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Г.А.Есенбаева

Интегралдық түрлендірулер және шеттік есептер

Мақала шектелмеген кеңістіктер үшін жылуөткізгіштік стационар емес теңдеулерді шешуге және Гельмгольцтің екі өлшемді теңдеулерін зерттеуге арналған. Қарастырылып отырған шеттік есептердің шешімдері аралас және екі еселі Фурье түрлендірулерінің көмегімен алынған. Сонымен қатар әр түрлі типтегі дербес туындылар теңдеулері үшін шеттік есептердің шешімдерін алуда интегралдық түрлендірулер әдісін қалай қолдануға болатыны көрсетілген. Пуассон екі өлшемді теңдеулері үшін Грин функциясы құрылған.

Г.А.Есенбаева

Интегральные преобразования и граничные задачи

Статья посвящена определению решения нестационарного уравнения теплопроводности для неограниченного пространства и исследованию двумерного уравнения Гельмгольца. Решения рассматриваемых граничных задач получены с помощью смешанного и двукратного преобразований Фурье. Исходя из этого, в работе проиллюстрировано, как метод интегральных преобразований может быть использован для получения решения граничных задач для уравнений в частных производных различных типов. Также в работе построена функция Грина для двумерного уравнения Пуассона.

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K.Zhetpisov[1], A.K.Tynyshtykbaiy[1], Sh.D.Kusbekov[2]

[1]*Ye.A.Buketov Karaganda State University;*
[2]*Karaganda State Technical University (E-mail: sherniyaz777@gmail.com)*

Application of Cantor pairing function in the two simplest tasks

In this paper application of Cantor pairing function is considered in solving the following two problems. 1. In determining the main Pythagorean triples. 2. When calculating the sum of the digits of *n*-digit numbers in the decimal number system. When calculating the sum of digits of all unequivocal to n-digit numbers in the decimal number system. For these two problems program was written in the programming language Borland Delphi 7.

Key words: Diophantine equation, Pythagorean equation, Pythagorean triple, Cantor pairing function, tuple, linear order, Cantor’s number.

In this paper considered Diophantine problems (Diophantine equations). Diophantine equations are called algebraic equations or systems of algebraic equations with rational (natural) coefficients, which are found in integer or rational numbers. Such equations have the number of unknowns (variables) which exceeds the number of equations. The theory of Diophantine equations is the most important section of number theory.

It is known that in general the problem of the set of solutions of a system of Diophantine equations algorithmically unsolvable (Yu.B. Matiyasevich, 1970).

This is, firstly, allowed to call the research of Diophantine equations the theory of such equations; second, led to the clarification of the difficulties that relate with the study of Diophantine equations, and, thirdly, we have greatly expanded our understandings about the role of Diophantine equations in mathematics [1].

Consider the classical Diophantine equation:

$$x^2 + y^2 = z^2, \tag{1}$$

where

$$x,\ y,\ z \in N. \tag{1'}$$

The Diophantine equation or an equation of Pythagoras is called Diophantine equation (1) with condition (1').

Equation (1) is the equation of second degree, as the variables x, y, z are not multiplied and each of them has degree 2: uncertain, since the number of equations less than number of variables. Pythagorean equation is an equation of the second degree.

By a solution of Diophantine equation of the second power understand finding all those integer values of variables that satisfy this equation. For several millennia Pythagorean equation (1) with condition (1') was the subject of the most thorough studies. As a result received, for example, the following formula

$$x = r\left(s^2 - t^2\right),\ \ y = r\left(2st\right),\ \ z = r\left(s^2 + t^2\right), \tag{2}$$

where

$$r, s, t \in N,\ \ s > t,\ \ \left(s, t\right) = 1,\ st \text{ — even.} \tag{2'}$$

So it is natural substitution and the solution of the following problem.

Substitution of the Task. Let

$$M = \{x, y, z \mid x, y, z \in N,\ x^2 + y^2 = z^2\} \text{ —}$$

the set of all Pythagorean triangles. It is required to find a common formula that describes all of these triangles. The objective here is that the amount of integers of arbitrary parameters, included in the general formula of all Pythagorean triangles, did not exceed three [2].

