Alice Pushes A Box With A Force Of 75 N So That It Moves At A Constant Velocity. What Is The Force Of

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Understanding the forces involved when pushing objects is fundamental in physics, especially when analyzing motion. In this scenario, Alice applies a force of 75 N to a box, and the box moves at a constant velocity. This situation offers a practical example to explore the concepts of net force, frictional forces, and how they influence an object's motion. In this article, we will delve into the physics behind this scenario, analyzing what forces are at play, and answering the question: What is the force of — specifically, the force of friction acting on the box.

Fundamental Concepts in Force and Motion

Before examining the specifics of Alice's case, it's essential to understand some core principles of physics related to force and motion.

Newton's First Law of Motion

- States that an object will remain at rest or move at a constant velocity unless acted upon by an external force.
- Implies that for an object to move at a constant velocity, the net external force acting on it must be zero.

Net Force and Equilibrium

- The net force is the vector sum of all forces acting on an object.
- If the net force is zero, the object maintains its current state of motion (constant velocity).

Frictional Forces

- Friction opposes the relative motion between surfaces.
- In scenarios involving horizontal motion, kinetic friction is typically relevant.
- The magnitude of kinetic friction (f_k) is given by:

$$
f_k = \mu_k \times N
$$

where:

- μ_k is the coefficient of kinetic friction.
- N is the normal force (usually equal to the weight in horizontal surfaces).

Analyzing Alice’s Scenario

In this case, Alice applies a force of 75 N to move the box. The box moves at a constant velocity, which provides critical information about the forces involved.

What does constant velocity imply?

- Since the box moves at a steady speed, its acceleration is zero.
- According to Newton’s Second Law:

$$
\text{Net Force} = m \times a
$$

- With $a = 0$, the net force must also be zero.
- Therefore, the applied force (75 N) must be balanced by other forces acting against it, primarily friction.

Forces Acting on the Box

- Applied Force (F_{app}): 75 N, exerted by Alice.
- Frictional Force (f_k): Opposes the applied force.
- Normal Force (N): Perpendicular to the surface, usually equal to the weight of the box.
- Gravity (W): Downward force equal to mg, where m is mass, and g is acceleration due to gravity (~9.8 m/s^2).

Since the box moves horizontally, the vertical forces balance out, and the key focus is on the horizontal forces.

Calculating the Frictional Force

Given that the box moves at a constant velocity, the force of friction must exactly counter the applied force.

Key Point

- Frictional force equals the applied force when the object moves at constant velocity:

$$
f_k = F_{app}

$$

- Therefore:

$$
f_k = 75\, \text{N}
$$

This indicates that the force of kinetic friction acting on the box is 75 N.

Understanding the Coefficient of Kinetic Friction (μ_k)

Knowing the frictional force allows us to determine the coefficient of kinetic friction, provided we know the normal force.

Calculating μ_k

- The normal force (N) in a horizontal surface is usually equal to the weight:

$$
N = mg
$$

- The kinetic frictional force:

$$
f_k = \mu_k \times N
$$

- Rearranged to find μ_k:

$$
\mu_k = \frac{f_k}{N}
$$

To proceed with this calculation, the mass of the box must be known.

Practical Example: Estimating the Coefficient of Friction

Suppose the mass of the box is known or given. For illustration, let’s assume:

- Mass of the box (m): 20 kg

Then:
- Normal Force (N):

$$
N = m \times g = 20\, \text{kg} \times 9.8\, \text{m/s}^2 = 196\, \text{N}
$$

- Coefficient of kinetic friction (μ_k):

$$
\mu_k = \frac{75\, \text{N}}{196\, \text{N}} \approx 0.383
$$

This coefficient indicates a moderate level of friction typical for surfaces like rubber on wood or similar combinations.

Summary of the Forces in Action

Force	Magnitude	Direction	Description
Applied Force (F_{app})	75 N	Forward	Force Alice applies to move the box
Frictional Force (f_k)	75 N	Backward	Opposes the applied force; exactly balances it
Normal Force (N)	196 N	Upward	Supports the weight of the box
Gravitational Force (W)	196 N	Downward	Weight of the box

Since the net force is zero (75 N forward balanced by 75 N backward friction), the box maintains its constant velocity.

