БЕЛОРУССКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ /
BELARUSIAN STATE UNIVERSITY

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CAE-ПРОГРАММНЫЕ СИСТЕМЫ В ИНЖЕНЕРНОМ ДЕЛЕ/ CAE SOFTWARE SYSTEMS IN ENGINEERING

Учебная программа учреждения образования по учебной дисциплине для специальности:
The program of the educational institution of the discipline for the speciality:

Специальность / Speciality:

7-06-0533-06 Mechanics and Mathematical Modelling / 7-06-0533-06 Механика и математическое моделирование

Профилизация / Profilization:

Theoretical and Applied Mechanics / Теоретическая и прикладная механика

2024 г.

Учебная программа составлена на основе ОСВО 7-06-0533-06-2023; и учебного плана № М54а-5.4-114/уч. от 11.04.2023.

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РЕКОМЕНДОВАНА К УТВЕРЖДЕНИЮ:

Кафедрой теоретической и прикладной механики БГУ
(протокол № 12 от 28.05.2024)

Научно-методическим советом БГУ
(протокол № 9 от 28.06.2024)

Заведующий кафедрой _____ М.А. Журавков

ПОЯСНИТЕЛЬНАЯ ЗАПИСКА

Цели и задачи учебной дисциплины

Цель учебной дисциплины – создание базы для освоения основных идей и методов современной механики и математики, подготовка высококвалифицированных специалистов, способных ставить и решать задачи из различных областей науки и техники. Формирование установки на творческую профессиональную деятельность; развитие профессионального мышления, которое обеспечило бы будущему специалисту возможность свободно оперировать профессиональными знаниями, видеть проблемы и оптимальные пути их решения в самостоятельной практической деятельности.

Задачи учебной дисциплины:

– ознакомление магистрантов с основными методами численного решения задач инженерных задач механики деформируемого твердого тела;

– формирование навыков решения прикладных инженерных задач с использование математических моделей механики сплошной среды и современных систем численного моделирования;

– применение полученных знаний для анализа напряженно-деформированного состояния тел, полученного путем численного решения прикладных инженерных задач.

Место учебной дисциплины в системе подготовки специалиста с углубленным высшим образованием (магистра).

Дисциплина «CAE software systems in engineering» посвящена изучению подходов к применению современных систем численного моделирования напряженно-деформированного состояния механических систем для решения прикладных задач механики деформируемого твердого тела.

Учебная дисциплина относится к модулю «Computational modelling of Physical processes» компонента учреждения образования

Учебная программа составлена с учетом межпредметных связей и программ по дисциплинам: «Partial differential equations, «Continuum mechanics» и «Analytical methods in structural engineering».

Требования к компетенциям

Освоение учебной дисциплины «CAE software systems in engineering» должно обеспечить формирование следующей **специализированной компетенции:**

Use typical software modules for the analysis of the generated analytical models of the problems posed, methods of mathematical and algorithmic modeling in solving problems of mechanics.

знать:

– основные типы численных анализов;

– особенности построения численных схем решения прикладных задач механики деформируемого твердого тела;

уметь:

– строить геометрию рассматриваемых систем, задавать физико-механические свойства ее элементов, определять граничные условия;

– составлять численные схемы и алгоритмы решения задач механики деформируемого твердого;

– проводить анализ полученных результатов решения поставленных граничных задач;

иметь навык:

– подходов к численному решению задач механики деформируемого твердого тела.

Структура учебной дисциплины

Дисциплина изучается в 3 семестре. Всего на изучение учебной дисциплины «CAE software systems in engineering» отведено:

– в очной форме получения углубленного высшего образования: 90 часов, в том числе 54 аудиторных часа, из них: лекции (в том числе дистанционно) – 18 часов, лабораторные (в том числе дистанционно) – 36 часов.

Трудоемкость учебной дисциплины составляет 3 зачетные единицы.

Форма промежуточной аттестации – зачет.

EXPLANATORY NOTE

Aim and tasks of the discipline

The aim of the discipline is to create a basis for mastering the basic ideas and methods of modern mechanics and mathematics, training of highly qualified specialists capable of setting and solving problems from various fields of science and technology. Formation of the attitude to creative professional activity; development of professional thinking, which would provide the future specialist with the ability to operate freely with professional knowledge, to see problems and optimal ways of their solution in independent practical activity.

Tasks of the discipline:

- familiarization of master students with the basic methods of engineering problems of deformable solid mechanics numerical solution;
- skills of solving applied engineering problems using mathematical models of continuum mechanics and modern systems of numerical modeling formation;
- application of the obtained knowledge to analyze the stress-strain state of bodies obtained by numerical solution of applied engineering problems.

Place of the academic discipline in the system of training a specialist with higher education.

The discipline "CAE software systems in engineering" is devoted to the study of approaches to the use of modern systems of stress-strain state of mechanical systems numerical modeling to solve applied problems of deformable solid mechanics.

The study discipline belongs to the module "Computational modeling of physical processes" of the educational institution component

The program is made taking into account the interdisciplinary links and programs for the disciplines: "Partial differential equations, "Continuum mechanics" and "Analytical methods in structural engineering".

