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OPERATIONS ON VECTORS

Makhmudov Azam Kudratovich
Teacher of mathematics at the Terdu Academic Lyceum.
Mamaraimov Bekzod Qodirovich
Teacher of mathematics at the Terdu Academic Lyceum.
Musurmonov Maruf Akrom ugli
Teacher of mathematics at the Terdu Academic Lyceum.

Abstract. This article is devoted to the study of the basic operations performed on vectors. Vectors are widely used in geometry and physics, and the operations performed on them include analytical and computational methods. Examples of operations such as addition, subtraction, scalar and vector multiplication of vectors are given, and the scientific and practical significance of these operations is also considered. The article provides the mathematical foundations necessary for working with vectors and helps to provide students with the necessary knowledge in this area.
Keywords: vectors, vector operations, scalar multiplication, vector multiplication, geometric calculations with angular vectors between vectors, vectors in physics.

Today, large-scale reforms are being carried out in all areas of life in New Uzbekistan, and the education system is one of the areas that has undergone changes in this process. The education system in the country is organized on the basis of modern requirements, and reforms are being carried out in the higher education system. As our President noted, the process of knowledge and education, which begins in school, will increase the opportunities for solving social problems, an economy developing on the basis of high technologies. Reforms in the education system are complemented by reforms in the field of higher education, aimed at training highly qualified personnel. The document defining these areas, the "Concept for the Development of the Higher Education System of the Republic of Uzbekistan until 2030", approved by the President on October 8, 2019, aims to effectively organize scientific and innovative activities, train competitive personnel and strengthen international cooperation. At the same time, reforms in the education system are aimed not only at modernizing higher education, but also at developing its integration with production and social sectors. The new education system will take the country to a new level by supporting science and technology, familiarizing itself with international experience and training personnel who meet the needs of society. Such reforms will help increase Uzbekistan's global competitiveness.

These innovations ensure the development not only of the educational sphere, but also of the entire society and economy, opening up new opportunities.

The use of innovative technologies in practical lessons also requires great skill and knowledge from the teacher. If innovative technology is used in its place, the set goal will be achieved. The teacher can also achieve high results by using proprietary technologies during the lesson, depending on the topic of the lesson.

Proprietary technology covers innovative systems that include a set of methods and tools for implementing certain areas of educational content. This includes technologies for teaching certain subjects and technologies for working with students by the teacher.

It is also worth noting that geometry is a branch of mathematics that studies the forms and formal relationships of objects. The name arose from this, in connection with land surveying. For example, the shape, volume, surface area of an open cylindrical container are objects of geometric study, their color, or what material they are made of. Also, even if the base is a circle,

its shape is described by an ellipse, which is a relation belonging to Geometry. Geometric concepts are studied by abstracting and idealizing them. For example, the base of a cylindrical container may differ slightly from a circle, the maker may not be perfectly straight, the surface may be thick, and the side surface may not be perpendicular to the base, but such details are omitted in geometry. In this way, concepts such as a point that has no dimensions, a straight line that continues indefinitely in both directions, and relations such as parallelism and symmetry are created. In return, the scope of application is very wide, and in a certain sense, laws of an absolute and universal nature are determined.

The first knowledge of geometry was acquired empirically in ancient Babylon and Egypt. For example, it was found that the angles formed by the intersection of parallel straight lines and one of the angles of a triangle with lengths 3, 4, 5 units were right. Geometric properties were continued by the Greeks, who tried to derive logical arguments through observation. The property proved in this process was called a theorem. The theorem of Thales (625-548 BC) is one of the first examples. Mathematics was given great importance in the Pythagorean Academy, and Euclid created the work "Fundamentals", which was of incomparable importance in mathematics and the development of thought, and for 2000 years was an example of logical observation. In the work "Fundamentals", Euclid described the basic geometric concepts and began to prove theorems using axioms and postulates.

Quantities encountered in the study of physical, chemical and other phenomena can be divided into two classes. There is a class of quantities called scalar quantities, and to characterize them it is enough to indicate the numerical values of these quantities. These are, for example, volume, mass, density, temperature, etc. However, there are quantities that are characterized not only by numerical values, but also by direction. They are called directed quantities or vector quantities. Examples of such quantities are the speed of movement, the strength of a magnetic or electric field, and other quantities. A vector is an object that has a starting point and a direction, and to describe it mathematically, a magnitude and direction must be specified. The magnitude indicates the length of the vector, and the direction indicates the direction of its movement. For example, the speed and direction of an airplane are expressed as a vector, which indicates the speed and direction of the airplane relative to the airfield. Another example is the motion of a soccer ball, which can be represented as a vector, where the vector is defined by the ball's starting point and the direction of its motion. Vectors are used in physics, engineering, mathematics, computer graphics, artificial intelligence, and many other fields. Vectors are used to perform mathematical operations, such as addition, multiplication, and division. Vectors can be combined to form a new vector, or one vector can be divided by another to form a new vector. Vectors are used in various areas of our lives, such as physics, engineering, transportation, and GPS systems to determine speed, direction, and position.[1]

Vectors that lie on the same straight line or on parallel straight lines are called collinear vectors. It is important to note that collinear vectors do not have to have the same direction.

