

Learning Quantities and Units in Elementary Schools

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ABSTRACT

Quantities and units are the main foundation in physics, forming an inseparable basis for understanding more complex physical concepts. This article explores various aspects of quantities and units, starting from basic quantities, derived quantities, to vector and scalar quantities. The discussion covers measurement topics, measurement techniques, units, international systems of units, and dimensions. The importance of quantities and units is not only as technical terminology, but as an integral component for measuring and conveying natural phenomena with precision. This article aims to provide comprehensive insight into the concept of quantity, from basic to complex, as well as applying this concept in measurement and scientific communication. Literature research methods are used to detail the main concepts of quantities and units. The results and discussion discuss types of quantities, basic quantities, derived quantities, and the role of the international system of units. The article also touches on measurements, dimensions, and research methods. In conclusion, a deep understanding of quantities and units provides a solid foundation for accurate measurement and effective communication in the physical sciences.

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INTRODUCTION

One component of basic educational science that plays an important role in various scientific disciplines is the subject of physics. Quantities and units are the main foundation in physics, forming an inseparable basis for understanding more complex physics concepts. In this article, we will deepen our understanding of various aspects of quantities and units, exploring various concepts ranging from basic quantities, derived quantities, to important aspects such as vector and scalar quantities. Apart from that, topics about measurement will also be discussed, including measurement techniques for various objects, as well as basic concepts about units and the international system of units.

It is important to remember that quantities and units are not just technical terminology in physics, but rather integral components that help measure and convey natural phenomena with the necessary precision. This article aims to provide comprehensive insight into the concept of quantity, from the most basic to the complex level, to help readers understand the essence and practicality of applying this concept in measurement and scientific communication. One of the key aspects to be explored is the difference between fundamental quantities and derived quantities, clarifying how these concepts are related and providing the foundation for modern physics. Apart from that, the discussion of vector and scalar quantities will provide a deeper perspective regarding the properties of quantities and how to convey them mathematically.

This article will also discuss measurement methods used in physics to obtain accurate and reliable data. By understanding the basic principles of measurement, readers will be able to apply these concepts in various contexts, both in laboratory experiments and in everyday life.

Units, as a support for quantity, are also highlighted in this article. The international system of units will be explained to provide a better understanding of the standards used globally in the physical sciences. Knowledge of this system of units is essential to ensure that measurement results can be understood and interpreted correctly by scientists around the world.

Finally, this article will touch on dimensions, introducing an abstract concept that involves investigating the properties of quantities without including numerical values. Understanding dimensions helps scientists to make broader connections between various quantities and simplify physical equations.

A deep understanding of quantities and units not only provides a foundation for scientists, but is also the key to achieving accurate measurement results and communicating effectively within the scientific community. Therefore, through this article, it is hoped that readers can gain a solid understanding of these basic concepts and apply them better in the context of physics.

METHOD

The method of writing articles on quantities and units using literature research involves a series of systematic steps to explore, assess, and synthesize information from various literature sources that are relevant to the theme. This approach reflects the desire to present an in-depth and up-to-date understanding of quantities and units in physics.

The process begins with identifying the main concepts of quantities and units that will be explained in the article and others that follow. Information gathering involves searching and exploring relevant literature material. This information involves key aspects such as definitions of quantities and units, magnitudes, basic quantities and derived quantities, vector quantities and scalar quantities, measuring, measuring various kinds of objects, units, international system of units, dimensions.

Additionally, this method validates information through authoritative sources such as leading research institutions and standard guides. This validation provides reliability to the information presented in the article, creating a solid foundation for understanding quantities and units. Lastly, this writing method maintains academic integrity by including accurate references for each concept or information presented. This allows readers to trace the origin of the information and engage in further exploration. Overall, the literature research method applied in this article aims to provide a solid, informative and up-to-date foundation regarding quantities and units in physics, which can provide readers with a better understanding.

RESULTS AND DISCUSSION

Quantity is a basic concept in physics that allows measurement, description and understanding of natural phenomena. This article will describe quantities in detail, including definitions, types of quantities, international system of units, unit dimensions, and measurement methods.

Definition of Quantity.

