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9. A Net Force Of 25 N Is Applied For 5.7 S To A 12-kg Box Initially At Rest. What Is The Speed Of The the box after the force has been applied? This question involves fundamental principles of physics, specifically Newton's Second Law of Motion. Understanding how to calculate the final speed of an object under a given force and time is essential for students and enthusiasts interested in mechanics. In this article, we will explore the process step-by-step, covering the relevant concepts, formulas, and practical applications to help you grasp how to solve such problems effectively.

Understanding the Problem

Before diving into calculations, it's crucial to understand what information is given and what is being asked.

Details Provided

- Net force applied (F) = 25 N
- Time duration of force application (t) = 5.7 seconds
- Mass of the box (m) = 12 kg
- Initial velocity (u) = 0 m/s (initially at rest)

What Is Being Asked

- To find the final velocity (v) of the box after the force has been applied for the given time.

Understanding these parameters helps in selecting the right physics principles to apply and ensures accurate calculations.

Key Physics Concepts Involved

This problem primarily involves Newton's Second Law, the concept of acceleration, and the equations of motion under constant acceleration.

Newton's Second Law of Motion

- States that the net force acting on an object is equal to the mass of the object multiplied by its acceleration:

$$F = m a$$

- Rearranged to find acceleration:

$$a = F / m$$

Constant Acceleration and Kinematic Equations

- When a constant force is applied, the acceleration remains constant.
- The final velocity can be found using the kinematic equation:

$$v = u + a t$$

where:

- v = final velocity,
- u = initial velocity,
- a = acceleration,
- t = time.

Given that the box starts from rest, initial velocity (u) is zero, simplifying calculations.

Step-by-Step Calculation

To find the final speed of the box, we follow these steps:

1. Calculate the acceleration

Using Newton's Second Law:

$$a = F / m$$

Substituting the known values:

$$a = 25 \text{ N} / 12 \text{ kg} \approx 2.083 \text{ m/s}^2$$

This is the acceleration experienced by the box due to the applied force.

2. Determine the final velocity

Applying the kinematic equation:

$$v = u + a t$$

Since the initial velocity (u) is zero:

$$v = 0 + 2.083 \text{ m/s}^2 \cdot 5.7 \text{ s} \approx 11.88 \text{ m/s}$$

The final speed of the box after 5.7 seconds of force application is approximately 11.88 meters per second.

Real-World Applications of the Calculation

Understanding how to compute the final velocity of an object under a net force has numerous practical applications across various fields.

1. Vehicle Acceleration and Safety

- Engineers calculate how quickly a vehicle can accelerate under certain forces to design safety features and performance standards.

2. Robotics and Automation

- Robots often rely on similar calculations to control motion precisely, ensuring they move with the desired speed.

3. Sports Science

- Athletes and trainers analyze force and acceleration to optimize performance and reduce injury risk.

Additional Considerations and Variations

While the above calculation assumes ideal conditions (constant force and no friction), real-world scenarios often involve additional factors.

1. Friction and Resistance

- Frictional forces oppose motion and reduce acceleration. Adjustments to calculations are necessary if frictional forces are significant.

2. Variable Forces

- If the applied force changes over time, calculus methods are necessary to determine the final velocity.

3. Air Resistance

- In high-speed situations, air resistance becomes a factor affecting the final speed.

Summary

To determine the speed of a box after a net force is applied for a specific duration, the process involves calculating acceleration using Newton's Second Law and then applying kinematic equations to find the final velocity. For the given problem:

- The acceleration is approximately 2.083 m/s^2 .
- The final velocity after 5.7 seconds of force application is approximately 11.88 m/s .

This straightforward approach exemplifies fundamental physics principles, enabling students and professionals to analyze motion scenarios effectively.

Conclusion

Mastering these calculations not only enhances understanding of basic physics but also provides a foundation for tackling more complex dynamics problems. Whether in academic settings or real-world engineering applications, knowing how to compute an object's final speed under a net force is an essential skill. Remember to always consider the assumptions made in ideal calculations and account for additional forces

or factors in practical situations. With practice, solving similar physics problems becomes intuitive, empowering you to analyze motion with confidence and precision.

Frequently Asked Questions

What is the formula to calculate the acceleration of a box when a net force is applied?

The acceleration can be calculated using Newton's second law: $a = F / m$, where F is the net force and m is the mass of the object.

How do you determine the final speed of the box after applying the net force?

Use the equation $v = u + at$, where u is the initial velocity (0 m/s), a is the acceleration, and t is the time.

What is the initial velocity of the box in this problem?

The initial velocity of the box is zero since it is initially at rest.

How do you calculate the acceleration of the box in this scenario?

Calculate acceleration by dividing the net force by the mass: $a = 25 \text{ N} / 12 \text{ kg} \approx 2.08 \text{ m/s}^2$.

What is the final speed of the box after 5.7 seconds?

Using $v = u + at$, the final speed $v = 0 + (2.08 \text{ m/s}^2)(5.7 \text{ s}) \approx 11.86 \text{ m/s}$.

Is energy conservation applicable in this problem?

Yes, the work done by the net force is converted into the kinetic energy of the box, assuming no other forces like friction are involved.

What assumptions are made in solving this problem?

Assumptions include that the net force remains constant during the time interval and that there are no other forces like friction acting on the box.

How would the answer change if the initial velocity was not zero?

If the initial velocity was not zero, the final speed would be $v = u + at$, with u being the initial velocity; the calculation would include the initial velocity value.

What is the importance of understanding net force and acceleration in physics problems?