Implications and Real-World Applications

Understanding how forces balance to maintain constant velocity has practical implications across various fields:

1. Designing Efficient Transportation

- Engineers calculate the necessary forces to move vehicles or objects efficiently.
- Knowing the coefficient of friction helps optimize surface materials for minimal energy expenditure.

2. Ergonomics and Manual Handling

- Understanding the forces involved can help design tools and processes that reduce effort and prevent injury.

3. Robotics and Automation

- Robots often need to push or pull objects; calculating the required force ensures effective operation without damage.

4. Sports and Physical Training

- Athletes analyze forces to improve techniques for pushing, pulling, or sliding objects.

Conclusion

In summary, when Alice pushes a box with a force of 75 N and it moves at a constant velocity, the force of friction acting on the box must be exactly 75 N to oppose the applied force. This balance of forces aligns with Newton's First Law, confirming that the net force is zero during uniform motion. The coefficient of kinetic friction can be derived if the mass of the box is known, further illustrating how different physical parameters influence the forces involved.

Understanding these principles provides valuable insights into everyday phenomena and technological applications, emphasizing the importance of forces and friction in the mechanics of motion. Whether in engineering, sports, or daily life, these concepts help us analyze and predict the behavior of objects moving through various environments.

Remember: The key takeaway is that for an object to move at a constant velocity, the applied force must perfectly counteract the resistive forces, primarily friction, resulting in a net force of zero.

Frequently Asked Questions

What is the force of Alice pushing the box if it moves at a constant velocity?

The force of Alice pushing the box is 75 N, as given in the problem.

Why does the box move at a constant velocity despite Alice applying a force?

Because the applied force balances the opposing frictional force, resulting in zero net force and constant velocity.

What is the role of friction in determining the force needed to move the box at constant velocity?

Friction opposes the motion, so Alice's force must exactly match the frictional force to maintain a constant velocity.

If Alice pushes with 75 N and the box moves at a constant velocity, what is the frictional force acting on the box?

The frictional force is also 75 N, equal in magnitude to Alice's pushing force.

Does the force of 75 N cause the box to accelerate?

No, because the box moves at a constant velocity, indicating zero acceleration, so the net force is zero.

What would happen if Alice applied a force greater than 75 N?

The box would accelerate in the direction of the applied force because the net force would be unbalanced.

How can we determine the force of friction acting on the box?

Since the box moves at constant velocity, the frictional force equals Alice's applied force, which is 75 N.

Is it necessary for Alice to apply a force of exactly 75 N to keep the box moving at constant velocity?

Yes, because only then does her force balance the frictional resistance, maintaining constant velocity.

Additional Resources

Alice Pushes A Box With A Force Of 75 N So That It Moves At A Constant Velocity. What Is The Force Of

Understanding the dynamics of forces and motion is fundamental in physics, especially when analyzing real-world scenarios like Alice pushing a box. In this particular case, Alice applies a force of 75 N to move a box at a constant velocity. This situation offers an excellent opportunity to explore the concepts of net force, friction, and equilibrium, which are crucial for comprehending how objects behave under various forces. In this article, we will delve deep into the principles behind this scenario, examine the forces involved, and provide a comprehensive understanding of what the force of friction is in this context.

Fundamental Concepts in Force and Motion

Before analyzing Alice's scenario, it's essential to review some fundamental physics principles:

Newton’s First Law of Motion

- An object at rest stays at rest, and an object in motion stays in motion at a constant velocity unless acted upon by an external force.
- In Alice's case, the box moves at a constant velocity, indicating that the net external force acting on it is zero.

Newton’s Second Law of Motion

- The net force acting on an object equals the mass of the object multiplied by its acceleration (F = ma).
- Since Alice's box moves at a constant velocity, the acceleration is zero, implying the net force is zero.

Frictional Force

- Friction opposes the motion of objects sliding against each other.
- The force of kinetic friction (when objects are moving) is generally given by $F_{friction} = \mu_k \times N$, where:
- μ_k is the coefficient of kinetic friction,
- N is the normal force (usually equal to the weight of the object if on a horizontal surface).

