MINISTRY OF EDUCATION AND SCIENCE
REPUBLIC OF KAZAKHSTAN

SATBAYEV UNIVERSITY

APPROVED BY

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Information Technology
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SILLABUS

GEN1603 « Finite element method in engineering»

3 (1/1/1) Credits

Semester: Autumn, 2019-2020 Academic year

For specialty 5B071200- Mechanical engineering

Almaty, 2019

Силлабус
Сатпаев Университет

Satpayev University
Institute of Cybernetics and Information Technology
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1. **Information about teachers:**

Lecturer
Naurushev B.K.
Office hours: Fr 11:05 – 11:55, room 905 MEB
Email: batyr_n@mail.ru

Teacher (practical lessons)
Naurushev B.K.
Office hours: Fr 12:10 – 13:00 room 905 MEB
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Teacher (laboratory lessons)
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2. **Course Objective:** teaching the future engineer the basics of applying the finite element method (FEM) in engineering when designing engineering products, structures, mechanisms, machines, preparing him for the right choice of calculation and design methods, getting acquainted with the latest achievements of science and technology in the field of computer-aided design and engineering (CAD,CAE), mechanics of a continuous deformable body, in the development of students' logical thinking, communicative skills, self-thinking skills, teamwork skills necessary in further work in solving certain problems of science and technology..

3. **Course Description:** Designing machine parts, mechanisms, structural elements and assemblies used in engineering practice both analytically and numerically using the finite element method (FEM) .

4. **Prerequisites:**
- ✓ Mathematics
- ✓ Theoretical mechanics
- ✓ Strength of materials

5. **Post-requisitioning:**
- ✓ Diploma work

6. **References:**

Basic Literature	Additional literature
[1] Singiresu S. Rao, The Finite Element Method in Engineering, 6th Edition, Butterworth-Heinemann press, 782 p., 2018	[4] Шелофаст В.В. Основы проектирования машин. – М.: издат-во АПМ., 2015 – 472 с.
[2] Замрий А.А. Проектирование и расчет методом конечных элементов трехмерных конструкций в среде APM Structure 3D. – М.: Издательство АПМ. 2015. – 288 с.	[5] Кунву Ли. Основы САПР (CAD/CAM/CAE). – СПб.: Питер, 2014. – 560 с.
[3] P. Solin, K. Segeth, I. Dolezel: Higher-Order Finite Element Methods, Chapman & Hall/CRC Press, 2003	[6] Шелофаст В.В., Чугунова Т.Б. Основы проектирования машин. Примеры решения задач. – М.: издат-во АПМ., 2015 – 240 с.

7. **Calendar - thematic plan:**

week	Theme of the lecture	Theme of practical work	Theme of laboratory work	Reference to literature	The task	Deadline
1	Introduction The main idea of the finite element method.	Creating a design model of the bar structure.	Static calculation of the rods model of the structure and analysis of the results.	[1] Chapter 1, pp. 11-35		
2	General concepts of computer aided design. General scheme of the FEM algorithm.	Additional functionality of the program module for creating rod models of structures.	Creation and calculation of the rod-plate model of the structure.	[1] Chapter 2, pp. 36-53	Design of the rod structure (truss).	4th week
3	Compilation of the stiffness matrix of a single finite element.	Preparation of the rods model of the structure for calculation. Setting material parameters. Defining cross sections. Assignment of supports. Assignment of external loads acting on model elements.	The action of loads on the nodes of the design model. Special cases of applying loads to the rod members. The action of loads on plate elements.	[1] Chapter 2, pp. 54-67		
4	Formation of the global stiffness matrix of the entire area and the nodal force vector.	The modes of splitting plates. Setting plate parameters and their loading.	Calculation of machine elements on for bending.	[1] Chapter 2, pp. 68-77	Design of the construction of bus stop.	6th week
5	Solution of the system stiffness matrix - a system of linear algebraic equations for nodal displacements.	Visualization of the results of the calculation of the rod-plate model of the structure.	Calculation of machine elements on for displacement.	[1] Chapter 2, pp. 92-102		
6	Calculation of the desired strains and stresses in the element	Introduction to the design model of concentrated masses and moments of inertia. An eccentric connection of the rod elements of	Cross-sectional selection of structural elements. Pressure on volumetric elements of the model. The effect of loads on the entire model as a whole.	[1], Chapter 2, pp. 111-136	The calculation of the span of the bridge structure.	8th week