Understanding net force and acceleration helps predict how objects move under various forces, essential for analyzing real-world motion scenarios.

Additional Resources

Understanding the Impact of a Net Force of 25 N Applied for 5.7 Seconds to a 12-kg Box Initially at Rest: A Detailed Analysis

When analyzing the motion of objects in physics, understanding how forces influence movement is fundamental. One common scenario involves applying a net force to an object and determining its resulting velocity. For instance, a net force of 25 N is applied for 5.7 seconds to a 12-kg box initially at rest. This situation provides a practical example to explore concepts such as Newton's Second Law, acceleration, and the calculation of final velocity. In this guide, we'll delve into the step-by-step process to determine the speed of the box after the force is applied, ensuring clarity and thoroughness throughout.

Fundamentals of Force and Motion

Before diving into the specific problem, let's briefly review some key physics principles:

- Newton's Second Law of Motion:

The acceleration of an object is directly proportional to the net force applied to it and inversely proportional to its mass. Mathematically,

$$F = m a$$

where:

- F is the net force (in Newtons, N)
- m is the mass of the object (in kilograms, kg)
- a is the acceleration (in meters per second squared, m/s^2)

- Kinematic Equations:

When an object starts from rest and accelerates uniformly, its velocity after a certain time can be calculated using:

$$v = v_0 + a t$$

Since the object starts at rest, $v_0 = 0$, so:

$$v = a t$$

- Work-Energy Principle:

The work done by the net force on the object results in a change in its kinetic energy. This principle can also be used to determine the final velocity when the force acts over a certain distance, but in this scenario, time is given, so the primary approach involves acceleration and kinematic equations.

Step-by-Step Approach to the Problem

Let's now analyze the problem in a systematic way:

1. Gather Given Data

- Force applied, F : 25 N
- Time of force application, t : 5.7 seconds
- Mass of the box, m : 12 kg
- Initial velocity, v_0 : 0 m/s (initially at rest)

2. Calculate the Acceleration

Using Newton's Second Law:

$$a = \frac{F}{m}$$

Plugging in the numbers:

$$a = \frac{25 \text{ N}}{12 \text{ kg}} \approx 2.083 \text{ m/s}^2$$

This acceleration indicates how quickly the box's velocity will increase while the force is applied.

3. Determine the Final Velocity

Since the box starts from rest and experiences constant acceleration over time t :

$$v = v_0 + a t$$

Given that $v_0 = 0$:

$$v = 0 + 2.083 \text{ m/s}^2 \times 5.7 \text{ s}$$

Calculating:

$$[v \approx 2.083 \times 5.7 \approx 11.88, \text{m/s}]$$

Therefore, the speed of the box after 5.7 seconds of applying the net force is approximately 11.88 m/s.

Understanding the Physical Context and Assumptions

It's essential to acknowledge some assumptions inherent in this calculation:

- Constant Force and Acceleration:

The force remains constant throughout the 5.7 seconds, resulting in uniform acceleration. In real-world scenarios, forces may vary, but for simplicity, we assume it is constant here.

- No Friction or External Forces:

The calculation neglects friction, air resistance, or other external forces that could oppose the motion. In practical applications, these factors might reduce the final speed.

- Object Starts From Rest:

The initial velocity is zero, simplifying the calculation. If the object were already moving, the initial velocity would need to be considered.

Additional Insights and Related Concepts

Work Done and Kinetic Energy

The work done by the net force over the 5.7 seconds translates into the kinetic energy of the box:

$$[W = F \times d]$$

Where d is the distance traveled during this time. Alternatively, using kinetic energy:

$$[KE = \frac{1}{2} m v^2]$$

Calculating the kinetic energy:

$$[KE = \frac{1}{2} \times 12, \text{kg} \times (11.88, \text{m/s})^2 \approx 6 \times 141.2 \approx 847.2, \text{J}]$$

This energy is the work done by the force:

$$W = F \times d \Rightarrow d = \frac{W}{F}$$

But since we haven't calculated d directly, this is an optional extension for more in-depth analysis.

Implications of Force Duration and Magnitude

The magnitude of the force and the duration for which it acts are crucial in determining the final velocity:

- Stronger Force or Longer Duration:

Will lead to higher final velocities.

- Shorter Duration or Smaller Force:

Will result in lower velocities.

Practical Applications and Real-World Examples

This type of analysis is fundamental in various fields:

- Engineering:

Designing systems where objects are moved or accelerated, such as conveyor belts or robotic arms.

- Automotive Safety:

Understanding how forces applied during collisions influence vehicle and pedestrian motion.

- Sports Science:

Analyzing how forces during a sprint or throw affect an athlete's velocity.

Summary of Key Steps and Takeaways

- Apply Newton's Second Law to find acceleration:

$$a = F/m$$

- Use the kinematic equation for velocity with initial rest:

$$v = a t$$

- Plug in known values to compute the final speed:

$$v \approx 11.88 \text{ m/s}$$

- Recognize assumptions such as constant force, no friction, and initial rest.

Final Thoughts

Understanding how a net force influences an object's motion is essential in physics. In this scenario, applying a net force of 25 N for 5.7 seconds to a 12-kg box initially at rest results in a final speed of approximately 11.88 meters per second. This analysis combines fundamental principles with practical calculations, illustrating how physics can predict real-world motion accurately when the right assumptions and formulas are applied.

By mastering these concepts, students and professionals alike can better comprehend and analyze the dynamics of moving objects, whether in academic problems or real-life engineering challenges.

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