An Apple Weighs 1.02 N . When You Hang It From The End Of A Long Spring Of Force Constant 1.50 N/m And

An Apple Weighs 1.02 N . When You Hang It From The End Of A Long Spring Of Force Constant 1.50 N/m And is a fascinating scenario that combines principles of physics, specifically Hooke's Law, to understand the behavior of elastic springs and the forces involved when an object is suspended from them. This article explores the physics behind this situation, providing insights into how springs work, calculating the extension of the spring when an apple is hung, and understanding the implications of the force constant and weight. Whether you're a physics student, a science enthusiast, or just curious about the mechanics of everyday objects, this comprehensive guide will deepen your understanding of how forces interact in such systems.

Understanding the Basics: Weight, Force, and Springs

The Weight of the Apple

The apple in this scenario weighs 1.02 Newtons. Weight is a force that results from gravity acting on an object's mass. It is calculated using the formula:

- **Weight (W) = mass (m) × acceleration due to gravity (g)**

Given that the weight is 1.02 N, and assuming standard gravity ($g \approx 9.81\ m/s^2$), the mass of the apple can be determined as:

- $m = W / g \approx 1.02\ N / 9.81\ m/s^2 \approx 0.104\ kg$

This small mass illustrates how even a modest object can exert a measurable force due to gravity.

Hooke’s Law and Spring Force

When an object is hung from a spring, the spring exerts an equal and opposite force known as the restoring force. Hooke's Law describes this behavior:

- $\mathbf{F_s = -k \times x}$

Where:

- *F_s* is the spring force,
- *k* is the spring constant (force constant),
- *x* is the extension or compression of the spring from its equilibrium position.

The negative sign indicates that the force exerted by the spring opposes the displacement. When the apple is hanging, the spring stretches until the restoring force balances the weight of the apple.

Calculating the Extension of the Spring

The key to understanding how much the spring stretches is to balance the forces acting on the apple.

Equilibrium Condition

In equilibrium, the upward force exerted by the spring equals the downward gravitational force (the weight):

- **$F_s = W$**

Substituting Hooke's Law:

- **$k \times x = W$**

Rearranged to solve for the extension:

- **$x = W / k$**

Given:
- $W = 1.02$ N
- $k = 1.50$ N/m

The extension x is:

- $x = 1.02$ N / 1.50 N/m ≈ 0.68 meters

This means the spring stretches approximately 0.68 meters when the apple is hanging from it.

Implications of the Extension

A stretch of approximately 0.68 meters (or about 68 centimeters) is quite significant, indicating the spring must be long enough to accommodate this extension without overstretching or risking damage. This extension reflects how elastic the spring is and provides insights into the design considerations for such systems.

Analyzing the System: Long Spring with Force Constant 1.50 N/m

Spring Constant and Its Significance

The spring constant, k = 1.50 N/m, measures the stiffness of the spring. A higher k value indicates a stiffer spring, which stretches less under the same load, while a lower k value indicates a more elastic spring that stretches more.

- In this case, 1.50 N/m is moderate, meaning the spring is neither too stiff nor too elastic.

Effect of Spring Length and Material

The length and material of the spring influence its force constant. Longer springs tend to be less stiff, resulting in a lower k value, while springs made of more elastic materials tend to have lower force constants. The design of such springs is crucial when considering applications in machinery, measurement devices, or even in everyday objects like bouncy toys or suspension systems.

Practical Applications and Considerations

Measuring Weight Using a Spring Scale

One of the most common uses of springs is in spring scales, which measure weight based on the extension of a spring under load. The principles discussed here underpin the design of these devices, allowing for precise measurement of objects' weights.

Designing Spring-Loaded Systems

Understanding the relationship between weight, spring constant, and extension is vital in engineering. For example:
- Designing suspension systems in vehicles,
- Creating measurement devices,
- Developing toys and mechanical devices that rely on spring action.

Limitations and Safety Considerations

When designing or using spring-based systems, safety is paramount:
- Avoid overstretching springs beyond their elastic limit to prevent permanent deformation,
- Ensure the spring length accommodates maximum expected loads,
- Regularly inspect for wear and tear.

