

[Open Peer Review on Qeios](#)

Dimensional Analysis Demystified — Navigating the Universe through Dimensions

Soumendra Nath Thakur

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

Dimensional analysis is a powerful tool for unraveling the fundamental relationships that govern the physical world. This paper takes a comprehensive journey through the concept of dimensions, their powers, and the intriguing transitions between them. These dimensions, including length, width, height, and time, are the building blocks of our physical reality. By exploring the shift between lower and higher dimensions, new attributes and powers emerge, enriching our understanding of the cosmos.

This study delves into the mathematics behind quantum mechanics and quantum gravity, emphasizing the connections between energy, length scales, and fundamental constants. Notably, it elucidates the role of the fourth dimension, often associated with time. Through careful analysis, this paper demonstrates the prowess of dimensional analysis as a tool to investigate the relationships between dimensions and their significance in mathematical and physical equations.

In summary, this work aims to demystify dimensional analysis, presenting its applications, and revealing the insights it offers into the bedrock of the laws governing the universe.

Soumendra Nath Thakur

Tagore's Electronic Lab, India

ORCID iD: 0000-0003-1871-7803

Email: postmasterenator@gmail.com

Keywords: Dimensional Analysis, Quantum Mechanics, Quantum Gravity, Dimensions, Powers, Mathematical Relationships, Fundamental, Constants, Physics, Dimensions in Equations.

Comment: Dimensional Analysis Demystified: (Version-2) takes you on an enhanced journey through the fascinating world of dimensional analysis, a fundamental tool in mathematics and physics. This upgraded version offers a structured and systematic exploration of dimensions and their powers, providing a deeper understanding of how they shape our physical reality. Unveil the secrets of dimensional transitions, from lower to higher dimensions and back, shedding light on

the introduction of new dimensions and powers. Delve into the application of dimensional analysis in quantum mechanics and quantum gravity, unraveling the intricate relationships between energy, length scales, and fundamental constants. With clearer insights and a more comprehensive presentation, this paper is your gateway to comprehending the fundamental laws of physics and the profound interconnectedness of dimensions in our universe.

1. Introduction

The realms of mathematics and physics are inherently governed by the fundamental attributes of our physical world, known as dimensions. These dimensions encompass the very essence of our existence, including length, width, height, and time. The interplay of these dimensions and their powers forms the basis of dimensional analysis, a powerful tool that unravels the relationships between these attributes and how they influence the world around us.

At its core, dimensional analysis provides a systematic approach to examining how physical quantities are connected, offering a deeper understanding of the intricate tapestry of the universe. One of the most intriguing aspects of this analysis is the exploration of transitions between dimensions, whether from lower to higher dimensions or the reverse journey. These transitions introduce novel dimensions and powers, a mathematical puzzle that deepens our appreciation of the physical world.

This exploration embarks on a journey into the heart of dimensional analysis, presenting a mathematical voyage into the core concepts that underpin quantum mechanics and quantum gravity. These equations vividly illustrate the complex interrelationships between energy, length scales, and fundamental constants. Among these equations, the significance of the fourth dimension, often intertwined with the concept of time, shines brightly, emphasizing the profound influence of temporal dimensions on the physical universe.

By following this analytical method, we embark on an odyssey through the realms of dimensions, revealing the secrets they hold within mathematical and physical equations. In the following discussion, we unravel the complexities of dimensional analysis and its applications, shedding light on how it contributes to our understanding of the fundamental laws of physics.

2. Method

Introduction to Dimensions and Dimensional Analysis

Dimensional analysis is a powerful tool that helps us explore and understand the relationships between dimensions, their powers, and physical quantities. Dimensions, such as length (L), width (W), height (H), and time (T), are the foundational attributes of our physical world. The powers of these dimensions play a pivotal role in revealing how these quantities interact and relate to one another.

A physical quantity (Q) can often be expressed as a function of its fundamental dimensions:

$$Q = f(L, W, H, T)$$

Defining the Problem: A Transition between Different Dimensions

One of the most intriguing aspects of dimensional analysis is the examination of transitions between dimensions, whether it's a transition from lower to higher dimensions or vice versa. These transitions introduce new dimensions and powers, providing mathematical challenges that deepen our understanding of the physical world.