		the design model. The task of elastic ties. Assignment of joint movement of structural model elements.				
7	Advantages and disadvantages of the finite element method.	Creation and calculation of models of structures containing plate and volume finite elements.	Dynamic load modeling. Checking the bearing capacity of the core elements of the structural model and the selection of cross sections.	[1] Chapter 2, pages 137-151	Control work	7th week
8	Advantages and disadvantages of the finite element method.	Creation and calculation of models of structures containing plate and volume finite elements.	Dynamic load modeling. Checking the bearing capacity of the core elements of the structural model and the selection of cross sections.	[1] Chapter 2, pages 137-151		8th week
	Midterm					
9	Discretization of the area. Types (types) of finite elements. One-dimensional elements.	Using a 3D preprocessor to create, load and generate a finite element mesh of three-dimensional models.	The solution of plane problems of the theory of elasticity using the finite element method.	[1] Chapter 4, pp. 204-239	Calculation of metal hangar.	10th week
10	Types of the finite element. Two-dimensional elements. Three-dimensional elements.	Shell models. Creation and calculation of models of structures containing volumetric finite elements.	Stiffness matrix of a triangular finite element	[1] Chapter 4, pp. 256-275		
11	Division of the area into elements. Node Numbering.	Three-dimensional editor for creating, importing and splitting models into finite elements.	Stiffness matrix for a triangular finite element.	[1] Chapter 6, pp. 282-317	Calculation of the stress-strain state of the coil model, using shells when creating.	12th week
12	Calculation of core systems according to the FEM.	Calculation of the structural model for stability.	Nonlinear calculation. Calculation of natural frequencies and natural forms. Calculation of	[1], Chapter 7.8,	Calculation of the stress-	14th week

	The stiffness matrix of an individual bar in the local coordinate system associated with the bar. Table of reactions of an individual rod.	Deformation calculation.	forced vibrations of a design model.	pp. 320-400	strain state of the wrench, when creating a model to use arrays of bodies.	
13	Stiffness matrix of the rod in the general coordinate system.	Create or import a volume model. Fixing a solid-state model and setting the loads acting on it. Generation of finite element mesh.	Thermal calculation and solution of the problem of thermoelasticity.	[1], Chapter 10, pp.401-407		
14	Compilation of a stiffness matrix for the entire structure.	Example calculation software rod system on a computer.	Source data preparation. Determination of internal forces in each individual rod based on the known movements of the units of the structure.	[1], Chapter 10, pp. 408-415	Control work	14th week
15	Compilation of a stiffness matrix for the entire structure.	Example calculation software rod system on a computer.	Source data preparation. Determination of internal forces in each individual rod based on the known movements of the units of the structure.	[1], Chapter 10, pp. 408-415		15th week
	End Term					
	Exam					

** The calendar - a thematic calendar is subject to change based on holidays*

Schedule of delivery of required work

№ п/п	Types of control	Max point of the week	Weeks														Total max points
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1	Activity in lecture discussions	0,1		*	*	*	*	*	*		*	*	*	*	*	*		1,2
2	Activity in practical classes	0,23		*	*	*	*	*	*		*	*	*	*	*	*		2,8
3	Laboratory works	0,5				*				*				*			*	2
3	Test papers	2							*							*		4
4	IWS	5				*		*		*		*		*		*		30

5	Midterm	10,0								*							10
6	Endterm	10,0														*	10
	Exam	40															40
	Total amount																100

8. <u>Tasks and brief guidelines for their implementation:</u>

✓ **Independent work of the student (IWS):**

Semester task 1. Designing the structure of the rods (trusses).
Semester task 2. Design of the construction of bus stop..
Semester task 3. The calculation of the span of the bridge structure.
Semester task 4. Calculation of metal hangar.
Semester task 5. Calculation of the stress-strain state of the coil model, when using shells.
Semester task 6. Calculation of the stress-strain state of the wrench, when creating a model to use arrays of bodies.