Conclusion: The Interplay of Force, Spring Constant, and Extension

The scenario of an apple weighing 1.02 N hanging from a spring with a force constant of 1.50 N/m illustrates fundamental physics principles in action. By understanding how the weight of the apple translates into a specific extension of the spring, we gain insights into elastic behavior, force equilibrium, and practical applications.

In summary:
- The apple's weight is about 1.02 N, corresponding to a mass of roughly 0.104 kg.
- The spring stretches approximately 0.68 meters under this load.
- The spring constant of 1.50 N/m indicates a moderate stiffness, influencing how much the spring extends.
- These principles are vital in designing measuring devices, mechanical systems, and understanding everyday phenomena involving springs.

By mastering these concepts, students and professionals alike can better analyze and design systems that involve elastic forces, ensuring safety, accuracy, and efficiency in various applications.

Frequently Asked Questions

What is the weight of the apple in kilograms?

The weight of the apple is approximately 0.104 kilograms, since weight (N) divided by gravity (9.8 m/s^2) gives mass: 1.02 N / 9.8 $m/s^2 \approx 0.104$ kg.

What is the extension of the spring when the apple is hung from it?

Using Hooke's Law, extension x = weight / spring constant = 1.02 N / 1.50 N/m ≈ 0.68 meters.

How does the spring constant affect the extension caused by the apple's weight?

A higher spring constant results in less extension for the same weight, while a lower spring constant causes more extension. In this case, a spring of 1.50 N/m stretches approximately 0.68 meters under the apple's weight.

What is the potential energy stored in the spring when the apple is hanging?

The potential energy stored is (1/2) spring constant extension² = 0.5 1.50 N/m (0.68 m)² ≈ 0.35 Joules.

If the spring's force constant were doubled, how would the extension change?

Doubling the spring constant to 3.00 N/m would reduce the extension to approximately 0.34 meters, halving the original extension of 0.68 meters.

What is the significance of the force constant in the context of this problem?

The force constant (spring constant) determines how much force is needed to stretch or compress the spring by a certain amount. It directly relates to how much the spring extends under a given weight.

Is the spring within its elastic limit when the apple is hanging?

Assuming typical spring properties and an extension of 0.68 meters, it is likely within the elastic limit, meaning the spring would return to its original length after the load is removed. However, this depends on the specific spring's elastic limit, which is not specified.

Additional Resources

Apple Weighs 1.02 N: An In-Depth Exploration of Weight, Force, and Spring Dynamics

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Introduction

When we consider everyday objects like an apple, our intuitive understanding of weight usually stops at the familiar measurements in grams or ounces. However, delving deeper into the physics reveals a fascinating interplay between force, mass, and mechanical systems such as springs. In this article, we explore the scenario where an apple weighing 1.02 N is suspended from a long spring with a force constant of 1.50 N/m. This setup provides an excellent opportunity to analyze concepts like force measurement, spring mechanics, and the implications of such a system on understanding weights and forces in a practical and theoretical context.

Understanding the Basic Concepts

Before diving into the specifics of the problem, it's essential to clarify some foundational physics principles.

Force and Weight

- Weight (W): The force exerted on an object due to gravity. It is calculated as:

$$
W = m \times g
$$

where:
- m = mass of the object (kg)
- g = acceleration due to gravity (~9.81 m/s^2 on Earth)

- Force (F): A vector quantity that causes an object to accelerate. Weight is a specific force due to gravity.

Given that the apple weighs 1.02 N, we can determine its mass:

$$
m = \frac{W}{g} = \frac{1.02\, \text{N}}{9.81\, \text{m/s}^2} \approx 0.104\, \text{kg}
$$

which is approximately 104 grams, a typical size for a medium apple.

The Spring System: Force Constant and Mechanical Response

Spring mechanics are fundamental in understanding how objects behave when attached to elastic materials. The key parameter here is the force constant (also called the spring constant), denoted as k.

