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**TRAINING OF HIGHER EDUCATIONAL INSTITUTION'S STUDENTS
FOR PERFORMING ENGINEERING DESIGNS (ГРАММАТИЧЕСКИЕ
ОШИБКИ) ИСПРАВИЛА.**

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The review of both scientific, methodological and specialized resources on the issue of increasing the level of students' mathematical education at the engineering faculties was made. The experience of implementing information technologies, the Systems of Computer Mathematics in particular, in the process of teaching university students, was studied. Necessity to form mathematical competence of the engineers-to-be by means of information technologies was proved. The technique of instructing students to make engineering designs using information technologies on examples of the subject "Numerical methods" and "Solution of the system of linear equations using Gaussian elimination with selecting the pivot element" was offered. The specific feature of this technique is combination of traditional and innovative educational methods and techniques. We were considering implementation of the methodology offered through the example of the practical lesson on the topic "Solution of nonlinear equation". We first of all offer to consider the Systems of Computer Mathematics as the way to check the results obtained, but after students' gaining corresponding skills, while performing design and graphic works, course and diploma projects, it is worth encouraging them to computerize computational process students several alternative methods of problem solving by means of ICT.

Keywords. *The development, methodology, training, calculations, engineering.*

Introduction.

Fast development of science and technology causes constant increase and complication of the scientific information flow. It requires from future specialists an ability to react quickly to the demands of current life, update independently and systematically the knowledge, perform complicated engineering designs. Therefore, the students must possess the skills of using spreadsheets, systems of statistical computations and the systems of computer mathematics (SCM), realize their computational capabilities and choose the most efficient ones for satisfying set objectives.

However, the number of lessons of mathematical subjects in technical higher educational institutions is reducing, and the level of mathematical preparation of applicants does not give them an opportunity to broaden the knowledge by themselves.

At the moment, handling the problem of improving the level of mathematical background among the students of technical educational institutions the specialists [4, p. 111] link to the large-scale implementation of educational software tools into teaching practice. In such case formation of students' mathematical competence takes place by means of increasing their motivation in learning mathematical subjects, they start have an opportunity to check by themselves the task they have completed, verify the obtained results or correct the design. We would like to emphasize that the SCM are widely spread in higher educational institutions.

The analysis of the literature.

As a result of the fact, that SCM is an environment for designing software tools to support learning mathematical subjects by the students of higher educational institutions, the specialists

[1, p. 60] consider such systems to be an innovative pedagogical technology. They emphasize that the efficiency of using computer programs for engineering designs depends on users' awareness of the program's specific features. Corresponding theoretical knowledge contributes to the best possible choice of design depending on the peculiarities of the set objective. Thus, one of the tasks of the system of training of would-be engineers is to form and deepen their knowledge and skills of using ICT in educational and scientific activity.

The review of scientific, methodological and specialized resources proved that nowadays the issue of forming mathematical competence of the engineers-to-be is of big importance for many scientists. Of the main directions of improving the educational process, the most popular among scientists are usage of information computer technologies in teaching mathematical subjects, implementation of SCM, cloud technologies, etc.

Scientific resources analysis enables to state that scientists offer to use SCM as a tool in teaching Advanced Mathematics [3], Operational Research [2], Linear Programming [5].

Studying the possibilities of educational software, which enables to simulate the whole process of completing a wide range of standard tasks in Advanced Mathematics, Ya. V. Krupsky developed and theoretically proved the concept of adapting SCM Maple for teaching Advanced Mathematics for students of technical faculties, developed the model of using educational Maple-simulators and proved the effectiveness of using the Maple system while teaching Advanced Mathematics for mechanics-to-be [4].

Looking for new methodological approaches to the organization of education in higher educational institutions, U. P. Kogut discovered educational possibilities to increase the level of ICT-competence formation among the specialists in Informatics-to-be by means of using SCM in their professional education [3].

Claiming that teaching Mathematics must be as simple, clear and natural, as possible, O. I. Tiutiunnyk developed the main components of the technique of using SCM while teaching linear programming for managers-to-be. The main means of teaching Advanced Mathematics were presented by the author in the form of educational Maple-simulators in linear programming [7].