Quantity in the context of physics refers to the physical properties of natural objects or phenomena that can be measured and expressed in numerical values. The concept of quantity is a very important foundation in understanding and explaining various aspects of the world of physics. By their quantitative nature, quantities enable systematic measurement, comparison and analysis of natural phenomena. When we talk about quantities, we are talking about concrete characteristics such as length, mass, time, temperature, speed, and so on. Each quantity has a specific unit of measurement, for example, length is measured in meters, mass in kilograms, and time in seconds.

There are two main categories of quantities, namely basic quantities and derived quantities. Basic quantities are basic quantities that cannot be described further, while derived quantities are obtained through a combination of basic quantities with certain mathematical operations.

It is important to understand the dimensions associated with quantities, which refer to their mathematical properties. Each quantity has dimensions that can be recorded using brackets, such as [L] for length, [M] for mass, and [T] for time.

Quantities can also be divided into scalar and vector. Scalar quantities only have magnitude or numerical value, while vector quantities have magnitude and direction. For example, velocity is a vector quantity because it includes both speed and direction, while temperature is a scalar quantity because it only has a numerical value without direction.

Types of Quantities

1) Principal amount.

Types of quantities Basic quantities in physics refer to types of basic quantities that cannot be further broken down into other quantities. They constitute the foundation of measurement systems and provide the basis for constructing derived quantities. The three main fundamental quantities that involve the dimensions of space and time are length, mass, and time.

a. Long.

Length is a basic quantity that measures the spatial dimensions of an object or the distance between two points in space. In the metric system, the basic unit of length is the meter. Length has the dimension [L] which shows the linear dimension attribute.

b. Mass.

Mass is a basic quantity that measures the amount of matter or materials contained in an object. The basic unit of mass in the metric system is the kilogram. Mass has dimensions [M] and plays an important role in determining gravitational forces and interactions.

c. Time.

Time is a basic quantity that measures the sequence of events or the duration of an event. The basic unit of time in the metric system is the second. Time has the dimension [T] and is a critical parameter in many physical laws, such as Newton's laws of motion.

These basic quantities form the basis of various physical laws and help in the construction of more complex derived quantities. By measuring length, mass and time, we can express other quantities such as speed, acceleration, force, energy and others. Fundamental quantities are an essential starting point in our understanding of the world of physics, and they form the basis for measurements and calculations in many fields of science.

2) Derived Quantity.

Derived quantities in physics are a type of quantity obtained through a combination of basic quantities with certain mathematical operations. In contrast to basic quantities which are the basis of measurement systems, derived quantities provide a richer understanding of natural phenomena and can be broken down into combinations of basic quantities. Several important derived quantities involve length, mass, and time as primary fundamental quantities.

a. Speed. Speed is a derived quantity resulting from the comparison of changes in length (distance traveled) with changes in time. Mathematically, speed (v) can be calculated as the ratio $\Delta d/\Delta t$, where Δd is the change in length and Δt is the change in time. Speed has dimensions [L]/[T], which indicates that its dimensions involve length and time.

b. Acceleration. Acceleration is another derived quantity that results from changes in speed with time. Mathematically, acceleration (a) can be calculated as the ratio $\Delta v/\Delta t$, where Δv is the

change in speed and Δt is the change in time. Acceleration has dimensions $[L]/[T^2]$, which indicates that its dimensions involve length and time squared.

- c. Momentum. Momentum is a derived quantity that involves the mass and speed of an object. Momentum (p) can be calculated as the product of mass (m) by speed (v). Mathematically, $p = m \times v$. Momentum has dimensions $[M][L]/[T]$.
- d. Energy. Energy is a derived quantity related to the ability of a system to do work. There are different forms of energy, such as kinetic energy which involves speed and potential energy which involves position. Kinetic energy (K) can be calculated as $\frac{1}{2} m \times v^2$, where m is mass and v is velocity. Energy has dimensions $[M][L]^2/[T^2]$.
- e. Power. Power is a derived quantity that measures the rate of change in energy or work of a system. Power (P) can be calculated as the result of dividing work (W) by time (t). Mathematically, $P = W/\Delta t$. Power has dimensions $[M][L]^2/[T^3]$. These derived quantities provide a framework for describing and understanding more complex physical phenomena. By utilizing derived quantities, scientists can construct more detailed mathematical models and analyze various aspects of the dynamics and properties of matter in various situations.

3) Scalar and Vector Quantities.

a. Scalar Quantities.