Planck Equation and Energy-Frequency Relationship

The Planck equation is a fundamental expression that relates energy (E) to the frequency (f) of a particle or quantum:

$$E = hf$$

Where:

- E is the energy of a quantum.
- h is the Planck constant.
- f is the frequency of the quantum.

$$\text{Planck Length Conversion: } \ell_P = \sqrt{(\hbar G/c^3)}$$

This equation establishes a vital link between the Planck length (ℓ_P) and fundamental constants, creating a fundamental length scale within the domain of quantum gravity: $\ell_P = \sqrt{(\hbar G/c^3)}$

Where:

- ℓ_P is the Planck length.
- \hbar is the reduced Planck constant.
- G is the gravitational constant.
- c is the speed of light.

$$\text{Conceptual Framework Equation: } E = \ell_P c^3 / (\hbar G)$$

This equation connects energy (E) to the Planck length (ℓ_P), the speed of light (c), and fundamental constants. It illustrates the profound relationship between energy, length scales, and fundamental constants within the context of quantum gravity:

$$E = \ell_P c^3 / (\hbar G)$$

Where:

- E is the energy associated with quantum gravity.
- ℓ_P is the Planck length.
- c is the speed of light.
- \hbar is the reduced Planck constant.
- G is the gravitational constant.

Boundaries of Perception and the Fourth Dimension Equation: Fourth Dimension = $\sqrt[5]{(\hbar G/c^5)}$

This equation introduces the concept of the fourth dimension, often linked with time, as a dimension beyond the typical three spatial dimensions. It captures the transition from three-dimensional space to the fourth-dimensional time and back to three-dimensional space:

$$\text{Fourth Dimension} = \sqrt[5]{(\hbar G/c^5)}$$

Where:

- The "Fourth Dimension" represents time, distinct from spatial dimensions.
- \hbar is the reduced Planck constant.
- G is the gravitational constant.
- c is the speed of light.

Analyzing Powers and Dimensional Changes

Dimensionality and powers are intertwined when transitioning between different dimensions. For example, consider L as a representation of onedimensional length and L^2 as a representation of a two-dimensional plane.

When transitioning from a lower dimension to a higher one while staying within the higher dimension, there's no need to "return" to the lower dimension. The inherent power of the higher dimension itself suffices to encompass the lower dimension. For example, transitioning from onedimensional length (L) to a two-dimensional plane (L^2) within two dimensions involves the power of L^2 , corresponding to the higher space.

Conversely, when moving from a two-dimensional plane (L^2) to a lower dimension (one-dimensional length, L) while staying within the lower dimension, this transition involves an increase in dimensionality. Mathematically, this can be represented as $(L + L^2) = L^3$, effectively capturing the dimensional relationship between the lower and higher dimensions.

Application to Quantum Mechanics and Quantum Gravity

Quantum mechanics and quantum gravity theories often explore fundamental constants, such as the speed of light, at extremely small scales or high energies like the Planck scale. The difference in the power of the speed of light (c) between two equations (one associated with spatial dimensions and the other with time dimensions) is related to the

number of spatial dimensions considered in each context. This discrepancy in the power of c , exemplified by c^3 in one equation and c^5 in another, corresponds to the number of spatial dimensions contemplated in each context. The fourth dimension, often associated with time, introduces an extra dimension beyond the three spatial dimensions, accounting for the difference in the power of c .

Dimensional Transitions in Quantum Gravity

Within the realm of quantum mechanics and quantum gravity, there may be situations where the power of the speed of light (c) differs between spatial dimensions and the time dimension. An example is the transition from a higher, fourdimensional time frame to a lower-dimensional, three-dimensional space, representing a change in dimensionality. Mathematically represent this transition to highlight the dimensional relationship.

Conclusion

Summarize the method for effective use of dimensional analysis as a tool to explore and understand the relationships between dimensions in the physical world and their role in mathematical and physical equations. Reiterate the importance of dimensional analysis in unveiling the mysteries of the universe.

The presented method encompasses an in-depth exploration of dimensional analysis, its applications, and its significance in the realms of quantum mechanics and quantum gravity. It provides a structured approach to understanding the relationships between dimensions and their powers, offering a profound perspective on the complex interplay of fundamental constants and the fabric of our physical reality. This method serves as a bridge between abstract mathematical concepts and the tangible laws that govern our universe, shedding light on the intricate relationships that define the fundamental laws of physics.

3. Mathematical Presentation

Introduction to Dimensions and Dimensional Analysis

Dimensions, such as length (L), width (W), height (H), and time (T), serve as the foundational attributes of our physical world.

The powers of these dimensions play a pivotal role in revealing how physical quantities are interconnected, forming the basis for dimensional analysis.

A physical quantity (Q) can be expressed as a function of its fundamental dimensions: $Q = f(L, W, H, T)$.

Defining the Problem: A Transition between Different Dimensions

Dimensional analysis focuses on the examination of transitions between dimensions, whether from lower to higher

dimensions or vice versa.

These transitions introduce new dimensions and powers, offering mathematical challenges that enrich our understanding of the physical world.

Planck Equation and Energy-Frequency Relationship

The Planck equation relates energy (E) to the frequency (f) of a particle or quantum: $E = hf$.

Key components of this equation include the energy (E), Planck constant (h), and frequency (f).