Proving that traditional methods of teaching mathematical subjects do not contribute to effective organization of students' individual work, N. V. Rashevskaya offered the technique of using mobile ICT while teaching Advanced Mathematics for students of technical higher educational institutions with using computer-oriented practical and individual tasks, SCM integrator and MathPiper dynamic geometry [5].

While developing mobile educational environment in Advanced Mathematics, M. A. Kislova started out from the idea, that in the process of teaching Advanced Mathematics modern ICTs are desirable to use for presenting educational material, performing calculations, visualizing mathematical dependences, forming skills of conducting educational mathematical investigations, as well as for supporting students' educational activity and organizing their individual work [1].

However, the problem of improving the training of technical students in performing engineering designs demands further investigation. We consider that search for the ways to increase the level of mathematical education of engineers-to-be, development of innovative approaches to formation of their mathematical competence, development of new methods of teaching mathematical subjects using the means of ICT have by half used potential.

The results of the investigation.

As a result of the conducted research, we developed the methodology of teaching students to perform engineering designs using ICT at the practical lessons of the subject "Numerical methods".

Both synthesis of the data from the scientific resources and own pedagogical experience allowed to define the stages of teaching engineers-to-be to conduct mathematical design at practical classes in mathematical subjects.

- Announcing the topic, goal.
- Updating basic knowledge.

- Self-checking the knowledge.
- Solving the task in a team by a traditional method.
- Computerizing the process of conducting design by means of MS Excel.
- Using SCM for solving the task.
- Comparing possibilities of different computer means of teaching and defining the purposefulness of using them while solving profession-oriented tasks.
- Receiving an individual task, which the student must solve by a traditional method and checking the results obtained by means of ICT.
- Evaluating the results of the work in a classroom.
- Giving the task for an individual work.

We will consider implementation of the methodology offered through the example of the practical lesson on the topic “Solution of nonlinear equation”.

At the stage of updating supportive knowledge, students use electronic educational resources and revise basic theoretical statements on the topic they learn. After this with the help of tests and the system of MS Power Point action buttons they perform self-assessment and fill in the knowledge gaps.

Updating basic knowledge.

We repeat the statement of the problem:

Let's analyze the problem of finding the root of a nonlinear equation

$$f(x) = 0, \quad (1)$$

We pay attention to the fact, that solving this problem can be split into several stages:

- analysis of root location and their multiplicity;
- root isolation, which is defining locations, which contain only one root;
- counting the root with the fixed precision by means of one of iterative algorithms.

We revise the methods of root isolation. We remind that roots can be isolated by a method of graphs, a trial method and a method of defining the monotonicity interval.

We revise the algorithm of a dichotomy method.

Algorithm.

- To isolate the root of the equation $f(x) = 0$ – to find an interval $[a_0; b_0]$, where the index changes: $f(a_0) \cdot f(b_0) < 0$.
- To define the midpoint of the interval
- Evaluate the function
- Depending on the index $f(x_0)$ to define new limits of the interval $[a_i; b_i]$, $i = 1, 2, \dots$ in the following way:
 - if $f(a_0) \cdot f(x_0) < 0$, then $a_i = a_{i-1}$, $b_i = x_{i-1}$, $i = 1, 2, \dots$,
 - if $f(a_0) \cdot f(x_0) > 0$, then $a_i = x_{i-1}$, $b_i = b_{i-1}$, $i = 1, 2, \dots$,
- Calculate $x_i = \frac{b_i + a_i}{2}$
- Calculate an inaccuracy using the formula $r_i = b_i - a_i$.
- Iteration process ends as soon as $r_i < \varepsilon$.

We demonstrate the process of the interval division with the help of the graph (Fig. 1).

We notice that in case, when inequation comes true

$$b_n - a_n = \frac{(b - a)}{2^n} \leq \varepsilon \quad (2)$$

which means the length on a n interval gets smaller than the fixed precision, we take up that

$$x_n = c_n = \frac{b_n - a_n}{2} \quad (3)$$

is a root of the equation.

