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ELEMENTS OF FIELD THEORY VECTOR FIELD

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Abstract
Vector field in this article. vector lines and the expression of the flow of the field through the surface in coordinates.

Keywords: Vector field. vector lines, scalar function in the field, field points, integral on the surface

Vector field. vector lines. Let's look at the bounded area of space.

At every point in this industry $\vec{R}$ if a vector quantity is defined, then the vector field is said to be defined. Vector field variable $\vec{R}$ determined by the transfer of the vector at each point in the field $\vec{R}$ has a definite value (situation).

For example: 1) An object charged by electricity creates an electric field in the space where that object is located. There is a voltage at each point in the field, which affects the positive unit charge at that point.

2) Fluid flow creates a field of velocities by affecting the volume of liquid filled.

Vector field theory studies the mathematical theory of a field, not the physical processes that occur through vector quantities and their physical properties.

The vector field at point M of the space field is a definite one $\vec{R}$ represented by a vector.

$\vec{R}$ vektor M radius vector of the point $\vec{r}$ is a function of.

$$\vec{R} = \vec{R}(\vec{r}) \qquad (1)$$

$B = \{0, \vec{i}, \vec{j}, \vec{k}\}$ Descartes reperida $\vec{r} = \overrightarrow{om}$ x, y, z Therefore it has Cartesian coordinates

$$\vec{R} = \vec{R}(x, y, z) \qquad (2)$$

if

$$\vec{R} = X\vec{i} + Y\vec{j} + Z\vec{k} \qquad (3)$$

if we look at the spread, $\vec{R}$ of X, Y, Z coordinates x, y, z are functions of variables.

$X = X(x, y, z)$,

$Y = Y(x, y, z)$,

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$$Z = Z(x, y, z), \qquad (4)$$

If a vector field does not depend on time, then it is called a stationary field.
It depends on the time

$$\vec{R} = \vec{R}(x, y, z, t) \qquad (5)$$

The vector field given by the vector in view (5) is called the variable field.
Definition: If a field vector is attempted at each point on a line in a field, it is called a field vector line.
Voltage lines in magnetic and electric fields are vector lines.
Vector line

$$L: \quad \vec{r} = \vec{r}(t) \qquad (6)$$

Let's look at $\frac{d\vec{r}}{d\vec{t}}$ and $\vec{R}$ vektorlar $M \in L$ is directed at the point of the attempt. They are collinear vectors,

$$\frac{d\vec{r}}{dt} = \lambda \vec{R} \qquad (7)$$

Or

$$d\vec{r} = \vec{R}\lambda dt \qquad (8)$$

(8) is the vector differential equation of the vector line in the parametric form. Let's write (8) in coordinates:

$$dx = X\lambda dt, \; dy = Y\lambda dt, \; dz = Z\lambda dt \qquad (9)$$

(9) and λdr If we subtract, we have the following system of differential equations of vector lines:

$$\frac{dx}{X} = \frac{dy}{Y} = \frac{dz}{Z} \qquad (10)$$

Integrating (10)

$$\varphi_1(x, y, z) = C_1, \; \varphi_2(x, y, z) = C_2 \qquad (11)$$

we have indeterminate equations.
For example,

$$\vec{R} = (bz - cy)\vec{i} + (cz - az)\vec{j} + (ay - bx)\vec{k}$$

given a field vector. Let us define vector lines. We construct the following system of differential equations.

$$\frac{dx}{bz - cy} = \frac{dy}{cx - dz} = \frac{dz}{ay - bx}$$

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we construct the following proportions.

$$\frac{xdx+ydy+zdz}{x(bz-cy)+y(cx-az)+z(ay-bx)}=\frac{xdx+ydy+zdz}{0}=0$$

$$\frac{adx+bdy+cdz}{a(bz-cy)+b(cx-az)+c(ay-bx)}=\frac{adx+bdy+cdz}{0}=0$$

we'll see

$$xdx+ydy+zdz=0$$

$$adx+bdy+cdz=0$$

Through integration

$$x^2+y^2+z^2=C_1^2$$

$$ax+by+cz=C_2$$

equations are generated.

A family of spheres in which the center of the vector line is the origin $\vec{N}\{a,b,c\}$ consists of the intersection of a family of planes perpendicular to the vector.

In § 10, the integral on a closed line in the field $\oint(\vec{a}d\vec{r})$ expressed in appearance $\vec{a}=\vec{R}$ and $d\vec{r}=\vec{\tau}ds$ for

$$\Gamma_L=\int_{(L)}(\vec{R}\vec{\tau})ds \qquad (12)$$

Γ_L in the field L along the line is called circulation.

(12) in terms of coordinates

$$\Gamma_L=\int_{(L)}Xdx+Ydy+Zdz \qquad (13)$$

The formula is determined.

$$(\vec{R}d\vec{r})=Xdx+Ydy+Zdz \qquad (14)$$

the quantity is called the circulating element.

Example: $\vec{R}=-y\vec{i}+x\vec{j}+x\vec{k}$ vector field $x^2-y^2=1,\ z=0$ is the circular circulation.

$$\Gamma_L=\int_{(L)}-ydx+xdy+cdz$$

$$x=\cos t, y=\sin t, z=0$$

$$dx=-\sin tdt, dy=\cos tdt, dz=0$$

$$\Gamma_L=\int_0^{2\pi}(\sin^2 t+\cos^2 t)dt=\int_0^{2\pi}dt=t\Big|_0^{2\pi}=2\pi$$

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Coordinate expression of the flow of a field through a surface.