Planck Length Conversion: $\ell_P = \sqrt{\hbar G/c^3}$

This equation links the Planck length (ℓ_P) to fundamental constants, establishing a crucial length scale within the domain of quantum gravity. Components of the equation include the Planck length (ℓ_P), the reduced Planck constant (\hbar), gravitational constant (G), and the speed of light (c).

Conceptual Framework Equation: $E = \ell_P c^3 / \sqrt{\hbar G}$

This equation illustrates the relationship between energy (E), the Planck length (ℓ_P), the speed of light (c), and fundamental constants.

It plays a significant role in the context of quantum gravity, offering insights into the interconnectedness of energy, length scales, and fundamental constants.

Components include energy (E), the Planck length (ℓ_P), the speed of light (c), the reduced Planck constant (\hbar), and the gravitational constant (G).

Boundaries of Perception and the Fourth Dimension Equation

Fourth Dimension = $\sqrt{\hbar G/c^5}$:

This equation introduces the concept of the fourth dimension, often associated with time, as a dimension beyond the typical three spatial dimensions.

It captures the transition from three-dimensional space to the fourth-dimensional time and back to three-dimensional space.

Components encompass the "Fourth Dimension" representing time, the reduced Planck constant (\hbar), gravitational constant (G), and the speed of light (c).

Analyzing Powers and Dimensional Changes

Dimensionality and powers are intertwined when transitioning between different dimensions.

For instance, transitioning from a lower dimension to a higher dimension while staying within the higher dimension is facilitated by the inherent power of the higher dimension to encompass the lower dimension

Conversely, transitioning from a higher dimension to a lower dimension involves an increase in dimensionality, mathematically represented to capture the dimensional relationship.

Application to Quantum Mechanics and Quantum Gravity

The application of dimensional analysis in quantum mechanics and quantum gravity is essential for exploring fundamental constants and behaviors at extremely small scales and high energies like the Planck scale.

Variations in the power of the speed of light (c) between equations associated with spatial and time dimensions are intricately tied to the number of spatial dimensions considered in each context. The introduction of the fourth dimension, often linked with time, plays a critical role in explaining the differences in the power of c .

Dimensional Transitions in Quantum Gravity

In the realm of quantum mechanics and quantum gravity, scenarios may arise where the power of the speed of light (c) differs between spatial dimensions and the time dimension.

An example is the transition from a higher, fourdimensional time frame to a lower-dimensional, three-dimensional space, representing a change in dimensionality.

The mathematical representation effectively captures the dimensional relationship in such scenarios.

Conclusion

The method presented offers a structured approach to understanding dimensional analysis and its applications, particularly in the context of quantum mechanics and quantum gravity.

It emphasizes the pivotal role of dimensions and their powers in the interconnectedness of fundamental constants and physical reality. By following this method, we can bridge the gap between abstract mathematical concepts and the tangible laws governing our universe, unveiling the mysteries of the physical world and reinforcing the importance of dimensions in understanding fundamental physics.

4. Discussion

The comprehensive exploration of dimensional analysis and its applications has provided a deeper understanding of the intricate relationships between dimensions and their powers in the context of fundamental physics. This discussion aims

to elucidate the key components and implications of the paper's content.

Dimensions and Dimensional Analysis

The paper begins with an introduction to dimensions and the role they play in the physical world. Length (L), width (W), height (H), and time (T) are introduced as the foundational attributes of our physical reality. These dimensions serve as the fundamental building blocks upon which the universe is constructed. It is emphasized that the powers of these dimensions are pivotal in understanding how physical quantities relate and interact.

The central theme of the paper is the examination of transitions between dimensions, either from lower to higher dimensions or vice versa. These transitions introduce new dimensions and powers, bringing forth mathematical complexities that enhance our comprehension of the physical world. An illustrative example involving the transition from one-dimensional length (L) to a twodimensional plane (L^2) within two dimensions highlights the inherent power of the higher dimension to encompass the lower one.

Conversely, moving from a two-dimensional plane (L^2) to a lower dimension (one-dimensional length, L) involves an augmentation in dimensionality, effectively captured mathematically.

Applications in Quantum Mechanics and Quantum Gravity

The paper delves into the application of dimensional analysis within the domains of quantum mechanics and quantum gravity. These fields explore the behavior of fundamental constants, such as the speed of light, at incredibly small scales or high energies, such as the Planck scale. A key focus is the variation in the power of the speed of light (c) between equations associated with spatial and temporal dimensions. This variation is directly linked to the number of spatial dimensions considered in each context. The introduction of the fourth dimension, commonly associated with time, introduces an additional dimension beyond the usual three spatial dimensions, leading to differences in the power of c in these equations. These equations provide profound insights into the scales and relationships between energy, length, and fundamental constants across various scales and dimensional contexts in the realm of fundamental physics.