In addition, a free vector is understood as a vector that can be moved parallel to any point in space without changing its length and direction. In particular, all free vectors can be moved parallel to a point with a common starting point.

[1] Anton, H., & Rorres, C. (2010). Elementary Linear Algebra: Applications Version (10th ed.). Wiley.

If three vectors a, b, and c are located in parallel planes or in the same plane, then these vectors are called coplanar. It can be said that given vectors a, b, and c are coplanar only if they all lie in the same plane when brought to a single starting point.

Vectors are also mathematical objects that are common in the fields of analytical geometry and physics. Vectors are used to describe points in two-dimensional and three-dimensional spaces and to perform other mathematical operations. Among the operations performed on vectors, there are such basic operations as addition, subtraction, scalar multiplication, and vector multiplication. Each operation has its own special mathematical properties, and a clear understanding of them makes it easier to work with vectors.

In mathematics, the concept of a vector is a more complex concept than the concept of a number. Not all operations that can be performed on numbers can be performed on vectors. For example, operations such as multiplication, division, exponentiation, and square root cannot be performed on vectors. Linear operations on vectors include adding, subtracting, and multiplying vectors by a number. The operations of adding and subtracting vectors are mainly used in geometric methods. To add two vectors, a new vector is created by joining their endpoints. When calculating the angle between vectors, a decision is made using their dot product.

Scalar multiplication is useful for calculating the angle between two vectors. The scalar product of vectors is calculated by multiplying their magnitudes by the cosine of the angle between them.

Vector multiplication is an operation that creates a new vector between two vectors. The resulting vector is always perpendicular to the two vectors, and its direction depends on the angle between the vectors.

The geometric meaning of vector multiplication is to create a new vector that occurs in the plane between the two vectors. The direction of this vector is perpendicular to the plane between the original vectors.

The angle between vectors can be calculated using the scalar multiplication formula. This angle is very important in physics and engineering, because many physical processes are evaluated based on the angles between vectors.

Vector multiplication is used to express many important concepts in physics. For example:

Scalar multiplication is used in calculating force and work. If you know the angle between the force vector and the motion vector, you can find the work done using scalar multiplication. This is important, for example, in mechanics or in calculating electrical energy.

Vector multiplication is used to determine the relationship between torque and forces. For example, vector multiplication is used to calculate the torque of forces acting on an object or to describe electromagnetic fields.

The operation of vector multiplication plays an important role in determining the relationship between two vectors and creating new vectors. Scalar multiplication and vector multiplication are operations that are widely used not only in mathematics and physics, but also in engineering, computer science, and other fields, and their correct understanding and application help in developing scientific and technological solutions.

Vectors entered the fields of mathematics, such as geometry and linear algebra. They were originally used as geometric objects, that is, to describe points or directions. The basic concepts of vectors and their methods of representation date back to the 17th century, especially to the work of René Descartes and Pierre de Fermat in the field of geometry.

In geometry, vectors were used primarily to describe the distance and direction between points. With the help of Descartes' coordinate system, vectors gained a mathematical basis for studying the relationships between points.

In linear algebra, vectors were introduced primarily to describe systems of linear equations, vector spaces, and operations between vectors.

In physics, vectors were originally introduced to describe quantities such as force and velocity. Vectors are also used to describe velocity, acceleration, force, torque, and many other physical quantities. Vectors were primarily needed to represent both direction and magnitude.

Isaac Newton and other physicists made important developments in explaining the motion of quantities such as force and velocity using vectors. Newton's third law of motion, for example, requires working with forces represented by vectors.

In engineering, vectors are used to analyze forces, moments, and motions, especially in the fields of mechanics and structures. Vectors are used as a primary tool in structural analysis and the study of mechanical systems. Forces and motions within mechanisms and systems are calculated using vectors.

Vectors are also important in the fields of electronics, thermodynamics, and electromagnetism. Electromagnetic fields, for example, are represented using special vectors.

In addition, vectors have entered the fields of graphics and algorithms in computer science. In computer graphics, vectors are used to determine the shapes, sizes, and locations of images and models. Vectors are also used in data structures and algorithms, particularly in the fields of neural networks and artificial intelligence.

Vectors are used in economics, especially in macroeconomic models. In modeling economic variables, production and consumption, sets and systems are worked out using vectors. In economic statistics, for example, various economic indicators can be described and analyzed using vectors.

The introduction of vectors into scientific fields is the result of many centuries of development. Initially introduced as geometric objects, vectors later became widespread as a result of their application in physics, engineering, economics, computer science and other fields. Today, they are used not only in mathematical and physical problems, but also as an important tool in performing technological and scientific work.

Conclusion, Studying operations on vectors helps to understand the necessary foundations in mathematical and physical sciences. By mastering these operations perfectly, it is possible to solve not only theoretical, but also practical problems. Operations based on vectors are also important for advanced technologies such as machine learning and artificial intelligence.

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