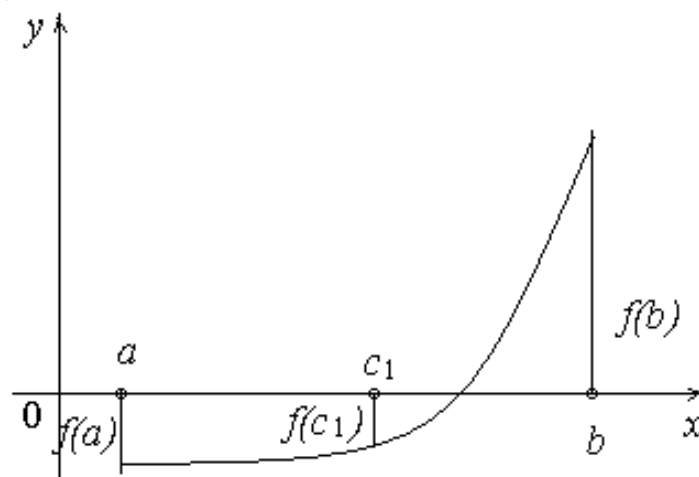


Fig. 1. Method of dividing the interval into halves.

In this condition convergence estimate takes place

$$|x_n - x_*| \leq \frac{b-a}{2^{n+1}} \quad (4)$$

The result is that the number of iterations, necessary to be conducted to find an approximate root of the equation (1.1) with the fixed precision ε complies with the correlation

$$n \geq \left\lceil \log_2 \frac{b-a}{\varepsilon} \right\rceil \quad (5)$$

At the stage of team work the method of finding equation solutions by approximate roots adjustments is offered.

We suggest solving the problem by means of a traditional method, using the MS Excel possibilities.

To find a solution of the equation $y - \sin\left(x + \frac{\pi}{3}\right) + \left(\frac{x}{2}\right)^2 = 0$ by means of a dichotomy method with precision $\varepsilon = 0,001$.

At first we isolate the equation roots by the method of defining the monotonicity interval. We use the following table (Table 1).

Table № 1.

Evaluation of the function index in definite points

| | | | | | | | | |
|----------|----|----|----|----|---|---|---|---|
| x | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 |
| signf(x) | - | - | - | - | + | + | - | - |

We can see from the table that the equation has two roots, which are located in the interval $[-1;0]$ and $[1;2]$.

Besides, we consider the process of isolating the equation root by means of the method of graphs. We build the function graph. We define that the intervals $[-1;0]$ and $[1;2]$ contain the equation roots (Fig. 2).

