A Boy Is Pushing A 60 KG Box Along The Floor By Applying A Horizontal Force Of 115 And The Box Is Accelerating

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When analyzing the scenario where a boy pushes a 60 kg box along the floor by exerting a horizontal force of 115 N, and the box begins to accelerate, it offers a fascinating exploration of fundamental physics concepts. Understanding the forces involved, the resulting acceleration, and how different factors influence the motion can deepen our grasp of Newton’s laws of motion. This article delves into the physics behind this situation, exploring key principles such as force, friction, acceleration, and net force, providing detailed explanations suitable for students, educators, and physics enthusiasts alike.

Understanding the Basic Scenario

Details of the Problem

- The mass of the box (m): 60 kg
- The applied horizontal force (F_applied): 115 N
- The box is accelerating along the floor

What makes this scenario interesting is that despite the considerable force of 115 N, whether the box accelerates depends on other forces acting on it, especially friction and possibly other resistive forces. To analyze the situation thoroughly, we need to understand the forces at play.

Forces Acting on the Box

Applied Force (F_applied)

This is the force exerted by the boy on the box. It acts horizontally in the direction of movement, attempting to set the box in motion and accelerate it.

Frictional Force (F_friction)

Friction opposes the motion of the box. The key types involved are:
- Static friction: when the box is initially at rest
- Kinetic friction: once the box starts moving

In this scenario, since the box is accelerating, kinetic friction is 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 between the box and the floor
- N is the normal force, which for a horizontal surface equals the weight of the box

Normal Force (N)

Since the floor is horizontal, the normal force equals the weight of the box:
$$N = m \times g$$
where:
- $g = 9.8\, m/s^2$ (acceleration due to gravity)

Calculating:
$$N = 60\, kg \times 9.8\, m/s^2 = 588\, N$$

Determining the Net Force and Acceleration

Calculating Frictional Force

To find the exact acceleration, we need the coefficient of kinetic friction μ_k. Typical values range from 0.2 to 0.5 for various surfaces. For the sake of this analysis, let's assume a common value:
- $\mu_k = 0.3$

Calculating:
$$F_k = 0.3 \times 588\, N = 176.4\, N$$

Since the applied force (115 N) is less than the kinetic frictional force (176.4 N), the box would not accelerate if kinetic friction dominates. Instead, it would tend to stay at rest or slow down. But the initial statement suggests the box is accelerating, implying either:
- The coefficient of kinetic friction is lower
- The applied force exceeds the frictional force
- Or other factors are involved

Assuming a lower μ_k or a scenario where the applied force exceeds friction, let's proceed with the calculations.

Calculating Net Force (F_net)

Net force is given by:
$$F_{net} = F_{applied} - F_{friction}$$

If friction is less than the applied force:
- For example, assuming $\mu_k = 0.2$

Then:
$$ F_k = 0.2 \times 588\, N = 117.6\, N $$

Calculating net force:
$$ F_{net} = 115\, N - 117.6\, N = -2.6\, N $$

This indicates a net force opposing the motion, so the box wouldn't accelerate forward unless the applied force exceeds friction.

Alternatively, if the applied force is greater than the kinetic friction:
- For example, if $\mu_k = 0.2$, and the applied force is 130 N
then:
$$ F_{net} = 130\, N - 117.6\, N = 12.4\, N $$

Using the net force, we can find acceleration.

Using Newton’s Second Law to Find Acceleration

Newton’s second law states:
$$ a = \frac{F_{net}}{m} $$

Suppose the net force is 12.4 N:
$$ a = \frac{12.4\, N}{60\, kg} \approx 0.2067\, m/s^2 $$

Therefore, the box accelerates at approximately 0.21 m/s^2 in the direction of the applied force.

Factors Influencing the Acceleration of the Box

Coefficient of Friction

The value of μ_k significantly impacts whether the box accelerates and at what rate. A lower μ_k means less frictional resistance, making it easier for the applied force to accelerate the box.

Magnitude of Applied Force

The larger the applied force relative to friction, the greater the net force and, consequently, the higher the acceleration.

Mass of the Object

The mass directly influences acceleration; heavier objects require more force to accelerate at the same rate due to inertia.

Real-World Applications and Significance

Understanding Force and Motion in Daily Life

This scenario exemplifies everyday situations where pushing objects involves balancing applied forces and resistive forces like friction.

Designing Efficient Moving Systems

Knowing how forces interact helps in designing transportation, manufacturing, and ergonomic tools to reduce effort and optimize movement.

Educational Importance

Analyzing such problems builds foundational knowledge in physics, fostering critical thinking about forces and motion.