Theorem 1 [3]. If $\left(x,\ y,\ z\right) = 1$, $x,\ z$ — odd, y — even, Pythagorean triangles that are included into the set *M*, can be defined by the formula

$$\left.\begin{aligned} x &= \left(2\alpha - 1\right)\left(2\alpha + \beta + 1\right) = 4\alpha^2 + 2\alpha\beta - \beta - 1 \\ y &= \frac{\left(4\alpha + \beta\right)\left(\beta + 2\right)}{2} = \frac{4\alpha\beta + 8\alpha + \beta^2 + 2\beta}{2} \\ z &= \frac{\left(4\alpha + \beta\right)\left(\beta + 2\right)}{2} + \left(2\alpha - 1\right)^2 = \frac{4\alpha\beta + 8\alpha^2 + \beta^2 + 2\beta + 2}{2} \end{aligned}\right\}, \tag{3}$$

where

$$\alpha \in N,\ \beta \in 2N^+\left(2N = \{0, 2, 4, \ldots\}\right). \tag{3'}$$

Each Pythagorean triple $\langle x, y, z\rangle$ system (3) and conditions (3') is unambiguous.

Proof. General description of the Pythagorean triangles defined Pythagorean triples in the following peculiarities determine the cathetus *x*:

$$\beta = 0 \begin{cases} \alpha = 1 & x = 1 \cdot 3 \\ \alpha = 2 & x = 3 \cdot 5 \\ \alpha = 3 & x = 5 \cdot 7 \\ \alpha = 4 & x = 7 \cdot 9 \\ \ldots \end{cases} \qquad \text{I–group}$$

$$\beta = 2 \begin{cases} \alpha = 1 & x = 1 \cdot 5 \\ \alpha = 2 & x = 3 \cdot 7 \\ \alpha = 3 & x = 5 \cdot 9 \\ \alpha = 4 & x = 7 \cdot 11 \\ \ldots \end{cases} \qquad \text{II}-\text{group}$$

$$\beta = 4 \begin{cases} \alpha = 1 & x = 1 \cdot 7 \\ \alpha = 2 & x = 3 \cdot 9 \\ \alpha = 3 & x = 5 \cdot 11 \\ \alpha = 4 & x = 7 \cdot 13 \\ \ldots \end{cases} \qquad \text{III}-\text{group}$$

Then the length of the cathetus x can be expressed through the parameters α and β in the following Table 1:

Table 1

α \ β	0	2	4	6	8	10	12	…
1	1·3	1·5	1·7	1·9	1·11	1·13	1·15	…
2	3·5	3·7	3·9	3·11	3·13	3·15	3·17	…
3	5·7	5·9	5·11	5·13	5·15	5·17	5·19	…
4	7·9	7·11	7·13	7·15	7·17	7·19	7·21	…
5	9·11	9·13	9·15	9·17	9·19	9·21	9·23	…
6	11·13	11·15	11·17	11·19	11·21	11·23	11·25	…
7	13·15	13·17	13·19	13·21	13·23	13·25	13·27	…
…	…	…	…	…	…	…	…	…

Using table 1 we can define the number of the column (e), cathetus (y), the hypotenuse (z), the radius of the inscribed circle, square of triangle (S) according to the following rules:

I. To determine the number of column e, from the product of cathetus $x = u \cdot v$ the larger multiplier subtract smaller and divide it by two, i.e. if $x = u \cdot v$, and $v > u$, then $e = \frac{v-u}{2}$.

Example: $x = 1 \cdot 3$, then $e = \frac{3-1}{2}$.

II. To determine the cathetus y, in expression of cathetus $x = u \cdot v$ adding multipliers u and v, and multiply it by the number of the column, i.e. $y = (u+v) \cdot e$

Example: $(1+3) \cdot 1 = 4$.