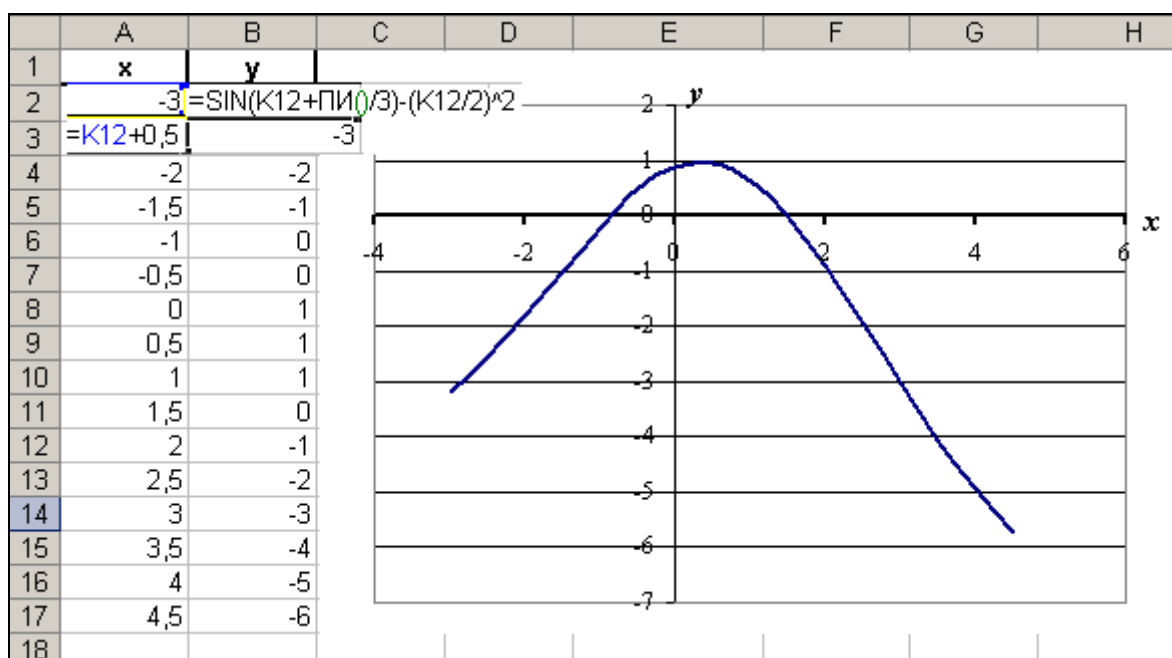


Fig. 2. Isolating the equation root by the method of graphs.

As we can see, one of the equation solution is located in the interval [1;2]. We choose $a_0 = 1, b_0 = 2$. According to the formula (5) we define, that to find the root with an accuracy 10^{-3} it is necessary to conduct ten iterations.

We make up and fill the MS Excel table. We leave the part of the interval, where the function values at the ends have different indexes (Fig. 3).

| n | a_n | b_n | $x_n=(a_n+b_n)/2$ | $f(a_n)$ | $f(x_n)$ | $(b_n - a_n)$ |
|---|----------|-------|-------------------|-----------|----------|---------------|
| 0 | 1 | 2 | 1,5 | 0,638651 | -0,00249 | 1 |
| 1 | 1 | 1,5 | 1,25 | 0,638651 | 0,356944 | 0,5 |
| 2 | 1,25 | 1,5 | 1,375 | 0,3569445 | 0,186274 | 0,25 |
| 3 | 1,375 | 1,5 | 1,4375 | 0,1862735 | 0,094059 | 0,125 |
| 4 | 1,4375 | 1,5 | 1,46875 | 0,0940595 | 0,046314 | 0,0625 |
| 5 | 1,46875 | 1,5 | 1,484375 | 0,0463137 | 0,022042 | 0,03125 |
| 6 | 1,484375 | 1,5 | 1,4921875 | 0,0220417 | 0,009807 | 0,015625 |
| 7 | 1,492188 | 1,5 | 1,49609375 | 0,0098072 | 0,003666 | 0,0078125 |
| 8 | 1,496094 | 1,5 | 1,498046875 | 0,0036656 | 0,000589 | 0,00390625 |

Fig. 3. Counting the equation positive root by means of the method of dividing the interval into halves.

After this we suggest partial computerizing of the counting process by means of introducing corresponding formulas (Fig. 4).

| a_n | b_n | $x_n=(a_n+b_n)/2$ | $f(a_n)$ | $f(x_n)$ | $(b_n - a_n)$ | 0,001 |
|----------------------|-------|-------------------|-----------------------------|----------|---------------|--------------------------|
| 1 | 2 | 1,5 | -0,0024923 | 0,638651 | 1 | |
| =ЕСЛИ(F2*G2<0;C2;E2) | | 1,25 | =(SIN((PI()/3+E3)-(E3/2)^2) | | 0,5 | =ЕСЛИ(H3<=\$I\$1;"End";" |

Fig. 4. Inserting the formulas for automatic fill of the table.

We get the equation negative root by means of auto fill and usage of the commands Service → Parameters → Count → Worksheet Recount (Fig. 5).

