differential work (dW) to lift this segment is:

dW = (weight of segment) × (height it is lifted)
= (2.5 × dy) × y

## Integrating to Find Total Work

To find the total work, integrate dW with respect to y from y = 10 ft (initial position of the bottom) to y = 0 ft (final position at the ceiling):

$W = \int_0^{10} 2.5\, y\, dy$

This integral accounts for lifting all segments of the chain from their initial positions up to the ceiling.

# Step-by-Step Calculation of the Work Done

## Performing the Integral

Calculate the integral:

$W = 2.5 \int_0^{10} y\, dy$

The integral of y with respect to y is:

$\int y \, dy = y^2 / 2$

Applying limits:

$$W = 2.5 \times (10^2 / 2 - 0^2 / 2) = 2.5 \times (100 / 2) = 2.5 \times 50 = 125 \text{ ft-lb}$$

### Interpreting the Result

The total work done in lifting the lower end of the chain to the ceiling is 125 foot-pounds. This represents the energy required to lift all the segments of the chain from their initial hanging positions to the ceiling.

## Additional Considerations and Real-World Applications

### Impact of Chain Density and Material

While the example assumes a uniform chain, variations in material density or non-uniform weight distribution can complicate the calculations. In such cases, the integral setup remains similar, but the weight per unit length (w) becomes a function of y.

### Applications in Engineering and Construction

Understanding the work involved in lifting chains, cables, or other materials is essential in designing cranes, hoists, and lifting equipment. Accurate calculations ensure safety, efficiency, and cost-effectiveness in construction, manufacturing, and logistics.

### Extensions to Other Problems

The approach used here can be extended to various problems involving:

- Ropes of varying density
- Objects lifted through different heights
- Multiple segments with different weights
- Inclined lifting scenarios

## Summary: Key Takeaways

- The problem involves calculating the work to lift a uniform chain from hanging to a fixed height.
- The weight per unit length is found by dividing total weight by total length.
- Differential work considers small segments of the chain, integrating over the entire length.
- The integral setup effectively accounts for the varying heights of different segments during lifting.
- The total work calculated provides insight into the energy required for such tasks and helps in designing appropriate lifting equipment.

## Final Thoughts

Calculating the work done in lifting a chain hanging from the ceiling demonstrates the power of calculus in solving real-world physics problems. Whether in engineering, construction, or physics education, understanding how to set up and evaluate these integrals is crucial. The example of a 10-foot, 25-pound chain highlights the importance of considering weight distribution and the changing position of segments during lifting. By mastering these principles, professionals and students can accurately assess the energy requirements for various lifting and lifting-related tasks.

If you are tackling similar problems, remember to:
- Clearly define your coordinate system.
- Express the weight of segments as a function of position.
- Set up the integral to sum the work over the entire length or height.
- Carefully evaluate the integral to find the total work.

This approach ensures precise calculations and a deeper understanding of the physical principles involved in lifting objects under gravity.

## Frequently Asked Questions

### What is the main concept used to calculate the work done in lifting a chain from the ceiling?

The main concept is to integrate the weight of each segment of the chain as it is lifted to the ceiling, considering the varying tension along the chain's length.

### How do you determine the weight per unit length of the chain?

Divide the total weight of the chain by its length: weight per unit length =

25 lb / 10 ft = 2.5 lb/ft.

## What is the significance of setting up an integral in this problem?

The integral accounts for the varying amount of chain being lifted at each point, calculating the total work by summing the infinitesimal work done to lift each segment.

## How do you express the variable length of the chain being lifted during the work calculation?

If we measure from the bottom end, at a height x (from the bottom), the length of chain to lift is (10 - x) ft, and the weight of that segment is (2.5)(10 - x) lb.

## What is the formula for calculating the work done in lifting the chain?

Work = ∫ from x=0 to x=10 of (weight per unit length) (distance lifted) dx, which simplifies to $\int_0^{10} 2.5(10 - x) x \, dx$.

## What is the final calculated work done in lifting the lower end of the chain?

Evaluating the integral, the work done is 625 foot-pounds.

## Why is it important to consider the chain's weight distribution in this problem?

Because the tension varies along the chain's length, and ignoring the weight distribution would lead to incorrect calculation of the work required to lift it.

# Additional Resources

A 10-ft Chain Weighs 25 Lb And Hangs From A Ceiling: Find The Work Done In Lifting The Lower End Of The Chain

Understanding the dynamics of lifting objects, especially chains, involves delving into concepts of physics such as work, energy, and force distribution. The problem of a 10-foot chain weighing 25 pounds hanging from a ceiling offers an excellent case study to explore these principles. It encompasses the calculation of work done in lifting the lower end of the chain to a certain height, considering the variation in the chain’s weight distribution and the changing force as the chain is lifted.

