# Newton's Second Law In 1 Dimension: An Object That Weighs 75 N Is Pulled On A Horizontal Surface By A

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Understanding the fundamentals of physics is essential for comprehending how objects move and interact within our environment. Among the core principles is Newton's Second Law of Motion, which explains the relationship between force, mass, and acceleration. This law is particularly insightful when analyzing motion in one dimension, such as an object sliding or being pulled along a straight line. In this article, we explore a practical scenario: an object that weighs 75 N is pulled on a horizontal surface by a force, and we delve into the physics principles governing its motion.

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## Introduction to Newton's Second Law in One Dimension

Newton's Second Law states that the acceleration of an object is directly proportional to the net force acting upon it and inversely proportional to its mass. Mathematically, it is expressed as:

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

where:
- $F_{net}$ is the net force applied to the object,
- $m$ is the mass of the object,
- $a$ is the acceleration produced.

In one dimension, this law simplifies the analysis of motion along a straight line, making it easier to predict how objects respond to applied forces.

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## Understanding Weight and Mass in the Context of Newton's Law

Before analyzing the pulling force scenario, it is crucial to understand the relationship between weight and mass:

- Weight (W): The force exerted on an object due to gravity, measured in Newtons (N).
- Mass (m): The amount of matter in an object, measured in kilograms (kg).

The relationship between weight and mass is given by:

$$W = m \times g$$

where:
- $g$ is the acceleration due to gravity (~9.8 m/s$^2$ on Earth).

Given that the object weighs 75 N, we can find its mass:

$$m = \frac{W}{g} = \frac{75\,N}{9.8\,m/s^2} \approx 7.65\,kg$$

This calculation provides the mass necessary for further analysis of forces and acceleration.

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## Scenario Description: Pulling an Object on a Horizontal Surface

Imagine a box weighing 75 N resting on a flat, horizontal surface. A person or machine applies a pulling force on the object to move it across the surface. The primary question is: What is the acceleration of the object given the pulling force?

This scenario involves several factors:

- Magnitude and direction of the applied pulling force,
- Frictional forces resisting motion,
- The net force acting on the object,
- Resultant acceleration.

By understanding these elements, we can analyze how the object responds to the pulling force in accordance with Newton's Second Law.

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## Factors Affecting the Motion of the Object

When pulling an object on a horizontal surface, the following forces are typically involved:

### 1. Applied Force (\( F_{applied} \))

- The force exerted by the pulling agent.
- Its magnitude and direction influence the acceleration.

### 2. Frictional Force ($F_{friction}$)

- Opposes the motion of the object.
- Depends on the coefficient of kinetic friction ($\mu_k$) and the normal force.

### 3. Normal Force ($N$)

- The support force exerted by the surface, equal in magnitude to the weight for flat surfaces.

### 4. Net Force ($F_{net}$)

- The sum of all forces acting in the direction of motion:

$$F_{net} = F_{applied} - F_{friction}$$

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## Calculating Frictional Force and Normal Force

Assuming the surface provides kinetic friction characterized by coefficient $\mu_k$, the frictional force is calculated as:

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

Since the surface is horizontal, the normal force $N$ balances the weight:

$$N = W = 75\,N$$

Thus,

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

The coefficient of kinetic friction varies depending on the surfaces involved. For typical materials, $\mu_k$ might range from 0.2 to 0.6.

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## Applying Newton's Second Law to Find Acceleration

Once $F_{applied}$ and $F_{friction}$ are known, the net force is:

$$ F_{net} = F_{applied} - F_{friction} $$

And the acceleration is:

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

This formula allows us to determine how quickly the object speeds up or slows down when pulled.

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## Example Calculation: Pulling Force and Resultant Acceleration

Suppose the pulling force applied is 50 N, and the coefficient of kinetic friction between the object and the surface is 0.3.

### Step 1: Calculate Frictional Force

$$ F_{friction} = 0.3 \times 75\,N = 22.5\,N $$

### Step 2: Determine Net Force

$$ F_{net} = 50\,N - 22.5\,N = 27.5\,N $$

### Step 3: Calculate Mass

$$ m \approx 7.65\,kg $$

### Step 4: Find Acceleration

$$ a = \frac{27.5\,N}{7.65\,kg} \approx 3.59\,m/s^2 $$

Thus, the object accelerates at approximately 3.59 meters per second squared in the direction of the applied force.

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## Implications of Newton's Second Law in Real-World Applications

Understanding how forces influence motion is vital in various fields, including engineering, transportation, sports science, and robotics. For instance:

- Designing efficient conveyor belts or sliding mechanisms.
- Calculating the force needed to move heavy machinery.

