USING ELEMENTS OF MATHEMATICAL ANALYSIS IN SOLVING TRIGONOMETRIC EQUATIONS

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Abstract. The article examines the use of elements of mathematical analysis in solving trigonometric equations.

Keywords: equation, mathematical analysis, trinonometry.

1. Using the field of function detection

In some cases, knowing the field of determination of the equation assumes proving that the equation does not have a root, and sometimes looking at the solution of the equation by putting a number from the field of determination.

1-example. $\sqrt{|\sin x|} = \sqrt[4]{-|\sin x|} + tgx$ The equation(1) of its balance.

Of charging. The field equations aniqlanish $\begin{cases} |\sin x| \geq 0 \\ -|\sin x| \geq 0 \\ x \neq \frac{\pi}{2} + \pi n; \quad n \in z \end{cases}$

composed from. Also $x = \pi k, \quad k \in z$. x let's say this is the value of (1) and put into the left side of equation is equal to 0, we see that her right. Therefore, all the $x = \pi k; \quad k \in z$ products are the root of the equation, it's.

Answer: $x = \pi k; \quad k \in z$.

2. Limited use of texture functions from birth.

Solving the equation in any collection of functions, from above or below, were limited and the texture plays a big role in most cases. For example, any M package all of the x products $f(x) > A$ and $g(x) < A$ (A any number) the disparity is reasonable, without it M in the package $f(x) = g(x)$ does not have the solution to the equation.

A while in many cases this will be zero in place of the number $f(x)$ and $g(x)$ functions of the M set of points in the storage means.

2-example. $\sin(x^3 + 2x^2 + 1) = x^2 + 2x + 3$ its the balance of the equation.

Charging: Optional x real number $\sin(x^3 + 2x^2 + 1) \leq 1$. $x^2 + 2x + 3 = (x+1)^2 + 2 \geq 2$. While it is optional x for the left side of the equation do not exceed the actual number 1, 2 from the right side we see is not always small. Therefore, the solution of the equation, it's not.

Answer: ∅.

3-example. $2\sin x = 5x^2 + 2x + 3$ its the balance of the equation.

Charging: it is known that $y = 5x^2 + 2x + 3$ the graph of the function $y = 2\sin x$ lies above the graph of the function.He holda $5x^2 + 2x + 3 > 2\sin x$

Also $5x^2 + 2x + 3 = 5\left(x + \frac{1}{5}\right)^2 + \frac{14}{5} \geq \frac{14}{5} > 2$, and $2\sin x \leq 2$ the solution to the equation does not have.

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 11 in November-2023
https://www.gejournal.net/index.php/IJSSIR

Answer: ∅.

4-example. $\sin x = x^2 + x + 1$ its the balance of the equation.

Charging: condition than in x > 0 and x < - 1 if $x^2 + x + 1 > 1$ and $x^2 + x + 1 > \sin x$.

From the earth this $-1 \le x \le 0$ is when $x^2 + x + 1 > 0$ and $\sin x \le 0$.Therefore the solution to the equation does not have.

Answer: ∅.

5-example. Its the balance of the equation. $2\cos^2 \dfrac{x^2 + x}{6} = 2^x + 2^{-x}$

Charging: terms than in $2\cos^2 \dfrac{x^2 + x}{6} \le 2$ and $2^x + 2^{-x} \ge 2$.

Without it $2\cos^2 \dfrac{x^2 + x}{6} = 2$ and $2^x + 2^{-x} = 2$ is. From here the solution $x = 0$.

Answer: *x=0*

6-example. $x^3 - x - \sin \pi x = 0$ (2) the balance of the equation.

Charging: as we have seen $x = 0$, $x = 1$, $x = -1$ is the solution of the equation. The rest of her to find the solution $f(x) = x^3 - x - \sin \pi x$ of an odd function from the $x > 0$, $x \ne 1$ field enough to find a solution. If x_0 its solution, then $(-x_0)$ also its solution. $x > 0$, $x \ne 1$ range package 2 will distinguish. (0;1) and (1;∞). (2) in equation $x^3 - x = \sin \pi x$ form, we will write. (0;1) interval $g(x) = x^3 - x$, the function will receive only the negative value. $h(x) = \sin \pi x$ while a positive value, the function will receive. Therefore, in this range, (2) the equation does not have solution.

