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SOLVING ALGEBRAIC PROBLEMS USING THE VECTOR CONCEPT

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Abstract: *This article shows the possibilities of algebraic problems, in particular, proving inequalities, solving algebraic equations and systems of equations, and finding the largest and smallest values of a function using the vector concept.*

Key words: *vector method, coordinate, equation, inequality, sum , root , system , trigonometry.*

Increasing the effectiveness of mathematical education depends in many ways on teaching students non-standard thinking along with scientific and principled thinking, gradually developing their mental perception system. Choosing and implementing non-standard methods and methods in accordance with the content of education is one of the important issues in the process of teaching mathematics. In this regard, the use of the concept of vectors in the teaching of mathematics, especially in solving algebraic problems, is of urgent importance in the wide introduction of acmeological models of sufficient development of students' creative, non-standard thinking skills into the practice of mathematics education. Because the concept of vector is one of the main concepts of mathematics, at the same time, many areas of this science, including linear algebra, analytical and differential geometry, are explained on the basis of vectors. Algebraic problems can be solved together with many problems of planometry and stereometry with the help of vector theory and vector method. The use of the vector method in solving algebraic problems, on the one hand, repeats the main aspects related to the properties of vectors, as well as ensures the internal integration of the mathematical subject, and on the other hand, eliminates the existing algebraic complexity, and leads to the solution of the problem in a purely analytical form[1,2,3,4,5,6,7,8,9,10,11]. A student each always is also given issue vectors using solve possible understand ca n't In this student _ mainly the text of the issue and algebraic relationships vectors to the language transfer to learn it is necessary Of this for algebraic issues vector method using in the solution first of all students the following concepts to know required :

-characteristics of vectors (vector length, unit and zero vectors, collihear and coplanarity of vectors, etc.);

-scalar multiplication of vectors and its properties;

-vectorial and mixed multiplication and his properties .

Description : $\vec{a}$ and $\vec{b}$ the number formed by multiplying the lengths of the vectors and the cosine of the angle between them is called the scalar product of vectors. $\vec{a}$ and is defined as the $\vec{b}$ scalar product of $\vec{a}\vec{b}$ vectors or $(\vec{a}\vec{b})$.

The following properties of scalar multiplication are mainly used in solving algebraic problems using the vector concept:

1. The scalar product of any vector by itself is equal to the square of the length of this vector: $\vec{a}=(x;y;z)$ for vector $\vec{a}\cdot\vec{a}=|\vec{a}|^2=x^2+y^2+z^2$
2. If the vectors are perpendicular ($\vec{a}\perp\vec{b}$), $\vec{a}\vec{b}=0$.
3. $y=\cos x$ since the function is a domain of values, it is derived from $|\cos\varphi|\le 1$ the scalar multiplication formula $\left|\frac{\vec{a}\cdot\vec{b}}{|\vec{a}|\cdot|\vec{b}|}\right|\le 1$ or $-|\vec{a}|\cdot|\vec{b}|\le|\vec{a}\cdot\vec{b}|\le|\vec{a}|\cdot|\vec{b}|$.

In particular, the equality sign holds only when $\vec{a}$ the $\vec{b}$ vectors are collinear.

Using the collinearity of vectors, scalar multiplication and its properties, you can prove inequalities, solve algebraic equations and systems of equations, find the largest and smallest values of a function. Below we give examples of problems for solving algebraic problems using the vector method [12,13,14,15,16,17,18,19,20,21].

1. Inequalities to prove circle issues .

Issue 1 . Prove that the inequality holds for all $a\in\left[\frac{3}{2};\frac{50}{3}\right]$ real numbers . $\sqrt{a+1}+\sqrt{2a-3}+\sqrt{50-3a}\le 12$

(*Ukraine. Republican Mathematics Olympiad-1984*)[2; page 165.]

Solving. $\vec{a}\left(\sqrt{a+1};\sqrt{2a-3};\sqrt{50-3a}\right)$ and $\vec{b}(1;1;1)$ consider vectors.

and for $\vec{b}$ the $\vec{a}$ vectors $\vec{a}\cdot\vec{b}=\sqrt{a+1}+\sqrt{2a-3}+\sqrt{50-3a}\ge 0$, $|\vec{a}|=\sqrt{(\sqrt{a+1})^2+(\sqrt{2a+3})^2+(\sqrt{50-3a})^2}=\sqrt{48}$ and $|\vec{b}|=\sqrt{3}$ the relationship is appropriate. For arbitrary $\vec{a}$ and $\vec{b}$ vectors **follows from the** $|\vec{a}\cdot\vec{b}|\le|\vec{a}|\cdot|\vec{b}|$ fact that the inequality is reasonable $\sqrt{a+1}+\sqrt{2a-3}+\sqrt{50-3a}\le\sqrt{48}\cdot\sqrt{3}=12$.