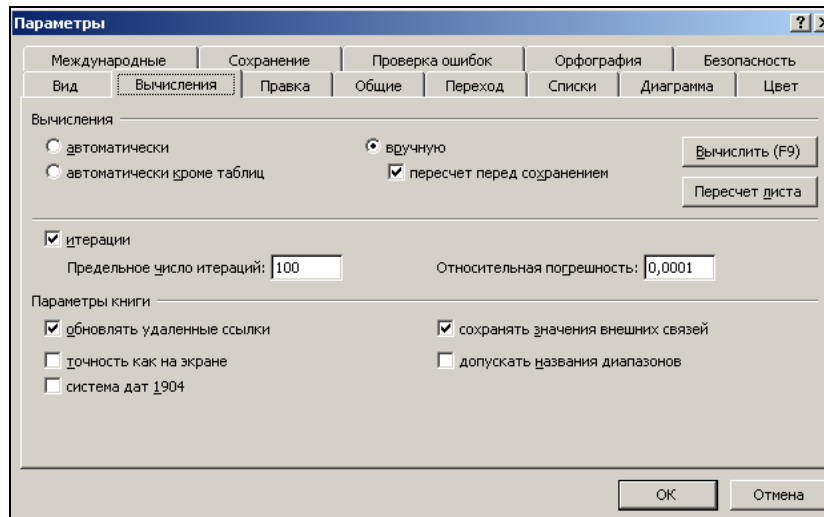


Fig. 5. Procedure of finding solution.

We receive (Fig. 6):

| n | a_n | b_n | $x_n = (a_n + b_n) / 2$ | $f(a_n)$ | $f(x_n)$ | $(b_n - a_n)$ |
|---|----------|----------|-------------------------|------------|----------|---------------|
| 0 | -1 | 0 | -0,5 | -0,20282 | 0,457796 | 1 |
| 1 | -1 | -0,5 | -0,75 | -0,20282 | 0,152217 | 0,5 |
| 2 | -1 | -0,75 | -0,875 | -0,20282 | -0,02006 | 0,25 |
| 3 | -0,875 | -0,75 | -0,8125 | -0,0200584 | 0,06751 | 0,125 |
| 4 | -0,875 | -0,8125 | -0,84375 | -0,0200584 | 0,024068 | 0,0625 |
| 5 | -0,875 | -0,84375 | -0,859375 | -0,0200584 | 0,002089 | 0,03125 |
| 6 | -0,875 | -0,85938 | -0,8671875 | -0,0200584 | -0,00896 | 0,015625 |
| 7 | -0,86719 | -0,85938 | -0,86328125 | -0,0089641 | -0,00343 | 0,0078125 |
| 8 | -0,86328 | -0,85938 | -0,861328125 | -0,0034324 | -0,00067 | 0,00390625 |

Fig. 6. Counting the negative positive root by means of partial count computerizing.

That done, the exponential equation is solved by the teacher with the help of the add-on Goal Seek of MS Excel spreadsheet (Fig. 7).

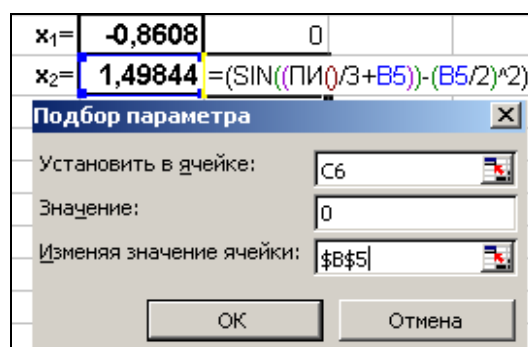


Fig. 7. Finding the equation roots by means of count computerizing
At the end, the equation is solved using SCM MathCAD (Fig. 8).

2. Gaussian elimination with partial pivoting (by a column). In this case the pivot at the i stage of elimination is selected as the pivot of the i column, which is equal to renumbering the equations on every stage of elimination;
3. Gaussian elimination with complete pivoting (by the whole matrix). In this case the pivot at the i stage of elimination is selected as the maximum one by the module among all elements of matrix, which means renumbering the variables and interchanging the equations.

We revise the algorithm of Gaussian elimination with pivoting.

Algorithm

To select the biggest element by the module, which does not belong to the column of absolute terms.

In this conditions the row, which contains the pivot is called a pivot row;

To calculate multipliers m_i for every matrix row, except for the pivot one, by the formula

$$m_i = -\frac{a_{iq}}{a_{pq}} \quad (7)$$

To add the pivot row, multiplied by the corresponding multiplier m_i for every not pivot row.

To eliminate the column with zero elements and the pivot row and get the matrix, which consists of one row and one column less.