III. To determine the hypotenuse z, add up the length of cathetus y and the square of the first factor of cathetus x, i.e., if $x = u \cdot v$ and $y = (u+v) \cdot e$, then $z = y + u^2$.

Example: if $x = 1 \cdot 3$ and $y = (1+3) \cdot 1 = 4$, then $z = 4 + 12 = 5$.

IV. To determine the radius of the inscribed circle in each row of table 1, the first factor of cathetus x multiplied by the number of the column, i.e., if $x = u \cdot v$ and e is the number of the column, then $r = u \cdot e$.

Example: $x = 1 \cdot 3$ and $e = \frac{v-u}{2} = \frac{3-1}{2} = 1$, then $r = u \cdot e = 1 \cdot 1 = 1$.

V. To find the area of Pythagorean triangle $\langle x, y, z \rangle$, use the formula

$$S = (x-r)(y-r) \text{ or } S = \frac{xy}{2}.$$

Then theorem 1 can be formulated as follows:

Theorem 1'. If $\langle x, y, z \rangle = 1$, x, z — odd, y — even, Pythagorean triangles that are included into the set *M*, can be defined by the formula

$$\begin{cases} x = (2\alpha - 1)(2 \cdot (\alpha + e) - 1) \\ y = (4\alpha + e - 2) \cdot e \\ z = (4\alpha + 2e - 2) + (2\alpha - 1)^2 \\ r = (2\alpha - 1) \cdot e \\ S = (x - r)(y - r) \end{cases}$$

Theorem 2 [3]. For any circle of radius $r \in N$ there is described Pythagorean triangle.

The radius of this circle is determined by the formula

$$r = (2\alpha - 1)\frac{\beta + 2}{2}.$$

The proof of this theorem can be obtained by building the Table 2.

Table 2

e \ α	1					2				
	x	*y*	*z*	*r*	*s*	*x*	*y*	*z*	*r*	*s*
1	1·3	4	5	1	6	1·5	12	13	2	30
2	3·5	8	17	3	60	3·7	20	29	6	210
3	5·7	12	37	5	210	5·9	28	53	10	630
4	7·9	16	65	7	604	7·11	36	85	14	1386
5	9·11	20	101	9	990	9·13	44	125	18	1287
e \ α	3					4				
	x	*y*	*z*	*r*	*s*	*x*	*y*	*z*	*r*	*s*
1	1·7	24	25	3	84	1·9	40	41	4	180
2	3·9	36	45	9	486	3·11	56	65	12	924
3	5·11	48	72	18	1320	5·13	72	97	20	2340
4	7·13	60	109	21	2730	7·15	88	137	28	4620
5	9·15	72	153	27	4860	9·17	104	185	36	7956
e \ α	5					6				
	x	*y*	*z*	*r*	*s*	*x*	*y*	*z*	*r*	*s*
1	1·11	60	61	5	330	1·13	84	85	6	540
2	3·13	80	89	15	1560	3·15	108	117	18	2430
3	5·15	100	125	25	3750	5·17	132	157	30	5185
4	7·17	120	169	35	7140	7·19	156	205	42	10374
5	9·19	140	221	45	11970	9·21	180	261	54	17010

If $\beta = 0$, $(e = 1)$, $\alpha \in N$, then $r = 1, 3, 5, \ldots, 2k - 1, \ldots$ — all odd natural numbers.

If $\beta = 4d - 2$, $\left(e = \frac{\beta + 2}{2}\right)$, $\beta, d \in N$, then $r = 2, 4, 6, \ldots, 2k, \ldots$ — all even natural numbers.

Theorem 1 allows us to tell that Pythagorean triple when $\langle x, y, z \rangle = 1$, x, z — odd, y — even, depends on the values of the parameter x. This is due to the fact that $x = u \cdot v$, where $u < v$, u and v — odd natural numbers. Then in the decomposition of x on multipliers we can introduce Cantor pairing function.

