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«ТОШКЕНТ ИРРИГАЦИЯ ВА ҚИШЛОҚ ХЎЖАЛИГИНИ МЕХАНИЗАЦИЯЛАШ МУҲАНДИСЛАРИ ИНСТИТУТИ» МИЛЛИЙ ТАДҚИҚОТ УНИВЕРСИТЕТИ

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“THE MODERN PROBLEMS OF AGRICULTURE AND WATER RESOURCES”

МАҚОЛАЛАР ТЎПЛАМИ

II ТОМ

Тошкент – 2023 йил, 12-13 май

14.	Ж.Б. Каримбоев, Г.Д. Шерматова-“ТИҚХММИ” Миллий Тадқиқот Университети	Аморф кремнийли қуёш элементлари	Илмий раҳбар: Г. Шерматова
15.	Ф.Ж.Тураев-Катта ўқитувчи, А.Қудратов-талаба-“ТИҚХММИ” Миллий Тадқиқот Университети, ЕРК факультети	Ҳисоблаш жараёнидаги хатоликларни ўрганиш.	Илмий раҳбар: катта ўқитувчи. Ф.Тураев
16.	С.Тошпўлатова- талабаси - “ТИҚХММИ” Миллий Тадқиқот Университети, ЕРК факультети	Матрицаларни амалий масалаларга тадбиқи	Илмий раҳбар: катта ўқитувчи. Ф.Тураев
17.	А.Нуриллаев- 2босқич, А. Ҳасанов-1босқич “ТИҚХММИ” Миллий Тадқиқот Университети (Энергетика факультети талабалари)	Кўп ўзгарувчили функцияларнинг баъзи бир тадбиқлари.	Илмий раҳбар: Қ. Жувонов
18.	А.У.Гаппаров., Ж.Ж. Турсунбоев–талаба, И. М Газиева–магистр. “ТИҚХММИ” Миллий тадқиқот университети	Суғориш сувининг физик хоссаларини электр ўтказувчанлик орқали ўрганиш.	
19.	F.Uzakbayev (1st grade student of “Land Resources and Management” faculty)	Applications of vectors in real life, engineering and physics	Supervisor: ass. Mardiyev A.Sh.
20.	М.К. Номонова, Г.Д. Шерматова “ТИҚХММИ” Миллий тадқиқот университети	Юқори фойдали иш коэффисиентига эга каскадли қуёш элементлари	Илмий раҳбар: Г. Шерматова
21.	М. Руҳиддинова, Г.Д. Шерматова “ТИҚХММИ” Миллий тадқиқот университети	Космик парвозда қуёш батареяларининг ориентацияси	Илмий раҳбар: Г. Шерматова
22.	С.Ў. Саидқулов-“ТИҚХММИ” Миллий тадқиқот университети ГМ факультети 1-босқич талабаси	Дифференциал тенгламаларга келтириладиган механик, физик ва геометрик масалалар	Илмий раҳбар: Н. Йўлдошев
23.	Д.Ш. Зиядуллаев-доцент, профессор, Д.Т. Мухамедиева, С.Д. Шамсиев-Студентка 4-курс БГУИР студенты 2 курса, Х.М.Ураимова, Ш.У.Сулаймонов Национальный исследовательский университет “ТИИИМСХ”	Использование искусственного интеллекта в агропромышленности	Илмий раҳбар: доц. проф. Д.Зиядуллаев
24.	Ж.И. Турдиалива – “ТИҚХММИ” Миллий тадқиқот университети талабаси.	Amaliy masalalarni yechishda kompleks Sonlarning qollanilishi	Ilmiy rahbar: dots. T. Ergashev
25.	У. Хабибуллаева -“ТИҚХММИ” Миллий тадқиқот университети докторант	Республикада цитрус меваларини етиштириш ва ривожлантириш муаммоларини ҳал қилиш йўлларини математик моделлаштириш орқали таҳлил қилиш	Илмий раҳбар: проф. Г. Шадманова
26.	С.С.Хамидов, Қ.М.Туражонов, И.О.Хазратқулов, А.Э.Алиев - - “ТИҚХММИ” Миллий тадқиқот университети,Таянч доктарантлари	Қовушқоқ-пластик стерженнинг зарбасига оид масала.	
27.	А.Н.Зиябеков , Г.Д. Шерматова -“ТИҚХММИ” Миллий тадқиқот университети	“Қуёш” уйлари	Илмий раҳбар: Г. Шерматова
28.	Н. Сафарбаева-Катта ўқитувчи, З. Рахимбердиева -ГТС факультети талабаси, “ТИҚХММИ” Миллий тадқиқот университети	Математик масалаларни ечиш ёрдамида ўқувчиларнинг мантиқий фикрлашларини кенгайтириш	Илмий раҳбар: Катта ўқитувчи Н. Сафарбаева
29.	Д.К Бекмуратов, Ш.Б.Бахтиёров–, “Муҳаммад ал-Хоразмий номидаги Тошкент ахборот технологиялари университети” 3-босқич талаба	Эталон танловдаги объектларни синфларга хатоли ажратувчи ҳал қилувчи қоидани қуриш алгоритми ва дастурий таъминоти	Илимий раҳбар: Д. Бекмуратов