To keep on iterating until the matrix gets triangle form.

To pass on to finding out unknown variables.

At the stage of team work we offer to solve this SLE by performing Gaussian elimination with pivoting “manually”, later on – to check the solution obtained using MS Excel.

Students are offered the task to solve this SLE by performing Gaussian elimination with pivoting:

$$\begin{cases} 2x_1 + 5x_2 + 4x_3 = 1 \\ 3x_1 + 2x_2 - x_3 = 8 \\ 4x_1 - x_2 - 2x_3 = -3 \end{cases}$$

Let us consider the pivot matrix of A system and the column B of absolute terms:

$$A = \begin{pmatrix} 2 & 5 & 4 \\ 3 & 2 & -1 \\ 4 & -1 & -2 \end{pmatrix}, \quad B = \begin{pmatrix} 1 \\ 8 \\ -3 \end{pmatrix}.$$

We select the pivot – the element, situated in the crossing of the first row and the second column, i.e. $a_{12} = 5$.

Let us calculate the multipliers m_i : $m_2 = -\frac{2}{5}$; $m_3 = \frac{1}{5}$;

At the next stage we add the pivot row, multiplied by the corresponding multiplier m_i , to the second and the third rows of the matrix. As a result, we receive the matrix of the following form:

$$A = \begin{pmatrix} 2 & 5 & 4 & 1 \\ 2,2 & 0 & -2,6 & 7,6 \\ 4,4 & 0 & -1,2 & -2,8 \end{pmatrix}$$

Later on, eliminating the second column and the pivot row, we receive the matrix $A^{(1)}$:

$$A^{(1)} = \begin{pmatrix} 2,2 & -2,6 & 7,6 \\ 4,4 & -1,2 & -2,8 \end{pmatrix}$$

After this we pass on to the Stage 2, and repeat the same actions over the matrix received, i.e:

1. Select the pivot 4,4.
2. For the first row of the matrix we calculate multipliers m_i : $m_1 = -\frac{2,2}{4,4} = -\frac{1}{2}$
3. We add the pivot row, multiplied by corresponding multiplier m_i , to every no pivot one of the matrix. The result of performing this stage is the matrix of the following form:

$$A^{(1)} = \begin{pmatrix} 0 & -2 & 9 \\ 4,4 & -1,2 & -2,8 \end{pmatrix}$$

Later on, by eliminating the first column and the pivot row, we receive the matrix, which consists of one row and two columns:

$$A^{(2)} = (-2 \ 9)$$

Now the procedure of transforming the matrix to triangular form can be considered done. We pass on to finding out unknown variables x_i . For this purpose we join all pivot rows, starting with the last one, being the part of the matrix $A^{(2)}$. As a result we receive the system which easily helps to find out unknown variables:

$$\begin{pmatrix} 2 & 5 & 4 & 1 \\ 0 & 0 & -2 & 9 \\ 4,4 & 0 & -1,2 & -2,8 \end{pmatrix} \Rightarrow \begin{cases} x_1 = \frac{-2,8 - 1,2 \cdot 4,5}{4,4} \\ x_2 = \frac{1 - 4x_3 - 2x_1}{5} \\ x_3 = -\frac{9}{2} \end{cases} \Rightarrow \begin{cases} x_1 = -1,86364 \\ x_2 = 4,545455 \\ x_3 = -4,5 \end{cases}$$

Now we check the results by MS Excel (Fig. 9).

1. Enter initial data.
2. Form the row x , where there will be the values of unknown variables received.
3. Form the constraint column, where we enter the formula: =СУММПРОИЗВ (SUMPRODUCT) (Row 1; X).

| | A | B | C | D | E | F | G | H |
|---|---|--------------|----|----|--------------|----------------------------------|---|---|
| 1 | | The matrix A | | | The matrix B | restrictions | | |
| 2 | | 2 | 5 | 4 | 1 | =СУММПРОИЗВ(B2:D2;\$B\$5:\$D\$5) | | |
| 3 | | 3 | 2 | -1 | 8 | | | |
| 4 | | 4 | -1 | -2 | -3 | | | |
| 5 | X | | | | | | | |

Fig. 9. Preparing the data for automatic solution finding.