✓ **Work with the teacher (WWT):**

Test work 1. Theme: Selection of the cross-section of structural elements operating in bending.
Test work 2. Theme: Calculation of a composite beam in a local coordinate system.

✓ **Practical work:**

Practical lesson №1 Creating a design model of the bar structure.
Practical lesson №2 Additional functionality of the program module for creating rod models of structures..
Practical lesson №3 Preparation of the rods model of the structure for calculation. Setting material parameters. Defining cross sections. Assignment of supports. Assignment of external loads acting on model elements..
Practical lesson №4 The modes of splitting plates. Setting plate parameters and their loading.
Practical lesson №5 Visualization of the results of the calculation of the rod-plate model of the structure.
Practical lesson №6 Introduction to the design model of concentrated masses and moments of inertia. An eccentric connection of the rod elements of the design model. The task of elastic ties. Assignment of joint movement of structural model elements..
Practical lesson №7 Creation and calculation of models of structures containing plate and volume finite elements.
Practical lesson №8 Creation and calculation of models of structures containing plate and volume finite elements.
Practical lesson №9 Using a 3D preprocessor to create, load and generate a finite element mesh of three-dimensional models..
Practical lesson №10 Shell models. Creation and calculation of models of structures containing volumetric finite elements..
Practical lesson №11 Three-dimensional editor for creating, importing and splitting models into finite elements..
Practical lesson №12 Calculation of the structural model for stability. Deformation calculation..
Practical lesson №13 Create or import a volume model. Fixing a solid-state model and setting the loads acting on it. Generation of finite element mesh.
Practical lesson №14 Calculation software rod system on a computer.
Practical lesson №15 Example calculation software rod system on a computer.

✓ **Laboratory work:**

Laboratory work №1 Static calculation of the rods model of the structure and analysis of the results..
Laboratory work №2 Creation and calculation of the rod-plate model of the structure..

Laboratory work №3 The action of loads on the nodes of the design model. Special cases of applying loads to the rod members. The action of loads on plate elements..
Laboratory work №4 Calculation of machine elements on for bending.
Laboratory work №5 Calculation of machine elements on for displacement..
Laboratory work №6 Cross-sectional selection of structural elements.
Pressure on volumetric elements of the model. The effect of loads on the entire model as a whole..
Laboratory work №7 Dynamic load modeling. Checking the bearing capacity of the core elements of the structural model and the selection of cross sections.
Laboratory work №8 Checking the bearing capacity of the core elements of the structural model and the selection of cross sections.
Laboratory work №9 The solution of plane problems of the theory of elasticity using the finite element method.
Laboratory work №10 Stiffness matrix of a triangular finite element.
Laboratory work №11 Stiffness matrix for a triangular finite element.
Laboratory work №12 Nonlinear calculation. Calculation of natural frequencies and natural forms. Calculation of forced vibrations of a design model.
Laboratory work №13 Thermal calculation and solution of the problem of thermoelasticity.
Laboratory work №14 Source data preparation. Determination of internal forces in each individual rod based on the known movements of the units of the structure.
Laboratory work №15 Determination of internal forces in each individual rod based on the known movements of the units of the structure.

✓ Midterm**:**

They represent an independent solution of tasks on the topics covered under the guidance of the teacher. Tasks will be presented during office hours. They are compulsory for all students, like the current independent work. When performing tests, you must use the knowledge obtained from textbooks and exercises.

✓ **Exam:**

The exam covers and summarizes the entire course material. The exam is conducted in writing and covers various types of assignments: theory questions, covering the lecture material covered, practical solution of specific problems. The duration of the exam is 2 academic hours.