When studying the velocity field of a liquid or gas in motion, we naturally come to the concept of field flow. The velocity vector of each particle of moving fluid $\vec{R}$ be the same Let us take a flat field in this flow. The volume of liquid that flows through the unit of time Q for the following

$$Q = SH = S\left(\vec{R}\vec{n}^{0}\right) \qquad (1)$$

The formula is appropriate.

Q volume is called the fluid flow across the field.

A smaller area on a curved surface and an optional one in it $M(x, y, z)$ Let M be the point called the base point. From this reference point, we draw a plane of experiment on the surface and project the area of the surface on the plane of experiment.

The face of a parallelogram corresponding to the sample plane is assumed to be approximately equal to the elementary area of the surface. The edge is a field vector $\vec{R}$ We construct a parallelepiped equal to and parallel curve: the amount of fluid moving through Q is represented by (1) as before. Q is called the elementary flow of the field across the field. The orbital vector of the normal at point M. $\vec{n}^{0}(x, y, z)$ Let's define. For elementary flow

$$Q = S\left(\vec{n}^{0}(x, y, z)\vec{R}(x, y, z)\right) \qquad (2)$$

the formula is reasonable, and its measurements express with sufficient accuracy the volume of the elementary flow of a liquid moving in a unit of time through a sufficiently small area.

The elementary flow is not a definite value for the field, but to the reference point and $\vec{n}^{0}$ depends on the direction of the vector.

Now the surface area is n $(S_1),(S_2),\ldots,(S_n)$ areas. (S_i) we define the base points within each of the section area. (S_i) elementary currents moving from a section area

$$Q_k = S_k\left(\vec{n}^{0}(x_k, y_k, z_k)\vec{R}(x_k, y_k, z_k)\right)$$

we determine the sum and $n \to \infty$ Let's move to the limit

$$Q = \lim_{n\to\infty}\sum_{k=1}^{n} Q_k = \lim_{n\to\infty}\sum_{n} S_k\left(\vec{n}^{0}(x_k, y_k, z_k)\vec{R}(x_k, y_{k,} z_k)\right)$$

In the course of mathematical analysis, this quantity Q is called the integral of the surface area, and it is equal to the surface integral, which is independent of the method

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of dividing the surface area into parts, as well as the choice of reference points within the separated area.

$$Q=\iint\limits_{(s)}\left(\vec{R}\vec{n}\right)ds=\iint\limits_{(s)}\left(\vec{R}d\vec{s}\right) \qquad (4)$$

$$\vec{R}=X\vec{i}+Y\vec{j}+Z\vec{k},\ \vec{n}^{0}=\cos\alpha\vec{i}+\cos\beta\vec{j}+\cos\gamma\vec{k} \qquad (5)$$

for vectors

$$Q=\iint\limits_{(s)}\left(X\cos\alpha+Y\cos\beta+Z\cos\gamma\right)ds \qquad (6)$$

(6) A vector on a surface is a coordinate representation of the flow.

$$ds=\frac{dydz}{\cos\alpha}=\frac{dzdx}{\cos\beta}=\frac{dxdy}{\cos\gamma} \qquad (7)$$

if we use conditional formulas in accordance with the expression under the integral

$$Q=\iint\limits_{(s)}Xdydz+Ydxdz+Zdxdy \qquad (8)$$

formula can be derived. This important formula is used to calculate vector flux on a surface.

$$\mathbf{Z}=f\left(x,y\right) \qquad (9)$$

(8) for a given surface in the view

$$Q=\iint\limits_{(s)}\left(-PX-qY+Z\right)dxdy \qquad (10)$$

You can write visually, that's it $P=\frac{\partial z}{\partial x},q=\frac{\partial z}{\partial y}$

$$\vec{r}=\vec{r}\left(u^{1},u^{2}\right) \qquad (11)$$

vector flow formula for a given surface by a parametric equation

$$Q=\iint\limits_{(s)}\left(\vec{r}_1\vec{r}_2\vec{R}\right)du^{1}du^{1} \qquad (12)$$

has the appearance, in this $\vec{r}_1=\frac{\partial\vec{r}}{\partial u^{1}},\vec{r}_2=\frac{\partial\vec{r}}{\partial u^{2}}$; $\left(\vec{r}_1\vec{r}_2\vec{R}_3\right)$- is a mixed product of three vectors.

For example. $\vec{R}=-\sqrt{x}\vec{i}+yz\vec{j}+\vec{k}$ of the field $z^2=4x$ tsilindrni $z^2=4\left(x^2+y^2\right)$ determine the amount of flow in the area separated by the intersection with the cone.

Subtracting from the equations of cylinder and cone $x^2+y^2=x,\ z=0$ we have the equation of a circle.

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$$Q = \iint\limits_{(S)} \left(\frac{2}{z}\sqrt{x} + 1 \right) dxdy$$

(S) we divide the field into lower and upper parts

$$Q = \iint\limits_{(S_1)} \left(\frac{2\sqrt{x}}{z} + 1 \right) dxdy + \iint\limits_{(S_2)} \left(\frac{2\sqrt{x}}{z} + 1 \right) dxdy$$

$(S_1): z = -2\sqrt{x}, (S_2): z = 2\sqrt{x}$

we determine Q in the formulas.

$$Q = \iint\limits_{(S_1)} Odxdy + \iint\limits_{(S_2)} 2dxdy = 2\iint\limits_{(S)} dxdy = \frac{\pi}{2}$$

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