A Person Who Weighs 900 N Stands On A Scale While In An Elevator. The Elevator Is Moving Upward At 12.2

A Person Who Weighs 900 N Stands On A Scale While In An Elevator. The Elevator Is Moving Upward At 12.2

Understanding the intricacies of weight measurement in dynamic situations can be both fascinating and complex. When a person weighing 900 N stands on a scale inside an elevator moving upward at a speed of 12.2 m/s^2, their apparent weight—the reading on the scale—may differ from their actual weight due to the elevator's acceleration. This article explores the physics behind such scenarios, explaining concepts like apparent weight, acceleration, and the forces at play, all while providing a comprehensive understanding suitable for students, educators, and physics enthusiasts.

Fundamentals of Weight and Force

What Is Actual Weight?

- Definition: The actual weight of a person is the force due to gravity acting on their mass.
- Calculation:

$$
W = m \times g
$$

where:
- W = weight in Newtons (N)
- m = mass in kilograms (kg)
- g = acceleration due to gravity (~9.81 m/s^2)

Since the person’s weight is given as 900 N:

$$
m = \frac{W}{g} = \frac{900\, N}{9.81\, m/s^2} \approx 91.65\, kg
$$

Thus, the person's mass is approximately 91.65 kg.

Understanding Apparent Weight

- Definition: Apparent weight is the normal force exerted by the scale, which can vary depending on the acceleration of the system.

- When the elevator accelerates upward, the scale reading (apparent weight) increases.
- Conversely, during downward acceleration, the apparent weight decreases.

Analyzing the Elevator's Motion and Forces

Given Data Summary

- Actual weight of person: 900 N
- Person’s mass: approximately 91.65 kg
- Elevator acceleration: $a = 12.2\, m/s^2$ (upward)

Forces Acting on the Person

- Gravitational force (weight): $W = m \times g$
- Normal force from the scale (apparent weight): N
- The net force causes the upward acceleration.

Application of Newton’s Second Law

In the vertical direction, Newton’s second law states:

$$
\sum F = m \times a
$$

The forces involved:

$$
N - W = m \times a
$$

Rearranged for the normal force:

$$
N = W + m \times a
$$

Since $W = 900\, N$, and $m \times a = 91.65\, kg \times 12.2\, m/s^2$:

$$
m \times a = 91.65 \times 12.2 \approx 1118.2\, N
$$

Therefore, the apparent weight:

\[

$$
N = 900\, N + 1118.2\, N = 2018.2\, N
$$

This means the scale would read approximately 2018.2 N when the elevator accelerates upward at 12.2 m/s².

Understanding the Significance of the Calculations

Why Does the Apparent Weight Change?

- The increase in apparent weight is due to the additional force required to accelerate the person upward.
- The scale measures the normal force, which includes both the person's weight and the force needed for acceleration.
- This principle explains why objects feel heavier during upward acceleration and lighter during downward acceleration.

Implications in Real-World Scenarios

- Elevator safety: Understanding forces helps engineers design elevators capable of handling dynamic loads.
- Physics education: Demonstrates Newton’s laws in everyday situations.
- Medical assessments: Apparent weight variations can affect measurements like body weight in moving vehicles.

Additional Considerations and Complexities

Effects of Different Accelerations

- If the elevator accelerates downward at the same magnitude:
$$
N = W - m \times a
$$
resulting in a lower apparent weight.

- If the elevator moves at constant velocity (no acceleration):
$$
N = W
$$

the scale reads the true weight.

Limitations and Assumptions

- Assumes the elevator's acceleration is constant.
- Neglects effects like air resistance or vibrations.
- Assumes the person remains stationary relative to the scale during acceleration.

Practical Examples and Applications

Example 1: Calculating Apparent Weight During Upward Acceleration

Suppose a person with a true weight of 900 N is in an elevator accelerating upward at 12.2 m/s^2:
- Apparent weight:
$$
N = 900\, N + (91.65\, kg \times 12.2\, m/s^2) \approx 2018.2\, N
$$
- The person feels significantly heavier, almost twice their normal weight.

Example 2: Downward Acceleration at the Same Magnitude

If the elevator accelerates downward at 12.2 m/s^2:
- Normal force:
$$
N = 900\, N - 1118.2\, N
$$
Since this results in a negative value, it indicates the person would momentarily feel weightless or even experience a sensation of floating if the downward acceleration equals gravity (which is not the case here). The normal force would be zero if the acceleration equals g.

Conclusion: The Physics Behind Weight in Accelerated Frames

Understanding how acceleration affects apparent weight is essential in physics, engineering, and everyday life. When an elevator accelerates upward, the normal force increases, making the person feel heavier, which is reflected in the scale reading. Conversely, downward acceleration reduces the normal force, making the person feel lighter or even weightless.

In the scenario where a person weighing 900 N is in an elevator moving upward at 12.2 m/s^2, their apparent weight surges to approximately 2018.2 N due to the additional force needed to accelerate upwards. This exemplifies Newton's second law in action and highlights the importance of considering acceleration when measuring weight in dynamic systems.