4. Perform autocompletion, having fixed the row X values.
5. Use the Tab **Service** → **Solver**

(changing the row X, we add constraints: the constraint column is equal to the column of absolute terms; Solver parameters – linear) and press the button Run (Fig. 10).

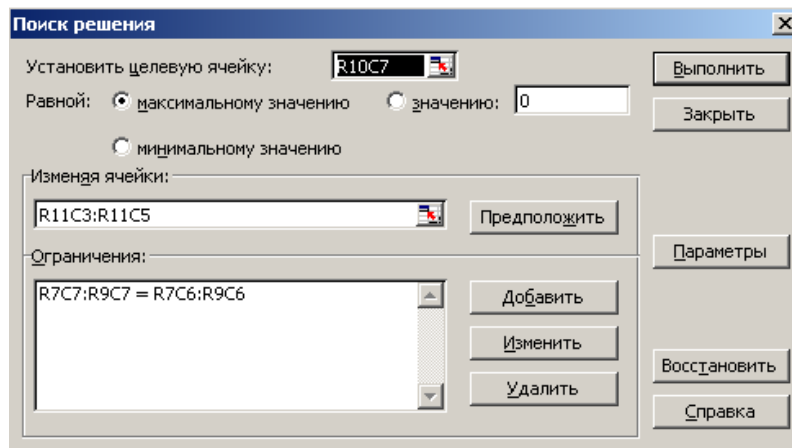


Fig. 10. Procedure of finding solution.

We receive (Fig. 11):

| | A | B | C | D | E | F |
|---|---|--------------|----------|------|--------------|--------------|
| 1 | | The matrix A | | | The matrix B | restrictions |
| 2 | | 2 | 5 | 4 | 1 | 1 |
| 3 | | 3 | 2 | -1 | 8 | 8 |
| 4 | | 4 | -1 | -2 | -3 | -3 |
| 5 | X | -1,86364 | 4,545455 | -4,5 | | |

Fig. 11. The result of the system's solving.

After, the SLE is solved using MathCAD system of computer Mathematics by the matrix method (Fig. 12).

Create the matrix A:

$$A := \begin{pmatrix} 2 & 5 & 4 \\ 3 & 2 & -1 \\ 4 & -1 & -2 \end{pmatrix}$$

Create the matrix B:

$$B := \begin{pmatrix} 1 \\ 8 \\ -3 \end{pmatrix}$$

Find the inverse matrix:

$$A^{-1} = \begin{pmatrix} 0.114 & -0.136 & 0.295 \\ -0.045 & 0.455 & -0.318 \\ 0.25 & -0.5 & 0.25 \end{pmatrix}$$

We find the solution of the formula $X=A^{-1}B$:

$$X := A^{-1} \cdot B = \begin{pmatrix} -1.864 \\ 4.545 \\ -4.5 \end{pmatrix}$$

Inspection:

$$A \cdot X = \begin{pmatrix} 1 \\ 8 \\ -3 \end{pmatrix}$$

Fig. 12. Finding the solution using MathCAD system.

At the current stage, regardless the topic of a practical class, discussion of alternative methods of performing calculations takes place.

The perspectives for further research lie in experimental validation of the efficiency of the method offered.

Practical lesson ends up with giving home assignment, which is individual for every student. Based on the result of home assignment, students are asked to prepare a report and make conclusions regarding the choice of the best possible way of coping with the task set.

The specific feature of the method offered is combination of traditional and innovational teaching means and techniques. Since SCM implementation simplifies computational process, it might prevent from students' understanding the procedure of solution and interpreting the results obtained. So we are convinced that using ICT for performing engineering designs is possible to be offered for students only after they have learnt the algorithm of solving the equation in a traditional way.

Thus, we first of all offer to consider SCM as the way to check the results obtained. However, after students' gaining corresponding skills, while performing design and graphic works, course and diploma projects, it is worth encouraging them to computerize computational process.

Besides, we are sure that it is necessary to offer the students several alternative methods of problem solving by means of ICT. Indeed, in different cases depending on the task set it is appropriate to use different computing facilities. Therefore, engineer-to-be must have an idea of possibilities of a wide range of ICT means for solving professional problems.