A scalar quantity is a concept in physics that describes physical properties without considering specific direction or orientation. In contrast to vector quantities which have magnitude and direction, scalar quantities are only related to the magnitude or value of the quantity without regard to direction.

Common examples of scalar quantities are temperature, mass, time, density, and so on. When we mention a temperature of 30 degrees Celsius, the information provided is only the large value of that temperature without any particular direction that needs to be considered. Likewise with mass, where mentioning a mass of 5 kilograms shows a large value of mass without taking into account direction.

Scalar quantities are often represented using simple mathematical notation, without arrows over the variables. For example, $T=25$ indicates the scalar quantity T with a value or magnitude of 25.

Operations on scalar quantities involve ordinary mathematical operations such as addition, subtraction, multiplication, and division. When performing operations between two scalar quantities, we only take into account the magnitude of the two quantities without paying attention to their direction. Scalar quantities do not depend on a particular coordinate or orientation system in their use. They provide information about the magnitude or magnitude of a quantity without regard to direction, and are often used in various aspects of physics as well as practical applications in everyday life. Even though it does not consider direction, scalar quantities remain an important concept in understanding the physical properties of various phenomena.

b. Vector Quantity.

Vector quantity is a concept in physics that describes physical properties with two main components, namely magnitude and direction. The main difference between vector quantities and scalar quantities lies in the inclusion of direction in vector quantities. Vector quantities have a magnitude that shows the magnitude or value of a quantity, such as a speed of 30 km/hour or a force of 50 Newtons. However, what differentiates vector quantities is the presence of a directional component which states the orientation or course of the quantity. For example, an object's speed of 20 m/s towards the east represents a vector quantity because it includes both value and direction.

Common examples of vector quantities include speed and force. Speed not only indicates how fast an object is moving, but also the direction in which it is moving. Likewise with force, which not only has magnitude (how big), but also direction (for example, up, to the left, and so on).

Vector quantities are often represented with mathematical notation using arrows over the variables, such as \vec{v} , for speed or \vec{F} , for force. In three-dimensional space, vectors can be decomposed into x, y, and z components to facilitate analysis.

Operations on vector quantities include addition, subtraction, and multiplication with scalars. The addition of vectors is carried out according to vector rules, that is, in parallel. The result of vector addition is a new vector that has a different magnitude and direction from the original vector.

Vector quantities are very important in analyzing motion, predicting the behavior of objects in force fields, and describing the physical state of an object or system. By understanding the concept of vector quantities, we can explore many aspects of physics, including dynamics, electromagnetism, and many other fields.

International System of Units.

The International System of Units (SI) is a globally accepted standard system for measuring physical quantities. Its primary goal is to provide a consistent and universal framework for measurements performed across a variety of scientific disciplines, including physics, chemistry, engineering, and other sciences.

SI is based on seven basic quantities which are the basis for all physical quantities. These basic quantities include length (meters), mass (kilograms), time (seconds), electric current (amperes), thermodynamic temperature (kelvin), amount of substance (mol), and light intensity (candela). Each has a basic unit that is defined and used as a reference. For example, meters are the basic unit for length, kilograms for mass, seconds for time, and so on.

Apart from basic units, SI also has derivative units which come from combinations or operations on basic units. For example, speed is expressed in meters per second (m/s), which is derived from the basic unit of length divided by the basic unit of time.

The main advantages of SI are its ease of use and its ability to facilitate effective scientific communication globally. Consistent use of these systems ensures accurate and standardized measurements in scientific experiments, as well as their use in technical applications across a wide range of industries.

SI is widely recognized by the international scientific community and is used by standards organizations and governments in almost all countries as an accepted standard for the measurement of physical quantities. This ensures compatibility, clarity and consistency in scientific communications worldwide.

Unit Dimensions.

Dimensions in the context of physics refer to the properties or characteristics that differentiate one physical quantity from another. Each quantity has dimensions which are a combination of basic quantities in a certain system of units. These dimensions are represented using square brackets, such as [L] for the length dimension, [M] for the mass dimension, [T] for the time dimension, and so on.

For example, speed has dimensions $[L][T]^{-1}$, which indicates that speed is the result of the dimension of length divided by time. The dimensional approach makes it possible to express relationships between quantities in the laws of physics. These laws often have dimensional agreement on both sides of the equation, allowing for mathematical verification and consistency.