Key Takeaways:

- Apparent weight depends on both gravitational force and acceleration.
- Upward acceleration increases apparent weight.
- Calculations involve applying Newton's second law and understanding forces in non-inertial frames.
- Real-world applications span safety engineering, physics education, and health sciences.

By grasping these principles, students and professionals can better analyze and interpret the forces at play in various accelerating systems, ensuring safety, accuracy, and deeper understanding of fundamental physics concepts.

Frequently Asked Questions

What is the person's apparent weight when standing on the scale in an elevator moving upward at 12.2 m/s²?

The apparent weight is approximately 1005.8 N, calculated by adding the person's weight (900 N) to the additional force from the upward acceleration: 900 N + (mass × acceleration). The mass is 900 N / 9.8 m/s^2 ≈ 91.84 kg, so the additional force is 91.84 kg × 12.2 m/s^2 ≈ 1121.5 N, making the apparent weight approximately 900 N + 1121.5 N = 2021.5 N. However, since the person weighs 900 N, the scale reading reflects the normal force, which would be about 2021.5 N in this scenario.

How does the elevator's upward acceleration affect the person's reading on the scale?

The upward acceleration increases the normal force exerted by the scale, making the person appear heavier. As a result, the scale reading (apparent weight) is greater than their actual weight when accelerating upward.

If the elevator were moving downward at 12.2 m/s^2 instead of upward, what would the person's apparent weight be?

The apparent weight would be reduced because the acceleration opposes gravity. Calculating: mass ≈ 91.84 kg, the net acceleration is -12.2 m/s^2, so the normal force (apparent weight) = mass × (g - 12.2) = 91.84 kg × (9.8 - 12.2) m/s^2 ≈ 91.84 kg × (-2.4) m/s^2 ≈ -220.4 N, indicating a loss of weight or a feeling of being lighter; physically, the scale would show a lower reading, possibly close to zero if the acceleration were equal to g.

What physical principles explain the change in the person's weight reading in an accelerating elevator?

Newton's second law (F = m × a) explains that when the elevator accelerates upward, an additional force is exerted on the person, increasing the normal force from the scale. Conversely, downward acceleration reduces the normal force. The scale measures this normal force, which varies with acceleration, affecting the apparent weight.

Why is it important to consider acceleration when determining a person's weight in an elevator?

Because the apparent weight depends not only on the person's actual mass and gravity but also on the acceleration of the elevator. Ignoring acceleration can lead to incorrect assumptions about weight, especially during rapid movements or changes in direction.

Additional Resources

A Person Who Weighs 900 N Stands On A Scale While In An Elevator Moving Upward At 12.2 m/s^2

Introduction

In the realm of physics, the seemingly simple act of standing on a scale can reveal a wealth of information about forces, motion, and the fundamental nature of weight. When that act occurs inside an elevator—especially one in motion—the scenario becomes even more intriguing, blending classical mechanics with real-world applications. This article explores a detailed analysis of a person who weighs 900 N while standing on a scale inside an elevator moving upward at an acceleration of 12.2 m/s^2. We will delve into the physics principles involved, perform calculations to determine the person's mass, interpret the significance of the elevator's acceleration, and discuss practical implications.

Understanding Weight and Force: The Foundations

Before diving into the specifics of the scenario, it is essential to clarify the concepts of weight, force, and acceleration.

What Is Weight?

- Definition: Weight is the force exerted on a mass due to gravity.
- Standard Measurement: The weight of an object is often measured in newtons (N), which is the SI unit of force.
- Relationship: $W = mg$, where:
- W is the weight,
- m is mass,
- g is the acceleration due to gravity (~9.81 m/s^2 on Earth's surface).

How Scales Measure Weight

- A scale typically measures the normal force (N) exerted by the scale on the person.
- When stationary or moving at constant velocity, the normal force equals the person's weight.
- When accelerating, the normal force adjusts accordingly, resulting in a reading that can be higher or lower than the person's actual weight.

The Scenario: Key Data and Variables

Let's summarize the given data:

- Measured weight (force): $W_{measured} = 900\, \mathrm{N}$
- Elevator acceleration upward: $a = 12.2\, \mathrm{m/s^2}$
- Gravitational acceleration: $g \approx 9.81\, \mathrm{m/s^2}$ (standard value)

From the problem, the person is standing on a scale inside an elevator that accelerates upward. The question is: what is the person's mass, and how does the elevator's acceleration influence the reading?

Calculating the Person's Mass

Step 1: Determine the Person's Mass

Since the normal force N exerted by the scale is equal to the apparent weight, and we know the apparent weight as the measured force:

\[

$$
N = W_{measured} = 900\, \mathrm{N}
$$

The key is to recognize that the apparent weight differs from the true weight due to acceleration.

The general formula for the normal force during acceleration is:

$$
N = m(g + a)
$$

Where:
- m is the person’s mass,
- g is gravity,
- a is the elevator's upward acceleration.

Rearranged to find m:

$$
m = \frac{N}{g + a}
$$

Substituting the known values:

$$
m = \frac{900\, \mathrm{N}}{9.81\, \mathrm{m/s^2} + 12.2\, \mathrm{m/s^2}} = \frac{900}{22.01} \approx 40.9\, \mathrm{kg}
$$

Result: The person's mass is approximately 40.9 kilograms.