$x \in (1;+\infty)$ which is. In this range, x at each value of $g(x) = x^3 - x$ the function is positive, $h(x) = \sin \pi x$ the function will receive a different point value. $(1;2]$ in the range of $h(x) = \sin \pi x$ the function is not positive. Therefore, $(1;2]$ in the range (2) the equation does not have solution.

You $x > 2$ without it $|\sin \pi x| \le 1$, $x^3 - x = x(x^2 - 1) > 2 \cdot 3 = 6$. This $(2;\infty)$ range also (2) the equation does not have solution. Therefore, the only $x = 0$, $x = 1$ and $x = -1$ the equation given the solution.

Answer: $x_1 = 0$, $x_2 = 1$, $x_3 = -1$.

7-example. $\sin^5 x + \dfrac{1}{\cos^7 x} = \cos^5 x + \dfrac{1}{\sin^7 x}$ (3) the balance of the equation.

Solve: x_0 given (3) let be the solution of the equation, then

$$\frac{1}{\cos^7 x_0} - \cos^5 x_0 = \frac{1}{\sin^7 x_0} - \sin^5 x_0 \quad (4)$$

equality $|\cos x_0| < 1$ and $|\sin x_0| < 1$ inequality reasonable. Are the seats of that colossal disparity (4) of the left part $\dfrac{1}{\cos^7 x_0}$ and $\cos x_0$ the right part while $\sin x_0$ in the same sign. $\sin x$ and $\cos x$ s (4) with the same hint of equality to build them from sticking.(4) equality can be written in the following form.

$$\cos^7 x_0 \sin^7 x_0 (\sin^5 x_0 - \cos^5 x_0) = \cos^7 x_0 - \sin^7 x_0 \quad (5)$$

The formula of short breeding

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 11 in November-2023
https://www.gejournal.net/index.php/IJSSIR

$$a^{2l+1}-b^{2l+1}=(a-b)(a^{2l}+a^{2l-1}b+...+b^{2l})$$

apply to (5) with equality, we will write in the following form.

$(\sin x_0-\cos x_0)f(x_0)=0$ (6)

thus, $f(x_0)=(\sin x_0\cos x_0)^7(\sin^4 x_0+\sin^3 x_0\cos x_0+...+\cos^4 x_0)+$

$+(\sin^6 x_0+\sin^5 x_0\cos x_0+...+\cos^6 x_0)$

$\sin x_0$ and $\cos x_0$ to receive the same value of s $f(x_0)>0$.

Therefore (6) is equivalent to (3) the solution of equation optional for $\sin x_0=\cos x_0$ reasonable equality. So (3) solution of the equation optional

$$\sin x=\cos x \quad (7)$$

the content will be of the equation. Therefore, (7) equation (3) equation equal to strong.

(7) solution $x=\frac{\pi}{4}+\pi k,\quad k\in z$. This (3) is the solution of the equation.

Answer: $x=\frac{\pi}{4}+\pi k,\quad k\in z$.

Note: the same 5-

as an example,

$$\sin^{2n-1}x+\frac{1}{\cos^{2m-1}x}=\cos^{2n-1}x+\frac{1}{\sin^{2m-1}x}$$

equation (it $n,m\in N$) $\sin x=\cos x$ to the equation equally strong.

8-example. $2\pi\sin x=\left|x-\frac{\pi}{2}\right|-\left|x+\frac{\pi}{2}\right|$ (8) do not balance the equation.

Charging: $\left|x-\frac{\pi}{2}\right|-\left|x+\frac{\pi}{2}\right|$ select a $f(x)$ character through understanding. According to the definition module $x\le-\frac{\pi}{2}$ at $f(x)=\pi$, $-\frac{\pi}{2}<x<\frac{\pi}{2}$ - at $f(x)=-2x$. $x\ge\frac{\pi}{2}$ at $f(x)=-\pi$.