The conclusions.

- One of the tasks of the higher education is to form mathematical competence of engineers-to-be, to provide them with necessary knowledge and skills of using modern information technologies in order to solve profession-oriented tasks.
- From our point of view, students' awareness of a wide range of computation software programs promotes choosing the most efficient ones among alternative ways of engineering designs.
- The technique of instructing students to make engineering designs using information technologies on example of the subject "Numerical methods" was offered.
- The specific feature of this technique is combination of traditional and innovative educational methods and techniques.
- Such approach widens students' design and scientific abilities, contributes to forming their scientific outlook, opens prospects for creative implementation of gained knowledge and skills.

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ПІДГОТОВКА СТУДЕНТІВ ВИЩИХ НАВЧАЛЬНИХ ЗАКЛАДІВ ДО ВИКОНАННЯ ІНЖЕНЕРНИХ РОЗРАХУНКІВ

У статті виконано огляд науково-методичної і спеціальної літератури з питань підвищення рівня математичної освіти студентів інженерних спеціальностей. У ході дослідження нами було вивчено досвід застосування інформаційних технологій, зокрема систем комп'ютерної математики, які використовуються в процесі підготовки студентів вищих навчальних закладів. Унаслідок систематизації даних літератури було доведено доцільність формування математичної компетентності майбутніх інженерів засобами інформаційних технологій. На підставі результатів дослідження було запропоновано методику навчання студентів виконувати інженерні розрахунки з використанням інформаційних технологій на прикладі дисципліни «Числові методи». Особливістю даної методики являється поєднання традиційних і інноваційних методів та засобів навчання. Ми розглядали реалізацію запропонованої методики на прикладі практичних занять за темами "Розв'язання нелінійного рівняння" і "Розв'язання системи лінійних рівнянь методом Гауса з вибором головного елемента". В першу чергу ми пропонуємо розглядати системи комп'ютерної математики як спосіб перевірити отримані результати, але після набуття студентами відповідних знань, навичок і вмінь, ми рекомендуємо заохочувати їх до автоматизації процесу розрахунків у ході виконання розрахунково-графічних, курсових або дипломних робіт. Ми переконані, що наявність у студентів відомостей про широке коло комп'ютерних програм обчислювального призначення дає можливість вибору найбільш ефективних з-поміж альтернативних засобів інженерних розрахунків.

Ключові слова: комплекс, навчання, засоби, практика, оцінки, впливу, ефективність.

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ПОДГОТОВКА СТУДЕНТОВ ВУЗОВ К ВЫПОЛНЕНИЮ ИНЖЕНЕРНЫХ РАСЧЕТОВ

В статье выполнен обзор научно-методической и специальной литературы по вопросам повышения уровня математического образования студентов инженерных специальностей. В ходе исследования нами был изучен опыт применения информационных технологий, в частности систем компьютерной математики, которые используются в процессе подготовки студентов высших учебных заведений. Вследствие систематизации данных литературы была доказана целесообразность формирования математической компетентности будущих инженеров средствами информационных технологий. На основании результатов исследования было предложено методику обучения студентов выполнять инженерные расчеты с использованием информационных технологий на примере дисциплины «Численные методы». Особенностью данной методики является сочетание традиционных и инновационных методов и средств обучения. Мы рассматривали реализацию предлагаемой методики на примере практических занятий по темам "Решение нелинейного уравнения" и "Решение системы линейных уравнений методом Гаусса с выбором главного элемента". В первую очередь мы предлагаем рассматривать системы компьютерной математики как способ проверить полученные результаты, но после приобретения студентами соответствующих знаний, навыков и

умений, мы рекомендуем поощрять их к автоматизации процесса расчетов в ходе выполнения расчетно-графических, курсовых или дипломных работ. Мы убеждены, что наличие у студентов сведений о широком круге компьютерных программ вычислительного назначения дает возможность выбора наиболее эффективных из числа альтернативных средств инженерных расчетов.

Ключевые слова: комплекс, обучение, средства, практика, оценки, влияние, эффективность.