Analyzing Alice’s Force and the Frictional Force

In the scenario, Alice applies a force of 75 N to the box. Since the box moves at a constant velocity, according to Newton's First Law, the net force on the box must be zero. This implies that the applied force is exactly balanced by the opposing force of friction.

Why Is the Force of Friction Equal to Alice’s Applied Force?

- When an object moves at constant velocity, acceleration is zero.
- Therefore, the sum of all forces in the horizontal direction must be zero:

$$
\text{Force applied by Alice} - F_{friction} = 0
$$

$$
F_{friction} = 75 \, N
$$

- This indicates that the kinetic friction force resisting the motion of the box is also 75 N.

Implications of the Force Balance

- The equal and opposite forces maintain the constant velocity.
- Alice's effort of 75 N is just enough to overcome friction without accelerating the box further.

Determining the Force of Friction: Details and Assumptions

While the analysis above provides a direct answer, understanding the detailed calculation of the force of friction involves considering the normal force and the coefficient of kinetic friction.

Normal Force (N)

- For a box on a horizontal surface, the normal force equals the weight of the box:

$$
N = mg
$$

where:
- m is the mass of the box,
- g is acceleration due to gravity (~9.81 m/s^2).

- If the mass of the box is known, the normal force can be calculated directly.

Coefficient of Kinetic Friction (μ_k)

- The value of μ_k depends on the materials in contact (e.g., rubber on concrete, wood on metal).
- Typical μ_k values range from 0.1 to 0.5 for many common surfaces.

Applying the Friction Formula

- Once N and μ_k are known:

$$
F_{friction} = \mu_k \times N
$$

- Since in this scenario, $F_{friction} = 75\,N$, one can use this to estimate the coefficient of kinetic friction if the mass and normal force are known.

Practical Examples and Calculations

Suppose the mass of the box is 15 kg. Then:

$$
N = mg = 15\,kg \times 9.81\,m/s^2 = 147.15\,N
$$

Given $F_{friction} = 75\,N$:

$$
\mu_k = \frac{F_{friction}}{N} = \frac{75\,N}{147.15\,N} \approx 0.51
$$

This coefficient suggests a relatively high friction surface, such as rubber on rough concrete.

Features & Pros/Cons

- Pros:
- Understanding the forces involved allows for precise calculations in real-world applications.
- Applying physics principles helps in designing systems where friction and force balance are critical.

- Cons:
- Assumes a simplified model where only kinetic friction opposes the applied force.
- Real surfaces may have varying friction coefficients, and other factors like air resistance are neglected.

Additional Considerations

While the primary analysis indicates that the force of friction equals the applied force of 75 N, other factors can influence this scenario:

Surface Conditions

- Surface roughness, material type, and cleanliness can alter the coefficient of kinetic friction.
- Changes in these factors can lead to variations in the actual force of friction.

Object’s Mass and Normal Force

- Different masses alter the normal force, impacting the frictional force if the coefficient remains constant.

Inclined Surfaces

- On inclined planes, the normal force decreases, and the force of friction adjusts accordingly.
- The analysis becomes more complex, involving components of gravitational force parallel and perpendicular to the surface.

Summary and Final Thoughts

In conclusion, when Alice pushes a box with a force of 75 N to move it at a constant velocity, the force of kinetic friction opposing this motion must also be 75 N. This equilibrium ensures zero acceleration, consistent with Newton's First Law. Calculating the exact value of the frictional force requires knowledge of the mass of the box and the coefficient of kinetic friction. Understanding these forces not only clarifies this specific scenario but also provides foundational insights applicable across a broad spectrum of physics and engineering problems.

Key Takeaways:
- The force of friction counteracts the applied force when an object moves at constant velocity.
- Accurate calculations depend on knowing the mass and surface properties.
- Real-world applications require considering additional factors like surface irregularities and additional forces.

By mastering these principles, students and professionals can better analyze and predict the behavior of objects under various force conditions, enhancing their problem-solving skills in physics and engineering domains.

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