The Force Of F = 50 N Is Applied To The Cord When S = 2 M. If The 6-kg Collar Is Orginally At Rest, Determine

The Force Of F = 50 N Is Applied To The Cord When S = 2 M. If The 6-kg Collar Is Originally At Rest, Determine

Understanding the dynamics of objects under applied forces is fundamental in physics, especially when analyzing systems involving tension, mass, and acceleration. In this comprehensive guide, we will explore the problem where a force of 50 N is applied to a cord, which is connected to a 6-kg collar initially at rest, and the cord is stretched by 2 meters. We aim to determine various physical quantities such as the acceleration of the collar, the tension in the cord, and the velocity after the displacement, providing detailed explanations, formulas, and step-by-step solutions.

Introduction to the Problem Setup

Before diving into calculations, it is essential to understand the physical scenario and the assumptions involved.

Scenario Description

- A force $F = 50\, \text{N}$ is applied to a cord.
- The cord is connected to a collar with a mass $m = 6\, \text{kg}$.
- The collar initially rests at a position where the displacement of the cord is $s = 2\, \text{m}$.
- The system is assumed to be ideal, meaning:
- The cord is massless and inextensible.
- The force is applied steadily.
- There is no friction or air resistance unless otherwise specified.

Goals of the Problem

- Find the acceleration of the collar immediately after the force is applied.
- Determine the tension within the cord during the motion.
- Calculate the velocity of the collar after the 2-meter stretch.
- Understand the energy transfer involved in stretching and moving the collar.

Fundamental Concepts and Assumptions

To approach this problem effectively, familiarity with Newton's second law and basic kinematic equations is necessary.

Newton’s Second Law

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

$$
F_{\text{net}} = m a
$$

- In systems involving tension, the net force is the applied force minus the tension in the cord.

Work-Energy Principle

- The work done by the applied force results in the kinetic energy of the collar:

$$
W = \Delta KE
$$

- When the cord is stretched, elastic potential energy may also be involved if the cord has elasticity, but in the case of a massless, inextensible cord, the elastic energy is negligible.

Assumptions for Simplification

- The cord is inextensible and massless.
- Frictional forces are negligible.
- The applied force is constant during the motion.
- The initial velocity of the collar is zero.

Step-by-Step Solution

1. Calculating the Acceleration of the Collar

Given the applied force and the mass, the immediate step is to determine the acceleration.

Applying Newton's Second Law

- The net force acting on the collar:

$$
F_{\text{net}} = F - T
$$

where T is the tension in the cord.

- Since the cord is massless and inextensible, the tension is the internal force resisting the applied force, and the collar accelerates accordingly.

- If the cord is taut and the force is applied directly to the collar via the cord, then the tension is related to the applied force and the system's acceleration.

- For simplicity, assuming the force F is transmitted entirely through the cord to the collar, the acceleration is:

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

This is valid if the tension equals the applied force (i.e., the cord's tension is equal to F) and the system is free to accelerate.

Calculation:

$$
a = \frac{50\, \text{N}}{6\, \text{kg}} \approx 8.33\, \text{m/s}^2
$$

---

2. Determining the Tension in the Cord

If the applied force is directly transmitted through the cord, and assuming no additional forces act, then the tension \(T \) in the cord is equal to the applied force \(F \).

Therefore:

\[
T = 50\, \text{N}
\]

However, if additional factors such as pulley or friction exist, the tension calculation would need adjustment, but in an ideal case:

\[
\boxed{
T = 50\, \text{N}
}
\]

---

3. Calculating the Velocity After Displacement of 2 Meters

Using kinematic equations, the velocity of the collar after moving a distance \(s = 2\, \text{m} \) with initial velocity \(u = 0 \) (since initially at rest) and acceleration \(a = 8.33\, \text{m/s}^2 \):

\[
v^2 = u^2 + 2 a s
\]

Plugging in the values:

\[
v^2 = 0 + 2 \times 8.33 \times 2 = 33.32
\]

\[
v = \sqrt{33.32} \approx 5.77\, \text{m/s}
\]

Result:

\[
\boxed{

\text{Velocity after 2 m} \approx 5.77\, \text{m/s}
}
\]

---

4. Additional Considerations: Work Done and Energy

The work done by the force F over the displacement s:

$$
W = F \times s = 50\, \text{N} \times 2\, \text{m} = 100\, \text{J}
$$

This work translates into the kinetic energy of the collar:

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

Calculating:

$$
KE = \frac{1}{2} \times 6\, \text{kg} \times (5.77)^2 \approx 100\, \text{J}
$$

which aligns perfectly with the work done, confirming energy conservation in an ideal system.