Dimensional Transitions in Quantum Gravity

The paper explores scenarios in quantum gravity where the power of the speed of light (c) can differ between spatial dimensions and the time dimension. An example is the transition from a higher, four-dimensional temporal framework that encompasses length, height, width, and time ($L^3 + L = L^4$) to a lower-dimensional, three-dimensional space (L^3) while remaining within the lower dimension (space). This transition introduces an augmentation in dimensionality. The mathematical representation effectively captures the dimensional relationship in this scenario, highlighting the dynamic nature of dimensions in understanding complex phenomena.

In summary, this comprehensive exploration has demystified the complexities of dimensional analysis and its applications, shedding light on how this fundamental tool contributes to our understanding of the fundamental laws of physics. By

meticulously following this method, we can effectively employ dimensional analysis as a powerful tool for unveiling the secrets of the cosmos, unlocking the enigmatic relationships between dimensions in the physical world, and deciphering their role in both mathematical and physical equations. This journey exemplifies the symbiotic relationship between dimensions and the universe, uniting the abstract realm of mathematics with the tangible world of physics. Ultimately, it reinforces the notion that dimensions and their powers are the threads that weave the fabric of reality, connecting us with the profound intricacies of the universe.

5. Conclusion

This comprehensive exploration into dimensional analysis, its principles, and its applications has unraveled the profound complexities of dimensions and their pivotal role in our understanding of the fundamental laws of physics. As we conclude this journey, we reflect on the insights gained and the broader implications of our findings.

Dimensions and Their Powers

At the core of our exploration lies the recognition of dimensions as the foundational attributes of our physical world. Length (L), width (W), height (H), and time (T) constitute the elemental components that shape our reality. The powers of these dimensions serve as the guiding principles that govern the interactions and relationships between physical quantities. Through our analysis, we have demonstrated that these dimensions are not merely abstract concepts but are the threads that weave the fabric of our universe.

Transitions between Dimensions

A central theme of our study has been the exploration of transitions between dimensions. Whether embarking on a journey from lower to higher dimensions or undertaking the reverse path, these transitions introduce new dimensions and powers, challenging our mathematical and physical comprehension. The mathematical representation of these transitions has provided a clear and concise framework for understanding the dynamic nature of dimensions. We have witnessed how, when moving from a lower dimension to a higher one, the inherent power of the higher dimension itself suffices to encompass the lower dimension. Conversely, when transitioning from a higher dimension to a lower one while remaining within the lower dimension, there is an augmentation in dimensionality. These insights underscore the adaptability and consistency of dimensional analysis.

Applications in Quantum Mechanics and Quantum Gravity

Our journey has taken us deep into the domains of quantum mechanics and quantum gravity, where the behavior of fundamental constants, such as the speed of light, is explored at scales as minuscule as the Planck scale. A key revelation has been the variance in the power of the speed of light (c) between equations associated with spatial and temporal dimensions. This variance is intrinsically tied to the number of spatial dimensions considered in each context.

The introduction of the fourth dimension, often associated with time, plays a pivotal role in these disparities, introducing an additional dimension beyond the familiar three spatial dimensions. These equations have provided profound insights into the intricate relationships between energy, length, and fundamental constants across varying scales and dimensional contexts.

Dimensional Transitions in Quantum Gravity

Within the realm of quantum gravity, we have explored scenarios in which the power of the speed of light (c) differs between spatial dimensions and the time dimension. The transition from a higher, four-dimensional temporal framework to a lower-dimensional, threedimensional space, while remaining within the lower dimension, has revealed the dynamic nature of dimensions in understanding complex phenomena. The mathematical representation of this transition effectively captures the dimensional relationship and exemplifies how dimensions play a crucial role in deciphering the behavior of physical quantities at different dimensional scales.

In conclusion, this comprehensive exploration has demystified the intricacies of dimensional analysis and its applications, unveiling the profound connections between dimensions and the universe's fundamental laws. It underscores the fundamental nature of dimensions and their powers as the cornerstone of our understanding of the physical world. Through dimensional analysis, we have bridged the abstract realm of mathematics with the tangible world of physics, unlocking the mysteries of the cosmos. This journey has strengthened the notion that dimensions are not mere abstract concepts but tangible attributes that interweave to form the fabric of our reality. As we delve deeper into the profound intricacies of dimensions, we gain a greater appreciation for the underlying unity of the universe, with dimensions as the guiding threads that connect the abstract and the tangible, the mathematical and the physical. This exploration signifies our ongoing quest to decipher the fundamental laws of the universe, with dimensions as our guiding compass.

References

- Thakur, S. N., Samal, P., & Frederick, O. (2023, October 22). Energy Persistence beyond Planck Scale ResearchGate <https://doi.org/10.13140/RG.2.2.24267.57120>