

4. A 2.00 Kg Object Is Accelerated Uniformly From Rest To 3.00 M/s While Moving 1.5 M Across Alevel Frictionless

4. A 2.00 Kg Object Is Accelerated Uniformly From Rest To 3.00 M/s While Moving 1.5 M Across Alevel Frictionless

Understanding the principles of motion and mechanics is fundamental in physics. This particular problem involves analyzing the motion of a 2.00 kg object that is accelerated uniformly from rest to a velocity of 3.00 m/s over a certain distance on a frictionless, level surface. It serves as an excellent example for exploring concepts such as acceleration, work-energy theorem, and kinematic equations. In this article, we will delve into the detailed solution process, explain the underlying physics principles, and discuss related concepts to provide a comprehensive understanding of this problem.

Problem Overview and Key Data

Let's begin by outlining the key details of the problem:

- Object mass (m): 2.00 kg
- Initial velocity (u): 0 m/s (rest)
- Final velocity (v): 3.00 m/s
- Distance moved (d): 1.5 m
- Surface: Level and frictionless

The main goal is to determine the acceleration experienced by the object during this motion and to analyze the work done on the object, applying the fundamental physics principles.

Understanding the Physics Principles Involved

Before jumping into calculations, it is essential to understand the concepts that underpin this problem:

1. Uniform Acceleration

- When an object accelerates uniformly, its acceleration (a) remains constant throughout the motion.
- The kinematic equations for constant acceleration can be used to relate initial and final velocities, acceleration, and displacement.

2. Work-Energy Theorem

- The work done on an object equals the change in its kinetic energy.
- Since the surface is frictionless, no energy is lost to friction, simplifying calculations.

3. Kinematic Equations

- These equations relate velocity, acceleration, displacement, and time in uniformly accelerated motion.

Step-by-Step Solution Approach

The problem can be approached systematically:

1. Determine the acceleration (a) using kinematic equations.
2. Calculate the work done on the object during acceleration.
3. Verify the results by cross-checking with energy considerations.

Let's explore these steps in detail.

1. Calculating the Acceleration

Since the initial velocity ($u = 0$), final velocity ($v = 3.00 \text{ m/s}$), and displacement ($d = 1.5 \text{ m}$), we can use the following kinematic equation:

$$v^2 = u^2 + 2ad$$

Substituting the known values:

$$(3.00)^2 = 0 + 2 \times a \times 1.5$$

$$9 = 3a$$

$$a = \frac{9}{3} = 3 \, \text{m/s}^2$$

Result: The object experiences a constant acceleration of $3.00 \, \text{m/s}^2$ during its motion.

2. Calculating the Work Done

Since the surface is frictionless, the work done on the object is entirely converted into its kinetic energy.

The kinetic energy (KE) at the final velocity:

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

Substituting values:

$$KE = \frac{1}{2} \times 2.00 \, \text{kg} \times (3.00 \, \text{m/s})^2$$

$$KE = 1 \times 9 = 9 \, \text{J}$$

Result: The work done on the object is 9 Joules, which increases its kinetic energy from zero to 9 Joules.

3. Confirming with Work-Energy Theorem

Work-energy theorem states:

$$\text{Work done} = \Delta KE$$

Since initial KE is zero and final KE is 9 J, the work done is 9 J, consistent with the previous calculation.

Additional Insights and Related Concepts

This problem not only involves straightforward calculations but also introduces several fundamental physics concepts that have broader applications.

1. Relationship Between Acceleration and Force

Using Newton's second law:

$$F = m a$$

Calculate the net force applied to the object:

$$F = 2.00 \, \mathrm{kg} \times 3.00 \, \mathrm{m/s^2} = 6.00 \, \mathrm{N}$$

This force is responsible for accelerating the object uniformly over the 1.5 m distance.

2. Time of Motion

To find the duration of acceleration, use the relation:

$$v = u + a t$$

Given $(u = 0)$:

$$t = \frac{v}{a} = \frac{3.00}{3.00} = 1.00 \, \mathrm{s}$$

Alternatively, using the displacement:

$$d = ut + \frac{1}{2} a t^2$$

$$1.5 = 0 + \frac{1}{2} \times 3.00 \times t^2$$

$$1.5 = 1.5 t^2$$

$$t^2 = 1 \Rightarrow t = 1.00 \, \mathrm{s}$$

Result: The object takes exactly 1 second to reach 3.00 m/s.

3. Implications for Real-World Applications

Understanding uniform acceleration and energy transfer is crucial in various engineering fields, such as:

- Designing vehicle acceleration profiles.
- Analyzing conveyor systems.
- Studying motion in robotics.

Summary and Conclusions

This detailed analysis of a 2.00 kg object accelerated uniformly over 1.5 meters highlights several fundamental physics principles:

- The acceleration is calculated as 3.00 m/s^2 .
- The work done on the object is 9 Joules, entirely converted into kinetic energy due to the frictionless surface.
- The acceleration phase lasts 1 second.