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# Introduction to Work and Its Relevance in Lifting Chains

Work, in physics, is defined as the product of the force applied to an object and the displacement in the direction of that force. When lifting objects like chains, the work done depends on the weight of the object and the height it is lifted. However, for objects with varying weight distribution, like a chain hanging from a ceiling, the calculation becomes more nuanced.

In this particular scenario, we have a chain of length 10 feet, weighing 25 pounds, hanging from the ceiling. The goal is to determine the work done in lifting the lower end of the chain to the ceiling, effectively lifting the entire chain upward by 10 feet. This problem is rooted in integral calculus, as the force exerted varies along the length of the chain as it is lifted.

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## Understanding the Physical Setup

### The Chain's Properties

- Length: 10 feet
- Total weight: 25 pounds
- Weight per unit length: \(\frac{25\, \text{lb}}{10\, \text{ft}} = 2.5\, \text{lb/ft}\)

### The Lifting Process

- The chain hangs vertically from the ceiling.
- The lower end of the chain is lifted to the ceiling position (i.e., moved upward by 10 feet).
- The work done involves lifting each segment of the chain through its respective distance.

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## Mathematical Model of the Problem

The key to solving this problem is understanding how the weight distribution affects the work calculation.

## Force at a Given Point

At any point along the chain, the weight being lifted is proportional to the length of the chain below that point.

Suppose we define:
- $x$: the distance from the ceiling down to a point on the chain.
- When lifting the chain, the lower end (at $x=0$) is lifted to the ceiling (to $x=10$ ft).

The force required to lift the segment at height $x$ is the weight of the chain below that point, which is:
$$ F(x) = \text{weight per unit length} \times \text{length of chain below } x = 2.5 \times x $$

The work done moving the chain from its initial position to the ceiling involves integrating the force over the distance lifted.

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# Calculating the Work Done

## Integral Approach

The work $W$ in lifting the entire chain can be calculated by integrating the force over the displacement as each segment is lifted.

Since the chain is lifted from $x=0$ to $x=10$ feet, and each segment must be moved through a distance equal to $x$, the differential work $dW$ for a small segment at height $x$ is:

$$ dW = F(x) \times dx = 2.5x \, dx $$

To find total work, integrate from 0 to 10:

$$
W = \int_{0}^{10} 2.5x \, dx
$$

Calculating the integral:

$$
W = 2.5 \int_{0}^{10} x \, dx = 2.5 \times \left[ \frac{x^2}{2} \right]_0^{10} = 2.5 \times \frac{10^2}{2} = 2.5 \times \frac{100}{2} = 2.5 \times 50 = 125\, \text{ft-lb}
$$

Result: The work done in lifting the lower end of the chain to the ceiling is 125 foot-pounds (ft-lb).

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# Key Features and Insights

- The calculation considers the chain's weight distribution, which increases linearly from zero at the top to maximum at the bottom.
- The integral approach effectively accounts for the varying force needed to lift each segment.
- The total work is proportional to the square of the chain's length, highlighting how longer chains require significantly more work.

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# Alternative Approaches and Considerations

While the integral method is standard for such problems, alternative approaches might involve approximate methods or different coordinate systems. However, the integral approach provides an exact solution based on calculus principles.

Considerations include:
- The assumption of uniform weight distribution.
- Neglecting friction or other forces besides gravity.
- The efficiency of lifting mechanisms, which could alter real-world work calculations.

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# Pros and Cons of the Calculation Method

Pros:
- Accurate representation of variable forces in lifting scenarios.
- Provides an exact value based on calculus.
- Useful in engineering applications for designing lifting equipment.

Cons:
- Requires understanding of calculus and integral calculus.
- Assumes uniform weight distribution; real chains may have irregularities.
- Does not account for dynamic factors like acceleration or friction.

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## Practical Implications and Applications

This analysis is critical in fields such as mechanical engineering, construction, and material handling, where precise calculations of work and energy are necessary for safety and efficiency.

Applications include:
- Designing hoisting equipment.
- Calculating energy requirements for lifting tasks.
- Assessing safety margins for lifting heavy objects.

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## Conclusion

The problem of determining the work done in lifting a chain from hanging to a ceiling position exemplifies the intersection of physics and calculus. By understanding how force varies along the length of the chain and applying integral calculus, one can accurately compute the total energy expended in such a task. The calculation reveals that lifting a 10-foot, 25-pound chain requires approximately 125 ft-lb of work, emphasizing the importance of precise mathematical modeling in real-world engineering and physics problems. Whether for educational purposes or practical applications, mastering these principles is essential for professionals involved in mechanics, construction, and material handling.

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