Interpreting the Results

How Does the Elevator's Acceleration Affect the Reading?

- When the elevator accelerates upward, the normal force increases, making the scale read higher than the person's true weight.
- Conversely, if the elevator were accelerating downward, the normal force—and thus the scale reading—would decrease.

In this case:

- The person’s true weight (if at rest or moving at constant velocity):

$$
W = mg = 40.9\, \mathrm{kg} \times 9.81\, \mathrm{m/s^2} \approx 402\, \mathrm{N}
$$

- The scale reads 900 N, which is more than double the actual weight, due to the upward acceleration.

Deep Dive: Physics Principles at Play

Newton's Second Law in a Non-Inertial Frame

The scenario is an excellent illustration of Newton's second law:

$$
\sum F = ma
$$

In the elevator's frame, which is non-inertial due to acceleration, the person experiences an apparent force. The forces acting are:

- Gravity downward: mg
- Normal force upward: N

In equilibrium (standing still relative to the elevator), the sum of forces is zero:

$$
N - mg = 0
$$

But when the elevator accelerates upward:

$$
N - mg = m a \Rightarrow N = m(g + a)
$$

The increased normal force results in a higher scale reading.

Implications of the Acceleration Magnitude

The acceleration of 12.2 m/s² is quite substantial—approximately 1.25 g, where:

$$
1\, g = 9.81\, \mathrm{m/s^2}
$$

Thus:

$$
a \approx 1.25\, g
$$

This level of acceleration is comparable to what one might experience in rapid elevator ascents or certain amusement park rides, which can produce sensations of increased weight.

Practical and Safety Considerations

Human Tolerance to Acceleration

- Typical elevator accelerations are much less than 12.2 m/s^2, often around 1-2 m/s^2 for comfort and safety.
- Accelerations exceeding 3-4 m/s^2 can cause discomfort, and higher accelerations (like 12.2 m/s^2) are uncommon and potentially unsafe for humans.

Impact on Equipment and Structures

- Elevators and their supporting structures are designed to withstand various forces, but extreme accelerations can impose stress.
- The scenario underscores the importance of engineering safety margins and the need for precise control systems.

Additional Considerations and Variations

Effect of Direction

- If the elevator were accelerating downward at 12.2 m/s^2, the normal force would decrease:

$$
N = m(g - a) \approx 40.9 \times (9.81 - 12.2) = 40.9 \times (-2.39) \approx -97.8\, \mathrm{N}
$$

Negative normal force indicates the person would be lifted off the scale, experiencing weightlessness or even a sensation of negative weight.

Real-World Measurement Challenges

- Scales are calibrated assuming constant gravity and no acceleration.
- During periods of acceleration or deceleration, the readings become "apparent weight," not the true weight.
- Accurate measurement of mass in such scenarios requires accounting for acceleration.

Broader Implications and Applications

For Physics Education

This scenario provides a compelling demonstration of Newtonian physics in everyday contexts, illustrating how acceleration influences perceived weight.

In Engineering

Understanding forces during acceleration is vital in designing safety systems for elevators, amusement rides, and spacecraft.

For Safety Protocols

Recognizing the effects of high acceleration on human physiology emphasizes the need for controlled acceleration profiles in transportation systems.

Conclusion

The exploration of a person weighing 900 N inside an accelerating elevator reveals the intricate interplay between forces, motion, and perception of weight. Calculations show that the individual's true mass is approximately 40.9 kg, but the significant upward acceleration of 12.2 m/s^2 causes the scale to register more than double this person's actual weight. Such analyses underscore fundamental physics principles and highlight the importance of engineering safety and effective design in systems involving acceleration.

This scenario serves as a vivid reminder that what we perceive as "weight" is not solely dictated by gravity but is profoundly affected by motion and acceleration—an essential concept with broad implications across science, engineering, and safety management.

References

- Halliday, D., Resnick, R., & Walker, J. (2014). Fundamentals of Physics (10th ed.). Wiley.
- Serway, R. A., & Jewett, J. W. (2014). Physics for Scientists and Engineers (9th ed.). Brooks Cole.
- Elevator Safety Guidelines, International Building Code (IBC), 2020.
- Human Tolerance to Acceleration, NASA Technical Reports.

Note: Always remember that in real-world applications, accelerations as high as 12.2 m/s^2 are rare and potentially dangerous. This analysis is primarily theoretical and intended for educational purposes.

A Person Who Weighs 900 N Stands On A Scale While In An Elevator The Elevator Is Moving Upward At 12 2

A Person Who Weighs 900 N Stands On A Scale While In An Elevator The Elevator Is Moving Upward At 12 2

Related Articles

- At The University Of Washington, Loftus (1979) Found That Eyewitnesses In A Hypothetical Robbery-murder
- Arrange The Level Of Cell Organization From The Simplest To The Most Complex, With 1 Being The Simplest
- A Firm Has Projected Earnings Of R10 Per Share. The Firm Payout Ratio Is 50% And Dividends Are Expected

Back to Home