Let the catheti x_1 and x_2 have factorizations $u_1 \cdot v_1$ and $u_2 \cdot v_2$ respectively. If they are from one group and $u_1 < u_2$ and $v_1 < v_2$, then $x_1 < x_2$, if they are from different groups b_1 and b_2, and $b_1 < b_2$, then $x_1 < x_2$,

If $u_1 = u_2$ and $v_1 < v_2$, then $x_1 < x_2$.

If $u_1 < u_2$ and $v_1 = v_2$, then $x_1 < x_2$.

An example of Cantor pairing function factorization of cathetus x is given in Table 3.

Briefly it can be written as follows:

The cathetus x can be defined using the table 1 in the form of a product

$$\left(2\alpha-1\right)\left(2\alpha+\beta+1\right).$$

The number $\left(2\alpha-1\right)\cdot\left(2\alpha+\beta+1\right)$ can be written as double tuple

$$\left\langle 2\alpha-1;2\alpha+\beta+1\right\rangle.$$

Then on the set $K=\left\{\left\langle 2\alpha-1;2\alpha+\beta+1\right\rangle | \alpha\in N,\beta\in 2N\right\}$ can define a linear order, i.e. Cantor pairing function $\left\langle K;<_2\right\rangle$.

Let $\left\langle e,f\right\rangle,\left\langle c,d\right\rangle\in K$.

Then, If $f<d$, then $\left\langle e,f\right\rangle <_2 \left\langle c,d\right\rangle$

If $f=d$, then $\left\langle e,f\right\rangle <_2 \left\langle c,d\right\rangle \Leftrightarrow e<c$.

Properties of Pythagorean triangles.

1. One of the catheti of Pythagorean triangles is divided by 4.

Proof:

Case 1. If α or β— even numbers, then $x=2\alpha\beta$ is divided by 4.

Case 2. If α and β— odd numbers, then $y=\alpha^2-\beta^2=\left(\alpha+\beta\right)\left(\alpha-\beta\right)$ is divided by 4.

2. One of the catheti of Pythagorean triangles is divided by 3.

Proof:

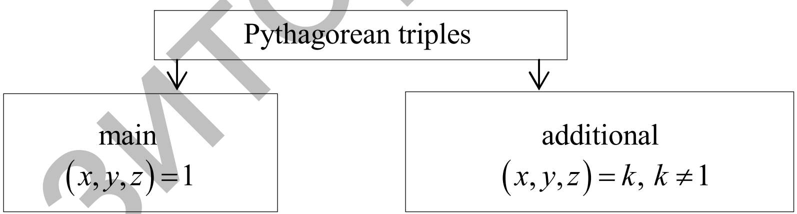
Case 1. If $\alpha=3k$ or $\beta=3p$, then $x=2\alpha\beta$ is divided by 3.

Case2. If $\alpha=3k+1$, $\beta=3p+1$, then $y=\alpha^2-\beta^2=\left(\alpha+\beta\right)\left(\alpha-\beta\right)=\left(3k+1-3p-1\right)\left(3k+1+3p+1\right)=$ $=3\left(k-p\right)\left(3k+3p+2\right)$ is divided by 3.

Case 3. If $\alpha=3k+1$, $\beta=3p+2$, then $y=\alpha^2-\beta^2=\left(\alpha+\beta\right)\left(\alpha-\beta\right)=\left(3k+1-3p-2\right)\left(3k+1+3p+2\right)= =3\left(3k-3p-1\right)\left(k+p+1\right)$ is divided by 3.

Case 4. When $\alpha=3k+2$ and $\beta=3p+2$ proved similarly as Case 3.

3. In Pythagorean triangle products of the catheti is divided by 12. The proof follows from the properties 1 and 2.



4. If x is a prime number, then the main Pythagorean triple is the only one.

Consider the following tasks.

Task 1. What is the sum of the digits of n-digit numbers in the decimal number system?

Task 2. What is the sum of digits of all unequivocal to *n*-digit numbers in the decimal number system?