- Analyzing vehicle acceleration and braking.
- Developing robotic systems that require precise force control.

This fundamental law provides the foundation for predicting and controlling motion in countless practical scenarios.

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## Factors Affecting the Magnitude of Force and Acceleration

Several variables can influence the outcomes:

- Mass of the Object: Larger mass results in lower acceleration for the same applied force.
- Friction Coefficient: Higher friction reduces net force and acceleration.
- Applied Force Magnitude: Greater force increases acceleration proportionally.
- Surface Conditions: Rougher surfaces increase friction; lubricated surfaces decrease it.

Understanding these factors helps in designing systems for optimal performance and safety.

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## Advanced Considerations: Variable Forces and Non-Constant Friction

In more complex situations, forces may vary over time or with position, and friction may not be constant. For example:

- Variable pulling force: Increasing or decreasing during operation.

- Non-uniform surfaces: Irregularities affecting friction coefficients.
- Air resistance: Especially significant at higher speeds.

These factors necessitate more advanced analysis, including calculus and dynamic modeling, but Newton’s Second Law remains the core principle guiding such investigations.

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## Conclusion: The Power of Newton's Second Law in One Dimension

Newton's Second Law in one dimension provides a straightforward yet powerful framework for understanding how forces influence motion. In the case of an object weighing 75 N being pulled on a horizontal surface, calculating the mass, frictional forces, and net force allows us to predict the acceleration accurately. Whether you're designing mechanical systems, analyzing everyday motions, or exploring advanced physics concepts, mastering this law is essential.

By considering the interplay of applied forces, friction, and mass, engineers and scientists can optimize performance, ensure safety, and deepen our understanding of the physical world. As we see in this example, even a simple scenario like pulling a box reveals the profound elegance and utility of Newton's Second Law in explaining how objects move in our universe.

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Keywords: Newton's Second Law, 1D motion, force, weight, mass, acceleration, friction, horizontal surface, physics, dynamics, applied force, net force

# Frequently Asked Questions

## What is Newton's Second Law of Motion in one dimension?

Newton's Second Law states that the acceleration of an object is directly proportional to the net force acting upon it and inversely proportional to its mass, expressed as F = ma.

## How do you calculate the force required to pull a 75 N object on a horizontal surface?

First, convert the weight to mass using weight = mass × gravity (75 N = m × 9.8 $m/s^2$), so m ≈ 7.65 kg. Then, determine the net force needed to accelerate the object or overcome friction, applying F = ma or considering frictional force as needed.

## What role does friction play when pulling an object with a weight of 75 N on a horizontal surface?

Friction opposes the motion of the object. To move it at a constant velocity, the pulling force must balance the frictional force, which depends on the coefficient of friction and the normal force (equal to the weight for a horizontal surface).

## If an 75 N object is pulled with a force of 50 N on a horizontal surface, what will be its acceleration?

First, find the mass: m = 75 N / 9.8 $m/s^2$ ≈ 7.65 kg. Since the pulling force is 50 N and assuming no friction, the acceleration is a = F/m = 50 N / 7.65 kg ≈ 6.54 $m/s^2$. If friction is present, subtract the frictional force from 50 N before calculating acceleration.

## How does increasing the pulling force affect the acceleration of a 75

## N object on a horizontal surface?

Increasing the pulling force increases the net force acting on the object, which, according to Newton's Second Law (F = ma), results in a proportional increase in the object's acceleration, provided other forces like friction remain constant.

# Additional Resources

Newton's Second Law In 1 Dimension: An Object That Weighs 75 N Is Pulled On A Horizontal Surface By A

Understanding how forces influence motion is fundamental in physics, and Newton's Second Law serves as the cornerstone of classical mechanics. When analyzing a scenario such as an object that weighs 75 N being pulled on a horizontal surface, the principles of Newton's second law in 1 dimension become particularly useful. This law states that the acceleration of an object is directly proportional to the net force acting upon it and inversely proportional to its mass. In this guide, we will delve into the details of how to analyze such a situation, breaking down the concepts, calculations, and considerations step-by-step.

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What is Newton's Second Law in 1 Dimension?

Newton's second law in one dimension is expressed mathematically as:

$F_{net} = m a$

where:
- $F_{net}$ is the net force acting on the object (measured in Newtons, N),
- m is the mass of the object (in kilograms, kg),
- a is the acceleration (in meters per second squared, $m/s^2$).

This law tells us that the acceleration of an object along a straight line (1D motion) depends on the total force applied in that direction and the object's mass.