UDK 514

APPLICATIONS OF VECTORS IN REAL LIFE, ENGINEERING AND PHYSICS

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Abstract:

Applications of vectors include real life applications, application of vector space, application of vector algebra, application of vector in Engineering, application of dot product of vectors and much more. In this article, we study all the applications of vectors. Some applications of vectors are learnt in detail in such as engineering, physics, daily life. There are given some examples that how to use vector calculus in different fields of science, and how to organize vectorial model of the problem.

Key words: vector, vector calculus, displacement, force, electric field intensity, vector quantity, vector space, torque.

Vector Introduction

A quantity that can be completely described using both magnitude and direction is called a vector quantity. Example: displacement, force, electric field intensity, etc.

Vector algebra is a huge world of math that uses pure logic. Geometrically, a vector is a directed line segment. If AB is a segment and if it is specified by a direction by means of an arrowhead as shown in the figure, then the directed line segment AB has magnitude as well as direction. The segment AB with the direction from A to B is represented by the vector $\overrightarrow{AB}$, while the segment AB with direction from B to A denotes vector $\overrightarrow{BA}$.

Applications of vectors

Vectors can be used by air-traffic controllers when tracking planes, by meteorologists when describing wind conditions, and by computer programmers when they are designing virtual worlds. In this section, we will present three applications of vectors that are commonly used in the study of physics: work, torque, and magnetic force.

Vector calculus

Vector calculus, or vector analysis is concerned with differentiation and integration of vector fields, primarily in three-dimensional Euclidean space represented by R^3. Vector calculus plays an important role in differential geometry and in the study of partial differential equations. Vector calculus also deals with two integrals known as the line integrals and surface integrals. Divergence and curl are two important operations on a vector field. They are important to the field of calculus for several reasons, including the use of curl and divergence to develop some higher-dimensional versions of the Fundamental Theorem of Calculus. In addition, curl and divergence appear in mathematical descriptions of fluid mechanics, electromagnetism, and elasticity theory, which are important concepts in physics and engineering.

Application of vector calculus

It is used extensively in physics snd engineering, espicially in the description of electromagnetic fields, gravitation fields, and fluid flow. Vector calculus is used in:

Geodesics on a Surface

Electric Field from Distributed Charge

Plotting a Slice of Vector Field

To find the rate of change of the mass of fluid flows

In rigid body dynamics in rectilinear and plane curvilinear motion along paths and in both rectangular

Solved Example of Application of Vector Calculus in Engineering Mathematics

1. Find the angle between the tangents to the curve $\vec{r} = 3t\vec{i} + 2t\vec{j} - t^3\vec{k}$ at the point $t = \pm 1$.

2. Differentiating the given curve by t, $\frac{d\vec{r}}{dt} = 3\vec{i} + 2\vec{j} - 3t^2\vec{k}$ which is the tangent vector to the curve at any point t.

Let $\vec{x}$ and $\vec{y}$ are the tangent vectors to the curve at $t = 1$ *and* $t = -1$ respectively, then $\vec{x} = 2\vec{i} + 2\vec{j} - 3\vec{k}$ *and* $\vec{y} = -2\vec{i} + 2\vec{j} - 3\vec{k}$. Let θ be the angle between the tangents $\vec{x}$ and $\vec{y}$ then:

$$\cos\theta = \frac{\vec{x}\cdot\vec{y}}{|\vec{x}|\cdot|\vec{y}|} = \frac{(2\vec{i} + 2\vec{j} - 3\vec{k})\cdot(-2\vec{i} + 2\vec{j} - 3\vec{k})}{|2\vec{i} + 2\vec{j} - 3\vec{k}|\cdot|-2\vec{i} + 2\vec{j} - 3\vec{k}|} = \frac{-4 + 4 + 9}{\sqrt{17}\cdot\sqrt{17}} = \frac{9}{17}$$

Vector Space

In mathematics, physics, and engineering, a vector space is a set of objects called vectors, which may be added together and multiplied by numbers called scalars. Scalars are often real numbers, but some vector spaces have scalar multiplication by complex numbers or, generally, by a scalar from any mathematical field. The simplest example of a vector is the trivial one: {0}, which contains only the zero vector.