Understanding these concepts provides a foundation for more complex dynamics problems, including those involving friction, non-uniform acceleration, and forces in multiple dimensions.

Further Exploration

Students and enthusiasts interested in expanding their understanding can explore:

- The effect of frictional forces on similar motion.
- Motion under variable acceleration.
- Energy conservation in inelastic collisions.
- Real-world applications like roller coaster physics or vehicle dynamics.

By mastering these principles, learners can develop a comprehensive understanding of motion, forces, and energy transfer, essential for advanced studies and practical problem-solving in physics and engineering.

Keywords for SEO:

- uniform acceleration physics
- work-energy theorem
- kinematic equations
- frictionless surface motion

- calculating acceleration
- kinetic energy calculation
- Newton's second law
- motion analysis
- physics problem-solving
- dynamics of moving objects

Frequently Asked Questions

What is the acceleration of the 2.00 kg object as it speeds up from rest to 3.00 m/s over 1.5 m?

Using the kinematic equation $v^2 = u^2 + 2as$, where $u=0$, $v=3.00$ m/s, and $s=1.5$ m, the acceleration $a = v^2/(2s) = (3.00)^2 / (2 \cdot 1.5) = 9 / 3 = 3.00$ m/s².

What is the net force acting on the object during acceleration?

The net force $F = m a = 2.00 \text{ kg} \cdot 3.00 \text{ m/s}^2 = 6.00 \text{ N}$.

How long does it take for the object to reach 3.00 m/s from rest?

Using $v = u + at$, with $u=0$, $v=3.00$ m/s, $a=3.00$ m/s², $t = v/a = 3.00 / 3.00 = 1.00$ second.

What is the work done on the object during the acceleration?

Work done $W = \text{change in kinetic energy} = (1/2) m v^2 = 0.5 \cdot 2.00 \text{ kg} \cdot (3.00 \text{ m/s})^2 = 1.00 \text{ kg} \cdot 9.00 \text{ m}^2/\text{s}^2 = 9.00 \text{ Joules}$.

Is there any frictional force acting on the object as it moves over the 1.5 m distance?

No, the surface is frictionless, so no frictional force opposes the motion.

What is the velocity of the object after moving 1.5 m?

The velocity after covering 1.5 m under constant acceleration is 3.00 m/s, as given in the problem statement.

If the object continues to accelerate at the same rate, what will be its velocity after 2 seconds?

Using $v = u + at$, with $u=0$, $a=3.00$ m/s², $t=2$ seconds, $v=0 + 3.00 \cdot 2 = 6.00$ m/s.

Additional Resources

A 2.00 Kg Object Is Accelerated Uniformly From Rest To 3.00 M/s While Moving 1.5 M Across A level Frictionless Surface

Understanding the dynamics of objects moving across surfaces is fundamental in classical mechanics, particularly when analyzing the effects of forces and energy transfer. In this detailed review, we examine the scenario of a 2.00 kg object that is uniformly accelerated from rest to a velocity of 3.00 m/s over a distance of 1.5 meters on a level, frictionless surface. This case study offers insights into the principles of motion, work-energy relationships, and the application of Newton's laws.

Overview of the Problem

The problem involves a small, solid object with a known mass, starting from rest, and reaching a specified velocity after traversing a certain distance. The key parameters include:

- Mass of the object, $(m = 2.00\text{ kg})$
- Initial velocity, $(v_0 = 0\text{ m/s})$
- Final velocity, $(v = 3.00\text{ m/s})$
- Distance traveled, $(s = 1.5\text{ m})$
- Surface type: Level and frictionless

Understanding this scenario requires applying fundamental physics concepts such as kinematic equations, Newton's second law, work-energy theorem, and the characteristics of frictionless motion.

Analyzing the Motion

Uniform Acceleration and Kinematic Equations

Since the object accelerates uniformly from rest, the core kinematic equations can be employed to determine the acceleration and verify the consistency of the motion.

The basic equations are:

- $(v^2 = v_0^2 + 2as)$
- $(v = v_0 + at)$
- $(s = v_0t + \frac{1}{2}at^2)$

Given $(v_0=0)$, $(v=3.00\text{ m/s})$, and $(s=1.5\text{ m})$:

$$[v^2 = 2a s \rightarrow a = \frac{v^2}{2s}]$$

Plugging in the values:

$$[a = \frac{(3.00)^2}{2 \times 1.5} = \frac{9}{3} = 3, \text{ m/s}^2]$$

This means the object experiences a constant acceleration of 3 m/s².

The time taken to reach this velocity:

$$[t = \frac{v - v_0}{a} = \frac{3.00 - 0}{3} = 1, \text{ second}]$$

Features:

- The acceleration is moderate, ensuring smooth motion.
- The time to reach the final velocity is straightforward to compute, aiding in understanding the dynamics.

Pros:

- Simple calculations facilitate understanding.
- Clear relationship between acceleration, distance, and final velocity.