Conclusion

The scenario of a boy pushing a 60 kg box with a force of 115 N and the box accelerating highlights key physics concepts, particularly Newton's second law of motion. The acceleration of the box depends critically on the balance between the applied force and the opposing frictional force. By calculating the normal force and estimating the coefficient of kinetic friction, we understand whether the force applied is sufficient to produce acceleration and at what rate.

In practice, factors such as surface type, the boy’s exertion, and the specific conditions of the surface influence the actual acceleration experienced by the box. Nevertheless, this analysis underscores the importance of understanding the interplay of forces—applied, frictional, normal—and how they govern motion. Whether in educational settings or real-world applications, grasping these principles enables better problem-solving and more efficient design of systems involving motion and force.

Keywords: physics, force, acceleration, friction, Newton's second law, normal force, kinetic friction, applied force, moving objects, physics problems

Frequently Asked Questions

What factors determine the acceleration of the box when a boy pushes it with a force of 115 N?

The acceleration depends on the applied force (115 N), the mass of the box (60 kg), and the frictional force between the box and the floor. According to Newton's second law, acceleration is equal to the net force divided by the mass.

How can we calculate the net force acting on the box in this scenario?

The net force is the difference between the applied force (115 N) and the opposing frictional force. If the frictional force is known or estimated, subtract it from 115 N to find the net force, which then can be used to determine acceleration.

What is the likely acceleration of the box given the applied force and its mass?

Assuming negligible friction, the acceleration can be calculated using Newton's second law: $a = F/m = 115 \text{ N} / 60 \text{ kg} \approx 1.92 \text{ m/s}^2$. If friction is present, the actual acceleration will be less.

Why does the box accelerate when pushed with a force of 115 N?

Because the applied force exceeds the opposing forces (like friction), resulting in a net force that causes the box to accelerate according to Newton's second law.

How would increasing the applied force affect the acceleration of the box?

Increasing the applied force would increase the net force acting on the box, thereby increasing its acceleration, assuming frictional forces remain constant or are accounted for.

Additional Resources

A Boy Is Pushing A 60 KG Box Along The Floor By Applying A Horizontal Force Of 115 N And The Box Is Accelerating — this scenario offers a fascinating glimpse into the principles of physics, specifically Newton's laws of motion, friction, and forces. Whether you're a student studying mechanics or an enthusiast interested in real-world applications of physics, understanding the forces at play in this situation provides valuable insight into how objects move and accelerate under various conditions.

Introduction

Picture a boy pushing a box with a mass of 60 kg across the floor. He applies a horizontal force of 115 N, and the box begins to accelerate. At first glance, it may seem straightforward — he pushes, the box moves, and acceleration occurs. However, beneath this simple narrative lies a complex interplay of forces, frictional resistance, and acceleration that can be thoroughly analyzed using fundamental physics principles. This guide aims to break down the problem step-by-step, helping you understand the underlying mechanics involved in this scenario.

Fundamental Concepts Involved

Before diving into calculations, it’s essential to understand some key concepts:

1. Newton's Second Law of Motion
- Statement: The acceleration of an object is directly proportional to the net force acting upon it and inversely proportional to its mass.
- Mathematical form:
$$ F_{net} = m \times a $$

2. Forces Acting on the Box
- Applied Force (F_a): The force exerted by the boy, horizontally applied, in this case, 115 N.
- Frictional Force (F_f): The resistive force opposing the motion due to contact between the box and the floor.
- Normal Force (N): The force exerted by the floor, equal in magnitude to the weight of the box when on a flat surface, acting vertically upward.
- Weight (W): The gravitational force acting downward, calculated as $W = m \times g$.

3. Friction Types
- Static Friction: Prevents initial movement; not relevant once the box is already moving.
- Kinetic Friction: Opposes ongoing motion of a sliding object; the relevant type here assuming the box is sliding.

Step-by-Step Analysis of the Scenario

Step 1: Calculating the Weight of the Box
The weight of the box is straightforward:

$$
W = m \times g
$$
where:
- $m = 60\, \text{kg}$
- $g \approx 9.8\, \text{m/s}^2$

$$
W = 60 \times 9.8 = 588\, \text{N}
$$

This is the normal force exerted by the ground on the box, assuming a flat horizontal surface and no additional vertical forces.