Real-World Applications and Implications

Understanding the dynamics of a collar under applied force has practical applications across various fields:

Mechanical Engineering

- Designing tensioned systems such as pulleys, conveyor belts, and cable cars.
- Calculating tension and acceleration ensures safety and efficiency in mechanical systems.

Physics Education

- Demonstrating fundamental principles like Newton's laws and work-energy theorem.
- Providing tangible examples for students to grasp complex concepts.

Robotics and Automation

- Controlling linear actuators and robotic arms involves similar calculations to ensure desired motion profiles.

Sports Science and Biomechanics

- Analyzing forces in movement and designing equipment that optimizes performance and safety.

Summary and Key Takeaways

- The acceleration of the 6-kg collar under a 50 N force is approximately 8.33 m/s^2.
- The tension in the cord during the motion equals the applied force, 50 N, assuming ideal conditions.
- After moving 2 meters, the collar reaches a velocity of approximately 5.77 m/s.
- The work done by the force over the displacement is 100 Joules, which converts into the collar's kinetic energy.

Conclusion

Analyzing the system where a force is applied to a collar connected via a cord involves applying Newton's laws, kinematic equations, and energy principles. In ideal conditions, the calculations are straightforward and provide insights into the behavior of the system. Such problems are fundamental in physics education and engineering design, helping students and professionals understand how forces translate into motion, tension, and energy transfer.

By mastering these principles and calculations, you can effectively analyze similar systems involving forces, masses, displacements, and velocities, which are prevalent in daily life and technological applications.

Remember: Always consider the assumptions involved in the problem. Real-world systems may involve additional factors such as friction, elasticity, and mass of the cord, which require more complex analysis.

Frequently Asked Questions

What is the acceleration of the 6-kg collar when a force of 50 N is applied to the cord over a distance of 2 meters?

Using Newton's second law: F = m a, so a = F / m = 50 N / 6 kg ≈ 8.33 m/s^2.

How far does the collar move when a force of 50 N is applied over 2 meters?

The collar moves 2 meters, as specified in the problem statement.

What is the work done on the collar by the applied force?

Work done, W = F s = 50 N 2 m = 100 Joules.

What is the final velocity of the collar after moving 2 meters under the applied force?

Using the work-energy principle: v = sqrt(2 W / m) = sqrt(2 100 J / 6 kg) ≈ 5.77 m/s.

If the collar starts from rest, what is its kinetic energy after moving 2 meters under the applied force?

Kinetic energy = work done = 100 Joules.

Does the applied force accelerate the collar, and how can we verify this?

Yes, the force causes acceleration. Verification is through Newton's second law and calculating the acceleration as approximately 8.33 m/s^2.

What assumptions are made in solving this problem?

Assumptions include neglecting friction, air resistance, and that the force is applied steadily over the entire 2 meters.

How would the result change if the applied force was increased to 100 N?

The acceleration would double to approximately 16.67 m/s^2, and the final velocity after 2 meters would increase accordingly.

Additional Resources

The Force Of F = 50 N Is Applied To The Cord When S = 2 M. If The 6-kg Collar Is Originally At Rest, Determine — this problem encapsulates fundamental principles of physics, particularly Newtonian mechanics, and provides an excellent opportunity to explore concepts such as force, mass, acceleration, and kinematic equations. Tackling such problems enhances understanding of how forces influence motion, especially in the context of pulleys, cords, and collared objects. This detailed review aims to dissect this problem comprehensively, providing clarity on the underlying concepts, solution strategies, and real-world applications.

Understanding the Problem: Key Concepts and Variables

Before delving into calculations, it's essential to understand the physical scenario and identify all relevant variables:

- Force (F): 50 Newtons
- Displacement (s): 2 meters
- Mass of the collar (m): 6 kg
- Initial velocity (u): 0 m/s (since the collar is initially at rest)

The problem asks us to determine certain quantities—most likely the acceleration of the collar, the final velocity after moving 2 meters, or the work done—based on these parameters. The precise question isn't fully specified here, but common related questions include:

- What is the acceleration of the collar under the applied force?
- What is the final velocity after moving 2 meters?
- How much work is done on the collar during this displacement?

Given the context, the problem appears to focus on kinematic and dynamic analysis—calculating acceleration and perhaps velocity or work—using Newton's second law of motion.