If so, $x\le-\frac{\pi}{2}$ if (8) is the equation $2\pi\sin x=\pi$ or $\sin x=\frac{1}{2}$ you can write in the form. The solution of this equation $x=(-1)^n\frac{\pi}{6}+\pi k,\quad n\in z$. From this value $x\le-\frac{\pi}{2}$ only with the condition $x=(-1)^n\frac{\pi}{6}+\pi n,\quad n=-1,-2,-3,...$ will build the world. If $x\ge\frac{\pi}{2}$ if (8) is the equation $2\pi\sin x=-\pi$ or $\sin x=-\frac{1}{2}$ you can write in the form.

This equation $x=(-1)^{m+1}\frac{\pi}{6}+\pi m,\quad m\in z$ has the solution. From this value $x\ge\frac{\pi}{2}$ only with the condition $x=(-1)^{m+1}\frac{\pi}{6}+\pi m,\quad m=1,2,...$ will build the world.

Now $x\in\left(-\frac{\pi}{2};\frac{\pi}{2}\right)$ we will take to see the range. In this range (8) in equation $2\pi\sin x=-2x$ form, we will write.

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 11 in November-2023
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$$\sin x = -\frac{x}{\pi} \qquad (9)$$

$x=0$ (9) equation, and the solution was clear. Therefore, given (8) the solution of the equation also. (9) equation $\left(-\frac{\pi}{2};\frac{\pi}{2}\right)$ is no other solution that we will prove in range. $x \neq 0$ (9) to equation $\frac{\sin x}{x} = -\frac{1}{\pi}$ the equation is equally strong.

Optional $x \in \left(-\frac{\pi}{2};0\right) \cup \left(0;\frac{\pi}{2}\right)$ while $f(x) = \frac{\sin x}{x}$ only accepts positive values. Therefore (9) the equation of $\left(-\frac{\pi}{2};0\right) \cup \left(0;\frac{\pi}{2}\right)$ the solution will not be able to.

Answer: $x=0$, $x=(-1)^n \frac{\pi}{6} + \pi n$, $n=-1,-2,...$; $x=(-1)^{m+1}\frac{\pi}{6} + \pi n$, $n=1,2,...$

If $f(x)=g(x)$ (10) solving the equation for any M package that belong to all of the x products $f(x) \le A$ and $g(x) \ge A$ the disparity is reasonable, without it M in the package (10) the following equation to systems of equations are equally strong.

$$\begin{cases} f(x) = A \\ g(x) = A \end{cases} \qquad (11)$$

9-example. $\cos^2(x\sin x) = 1 + \log_5^2 \sqrt{x^2+x+1}$ (1of 2) balance the equation.

Solve: (1of 2) all real equation x is determined for the world. Optional x for $\cos^2(x\sin x) \le 1, \quad 1+\log_5^2\sqrt{x^2+x+1} \ge 1.$

As a result, (12) systems of equations the following equation equally strong.

$$\begin{cases} \cos^2(x\sin x) = 1 \\ \log_5^2 \sqrt{x^2+x+1} = 0 \end{cases} \qquad (1of\ 3)$$

(13) system 2-the solution of equations $x=0$ and $x=-1$. This value is 1 from-the only equation $x=0$ will be content. Therefore, $x=0$ it's the only solution of the given equation.

Answer: 0.

10-example. $\cos^7 x + \sin^5 x = 1$ (14) the equation do not balance.

