A 1200-kilogram Car Traveling At 10. Meters Per Second Is Brought To Rest In 0. 10 Second. What Is The

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Understanding the physics behind vehicle deceleration is crucial for safety analysis, engineering design, and accident reconstruction. When a car with a known mass and velocity comes to a sudden stop within a specific time frame, various forces and energy concepts come into play. In this article, we explore the detailed calculations, fundamental principles, and real-world implications of such a scenario, focusing on a 1200-kilogram car traveling at 10 meters per second and coming to rest in 0.10 seconds. Whether you are a student, engineer, or enthusiast, this comprehensive guide will help clarify the physics involved and its practical applications.

Understanding the Scenario

Basic Data

- Mass of the vehicle: 1200 kg
- Initial velocity: 10 m/s
- Final velocity: 0 m/s (the car comes to rest)
- Time taken to stop: 0.10 seconds

This scenario represents an abrupt deceleration, such as during a collision or sudden braking. Analyzing this situation involves calculating the deceleration, force, and energy dissipation involved.

Fundamental Concepts in Vehicle Deceleration

1. Kinematic Equations

Kinematic equations describe the motion of an object under constant acceleration (or deceleration). The key equations used include:

- $v = u + a t$
- $s = ut + \frac{1}{2} a t^2$
- $v^2 = u^2 + 2 a s$

Where:
- v = final velocity
- u = initial velocity

- a = acceleration (or deceleration)
- t = time
- s = displacement

2. Newton's Second Law

States that force equals mass times acceleration:

$$F = m \times a$$

This law allows us to determine the force applied during deceleration.

3. Energy Principles

The kinetic energy of the vehicle:

$$KE = \frac{1}{2} m u^2$$

is dissipated during braking due to forces like friction or braking force, often converted into heat and deformation.

Calculating the Deceleration

Using the given data:

- Initial velocity, $u = 10\, \text{m/s}$
- Final velocity, $v = 0\, \text{m/s}$
- Time to stop, $t = 0.10\, \text{s}$

Apply the first kinematic equation:

$$v = u + a t$$

Rearranged to find acceleration:

$$a = \frac{v - u}{t}$$

Substituting the values:

$$a = \frac{0 - 10}{0.10} = -100\, \text{m/s}^2$$

The negative sign indicates deceleration (opposite to the direction of motion).

Key Point: The car experiences an average deceleration of 100 m/s^2 over 0.10 seconds.

Force Exerted During Braking

Applying Newton's second law:

$$ F = m \times a $$

$$ F = 1200\, \text{kg} \times (-100\, \text{m/s}^2) = -120,000\, \text{N} $$

The magnitude of the force is 120,000 Newtons, acting opposite to the vehicle's initial direction.

Implication: This is an immense force, emphasizing the importance of safety features like airbags and crumple zones to absorb such forces safely.

Energy Dissipation and Impact Analysis

1. Initial Kinetic Energy

Calculate the kinetic energy before stopping:

$$ KE = \frac{1}{2} m u^2 $$

$$ KE = \frac{1}{2} \times 1200\, \text{kg} \times (10\, \text{m/s})^2 = 600 \times 100 = 60,000\, \text{J} $$

The vehicle's initial kinetic energy is 60,000 Joules.

2. Energy Dissipated During Braking

Since the car comes to rest, the entire kinetic energy is dissipated, mainly as heat via friction, brake pad deformation, and other mechanisms.

3. Implications for Safety and Design

- Braking systems must be capable of dissipating large amounts of energy rapidly.
- Crash safety features are designed considering such energy levels to prevent injuries.

Real-World Applications of Deceleration Calculations

1. Vehicle Safety Engineering

Engineers use such calculations to design braking systems, airbags, and crumple zones that can withstand or absorb forces during collisions.

2. Accident Reconstruction

Forensic experts analyze crash data to determine collision forces, vehicle speeds, and contributing factors.

3. Regulatory Standards

Standards like crash test protocols rely on understanding the forces involved in vehicle deceleration to ensure safety.