In decimal system form any non-negative number $\alpha\in N^{+}$ can be represented in the form

$$\alpha=\overline{a_1a_2\ldots a_n},$$

where

$$a_1\neq 0,\ a_i\in\{0,1,...,9\},\ i=2,3,...,n, a_1\in\{1,2,...,9\}.$$

Let sum α of the digits of the number α be denoted by $l\left(\alpha\right)$, i.e.

$$l\left(\alpha\right)=a_1+a_2+\ldots a_n.$$

Sum of single-digit numbers: 0,1,2,3…,9

$$S_1=\frac{0+9}{2}\cdot 10=45=1\cdot 45=1\cdot 10^0\cdot 45.$$

Define the sum of digits of all two-digit numbers.

Table 3

$$\begin{cases} 10,11,\ldots,19 \\ 20,21,\ldots,29 \\ 30,31,\ldots,39 \\ \ldots\ldots\ldots\ldots\ldots \\ 90,91,\ldots,99 \end{cases}$$

In this table we can introduce Cantor pairing function.

If $\alpha = \overline{xy}$ is two-digit number, then we insert in accordance tuple $\langle x, y\rangle$.

On the set $(N^+)^2 = N^+ \times N^+ = \{\langle x, y\rangle \mid \alpha = \overline{xy}\}$ determine Cantor pairing function, i.e. $\langle (N^+);\leq_2\rangle$ — linearly ordered set.

If $\alpha = \overline{xy}$, $\beta = \overline{uv}$ and $l(\alpha) < l(\beta)$, then $\langle x, y\rangle \leq_2 \langle u, v\rangle$;

If $\alpha = \overline{xy}$, $\beta = \overline{uv}$ and $l(\alpha) = l(\beta)$, then $\langle x, y\rangle \leq_2 \langle u, v\rangle \Leftrightarrow x < y$.

Some properties of the Table 3:

1. Table 3 is symmetric, i.e. the amounts of natural numbers with length of k and $n-k$ are equal, when $n = 19, k = 1,2,\ldots,18$.

2. If two-digital numbers α and β are symmetric, then $l(\alpha) + l(\beta) = 19$.

3. The amount of numbers with length 1 — one;
The amount of numbers with length 18 — one;
The amount of numbers with length 2 — two;
The amount of numbers with length 17 — two;
. . . .
The amount of numbers with length 8 — eight;
The amount of numbers with length 11 — eight;
The amount of numbers with length 9 — nine;
The amount of numbers with length 10 — nine;

Then we can obtain the following formulas:

$$S_2 = 19 \cdot \sum_{k=1}^{9} k = 19 \cdot \frac{1+9}{2} \cdot 9 = 19 \cdot 45 = 45 \cdot (9+10) = 855.$$

$$S_1 + S_2 = 45 + 855 = 900 = 20 \cdot 45 = 2 \cdot 10^1 \cdot 45.$$

Determine the sum of three-digit numbers.

Table 4

$$\begin{cases} 100,101,\ldots,199 \\ 200,201,\ldots,299 \\ 300,301,\ldots,399 \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ 900,901,\ldots,999 \end{cases}$$

In Table 4 we can introduce the Cantor pairing function.

For this, natural number $\alpha = \overline{a_1 a_2 a_3}$ represent as tuple $\langle a_1, \alpha_2, \alpha_3\rangle$.

Then $\langle a_1, \alpha_2, \alpha_3\rangle = \langle\langle a_1, \alpha_2\rangle, \alpha_3\rangle = \langle C(a_1, \alpha_2); \alpha_3\rangle$, where $C(a_1, \alpha_2)$ — Cantor's number of tuple $C(a_1, \alpha_2)$, i.e. Cantor's number of natural two-digit number $\alpha' = \overline{a_1 a}$.

Continuing this process inductively, we can determine Cantor's number n-digit natural number $\alpha = \overline{a_1 a_2 \ldots a_n}$.

$$\langle a_1, a_2, ..., a_{n-1}, a_n \rangle = \langle \langle a_1, a_2, ..., a_{n-1} \rangle ; a_n \rangle.$$

Some properties of the table 4:

1. Table 4 symmetric, i.e. the amounts of natural numbers with length q and $m-q$ are equal, where $m=28$, $q=1,2,\ldots,27$.