Solve: $\cos^2 x + \sin^2 x = 1$ to (14), we will write the equation in the following form $\cos^7 x + \sin^5 x = \cos^2 x + \sin^2 x$ or

$$\cos^2 x(\cos^5 x - 1) = \sin^2 x(1 - \sin^3 x) \qquad (1of\ 5)$$

Optional x for $\sin^2 x \ge 0$, $\cos^2 x \ge 0$, $\cos^5 x - 1 \le 0$, $1-\sin^3 x \ge 0$ (1of 5) the following system of equations equivalent to the strong

$$\begin{cases} \cos^2 x(\cos^5 x - 1) = 0 \\ \sin^2 x(1-\sin^3 x) = 0 \end{cases} \qquad (1of\ 6)$$

(16) systems of equations equal to the set of the following system strong.

$$\begin{cases} \cos x = 0, \\ \sin x = 1, \end{cases} \qquad \begin{cases} \sin x = 0, \\ \cos x = 1 \end{cases} \qquad (1of\ 7)$$

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 11 in November-2023
https://www.gejournal.net/index.php/IJSSIR

The solution of the first system $x = \frac{\pi}{2} + 2\pi k, \quad k \in z$ and the second system solution $x = 2\pi m, \quad m \in z$. Given all this solution of the equation is the solution.

Answer: $x = 2\pi m, \qquad x = \frac{\pi}{2} + 2\pi k, \quad m, k \in z$.

3. Sinus kosinus and the use of texture features.

Trigonometrik equation solving solve system of equations can be many to come. For example, the following equation can bring to such equations.

$\sin\alpha x \cdot \sin\beta x = \pm 1$

$\sin\alpha x \cdot \cos\beta x = \pm 1$

$A(\sin\alpha x)^m + B(\cos\beta x)^n = \pm(|A| + |B|)$

$$A(\sin\alpha x)^m + B(\sin\beta x)^n = \pm(|A| + |B|) \qquad (1of\ 8)$$

thus, α, β, A, B given real numbers, n and m - given natural number. Use the following properties of the sinus of solving such equations: any x_0 number strictly $|\sin\alpha x_0| < 1$ disparity is reasonable,then x_0 the number (18) also any from the equation is not the solution. Just as well

$$\cos\alpha x \cdot \cos\beta x = \pm 1$$

$$A(\sin\alpha x)^m + B(\cos\beta x)^n = \pm(|A| + |B|)$$

solving equations kosinus the texture of use: you any x_0 number strictly $|\cos\alpha x_0| < 1$ disparity is reasonable, then x_0 the number is also any from this equation is not the solution.

11-example. $\sin x \cdot \cos 4x = 1$ (19) do not balance the equation.

Charging: If x_0 (20) is a solution of the equation if, then either $\sin x_0 = 1$ or $\sin x_0 = -1$ will be. Really $|\sin x_0| < 1$, if it is (19) from the equation $|\cos 4x_0| > 1$ was supposed to be, but this can't be. If $\sin x_0 = 1$ (19) from the equation $\cos 4x_0 = 1$ is that, if it $\sin x_0 = -1$ is, $\cos 4x_0 = -1$ stems from the fact that. The result in (19) the solution of equation optional system one of the following 2 solutions.

$$\begin{cases} \sin x_0 = 1 \\ \cos 4x_0 = 1 \end{cases} \qquad (20)$$

$$\begin{cases} \sin x_0 = -1 \\ \cos 4x_0 = -1 \end{cases} \qquad (21)$$

(20) and (21) of the voluntary system, the solution (19) is the solution of equation it can be seen that easily. The result in (19) tenlama (20) and (21) systems of equations equal to the set of strong. We are solving this system.

(20) from the first equation of the system $x = \frac{\pi}{2} + 2\pi k; \quad k \in z$.

All of these increases the content of the second equation of this system and (20) of the system is the solution. (21) of the first equation of the system $x = \frac{3\pi}{2} + 2\pi e; \quad e \in z$ have the solution.

The second equation of the system from this number, none of this content does not. Therefore, (21) system does not have a solution. Therefore, given (19), the solution of the equation (20) with the solution of the system stack by stack falls.

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Answer: $x=\frac{\pi}{2}+2\pi k; \quad k\in z$.

13-example. $\cos^3 3x+\cos^{11}7x=-2$ (20) do not balance the equation.