Requirements for competences

Mastering the academic discipline "CAE software systems in engineering" should ensure the formation of the following specialized competence:

Use typical software modules for the analysis of the generated analytical models of the problems posed, methods of mathematical and algorithmic modeling in solving problems of mechanics.

know:

- main types of numerical analyses;
- peculiarities of construction of numerical schemes for solving applied problems of deformable solid mechanics;

be able to:

- build the geometry of considered systems, set physical and mechanical properties of its elements, determine boundary conditions;
- compose numerical schemes and algorithms for solving problems of deformable solid mechanics;
- analyze the obtained results of solving the set boundary problems;

have skills in:

- approaches to numerical solution of problems of deformable solid mechanics.

Structure of the academic discipline

The discipline is studied in the 3 semester. In total for the study of the discipline "CAE software systems in engineering" is allocated:

– for full-time higher education – 90 hours, including 54 classroom hours, of which: lectures (including remotely) - 18 hours, laboratory (including remotely) - 36 hours.

The labor intensity of the discipline is 3 credit units.

Form of interim certification on the discipline - end-of-term test.

CONTENT OF THE STUDY MATERIAL

Theme 1. General concepts and definitions. Purpose, essence and content of CAE-technologies in relation to the tasks of modern mechanics.

Definition of CAE technologies. Application of CAE systems for stress-strain state of engineering systems analysis. Overview of modern CAE systems.

Theme 2. Application of CAE-systems to analyze the stress-strain state, perform strength calculations of engineering products and structures.

Architecture of CAE systems. Basic principles of CAE systems. Calculation part of CAE packages, basic numerical methods of engineering calculations. Algorithms for performing calculations on the basis of CAE software, content of the main calculation stages. Types of applied problems of modern mechanics solved on the basis of CAE software. Examples from various branches of modern mechanics.

Theme 3: Algorithm of applied deformable solid mechanics problems numerical solution

Creating a geometric model. Specifying physical and mechanical properties of materials. Creation and optimization of finite element mesh. Setting of boundary conditions. Solver settings. Analyzing the results of the problem solution.

Theme 4. Different types of numerical analyses using the finite element method overview

Static structural and transient structural numerical analysis. Analysis of natural and forced vibrations. Fatigue analysis. Rigid dynamics analysis.

Theme 5. Solving classical problems of deformable solid mechanics using CAE systems

Beam, bars and rods calculations. Analysis of structures under different types of loading stress-strain state. Theory of elasticity and plasticity problems solution. Solving problems with temperature effects. Solution of some contact problems.

Theme 6. Some problems of geomechanics using modern CAE systems solution

Assessment of rock massif in the vicinity of a single excavation stress-strain state. Determination of continuity disturbance zones in the rock massif during large-scale mining operations.*Filling Example*

TEACHING AND METHODOLOGICAL MAP OF THE DISCIPLINE

Full-time form of higher education with the use of distance learning technologies (DLT)

Title of section, topic	Title of section, topic	In-class hours					Independent work	Form of control
		Lectures	Practical classes	Seminar classes	Laboratory classes	Other		
1	2	3	4	5	6	7	8	9
1	General concepts and definitions. Purpose, essence and content of CAE-technologies in relation to the tasks of modern mechanics	3						Oral questioning
2	Application of CAE-systems to analyze the stress-strain state, perform strength calculations of engineering products and structures	3						Oral questioning
3	Algorithm of applied deformable solid mechanics problems numerical solution	3			6			Self-check questions, oral questioning, problem solving, laboratory work report
4	Different types of numerical analyses using the finite element method overview	3			10			Self-check questions, oral questioning, problem solving, laboratory work report
5	Solving classical problems of deformable solid mechanics using CAE systems	3			10			Self-check questions, oral questioning, problem solving, laboratory work report
6	Some problems of geomechanics using modern CAE systems solution	3			10			Self-check questions, oral questioning, problem solving, laboratory work report

INFORMATION AND METHODOLOGICAL PART

List of basic literature

1. Zohdi T. A finite element primer for beginners. The basics, 2nd ed. – Springer, 2018. – 135 p.
2. Meirovitch L. Computational methods in structural dynamics. – Sijthoff and Noordhoff, 1980. – 439 p.
3. Ghaboussi J., Wu X.S. Numerical methods in computational mechanics. – CRC Press, 2017. – 313 p.
4. Moaveni S. Finite Element Analysis. Theory and application with ANSYS. – Prentice Hall, NJ,1999 – 929 p.
5. Chang K.-H. Product Design Modeling using CAD/CAE, Academic Press, 2014. – 438 p.

List of additional literature

6. Welcome to ANSYS, Inc. – Corporate Homepage. http://www.ansys.com.
7. ANSYS, Inc. Products. http://www.ansys.com/products/default.asp.
8. FEA.RU|CompMechLab – О системе Unigraphics. http://www.fea.ru/education/cad/unigraphics/.
9. FEA.RU|CompMechLab – О системе CATIA. http://www.fea.ru/education/cad/catia/.