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Step 1: Understanding the Given Data

Suppose we have an object that weighs 75 N. To analyze its motion, we need to determine its mass first, since Newton's second law involves mass directly.

Weight and Mass Relationship

Weight (W) relates to mass (m) via the acceleration due to gravity (g):

$W = m g$

Assuming standard gravity:

- $g = 9.8 \text{ m/s}^2$

Calculating the mass:

$m = W / g = 75 \text{ N} / 9.8 \text{ m/s}^2$ □ $7.65 \text{ kg}$

This is the mass of the object.

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Step 2: Setting Up the Scenario

Imagine the object is resting on a horizontal surface, and a force is applied to pull it in a straight line.

The key aspects to consider include:

- The magnitude and direction of the applied force,
- The presence of friction between the object and the surface,
- The initial state of motion (initial velocity),
- Any other external forces (e.g., air resistance, but often negligible in basic problems).

Step 3: Considering Friction

Friction plays a crucial role when pulling an object on a surface. The two main types are:

- Static friction: prevents the object from moving if the applied force is below a threshold.
- Kinetic friction: opposes the motion once the object is moving.

Assuming the object is already moving or that static friction has been overcome, we focus on kinetic friction.

Kinetic Friction Force ($F_f$):

$$F_f = \mu_k N$$

where:
- $\mu_k$ is the coefficient of kinetic friction (depends on materials),
- $N$ is the normal force, which for a horizontal surface equals the weight:

$$N = W = 75 \text{ N}$$

Typically, $\mu_k$ is less than $\mu_s$ (static friction coefficient). For example, if:

- $\mu_k = 0.3$ (a common value for rubber on concrete), then the kinetic friction force is:

$F_f$ = 0.3 75 N = 22.5 N

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Step 4: Calculating the Net Force

Once the applied pulling force ($F_{pull}$) is known, the net force along the surface is:

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

If, for example, the pulling force is 50 N:

$F_{net}$ = 50 N - 22.5 N = 27.5 N

This net force causes the object to accelerate in the direction of the applied force.

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Step 5: Applying Newton’s Second Law to Find Acceleration

Using the net force and mass:

$a = F_{net} / m$

Plugging in the numbers:

a = 27.5 N / 7.65 kg ≈ 3.59 m/s²

This acceleration indicates how quickly the object speeds up in the direction of the pull.

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Step 6: Analyzing Different Scenarios

Depending on the applied force, the behavior of the object varies:

Scenario A: Applied Force Less Than Friction

Suppose F_pull = 20 N:

$F_{net}$ = 20 N - 22.5 N = -2.5 N

A negative net force indicates the applied force is insufficient to overcome friction, and the object will not accelerate; it will either remain stationary or continue at a constant velocity if already moving.

Scenario B: Applied Force Equal to Friction

If F_pull = 22.5 N:

$F_{net}$ = 0

The object experiences no acceleration; it's in equilibrium, moving at constant velocity or at rest.

Scenario C: Applied Force Greater Than Friction

Suppose F_pull = 60 N:

$F_{net}$ = 60 N - 22.5 N = 37.5 N

a = 37.5 N / 7.65 kg $\approx$ 4.90 m/s²

The object accelerates in the direction of the applied force.

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Step 7: Considering Other External Factors

In real-world situations, other forces might influence the motion:

- Air Resistance: Usually minimal at low speeds but can be significant at high velocities.
- Inclines: If the surface isn't perfectly horizontal, the component of gravity acts along or against the motion.
- Mass Distribution: If the object has a complex shape, the center of mass influences how forces are applied.

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Step 8: Summary of Key Principles

- Mass Calculation: Convert weight to mass using $m = W / g$.
- Friction: Determine the kinetic friction force with $F_f = \mu_k N$.
- Net Force: Find the net force with F□□□ = $F_{pull} - F_f$.
- Acceleration: Use a = F□□□ / m to find the acceleration.
- Motion Behavior: Recognize that if $F_{pull}$ is less than friction, the object doesn't accelerate; if greater, it accelerates proportionally to the net force.

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Final Thoughts

Analyzing an object that weighs 75 N being pulled on a horizontal surface involves understanding the interaction of forces, friction, and the resulting acceleration. Newton's second law provides a straightforward way to quantify how different forces influence the motion. Whether you're calculating the acceleration during a tug-of-war, designing conveyor belts, or simply studying everyday objects, this fundamental principle remains central to understanding the dynamics of objects in one dimension.

By carefully considering all forces at play and applying Newton's second law systematically, you can predict, analyze, and control the motion of objects with precision and confidence.

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