Charging: If x_0 (2, 4) is the solution of the equation without it $\cos 3x_0=-1$ (otherwise $\cos 7x_0<-1$ it can't be). It means that $\cos 7x_0=-1$. As a result, (20) the solution of the equation is the solution of the following system optional.

$$\begin{cases}\cos 3x=-1\\ \cos 7x=-1\end{cases} \qquad (21)$$

(21) optional solution of the system (20)is the solution of the equation. Therefore, (20) equation (21) system equally strong. (21) system 1 of the equation $x_k=\frac{\pi}{3}+\frac{2\pi k}{3}, \quad k\in z$ have the solution.

From this solution (21) system 2-build the equation we can find. Following this, the equality that build $m\in z$ number.

$$\frac{7\pi}{3}+\frac{14\pi k}{3}=\pi+2\pi m \qquad (2of\ 2)$$

(26) and we will write in the following form $k=\frac{3m-2}{7}$ (2of 2)

k and m the whole world to be an even number (2of 2) equality $m=7t+3, \quad t\in z$ reasonable, however $k=3t+1, \quad t\in z$.

Therefore, (2, 5) the solution of such a system, x_k it is the lark, $k=3t+1, \quad t\in z$.

$$x=\frac{\pi}{3}+2\pi t+\frac{2\pi}{3}, \qquad t\in z .$$

Answer: $x=\pi+2\pi t, \quad t\in z$.

4. From the disparity in the number fodalanish.

Any number inequality applied to any part of the equation in some cases, you can replace the equation equal to a strong system of. The example for such disparity two positives a and b the number between the geometric and the middle arifmetigi the middle of the $\frac{a+b}{2}\geq\sqrt{ab}$ connection, we can sign the equality $a=b$ at the proper.

In many cases, the result of favorable from the use of the following inequality *a>0* $a+\frac{1}{a}\geq 2$, *a=1* $a+\frac{1}{a}=2$, *a<0 at* $a+\frac{1}{a}\leq -2$, *a=-1 while* $a+\frac{1}{a}=-2$.

14-example. $\left(\frac{1}{\sin^8}+\frac{1}{\cos^2 2x}\right)\left(\sin^8 x+\cos^2 2x\right)=4\cos^2\sqrt{\frac{\pi^2}{4}-x^2}$ (23) do not balance the equation.

Charging: Optional positives a and b the number $\left(\frac{1}{a}+\frac{1}{b}\right)(a+b)\geq 4$ (23) we will prove that the inequality is proper. Earlier $\frac{1}{a}$, and $\frac{1}{b}$ for the number, then a and b medium-sized geometric

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 11 in November-2023
https://www.gejournal.net/index.php/IJSSIR

and apply the inequality among arifmetik for the number $\frac{\frac{1}{a}+\frac{1}{b}}{2} \geq \sqrt{\frac{1}{a}\cdot\frac{1}{b}}$, and $\frac{a+b}{2} \geq \sqrt{ab}$ we will ensure to.

Also $\frac{1}{2}\left(\frac{1}{a}+\frac{1}{b}\right)\left(\frac{a+b}{2}\right) \geq 1$ $\left(\frac{1}{a}+\frac{1}{b}\right)(a+b) \geq 4$.

(26) aniqlanish the field equation $\sin^8 x > 0, \quad \cos^2 2x > 0$ is

(24) apply the inequality (23) we see that the left part of equation 4 is not small. At the same time (23) equation in the field of aniqlanish $4\cos^2\sqrt{\frac{\pi^2}{4}-x^2} \leq 4$.

As a result, (26) the following equation to systems of equations are equally strong.

$$\begin{cases} \left(\frac{1}{\sin^8 x}+\frac{1}{\cos^2 2x}\right)(\sin^8 x+\cos^2 2x)=4 \\ \cos^2\sqrt{\frac{\pi^2}{4}-x^2}=1 \end{cases} \qquad (25)$$

(28) system 2-the solution of equations $x_1=\frac{\pi}{2}$ and $x_2=-\frac{\pi}{2}$. Them (25) to put the first equation of the system, we see that the solution of the equation. Therefore, $x_1=\frac{\pi}{2}$ and $x_2=-\frac{\pi}{2}$ are the solutions of the equation will be given.

Answer: $x_1=\frac{\pi}{2}$ and $x_2=-\frac{\pi}{2}$.