Step 2: Understanding Frictional Resistance
The force opposing the boy's push is primarily kinetic friction, which depends on the

coefficient of kinetic friction (μ_k) between the box and the floor:

$$
F_f = \mu_k \times N
$$

- Since the normal force N equals the weight W on a flat surface:

$$
F_f = \mu_k \times 588\, \text{N}
$$

To proceed, the value of μ_k is essential. Typical coefficients range:

Floor Type	Coefficient of Kinetic Friction (μ_k)
Wooden floor	0.3 – 0.6
Tile floor	0.4 – 0.7
Carpeted floor	0.4 – 0.8

Suppose, for this example, the floor has a coefficient of kinetic friction $\mu_k = 0.4$.

Calculating the frictional force:

$$
F_f = 0.4 \times 588 = 235.2\, \text{N}
$$

Step 3: Determining the Net Force
The net force acting on the box is the difference between the applied force and the frictional force:

$$
F_{net} = F_a - F_f
$$

Using the values:

$$
F_{net} = 115 - 235.2 = -120.2\, \text{N}
$$

The negative sign indicates that the applied force is insufficient to overcome the kinetic friction, meaning the box would not accelerate forward under these conditions; it would either remain stationary or slide backward if force is applied insufficiently.

However, the problem states that the box is accelerating, which suggests one or more of the following:

- The coefficient of kinetic friction is lower than assumed.
- The applied force is greater than the static friction threshold at the start.

- There are additional forces or conditions not specified.

Step 4: Adjusting Assumptions — Achieving Acceleration
Given the scenario states that the box is accelerating under the applied force of 115 N, we need to reconcile this with the previous calculation. Let's assume:

- The coefficient of kinetic friction is lower, say $\mu_k = 0.2$.

Calculating the frictional force again:

$$
F_f = 0.2 \times 588 = 117.6\, \text{N}
$$

Now, the net force:

$$
F_{net} = 115 - 117.6 = -2.6\, \text{N}
$$

Still negative, meaning no acceleration forward. To produce positive acceleration, the applied force must exceed the frictional force:

$$
F_a > F_f
$$

Suppose the applied force of 115 N is the maximum the boy can exert, then the actual friction coefficient must be less than:

$$
\mu_k = \frac{F_a}{W} = \frac{115}{588} \approx 0.195
$$

In this case, with $\mu_k \approx 0.195$, the net force would be:

$$
F_{net} = 115 - (0.195 \times 588) \approx 115 - 114.6 = 0.4\, \text{N}
$$

which is positive and small, resulting in a slight acceleration.

Calculating the Acceleration of the Box

Assuming the actual kinetic friction coefficient μ_k is known or estimated, the acceleration a can be calculated using Newton's second law:

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

\]

where:

$$
F_{net} = F_a - F_f
$$

Example Calculation:

Let’s assume:
- $F_a = 115\, \text{N}$
- $\mu_k = 0.2$

Then:

$$
F_f = 0.2 \times 588 = 117.6\, \text{N}
$$

Since $F_a = 115\, \text{N}$, the net force is:

$$
F_{net} = 115 - 117.6 = -2.6\, \text{N}
$$

Negative net force implies deceleration or no movement. To get acceleration, the applied force must be greater than the frictional force:

Suppose the boy applies a force of 120 N instead:

$$
F_{net} = 120 - 117.6 = 2.4\, \text{N}
$$

Now, the acceleration:

$$
a = \frac{2.4}{60} = 0.04\, \text{m/s}^2
$$

This positive acceleration indicates the box is speeding up.

Key Takeaways and Practical Insights

- Force must overcome friction for an object to accelerate.
- The actual acceleration depends on the difference between the applied force and the resistive frictional force.
- Friction coefficients vary based on surface types and environmental conditions, affecting

the net force.
- Even with a significant applied force, high friction can prevent acceleration.

Additional Considerations

1. Effect of Surface and Material
- Slippery surfaces or lubricated floors significantly reduce μ_k, easing acceleration.
- Rough or sticky surfaces increase friction, requiring more force to accelerate.

2. Impact of External Factors
- Inclines or declines change the normal force and thus the friction.
- Additional forces such as pushing at an angle or applying extra vertical force can alter normal force and friction.

3. Real-World Applications
- Engineers designing moving systems consider these principles to optimize force and friction.
- Physicists analyze similar scenarios in vehicle dynamics, sports, and robotics.

Conclusion

The scenario of a boy pushing a 60 kg box along the floor with a force of 115 N, resulting in acceleration, underscores the fundamental importance of force and friction in motion. By applying Newton's second law and understanding the role of coefficients of friction, we can accurately determine whether the applied force is sufficient to produce acceleration, and if so, calculate its magnitude. Remember, the key to analyzing such situations lies in carefully assessing all forces involved and understanding how they interact to influence motion.

Understanding these principles not only enriches your grasp of physics but also equips you to analyze and solve real-world mechanical problems with confidence.

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