List of recommended diagnostic tools and methodology for final mark formation

The object of diagnostics of students' competences is the knowledge and skills acquired as a result of studying the academic discipline. Identification of students' learning achievements is carried out by means of current and interim certification.

The following means of current certification can be used to diagnose competences: Self-check questions, oral questioning, problem solving, laboratory work report

The form of interim certification in the discipline "CAE software systems in engineering" in accordance with the curriculum end-of-term test.

Approximate list of laboratory classes

Theme 1. Algorithm of applied deformable solid mechanics problems numerical solution. (6p.)

(From of control – laboratory work report).

Theme 2. Different types of numerical analyses using the finite element method overview (10p.)

(From of control – laboratory work report).

Theme 3. Solving classical problems of deformable solid mechanics using CAE systems (10p.)

(From of control – laboratory work report).

Theme 4. Some problems of geomechanics using modern CAE systems solution (10p.)

(From of control – laboratory work report).

Description of innovative approaches and methods for teaching the discipline

When organizing the educational process, a practice-based approach is used, which entails the following:

- mastering the educational content through solving practical tasks;
- acquiring skills for effective performance in various types of professional activities;
- orientation towards idea generation, implementation of students' group projects, development of business culture;
- use of evaluation procedures, assessment methods, indicating the formation of professional competences.

Methodological recommendations for the organization of independent work

1. Self-work while working through the literature.

Review the lecture notes immediately after class. Mark the material in the lecture notes that is difficult to understand.

Try to find answers to difficult questions using the literature.

If you are unable to understand the material on your own, formulate questions and ask the instructor for help at the next lecture.

Every week it is recommended to set aside time to repeat the material, testing your knowledge, skills and abilities by control questions.

2. Independent work on making an outline.

1. Collect literature on the topic. Study the source where it is presented in the most complete and up-to-date manner.

2. Based on this source, make a detailed outline, indicating the pages of the book that relate to a particular point of the outline.

3. Study other sources. If they contain material on the already existing point of the plan, write down in the plan and the new source, indicating the pages. If the material in the other source reveals the topic from a different perspective, add another paragraph to the outline.

4. Having analyzed all the literature collected on the topic, you will have a final plan, on which you can write a synopsis, combining the material from different sources.

5. Edit your outline, read it carefully and think: - whether you are satisfied with its general plan; - whether the semantic, logical connection between the individual elements of the content is well perceived; - whether the quotations are successfully used, whether the connection between turns of speech and phrases is correctly established; - whether the punctuation marks in the quotations are correctly placed.

3. Preparation for laboratory classes

The purpose of laboratory classes is to deepen and elaborate the theoretical material of the subject by means of regular and systematic self-activity of students throughout the course. Directly conducting a laboratory class involves: solving problems and exercises according to the sample; analyzing the results; systematizing the material and preparing a report on the work done.

Instructions:

Study normative documents, mandatory and additional literature on the issue under consideration.

Read the lecture notes on the topic.

Carefully study the order of individual practical work or the algorithm presented by the teacher.

4. Preparing for the credit

Carefully read the material on the outline made at the lessons.

Read the same material in the textbook, study guide.

Try to understand the unclear, in particular new terms. Often ignorance of terminology prevents students from perceiving the material in the classroom at the proper level.

Answer the self-check questions in the textbook.

Briefly retell the content of the studied material “in your own words”.

Memorize “working definitions” of basic concepts and laws.

Having mastered the theoretical material, proceed to the performance of tasks, exercises, solving problems, calculations on individual tasks, etc.

Approximate list of questions for end-of-term test

1. Finite element method.
2. Algorithm for numerical solution of mechanics problems.
3. Modern program complexes designed to solve applied problems of mechanics.
4. Structural numerical analysis conduction.
5. Numerical solution of dynamic problems.
6. Numerical solution of contact problems.
7. Analyzing the stability of structures.
8. Numerical solution of mechanics nonlinear problems.

9. Numerical solution of applied problems of geomechanics.

10. Application of systems state estimation complex criteria in the analysis of numerical simulation results.

ПРОТОКОЛ СОГЛАСОВАНИЯ УЧЕБНОЙ ПРОГРАММЫ УО

Название учебной дисциплины, с которой требуется согласование	Название кафедры	Предложения об изменениях в содержании учебной программы учреждения высшего образования по учебной дисциплине	Решение, принятое кафедрой, разработавшей учебную программу (с указанием даты и номера протокола)
Учебная дисциплина не требует согласования			

Заведующий кафедрой
д. физ-мат.наук, профессор _____ М.А. Журавков

28. 05 2024 г.

ДОПОЛНЕНИЯ И ИЗМЕНЕНИЯ К УЧЕБНОЙ ПРОГРАММЕ ПО ИЗУЧАЕМОЙ УЧЕБНОЙ ДИСЦИПЛИНЕ

на _____/_____ учебный год

№ п/п	Дополнения и изменения	Основание

Учебная программа пересмотрена и одобрена на заседании кафедры
_____ (протокол № ____ от _____ 202_ г.)

Заведующий кафедрой
_____ _____

УТВЕРЖДАЮ
Декан факультета
_____ _____