Furthermore, the concept of dimensions is also useful in evaluating the validity of physical equations. A dimensionally correct equation will have dimensional alignment on both sides of the equation, which helps avoid errors in the formulation or use of the laws of physics.

The concept of dimensions is found in various fields of physics, including mechanics, thermodynamics, electromagnetism, and others. They form the basis for understanding the relationships between quantities and the fundamental laws of physics.

Unit Measurement Method.

Measuring is a critical aspect in physics that allows us to understand and describe natural phenomena quantitatively. This article will detail the approach, process, and significance of measuring activities in the physical sciences, investigating how measurement provides the basis for building accurate and reliable scientific knowledge. Measuring requires a careful and systematic approach. This approach includes identifying the quantity to be measured, selecting appropriate measuring instruments, and developing methods that can produce accurate results. In this case, direct and indirect measurement methods will be detailed to illustrate the approach used in evaluating certain quantities.

The measurement process involves a series of orderly steps. Starting from instrument calibration, data collection, to results analysis, each stage has an important role in ensuring measurement accuracy. An explanation of the concept of measurement uncertainty will also be described to provide a deeper understanding of the limits of uncertainty in measurement results. Measuring requires the use of instruments appropriate to the quantity being measured. Explanations of various instruments, such as rulers, micrometers, thermometers, or advanced measuring tools such as spectrometers, will be given to show the diversity of measurement techniques available. Measuring various objects is a critical element in physics that allows observation, analysis, and a deeper understanding of the physical properties of natural objects and phenomena.

Length and Dimension Measurements.

a. Length and Distance.

Measuring length involves the use of various instruments such as rulers, micrometers, or more advanced mapping tools. The concepts of instrument calibration and accuracy will be explained to show how to accurately measure length.

b. Three Dimensional Size.

To measure three-dimensional measures, such as the volume or dimensions of complex objects, measurement techniques involving geometric principles or 3D scanning technology can be applied.

Measuring Mass and Weight.

a. Mass of Static Objects.

The mass of an object can be measured using a precisely calibrated scale. The working principle of the balance and strategies to overcome uncertainty in mass measurements are explained.

b. Weight and Gravity.

The weight of an object involves the force of gravity. Weight measurement instruments such as spring scales or electronic scales will be explained along with how to compensate for changes in gravitational acceleration at various locations.

Temperature and Heat Measurement.

a. Temperature Measurement.

Instruments such as thermometers or thermocouples are used to measure temperature. The concepts of thermometer calibration and conversion between temperature scales will be explained.

b. Heat Measurement.

Heat can be measured with tools such as a calorimeter. Thermal energy and heat transfer measurements will be detailed.

Electricity and Magnetism Measurements.

a. Measurement of Electric Current and Voltage.

Tools such as multimeters are used to measure electric current and voltage. The basic principles and techniques of electrical measurement will be described.

b. Magnetic Field Measurement.

Gaussmeter or magnetic compass is used to measure magnetic fields. The concept of measuring the intensity and direction of a magnetic field will be explained

CONCLUSION

Units in the context of physics refer to the value given to measure or express a physical quantity. They are standards used to measure quantities and provide a consistent frame of reference for measurements. Units can be divided into two main types: basic units and derived units. Basic units are units that cannot be described further and are used to measure basic quantities such as length (meters), mass (kilograms), time (seconds), electric current (amperes), thermodynamic temperature (kelvin), amount of substance (mol), and light intensity (kandela). On the other hand, derived units are the result of a combination or multiplication of basic units. For example, speed is expressed in meters per second (m/s), which is the result of dividing the basic unit of length by the basic unit of time. The use of units in physical science is very important because it allows clear and consistent communication about physical quantities among scientists and in various experiments and technical applications. This standardization allows measurement results to be compared universally, ensuring consistency and clarity in the understanding of the physical properties of various phenomena. Units also play an important role in the formulation of the laws of physics. These laws often have consistent units on both sides of the equation, providing a strong mathematical basis for the analysis and prediction of physical phenomena. In addition, there is an internationally accepted and widely used system of units called the International System of Units (SI). SI is a standard for international measurement that bases its basic units on basic quantities, and its use is recognized globally for consistency and uniformity in the measurement of physical quantities.

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