Issue 2. $\sin x\cdot\sin y\cdot\sin z+\cos x\cdot\cos y\cdot\cos z\le 1$ prove the inequality.

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Proof. $\vec{a}(\sin x \cdot \sin y; \cos x \cdot \cos y)$ and $\vec{b}(\sin z; \cos z)$ consider vectors. Their scalar product $\vec{a} \cdot \vec{b} = \sin x \cdot \sin y \cdot \sin z + \cos x \cdot \cos y \cdot \cos z$ Modules $|\vec{b}| = 1,$ $|\vec{a}| = \sqrt{\sin^2 x \cdot \sin^2 y + \cos^2 x \cdot \cos^2 y} \le \sqrt{\sin^2 x + \cos^2 x} = 1.$ $|\vec{a} \cdot \vec{b}| \le |\vec{a}| \cdot |\vec{b}|$ is formed by inequality $\sin x \cdot \sin y \cdot \sin z + \cos x \cdot \cos y \cdot \cos z \le 1$ [22,23,24,25,26,27,28,29,30,31,32,33,34].

2. Problems related to trigonometric equations.

Issue 1 . Eq untie $\sqrt{4\cos^2 x + 1} + \sqrt{4\sin^2 x + 3} = 4$. (*Mathematical Olympiad Treasures", Boston-2006*) [1 ; 204 - p.]

Solving . $\vec{a}\left(\sqrt{4\cos^2 x + 1}, \sqrt{4\sin^2 x + 3}\right)$ and $\vec{b}(1,1)$ of vectors modules $|\vec{a}| = \sqrt{\left(\sqrt{4\cos^2 x + 1}\right)^2 + \left(\sqrt{4\sin^2 x + 3}\right)^2} = \sqrt{8}, |\vec{b}| = \sqrt{2}$ to equal to Their scalar product is $\vec{a} \cdot \vec{b} = \sqrt{4\cos^2 x + 1} + \sqrt{4\sin^2 x + 3} > 0$. $|\vec{a} \cdot \vec{b}| \le |\vec{a}| \cdot |\vec{b}|$ according to inequality, $\sqrt{4\cos^2 x + 1} + \sqrt{4\sin^2 x + 3} \le 4$ relation appropriate . Only if the equals sign $\vec{a}$ and the $\vec{b}$ vectors are collinear satisfies . So , of vectors coordinates proportional : $\sqrt{4\cos^2 x + 1} = \sqrt{4\sin^2 x + 3} \Rightarrow$ $\cos 2x = \frac{1}{2} \Rightarrow x = \pm\frac{\pi}{6} + \pi n, n \in Z$.

Issue 2 . Eq untie $\sqrt{2 + \cos^2 2x} = \sin 3x - \cos 3x.$

Solving. $\vec{a}(\sin 3x; \cos 3x)$ and $\vec{b}(1; -1)$ consider vectors. Let's find the scalar product of vectors in the defined domain of the equation: $\vec{a} \cdot \vec{b} = \sin 3x - \cos 3x \ge 0$. $\vec{a}$ and $\vec{b}$ we calculate the modules of the vectors: $|\vec{a}| = 1;$ $|\vec{b}| = \sqrt{2}$ and the product of their lengths $|\vec{a}| \cdot |\vec{b}| = \sqrt{2}$. Thus, $|\vec{a} \cdot \vec{b}| \le |\vec{a}| \cdot |\vec{b}|$ according to the inequality $\sin 3x - \cos 3x \le \sqrt{2}$. So, for the given equation to have a solution $\cos^2 2x = 0$ a must execution necessary _ From this yeah of Eq the solution $x = \frac{\pi}{4} + \pi n,\ n \in Z$ to equal to [35,36,37,38,39,40,41,42,43,45,46,47,48,].

3. Equations to the system circle issues .

Issue 1 . Equations system solve :

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$$\begin{cases} \sqrt{(x-1)^2+y^2}+\sqrt{(x+1)^2+y^2}=2 \\ x^2+y^2=\sin^2 x. \end{cases}$$

Solving. $\vec{a}\left(\sqrt{(x-1)^2+y^2},\sqrt{(x+1)^2+y^2}\right)$ and $\vec{b}(1,1)$ vectors given let it be Then $|\vec{b}|=\sqrt{2}$, $\vec{a}\cdot\vec{b}=\sqrt{(x-1)^2+y^2}+\sqrt{(x+1)^2+y^2}>0$ and $|\vec{a}|=\sqrt{2(1+x^2+y^2)}$. For arbitrary $\vec{a}$ and $\vec{b}$ vectors $|\vec{a}\cdot\vec{b}|\le|\vec{a}|\cdot|\vec{b}|$ by condition $\sqrt{(x-1)^2+y^2}+\sqrt{(x+1)^2+y^2}\le 2\sqrt{(1+x^2+y^2)}$ we have an inequality. The equals sign is satisfied only if $\vec{a}$ the $\vec{b}$ vectors are collinear. So, $\sqrt{(x-1)^2+y^2}=\sqrt{(x+1)^2+y^2}\Rightarrow x=0.$ According to the second $x^2+y^2=\sin^2 x$ condition $y=0.$ Hence, Eqs system the only one to the solution has : $x=0$ and $y=0$.