2. If three-digit numbers c and d are symmetric, then

$$l(c)+l(d)=28.$$

3. The amount of numbers with length 1 — one;
The amount of numbers with length 27 — one;
The amount of numbers with length 2 — three;
The amount of numbers with length 26 — three;
The amount of numbers with length 3 — six;
The amount of numbers with length 25 — six;
. . . .
The amount of numbers with length 13 — sixty nine;
The amount of numbers with length 15 — sixty nine;
The amount of numbers with length 14 — seventy;
From here we can obtain the following formulas

$$S_3 = 28 \cdot \left(\sum_{k=1}^{9} \frac{k(k+1)}{2} + \sum_{k=1}^{9} k) \right) + 14 \cdot 70 = 28 \cdot 450 = 12600 == 45 \cdot (1+3 \cdot 9) \cdot 10;$$

$$S_1 + S_2 + S_3 = 45 + 855 + 12600 = 13500 = 45 \cdot 300 = 3 \cdot 10^2 \cdot 45.$$

Continuing this process by induction, we can obtain:
Approval 1
In decimal number system sum of the digits of all n-digit numbers

$$S_n = 10^{n-2}(1+9 \cdot n) \cdot 45.$$

Approval 2
In decimal number system sum of the digits from single-digit numbers to n-digit numbers:

$$S = \sum_{i=1}^{n} S_i = 45 \cdot n \cdot 10^{n-1}.$$

There is the program written in a Delphi 7 language.

This program can calculate sum of the digits from single-digit numbers to n-digit numbers S_n and of the digits of all n-digit numbers S.

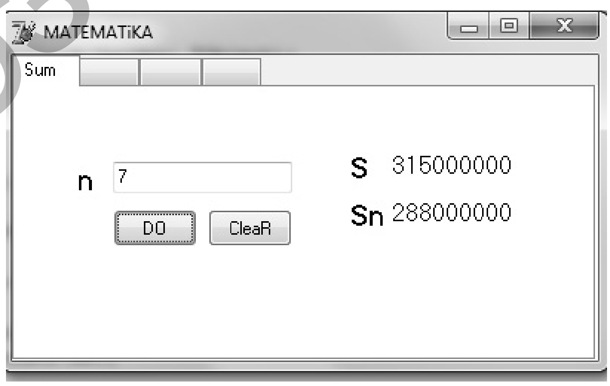


Image 1. Enter value of n to find S_n and S

The program in Delphi 7 allows to calculate the appropriate Pythagorean triple for any $r \in N$.

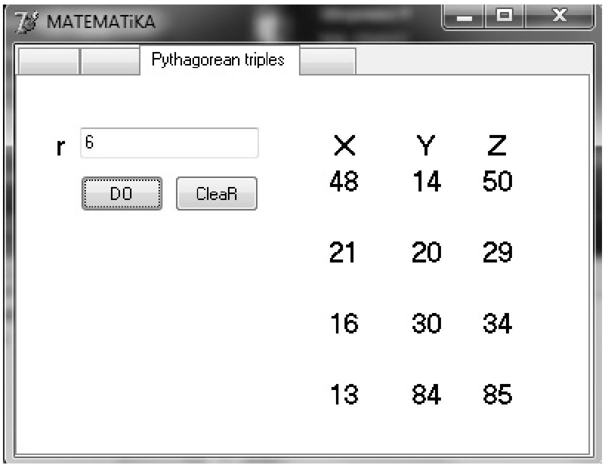


Image 2. By entering value of radius of the inscribed circle,
Pythagorean triples can be found

Program can calculate Pythagorean triple by the formula (3) with the condition (3`).