Fundamental Principles Involved

Newton's Second Law of Motion

This law states that the net force acting on an object equals the mass of the object multiplied by its acceleration:

$$ F_{\text{net}} = m \times a $$

In this context:

- The applied force $F = 50\, \mathrm{N}$
- The mass $m = 6\, \mathrm{kg}$
- The unknown is the acceleration a

If there are no other forces like friction or tension in the opposite direction, then:

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

Work-Energy Principle

This principle relates the work done on an object to its change in kinetic energy:

$$ W = \Delta KE = \frac{1}{2} m v^2 - \frac{1}{2} m u^2 $$

where:
- u is the initial velocity
- v is the final velocity after displacement s

Step-by-Step Solution Methodology

To analyze this problem, we proceed systematically:

Step 1: Determine the Acceleration

Assuming the only external horizontal force is $F = 50\, \mathrm{N}$, and neglecting other resistive forces:

$$a = \frac{F}{m} = \frac{50\, \mathrm{N}}{6\, \mathrm{kg}} \approx 8.33\, \mathrm{m/s^2}$$

Pros: Simple calculation, straightforward application of Newton's second law.

Cons: Assumes no friction or other forces, which may not be realistic in real-world scenarios.

Step 2: Calculate the Final Velocity After Moving 2 Meters

Using the kinematic equation:

$$v^2 = u^2 + 2 a s$$

Given:
- $u = 0\, \mathrm{m/s}$
- $a = 8.33\, \mathrm{m/s^2}$
- $s = 2\, \mathrm{m}$

Calculate:

$$v^2 = 0 + 2 \times 8.33 \times 2 = 33.32$$

$$v = \sqrt{33.32} \approx 5.77\, \mathrm{m/s}$$

Pros: Provides an exact final velocity after displacement.

Cons: Ignores possible energy losses or other damping forces.

Step 3: Compute the Work Done on the Collar

Work done by the applied force:

$$W = F \times s = 50\, \mathrm{N} \times 2\, \mathrm{m} = 100\, \mathrm{J}$$

Compare to the change in kinetic energy:

$$\Delta KE = \frac{1}{2} m v^2 = \frac{1}{2} \times 6 \times (5.77)^2 \approx 100\, \mathrm{J}$$

The work done equals the change in kinetic energy, confirming energy conservation (assuming no losses).

Assumptions and Limitations

While the above calculations are straightforward, real-world applications involve complexities:

- Friction and Resistance: Frictional forces oppose motion, reducing acceleration and the final velocity. If present, these forces need to be subtracted from the applied force to find the net force.

- Massless or Ideal Cords: Assumes the cord's mass and elasticity are negligible, which may not be valid in practical systems.

- Constant Force Application: The problem presumes the 50 N force is maintained constantly during the 2 meters, which might not be feasible in real situations.

- Gravity and Vertical Components: If the system involves vertical motion or inclined planes, gravity's component must be considered.

Pros: Recognizing these limitations helps refine models for more accurate results.

Cons: Adds complexity, requiring more data and advanced analysis.

Alternative Approaches and Extensions

- Using Work-Energy Theorem: Instead of directly calculating acceleration, one could analyze the work-energy relationship, especially if initial velocities are known or non-zero.

- Including Friction: Introducing a coefficient of friction μ would modify the net force:

$$F_{\text{net}} = F - f_{\text{friction}} = F - \mu m g$$

and alter acceleration and final velocity calculations.

- Dynamic Systems with Pulley and Rope Mechanics: If the system involves pulleys, tension calculations become critical, and free-body diagrams are essential.

Practical Applications and Relevance

Understanding these principles is vital in numerous engineering and physics applications:

- Designing Lifting Systems: Calculating the forces and accelerations in pulley-based lifting mechanisms.

- Automotive Engineering: Analyzing forces during acceleration or deceleration.

- Robotics: Programming actuators to apply precise forces for movement.

- Material Handling: Ensuring safety and efficiency in moving heavy objects over specified distances.

Features and Pros/Cons Summary

Features:

- Clear application of Newton's second law.
- Use of kinematic equations for motion analysis.
- Energy conservation principles for validation.
- Simplification assuming ideal conditions.

Pros:

- Straightforward calculations.
- Insight into physical relationships.
- Useful as a foundational example in mechanics.

Cons:

- Oversimplification ignores friction, air resistance, and other real-world factors.
- Assumes constant force and no energy losses.
- Limited to horizontal or idealized systems unless specified otherwise.

Conclusion

The problem involving a 50 N force applied to a 6 kg collar over a 2-meter displacement offers a rich exploration of classical mechanics principles. By systematically applying Newton's second law and kinematic equations, we can determine the acceleration, velocity, and work involved in the process. While the simplified model provides valuable insights, real-world scenarios require considering additional factors such as friction, pulleys, and energy losses. Mastery of these fundamental concepts not only aids in solving academic problems but also forms the backbone of engineering solutions across various industries. Understanding the interplay of forces, motion, and energy is essential for designing efficient, safe, and functional mechanical systems.

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