Issue $\begin{cases} x^2+y^2=3, \\ z^2+v^2=25, \\ xv+yz=5\sqrt{3} \end{cases}$ **2 .** find the expression that takes the largest value among all the solutions that satisfy the system of equations . $x+z$

[3; page 307.]

Solving. $\vec{a}(x;y)$ and $\vec{b}(v;z)$ consider vectors. According to the condition $|\vec{a}|=\sqrt{x^2+y^2}=\sqrt{3}$, $|\vec{b}|=\sqrt{v^2+z^2}=\sqrt{25}=5$ and $\vec{a}\cdot\vec{b}=xv+yz=5\sqrt{3}$. It $\vec{a}\cdot\vec{b}=|\vec{a}|\cdot|\vec{b}|=5\sqrt{3}$ turns out that it is. It follows that $\vec{a}$ the vectors and $\vec{b}$ are collinear and have the same direction. $\vec{e}=(u;w)$ be a unit vector . In that case $\vec{a}=\sqrt{3}\cdot\vec{e}=(\sqrt{3}u;\sqrt{3}w)$ and $\vec{b}=5\cdot\vec{e}=(5u;5w)$. If $u=\cos\varphi$ and $w=\sin\varphi$ if we specify that , $x=\sqrt{3}\cos\varphi$ and $z=5\sin\varphi.$ In that case $x+z=\sqrt{3}\cos\varphi+5\sin\varphi=\sqrt{28}\sin(\varphi+\alpha)\le\sqrt{28}$. Hence, $x+z$ the largest value of the expression $\sqrt{28}$ is equal to [48,49,50,51,52,53,54,55,56,57,58,59,60].

4. The largest and smallest of the function find the values .

Issue $y=\sqrt{x}+4\sqrt{1-\frac{x}{2}}$ **1 .** find the maximum and minimum value of the function.

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Solving. $y=\sqrt{x}+4\sqrt{1-\frac{x}{2}}$ the function $[0;2]$ is defined in the interval . We change the function form: $y=\sqrt{x}+4\sqrt{1-\frac{x}{2}}=\sqrt{x}+2\sqrt{2}\cdot\sqrt{2-x}$. Consider the following vectors: $\vec{a}\left(1;2\sqrt{2}\right)$ and $\vec{b}\left(\sqrt{x};\sqrt{2-x}\right)$. The coordinates of these vectors are defined in the positive interval. So, $\vec{a}\cdot\vec{b}=\sqrt{x}+2\sqrt{2}\cdot\sqrt{2-x}$, $\left|\vec{a}\right|=\sqrt{(1)^2+\left(2\sqrt{2}\right)^2}=3$, $\left|\vec{b}\right|=\sqrt{(\sqrt{x})^2+(\sqrt{2-x})^2}=\sqrt{2}$. Note that the inequality holds $\vec{a}\cdot\vec{b}=\sqrt{x}+2\sqrt{2}\cdot\sqrt{2-x}\le 3\sqrt{2}$ for these vectors $0<\left|\vec{a}\cdot\vec{b}\right|\le\left|\vec{a}\right|\cdot\left|\vec{b}\right|$. Specifically, the equal sign $\vec{a}$ and when the $\vec{b}$ vectors are parallel achieves , that is their coordinates proportionally : $\frac{1}{2\sqrt{2}}=\frac{\sqrt{x}}{\sqrt{2-x}} \Rightarrow x=\frac{9}{2}$. So, the largest value of the function is $y_{\max}=y\left(\frac{9}{2}\right)=3\sqrt{2}$ equal to . If $\vec{b}\left(2;0\right)$, that is, the $x=2$ function is smallest $y_{\min}=y\left(2\right)=\sqrt{2}$ achieves a value [61.62.63.64.65.66.67.68.69.70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92].

Issues for independent work

1. $A,B,C>0,\ A+B+C=\pi$ If so, prove the following inequality. $\cos A+\cos B+\cos C\le\frac{3}{2}$

2. Prove the inequality. $\left|\frac{(x+y)(1-xy)}{(1+x^2)(1+y^2)}\right|\le\frac{1}{2}$

3. Find the maximum and minimum value of the function. $y=3\cos x+4\sin x$

4. **The** inequality holds for all $a\in[0;16]$ real numbers $4\sqrt{a}+3\sqrt{16-a}\le 20$ that prove it

5. Of the function the most big find $y\left(x\right)=\sqrt{x-8}+\sqrt{16-x}$ the value of .

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