Application of Vector Space

Application of vectors is required in Engineering and computer science. Vector spaces have many applications as they occur frequently in common circumstances, namely wherever functions with values in some fields are involved.

They are used in Fourier Transformation.

Vector spaces furnish an abstract, coordinate-free way of dealing with geometrical and physical objects such as tensors.

Application of vector space in computer science: The minimax theorem of game theory stating the existence of a unique payoff when all players play optimally can be formulated and proven using vector space methods.

Application of vector space in linear algebra: Quantum Mechanics is entirely based on it. Also important for time domain (state space) control theory and stress in material using tensors.

In differential geometry, the tangent plane to a surface at a point is naturally a vector space whose origin is identified with the point of contract.

Vector Algebra

Vector algebra is specifically the basic algebraic operations of vector addition and scalar multiplication. Vector algebra includes addition and subtraction of vectors, division and multiplication of vectors, along with dot product and cross product.

Application of Vector Algebra

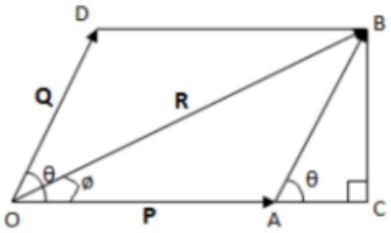
The list below is some of the most common Application of Vector Algebra:

In many physical situations, we often need to know the direction of a vector. For example, we may want to know the direction of a magnetic field vector at some point or the direction of motion of an object.

Vector algebra is useful to find the component of the force in a particular direction.

In kinematics to find resultant displacement vectors and resultant velocity vectors

In mechanics to find resultant force vectors and the resultants of many derived vector quantities.



In electricity and magnetism to find resultant electric or magnetic vector fields.

Application of vectors in physics: Vectors can be used to represent physical quantities. Most commonly in physics, vectors are used to represent displacement, velocity, and acceleration. Vectors are a combination of magnitude and direction and are drawn as arrows.

Application of Resolution of Vectors in Daily Life

Application of Resolution of Vectors in Daily Life is as listed below:

Banking of Roads. A road at curves is elevated at the farther end of curvature. The angle of banking is ϕ. The normal reaction from the ground is N. The vehicles are inclined to vertical by angle ϕ. $N\cos\phi$ balances the weight mg of the vehicle along vertical lines. $N\sin\phi$ supplies the centripetal force along the radius of curvature. That determines the maximum speed of the vehicle to avoid slipping.

Projectile Motion. A projectile (stone) thrown with an initial speed u at angle ϕ with the horizontal line, has a vertical component of $(u\sin\phi - gt)$ and the horizontal component of $u\cos\phi$ under components of vector.

Sharpening wooden pencil with a blade. We cut the pencil at an angle. The component of force in the direction perpendicular to the pencil cuts the pencil. The component of force in the direction parallel to the pencil removes the thin wooden part.

Earth's magnetic field. Earth's magnetic field has two components B and H: perpendicular to Earth's surface and parallel to the surface.

Pendulum. The tension in the string has two components to balance the weight and to give the centripetal force.

Real Life Application of Parallelogram Law of Vectors. Let P and Q be two vectors acting simultaneously at a point and represented both in magnitude and direction by two adjacent sides OA and OD of a parallelogram OABD as shown in the figure. Let θ be the angle between P and Q, and R be the result vector. Then, according to the parallelogram law of vector addition, diagonal OB represents the resultant of P and Q.

The magnitude of resultant vector is given by the following formula

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}, \phi = tg^{-}\left(\frac{Q\sin\theta}{P+Q\sin\theta}\right)$$

1. Two forces of magnitude 6 N and 10 N are inclined at an angle of 60^0 with each other. Calculate the magnitude of the resultant and the angle made by the resultant with 6 N force.

Let P and Q be two forces with magnitude 6 N and 10 N respectively and θ be the angle between them. Let R be the resultant force.

So, P=6 N, Q=10 N and $\theta = 60°$. We have

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta} \Rightarrow R = \sqrt{6^2 + 10^2 + 2\cdot 6\cdot 10\cdot\cos 60°} \Rightarrow R = 14.$$

Common Examples Applications of Vector Quantities

The list below is some of the most common applications of vectors.

Work. In physics, the term work is used to describe the energy that is added to or removed from an object or system when a force is applied to it. From the experiment, it has been determined that work is maximized when the applied force is parallel to the motion of the object and that no work is done when the force is applied perpendicular to the motion. Therefore, the work done by a force can be described by the dot product of the force vector and the displacement vector.

By using vector calculus we can find the formula for work. The formula for work: $W = \vec{F} \cdot \vec{d}$. This means that work is a scalar quantity. It is the dot product of two vectors. Hence, $W = Fd\cos\theta$, where θ –is the angle between force and displacement.