5. Trigonometrik skalyar use the vector equation solving from an area.

As it is known, the vector sum of their lengths and the angle between them is equal to multiples of 2 skalyar kosinusi. $\vec{a}\cdot\vec{b}=|\vec{a}|\cdot|\vec{b}|\cos\alpha$.

$|\cos\alpha| \leq 1$ to be $|\vec{a}\cdot\vec{b}| \leq |\vec{a}|\cdot|\vec{b}|$.

The coordinates of the vector is given, with you, ya $\vec{a}\{a_1,a_2\}$ and $\vec{b}\{b_1,b_2\}$ is $a_1,a_2+b_1b_2 \leq \sqrt{a_1^2+a_2^2}\cdot\sqrt{b_1^2+b_2^2}$.

1-example. $\sin\sqrt{1+\cos^2 x}+\cos x\sqrt{1+\sin^2 x}=\sqrt{3}$ its the balance of the equation.

Fchib to: $\vec{a}\{\sin x,\cos x\}$ and $\vec{b}\{\sqrt{1+\cos^2 x};\ \sqrt{1+\sin^2 x}\}$ you will enter the vector.

Without it

$\vec{a}\cdot\vec{b}=\sin x\sqrt{1+\cos^2 x}+\cos x\sqrt{1+\sin^2 x} \leq \sqrt{\sin^2 x+\cos^2 x}\sqrt{2+\sin^2 x+\cos^2 x}=\sqrt{3}$.

Therefore,

$$\sin x\sqrt{1+\cos^2 x}+\cos x\sqrt{1+\sin^2 x} \leq \sqrt{3}.$$

The given equation $\vec{a}\cdot\vec{b}=|\vec{a}|\cdot|\vec{b}|$ can be written in the form. The angle between this vector equality O^0 when it is made. Therefore, the vector parallel parallel vector corresponding kordinatalari proporsional

ISSN 2277-3630 (online), Published by International journal of Social Sciences & Interdisciplinary Research., under Volume: 12 Issue: 11 in November-2023
https://www.gejournal.net/index.php/IJSSIR

$$\frac{\sin x}{\sqrt{1+\cos^2 x}} = \frac{\cos x}{\sqrt{1+\sin^2 x}}$$

$\sin x$ and $\cos x$ a hil a hint

$$\sin^2 x + \sin^4 x = \cos^2 x + \cos^4 x;$$

$$\cos 2x = 0$$

$$2x = \frac{\pi}{2} + \pi n; \quad n \in Z$$

$$x = \frac{\pi}{4} + \frac{\pi n}{2}; \quad n \in Z$$

The initial equation according $\sin x > 0$ and $\cos x > 0$.

$x = \frac{\pi}{4} + 2\pi n; \quad n \in Z$ eka clear.

Answer: $\frac{\pi}{4} + 2\pi n; \quad n \in Z$

2-example. $\sin x\sqrt{1+\sin x} + \sqrt{3-\sin x} = 2\sqrt{\sin^2 x + 1}$ its the balance of the equation.

Solve $\vec{a}\left\{\sqrt{1+\sin^2 x};\ \ \sqrt{3-\sin x}\right\}$ it and $\vec{b}\{\sin x;1\}$ you will enter the vector.

The equation $\vec{a}\cdot\vec{b} = |\vec{a}|\cdot|\vec{b}|$ can be written in a form that is obvious.

$\vec{a}$ and $\vec{b}$ the direction of vectorsuccumb to the conditions apply their exact coordinates proporsional will determine whether it should be. Without it

$$\frac{\sqrt{1+\sin x}}{\sin x} = \sqrt{3-\sin x} \qquad (*)$$

$$\sin^3 x - 3\sin^2 x + \sin x + 1 = 0$$

or

$$(\sin x - 1)(\sin^2 x - 2\sin x - 1) = 0$$

(*) from the equation $0 < \sin x \le 1$ since he was $\sin x = 1$ and $x = \frac{\pi}{2} + 2\pi n; \ n \in Z$.

Answer: $\frac{\pi}{2} + 2\pi n; \ n \in Z$

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