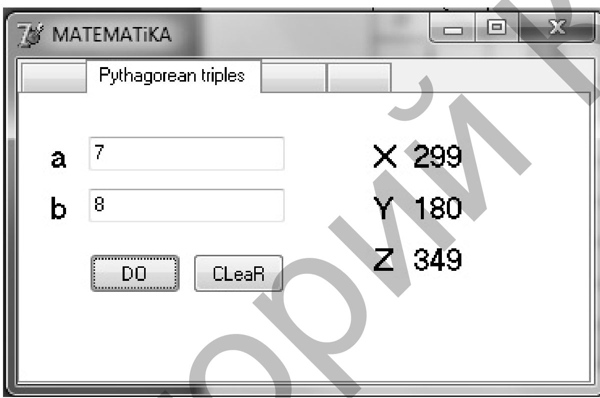


Image 3. To deterrmine Pythagorean triple, enter parameters *a* and *b*

Cantor pairing function of expansion of cathetus *x* allows to define unambiguously Pythagorean triples $\langle x, y, z \rangle$ and backward.

Compiled program can determine Cantor's number of any n-digit natural number and reverse, define *n*-digit natural number by Cantor's number.

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Қ.Жетпісов, А.Қ.Тыныштықбай, Ш.Д.Құсбеков

Канторлық номерлерді қарапайым екі есепті шешуде қолдану

Мақалада канторлық номерлеудің келесі екі есепті шешуде қолданулары көрсетілді: 1) негізгі пифагорлық үштіктерді анықтауда; 2) ондық санау жүйесіндегі барлық *n*-таңбалы сандардың цифраларының қосындысын табуда. Ондық санау жүйесіндегі біртаңбалықтан *n*-таңбалыға дейінгі сандардың цифрларының қосындысы табылды. Сонымен қатар бұл есептер үшін Borland Delphi 7 тілінде программа құрылған.

К.Жетписов, А.К.Тыныштыкбай, Ш.Д.Кусбеков

Применение канторовской нумерации в двух простейших задачах

В статье показаны применения канторовой нумерации при решении следующих задач: 1) при определении основных пифагоровых троек; 2) при вычислении суммы цифр всех *n*-значных чисел в десятичной системе счисления. При вычислении суммы цифр от однозначных до *n*-значных чисел. Для этих двух задач была написана программа на языке программирования Borland Delphi 7.

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С.К.Жумагулова[1], Б.М.Саданова[2]

[1]Карагандинский государственный университет им. Е.А.Букетова;
[2]Карагандинский государственный технический университет (E-mail: sadanova@mail.ru)

FTP-соединение как средство защиты информации в локальной сети

В статье рассмотрены принципы защиты информации в локальных сетях с использованием FTP-сервера. Приведено описание требований к программному и техническому обеспечению создаваемой программы. Рассмотрен алгоритм реализации информационной системы FTP-соединения. Описаны и проанализированы структурные элементы FTP-соединения, определены требования для создания данных элементов, а также описан механизм действия разработанной программы.

Ключевые слова: система, сервер, соединение, надежность, приложение, объект, логин, пароль, форма, сеть.

Развитие и рост автоматизации производственно-хозяйственных процессов крупных промышленных организаций, а также повсеместное внедрение информационных технологий привели к значительному увеличению информационной среды организаций. Вместе с тем возросла и вероятность утечки информации, т.е. возросла возможность нанесения вреда организациям и их безопасности.

Набор программно-технических, организационных, административно-правовых и других мероприятий, реализуемых для защиты информационной среды, называют системой обеспечения информационной безопасности. К объектам комплексной интегрированной системы защиты организации можно отнести:

– автоматизированные системы (системы, используемые для хранения, поиска и выдачи данных, затребованных пользователями);
– информационные процессы (процессы обработки, преобразования, сохранения и передачи данных, которые обеспечиваются информационными системами и средствами передачи данных);
– информационные ресурсы — комплекс ценных данных организации, которые выступают в качестве материальных ресурсов: хранящиеся во внешней памяти основные и вспомогательные массивы данных и входящие документы.

Защищенность вычислительной сети напрямую зависит от того, сколько средств будет вложено в ее защиту. Но важно учесть соотношение затраченных финансов к нужной степени защиты,