Example. Application of dot product of vectors. Akbar turns a crank to lower a bucket of water into a well. Determine the total work done on the bucket if the weight of the bucket is 15 N, and the tension force in the rope is 13 N. The bucket rises a distance of 4,5 m while he is cranking in a vertically downwards direction.

The rope does negative work on the bucket because the motion and the force are in opposite directions. If the force is measured in newtons and the displacement in meters, the work is measured in Joules.

$W_{rope} = \vec{F}_{rope}\vec{d} \quad \cos\theta = 13\ N \cdot 4{,}5\ m \cdot \cos 180° = -58{,}5\ J$

The weight force does positive work on the bucket because the motion and the force is in the same direction.

$W_{weight} = \vec{F}_{weight}\vec{d} \quad \cos\theta = 15\ N \cdot 4{,}5\ m \cdot \cos 0° = 67{,}5\ J$

Total work done $W = W_{rope} + W_{weight} = -58{,}5\ J + 67{,}5\ J = 9{,}0\ J$

Magnetic force. The force that a magnetic field exerts on a charged particle is strongest when the particle moves perpendicular to the field and the magnetic force on the particle is equal to zero when it moves parallel to the field. Therefore, the magnetic force can be described using the cross-product of the field strength vector and the particle's velocity vector: $\vec{F} = q\vec{v}\vec{B}$ where $\vec{F}$ is the force on the particle, q is the charge of the particle, $\vec{v}$ is the velocity if the particle, and $\vec{B}$ is the vector representing the magnetic field. If the velocity is measured in m/s and if the magnetic field is measured in tesla, the force will be measured in newtons, the metric base unit of force. This means that magnetic force is a vector quantity. It is the cross product of two vectors. Hence, $F = qvB\sin\theta$

Example. Application of cross product of vectors. Determine the magnetic force between two parallel conductors of length 1 m separated by 50 cm in air and carrying currents of 30 A in the same direction and opposite direction.

Given as, $I_1 = I_2 = 30\ A, d = 0{,}5\ m, L = 1\ m.$ The magnetic force between the two conductors is:

$F = 0{,}36 \cdot 10^{-3}\ N, F_{21} = \frac{\mu_0 I_1 I_2 L}{2\pi d} = \frac{4\pi \cdot 10^{-7} \cdot 30^2 \cdot 1}{2\pi \cdot 0{,}5} = 0{,}36 \cdot 10^{-3} N$

Application of Magnetic Vector Potential. The vector potential is defined to be consistent with Ampere's Law and can be expressed in terms of either current I or current density j (the sources of magnetic field). In various texts this definition takes the forms:

$$A = \frac{\mu_0 I}{4\pi}\oint \frac{\vec{dl}}{r}$$

Torque

When you lift a baseball off a table-top, you are exerting a force that moves the object as a whole. When you apply a force to a doorknob, you cause the door to rotate on its hinges. Scientists use the term torque to describe the force-like property that affects the rotation of an object. The torque can be

described using the cross-product of the force vector and the lever arm, a vector pointing radially outward from the axis of rotation to the point where the force vector is applied to the object: $\vec{\tau} = \vec{r} \cdot \vec{F}$, where $\vec{\tau}$ is the torque, $\vec{r}$ is the perpendicular distance, and $\vec{F}$ is the applied force. This means that torque is a vector quantity. It is the cross product of two vectors. Hence, $\tau = Fr \sin\theta$.

Example. Application of cross product of vectors. If the force applied is perpendicular to the handle of the spanner as shown in the diagram, find the (i) torque exerted by the force about the centre of the nut, (ii) direction of torque and (iii) type of rotation caused by the torque about the nut. Arm length of the spanner, $r = 15\ cm = 15 \cdot 10^{-2} m$

Force, $F = 2{,}5\ N$. Angle between r and $F, \theta = 90°$.

$\tau = Fr \sin\theta, \tau = 2{,}5 \cdot 15 \cdot 10^{-2} \cdot \sin 90° \Rightarrow \tau = 37{,}5 \cdot 10^{-2}\ Nm$

As per the right-hand rule, the direction of the torque is out of the page. The type of rotation caused by the torque is an anticlockwise.

Daily Life Applications of Vectors

Following are the everyday applications of vectors in daily life:

Navigating by air and by boat is generally done using vectors.

Planes are given a vector to travel, and they use their speed to determine how far they need to go before turning or landing. Flight plans are made using a series of vectors.

Sports instructions are based on using vectors. For example, wide receivers playing American football might run a route where they run seven meters down the field before turning left $45°$ and running in that direction. Sports commentary also depends on vectors. Only a few sports have with grids, so discussion revolve around the direction and speed of the player.

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