Cons:

- Assumes ideal conditions; real-world factors like air resistance are neglected.

Force Analysis and Newton's Laws

Determining the Force Applied

According to Newton's second law:

$$[F = m a]$$

Substituting the known values:

$$[F = 2.00, \text{ kg} \times 3, \text{ m/s}^2 = 6, \text{ N}]$$

Since the surface is frictionless, the only horizontal force doing work on the object is the applied force.

Features:

- The force remains constant due to uniform acceleration.

- The force required is directly proportional to the mass and acceleration.

Pros:

- Straightforward application of Newton's second law.
- No need to consider frictional forces simplifies calculations.

Cons:

- Assumes perfect application of force; in practice, force application may vary.

Work-Energy Perspective

Work Done on the Object

The work-energy theorem states:

$$W = \Delta KE$$

Where:

- $KE_{\text{initial}} = 0$ (since at rest),
- $KE_{\text{final}} = \frac{1}{2} m v^2$.

Calculating the final kinetic energy:

$$KE_{\text{final}} = \frac{1}{2} \times 2.00 \, \text{kg} \times (3.00)^2 = 1 \times 9 = 9 \, \text{J}$$

Since the surface is frictionless, the work done by the applied force equals the change in kinetic energy:

$$W = 9 \, \text{J}$$

The work done by an applied force over distance s :

$$W = F \times s$$

Check consistency:

$$F \times s = 6 \, \text{N} \times 1.5 \, \text{m} = 9 \, \text{J}$$

which matches the kinetic energy gained.

Features:

- Demonstrates the conservation of energy.
- Validates the force calculation.

Pros:

- Reinforces the link between force, work, and energy.
- Simplifies understanding of energy transfer in motion.

Cons:

- Assumes no energy losses; in real systems, factors like air resistance or internal friction could reduce efficiency.

Implications and Real-World Applications

Understanding such a motion scenario provides insights into various practical applications:

- Design of Vehicles and Conveyors: Ensuring uniform acceleration over a specified distance.
- Robotics and Automation: Programming motion profiles with controlled acceleration.
- Sports Science: Analyzing athlete movements over measured distances.
- Physics Education: Demonstrating fundamental principles through tangible examples.

Features, Advantages, and Limitations of the Model

Features:

- Idealized frictionless surface simplifies analysis.
- Constant acceleration provides a clear framework for calculations.
- Direct application of Newtonian mechanics and energy principles.

Advantages:

- Easy to compute and predict outcomes.
- Demonstrates core physics concepts efficiently.
- Serves as a foundation for more complex systems involving friction, air resistance, or variable acceleration.

Limitations:

- Real-world surfaces are rarely frictionless.
- External influences such as air resistance are ignored.
- Assumes perfect uniform acceleration without any external disturbances.

- Does not consider rotational effects or additional forces.

Extensions and Further Considerations

To deepen understanding or adapt this scenario to more realistic situations, consider:

- Incorporating Friction: How does the presence of friction alter the force required and the work done?
- Variable Acceleration: What if acceleration is not uniform? How does this change the calculations?
- Inclined Surfaces: How would gravity influence the motion on inclined planes?
- Energy Dissipation: How do factors like air resistance affect the energy transfer?

Conclusion

Analyzing the motion of a 2.00 kg object accelerated uniformly from rest to 3.00 m/s across 1.5 meters on a frictionless surface encapsulates fundamental physics principles. The problem elegantly demonstrates how Newton's laws, kinematic equations, and energy considerations intertwine to describe motion precisely. The calculated acceleration of 3 m/s^2 , force of 6 N, and work done of 9 J highlight the direct relationships between force, displacement, and energy transfer. While the model assumes ideal conditions, it forms a foundational understanding essential for more complex real-world applications. Such analyses serve as valuable educational tools and practical guides in designing systems where controlled motion is critical.

In summary:

- The problem exemplifies uniform acceleration on a frictionless surface.
- Calculations confirm consistent application of Newtonian physics.
- It provides a clear illustration of energy transfer during motion.
- Recognizing the model's limitations encourages exploration of more complex scenarios.

By mastering these concepts, students and engineers can better analyze and design systems involving controlled motion, energy efficiency, and force management, laying the groundwork for advanced studies in mechanics and engineering disciplines.

4 A 2 00 Kg Object Is Accelerated Uniformly From Rest To 3 00 M S While Moving 1 5 M Across Alevel Frictionless

4 A 2 00 Kg Object Is Accelerated Uniformly From Rest To 3 00 M S While Moving 1 5 M Across Alevel Frictionless

Related Articles

- [Know The Names And Importance Of The Seven Ligaments Of The Hip. Know Which Nerves Are Part Of The Lumbosacral](#)
- [If You Read The Story "Pygmalion" Help Please!-----Part](#)
- [Explain One \(1\) Thing You Learned From The Coding Guidelines At The Beginning Of The Evaluation And Management](#)

[Back to Home](#)