Force Constant (k)

- It quantifies the stiffness of the spring.
- Defined by Hooke’s Law:

$$
F = -k \times x
$$

where:
- F = restoring force exerted by the spring
- x = displacement of the spring from its natural (unstretched) length

In this scenario, the spring has:

$$
k = 1.50\, \text{N/m}
$$

This means for every meter the spring stretches or compresses, it exerts a force of 1.50 N.

Analyzing the System: Hanging the Apple from the Spring

When the apple is hung from the spring, it exerts a downward force equal to its weight (1.02 N). The spring responds by stretching until the restoring force balances this weight.

Equilibrium Condition

At equilibrium, the upward spring force equals the downward weight:

$$
k \times x = W
$$

where:
- x = extension of the spring under the apple's weight

Rearranging:

$$
x = \frac{W}{k} = \frac{1.02\, \text{N}}{1.50\, \text{N/m}} = 0.68\, \text{m}
$$

This indicates that the spring stretches approximately 0.68 meters when supporting the apple.

Practical Implications of the Spring's Extension

A stretch of nearly two-thirds of a meter is quite significant for a typical laboratory or household spring, suggesting that:

- The spring is relatively flexible or long, designed to accommodate larger displacements.
- The system is idealized; in real-world scenarios, springs may have nonlinear behavior at large extensions, but for this analysis, we're assuming Hooke's Law applies within this range.

Additional Considerations: Dynamics and Measurement

Oscillations and Mechanical Behavior

If the apple is suddenly released or displaced further, the system would oscillate with a period:

$$
T = 2\pi \sqrt{\frac{m}{k}}
$$

Plugging in the values:

$$
T = 2\pi \sqrt{\frac{0.104\, \text{kg}}{1.50\, \text{N/m}}} \approx 2\pi \times 0.268 \approx 1.68\, \text{seconds}
$$

This oscillation period indicates that the system would vibrate approximately every 1.68 seconds if disturbed, revealing the dynamic response of the spring-mass system.

Measuring Force with Springs

This setup also illustrates a fundamental principle in force measurement:

- Spring scales (or force gauges) operate on similar principles, where the displacement of a spring under a known force allows for an accurate measurement of that force.
- The calibration of such devices involves knowing the spring constant precisely.

Broader Context: From Apple to Engineering

While this analysis centers on a simple apple, the principles extend into various fields:

- Biomechanics: Understanding how muscles and tendons behave under load.
- Material Science: Designing springs and elastic materials for specific force and displacement ranges.
- Engineering: Calculating stresses and strains in mechanical systems involving springs and elastic components.
- Education: Demonstrating fundamental physics concepts through tangible experiments.

Real-World Applications and Insights

This scenario underscores several practical insights:

1. Force Measurement Techniques: Using springs to measure forces relies on precise knowledge of spring constants and understanding equilibrium conditions.
2. Designing Elastic Systems: Engineers can tailor spring stiffness to achieve desired displacements under specific loads, critical in suspension systems, clocks, and measuring devices.
3. Understanding Limits: Recognizing the elastic limit of springs prevents permanent deformation, which is vital in designing safe and durable mechanical systems.
4. Educational Value: Simple experiments involving hanging objects from springs help students grasp complex physics concepts intuitively.

Summary of Key Points

- The apple's weight of 1.02 N corresponds to a mass of approximately 104 grams.
- When hung from a spring with a force constant of 1.50 N/m, the spring stretches about 0.68 meters to balance the weight.
- The system exhibits oscillations with a period of roughly 1.68 seconds if disturbed.

- The principles demonstrated are foundational in force measurement, material science, and mechanical engineering.

Conclusion

Analyzing an apple weighing 1.02 N suspended from a spring with a force constant of 1.50 N/m offers a rich exploration of fundamental physics. It exemplifies how forces, elasticity, and oscillations interplay in both everyday objects and complex engineering systems. Such insights deepen our understanding of mechanical behavior, guiding the design of measuring devices, elastic materials, and dynamic systems. Whether for educational purposes or practical applications, this scenario beautifully illustrates the elegance and utility of classical mechanics in describing the world around us.

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