9. Criteria for evaluation of works:

Evaluation by letter system	Digital equivalent of evaluation	Criterions
A	**95 – 100**	Correctness and completeness of answers and solving problems, accuracy and accuracy of presentation, calculation and timely delivery, presentability and communicative protection.
A -	**90 – 94**	Correctness and completeness of answers and problem solving. Timely delivery, presentable and communicative on protection.
B +	**85 – 89**	Correctness and completeness of answers and problem solving. Timely delivery, presentable and communicative on protection. But inaccurate in the design of work.
B	**80 – 84**	Correctness and completeness of answers and problem solving. Timely delivery, presentable and communicative on protection. But minor errors in mathematical calculations are allowed.
B -	**75 – 79**	Correctness and completeness of answers and problem solving.
C +	**70 – 74**	The work was completed in full. There are gaps in the theoretical material.
C	**65 – 69**	The work was completed in full. There are errors in the

		calculations, gaps in the theoretical material.
C -	**60 – 64**	The work was completed in full. There are errors in the calculations, gaps in the theoretical material. Ignorance of the methodology of the work. The answer is not given.
D +	**55 – 59**	The work was done in incomplete volume. Some correct necessary formulas or theoretical calculations or laws are given. A partial solution is given.
D	**50 – 54**	The work was done in incomplete volume. Some correct necessary formulas or theoretical calculations or laws are given. There is no complete solution.
F	**0 – 49**	Not done. Absence without good reason.

** It is possible to receive bonus points for additional tasks*

10. Policy for late performance of works:

It requires timely and full implementation of all types of work. Tasks must be performed in writing and handed over as soon as the deadline is reached. Timeliness of performance and delivery of works will be taken into account. The reduction of the maximum score by 10% is envisaged for inactivated work. If you do not keep within the calendar deadlines for the delivery of work for valid reasons, you must notify the teacher in advance of the deadline for the submission of work.

11. Attendance Policy:

Visiting lecture, laboratory and practical classes is mandatory and is one of the components of your final score / evaluation. Skipping classes can affect your academic performance and final grade. Each two delays and / or departures before the end of the lesson for any reason will be considered as one *missed classes*. However, attending classes in itself does not mean an increase in scores. You need your constant active participation in the class. An obligatory requirement of the course is preparation for each lesson. It is necessary to review the indicated sections of the textbook and additional material not only in preparation for practical classes, but also before attending a relevant lecture. Such training will facilitate the perception of new material by you and will help your active acquisition of knowledge within the university. Students who missed 20% of classes are not allowed to take exams and receive a final rating of "F".

12. Assessment of knowledge:

7.11.1 Grade "F" is given to the student:

- in case of missing more than 20% of the total number of classroom activities in the discipline, with the exception of cases provided for in clause 7.11.3;
- if the student scored less than 25 points during the semester (0-24 points);
- in the event of the fact of non-independent performance of the final control (exam), including the use of prohibited means and other violations by the student of the Rules of conduct in the exam;
- in the event that the assessment of the final control (exam) is less than 10 points;
- in case of failure to appear for the exam without a good reason.
- if the student was unable to confirm the total threshold level of 50 or more points during the retake of the exam of FX assessment

7.11.2. The grade “FX” is given to the student if the student scored a total of at least 25 points during the semester, but could not confirm the total threshold level of 50 or more points in the exam.

7.11.3. The examiner has the right to admit to the exam a student who has more than 20%, but less than 30% of admissions in case of his positive certification and active work in the academic period, for which he must send a notice to the PR agreed with the department and the institute in the prescribed manner.

7.11.4 When the fact of non-independent performance of the final control or the presence of a student’s cheat sheet, as well as in other cases, when a student violates the Rules of conduct in the exam (cheating, using electronic means of communication, etc.), the student is removed from the exam. At the same time, the student is given the final grade “F” in discipline, regardless of the number of points scored by him during the semester

13. Policy of academic behavior and ethics:

Be tolerant, respect someone else's opinion. Objections formulate in the correct form. Plagiarism and other forms of dishonest work are unacceptable. It is unacceptable to hint and cheat during the exams, passing the exam for another student. A student who is found to falsify any course information will receive a final rating of "F".

Considered at a meeting of the department Applied Mechanics and Engineering Graphics, protocol №1, August 12, 2019

Compiled by: Lector Naurushev B.