Additional Considerations

1. Variability of Deceleration

- The calculated deceleration is an average; actual deceleration may vary due to factors like road conditions, brake efficiency, and tire grip.

2. Role of Friction

- Friction between tires and road surface plays a critical role in deceleration.
- Maximum possible deceleration depends on the coefficient of friction (μ):

$$a_{max} = \mu g$$

where g is acceleration due to gravity (~9.81 m/s²).

- For example, with $\mu = 0.8$:

$$a_{max} = 0.8 \times 9.81 \approx 7.85\, \text{m/s}^2$$

which is much less than the 100 m/s² calculated, indicating that such rapid stopping requires specialized conditions or equipment.

3. Limitations of Calculations

- Real-world deceleration is often less than the calculated average due to various factors.
- Sudden stops like this are rare and usually associated with collisions or emergency braking.

Conclusion

The analysis of a 1200-kilogram vehicle traveling at 10 meters per second and coming to rest in 0.10 seconds reveals the incredible forces and energy involved in rapid deceleration. The key takeaways include:

- The vehicle experiences an average deceleration of 100 m/s^2.
- The force exerted during braking reaches 120,000 Newtons.
- All of the initial kinetic energy (~60,000 Joules) must be dissipated through braking systems and safety features.
- Such calculations are essential for vehicle design, safety standards, and accident investigations.

Understanding these principles helps in designing safer vehicles, improving crashworthiness, and developing effective safety regulations. It also underscores the importance of driver safety measures and advanced automotive technology to manage such forces effectively.

Keywords for SEO Optimization: vehicle deceleration, crash physics, kinetic energy, braking force, vehicle safety engineering, accident reconstruction, vehicle stopping distance, impact forces, safety features, emergency braking, physics of car crashes

Frequently Asked Questions

What is the initial kinetic energy of the 1200 kg car traveling at 10 m/s?

The initial kinetic energy is (1/2) 1200 kg (10 m/s)^2 = 60,000 Joules.

How much work is done to bring the car to rest in 0.10 seconds?

The work done is equal to the initial kinetic energy, which is 60,000 Joules, assuming all energy is dissipated through work like braking.

What is the average power exerted during the braking process?

Average power = Work done / Time = 60,000 Joules / 0.10 s = 600,000 Watts or 600 kW.

What is the magnitude of the average force applied to stop the car?

Force = Change in momentum / time = (1200 kg 10 m/s) / 0.10 s = 120,000 Newtons.

Is the force applied to stop the car in the direction of motion?

Yes, the force is applied opposite to the direction of travel to decelerate the car.

What assumptions are made in calculating the stopping work and power?

Assumptions include that all kinetic energy is dissipated by the braking force with no other energy losses and that the force is constant during the stopping time.

How does the stopping time affect the force required to stop the car?

Shorter stopping times require larger forces, as force is inversely proportional to the stopping time for a given initial momentum.

Additional Resources

A 1200-kilogram Car Traveling At 10 Meters Per Second Is Brought To Rest In 0.10 Second. What Is The

Understanding the physics behind how a car's motion is affected by forces and impacts is crucial not only for automotive safety engineers but also for students and enthusiasts interested in mechanics. In this detailed analysis, we'll explore the scenario where a 1200-kilogram car traveling at 10 meters per second is brought to rest in 0.10 seconds. We will break down the problem step-by-step, examining concepts such as momentum, force, impulse, and energy, to determine the key quantities involved, especially the magnitude of the force exerted during the stopping process.

Introduction to the Problem

Imagine a car with a mass of 1200 kg moving at a velocity of 10 m/s. Suddenly, it comes to a complete stop within a very short time frame of 0.10 seconds. This situation is typical in high-speed braking scenarios, crash analysis, and safety testing. The primary question we seek to answer is:

What is the average force exerted on the car during this deceleration?

Fundamental Concepts

Before diving into calculations, it's essential to understand the fundamental physics principles involved:

1. Momentum (Linear Momentum)

- Definition: The product of an object’s mass and its velocity.

- Formula: $p = m \times v$

2. Impulse

- Definition: The change in momentum of an object caused by a force applied over a time interval.
- Formula: $J = F \times \Delta t$
- Relation to momentum: $J = \Delta p = p_{final} - p_{initial}$

3. Force

- Average Force: The net force applied over a time interval to change an object’s momentum.
- Relation to impulse: $F_{avg} = \frac{\Delta p}{\Delta t}$

4. Kinetic Energy

- Definition: The energy an object possesses due to its motion.
- Formula: $KE = \frac{1}{2} m v^2$

Step-by-Step Solution

Step 1: Calculate the initial momentum of the car

Given:
- Mass, $m = 1200 \, \text{kg}$
- Initial velocity, $v_i = 10 \, \text{m/s}$

$$p_i = m \times v_i = 1200 \times 10 = 12,000 \, \text{kg·m/s}$$

Step 2: Determine the final momentum

Since the car is brought to rest:
- Final velocity, $v_f = 0$
- Final momentum,

$$p_f = m \times v_f = 1200 \times 0 = 0 \, \text{kg·m/s}$$

Step 3: Calculate the change in momentum (Impulse)

$$\Delta p = p_f - p_i = 0 - 12,000 = -12,000 \, \text{kg·m/s}$$

The negative sign indicates a reduction in momentum, corresponding to deceleration.

Step 4: Calculate the average force exerted during deceleration

Given:
- Time interval, $\Delta t = 0.10 \, \text{s}$

Using impulse-momentum theorem:

$$
F_{avg} = \frac{\Delta p}{\Delta t} = \frac{-12,000}{0.10} = -120,000 \, \text{N}
$$

The negative sign indicates the force acts in the direction opposite to the initial motion, i.e., a braking force.

Therefore, the magnitude of the average force is 120,000 N.

Interpreting the Result

This is an enormous force—equivalent to roughly the weight of 12 average cars—acting on the vehicle during braking. Such a force explains why crash barriers, seat belts, and airbags are critical safety features: they help distribute and absorb this energy safely.

Key Takeaways:
- The magnitude of the average force is 120,000 N.
- The direction of the force is opposite to the initial motion.
- The deceleration is extremely rapid, happening in just 0.10 seconds.

Additional Insights and Considerations

1. Energy Perspective

While we've focused on momentum, let's look at the kinetic energy involved:

$$
KE_{initial} = \frac{1}{2} m v^2 = \frac{1}{2} \times 1200 \times 10^2 = 6000 \times 10 = 60,000 \, \text{J}
$$

This energy is dissipated during braking, primarily through heat in brake systems, deformation, and other energy-absorbing mechanisms.

2. Real-World Factors

In real crash scenarios:
- The force isn't constant; it varies during deceleration.
- The stopping distance is a critical safety parameter.
- Engineers design braking systems to manage the forces and energy dissipation effectively.

3. Safety Implications

Understanding the magnitude of forces during rapid stops informs:
- Design of brake systems.

- Safety features like crumple zones.
- Speed limits and driving regulations.

Summary of Key Calculations

Quantity	Value	Explanation
Initial momentum p_i	12,000 kg·m/s	Momentum before braking
Final momentum p_f	0	Momentum after stopping
Change in momentum Δp	-12,000 kg·m/s	Momentum reduction
Average force F_{avg}	120,000 N	Force needed to stop in 0.10 s

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Final Thoughts

The physics of a car coming to a sudden stop involves a combination of momentum, impulse, and energy transfer. The calculation above demonstrates how a seemingly simple problem—stopping a vehicle—can involve forces of staggering magnitude. Recognizing these forces underscores the importance of safety features and proper maintenance of braking systems. For engineers and safety analysts, such calculations are vital in designing safer vehicles and infrastructure.

This detailed analysis provides a comprehensive understanding of the forces at play when a car is brought to rest rapidly, illustrating both fundamental physics principles and their real-world applications.

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