Ministry of Science and Higher Education of the Russian Federation

Federal State Budgetary Educational Institution of Higher Education
Perm National Research Polytechnic University

APPROVED BY
Pro-rector for Academic Affairs
_____ N.V. Lobov
25 03 2021.

ACADEMIC COURSE WORKING PROGRAM

Academic course: Theoretical mechanics
(Name)

Form of education: Full-time
(Full-time /full-time – correspondence/correspondence)

Level of higher education: Bachelor's degree
(Bachelor's program/specialist program/
Master's program)

Workload in hours (in credits): 180 (5)
(Hours (CU))

Training program (degree): 21.03.01 Oil and Gas Engineering
(Code and denomination of degree)

Direction: Oil and Gas Engineering
(Title of curriculum)

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1. GENERAL PROVISIONS

1.1. GOALS AND OBJECTIVES OF THE COURSE

The theoretical mechanics studies the mechanical motion, defined as the change of the relative position of a body or a part thereof about another body considered as a reference or in relation with a reference system. Also theoretical mechanics studies the loads and equilibrium conditions for a statically determined and stable rigid body.

The theoretical mechanics may be divided into other three parts: statics, kinematics and dynamics. Statics is that part of theoretical mechanics which studies the transformation of the systems of forces in other simpler systems and of the conditions of equilibrium of the bodies.

Kinematics is the part of the theoretical mechanics that deals with the motions of the bodies without to consider their masses and the forces that act about them, so kinematics studies the motion from a geometrical point of view, namely the pure motion.

Dynamics is the part of theoretical mechanics which deals with the study of the motion of the bodies considering the masses of them and the forces that act about them. In all these definitions the bodies are considered rigid bodies that are not the deformable bodies.

1.2. STUDIED OBJECTS OF THE COURSE

Particle (material point), systems of material points, rigid body.

1.3. STARTING CONDITIONS

Higher Mathematics, Physics

2. PLANNED RESULTS OF THE COURSE TRAINING

Compe-tence	**Indicator's Index**	**Planned Results of the Course Training (to know, be able to, to master)**	**Indicator of Attaining Competence which the planned results of training are correlated with**	**Means of Assessment**
1	**2**	**3**	**4**	**5**
GPC-1.	**IA-1$_{gpc-1.}$**	**To know** principle features of modelling mathematical, physical and chemical processes assigned for definite technological processes.	**Knows** the basic concepts, axioms and theorems of mechanics; methods of finding reactions in the equilibrium system of rigid bodies; the kinematic characteristics of the motion of the particle and the rigid body; the differential equations of motion of the particle and the rigid body relative to the inertial and non-inertial coordinate system.	Test

1	2	3	4	5
	IA-2$_{gpc-1.}$	**To be able to** use general laws of the disciplines of mechanical-engineering module; to use general laws of natural-scientific disciplines, the rules of technical drafting and plotting.	**Is able** to make and solve the equilibrium conditions for statically determined and stable rigid body under influence of some force system; to determine the speed and acceleration of the particle and the rigid body performing translational, rotational and plane motion; to solve the first and the second general problems of dynamics, to use the general theorems of dynamics and basic principles.	Control work Written work Settlement and graphic work
	IA-3$_{gpc-1.}$	**To masters** basic procedures of technological and economic analysis, has the skill of drafting as a member of creative team; participates knowledgeably in the work aimed at production processes improvement using experimental data and results of modelling; masters business interaction with maintenance department and can estimate their recommendations taking into account experimental work of the enterprise technological department.	**Masters** the skill of studying the equilibrium conditions of the rigid body under influence of some force system; the skill of solving problems in kinematics of the particle and the rigid body; the skill of making and solving differential equations of motion of the particle and the rigid body; the skill of using the basic provisions and methods of mechanics that are necessary for studying the disciplines of the professional cycle.	Differential pass (grading test)

3. FULL TIME AND FORMS OF ACADEMIC WORK

Form of academic work	**Hours in all**	**Distribution in hours according to semesters**		
		Number of semester		
		2		
1	**2**	**3**	**4**	**5**
1. Holding classes (including results monitoring) in the form: 1.1.Contact classwork, including:	72	72		
– lectures (L)	27	27		
– laboratory work (LW)				
– practice, seminars and/or other seminar-type work (PW)	41	41		
–control of self-work (CSW)	4	4		
–test				
1.2. Students' self-work (SSW)	108	108		
2. Intermediate attestation				
Exam				

1	2	3	4	5
Grading test	+	+		
Test (Credit)				
Course Project (CP)				
Course Work (CW)				
Workload in hours	**180**	**180**		

4. COURSE OUTLINE

Name of the units with the course outline	Full time of classroom activity in hours according to the forms			Full time of extracurricular work in hours according to the forms
	L	LW	PW	SSW
1	2	3	4	5
Semester 2				
Introduction.	1		0	4
1. Statics.	3		8	18
Forces and systems of forces. Projection of a force on an axis. Component of the force on the direction of an axis. Moment of a force about a given point. Varignon's theorem. Moment of a force about a given axis.	1		0	6
Equilibrium of the free particle. Constraints. Axiom of the constraints. Equilibrium of the particle with ideal constraints. Equilibrium of the free rigid body. Ideal constraints of the rigid body in two dimensions (in plane) and in three dimensions.	1		4	6
Loads and equilibrium conditions for statically determined and stable rigid body in two dimensions (in plane) and in three dimensions. Steps to solve the reactions from the constraints of a statically determined and stable rigid body.	1		4	6
2. Kinematics.	8		15	24
Kinematics of the particle. Position of the particle and trajectory. Velocity and acceleration.	2		4	6
Kinematics of the rigid body. Particular motions of a rigid body. Translation motion. Rotational motion about a fixed axis. Sample problems.	2		3	6
Relative motion of the particle. Absolute and relative derivatives. Composition of the velocities in the relative motion of a particle. Composition of the accelerations in relative motion of the particle.	2		4	6
Plane motion. Instantaneous center of rotation (ICR). Instantaneous center of the accelerations. Sample problems. Proprieties of the distribution of velocities and accelerations in general motion of a rigid body. Sample problems.	2		4	6
3. Dynamics.	14		18	48
Dynamics of the absolute motion of the particle (the material point). Newton's law of motion (the first, the	2		4	6

1	2	3	4	5
second and the third principles of mechanics). The first and the second general problems of dynamics. Dynamics of the free particle. Dynamics of the constrained particle. Sample problems.				
Dynamics of the relative motion of the particle (material point).	1		0	8
Dynamics of the rigid body and dynamics of the systems. General theorems of dynamics. Interior and exterior forces. Mass and center of mass of the systems.	1		0	6
Moments of inertia. Proprieties of the moments of inertia. Moment of inertia's variation with respect to parallel axes. Moments of inertia for simple usual homogeneous bodies. Sample problems.	2		0	6
Linear momentum. Theorem of the motion of the center of mass. Theorem of the linear momentum. Theorem of the linear momentum conservation.	2		4	6
Angular momentum. Theorem of the angular momentum. Theorem of the angular momentum conservation.	2		4	6
Kinetic energy. Elementary work (mechanical work) and total work of a force. Theorem of the kinetic energy. Conservative forces, force function. Potential energy. Mechanical energy. Mechanical energy conservation.	2		4	6
Dynamics of the plane motion.	1		1	8
D'Alembert's principle. The inertia force. The force-couple system of the inertia forces. Kineto-static method.	1		1	8
Conclusion	1		0	4
Total with regard to semester	27	0	41	108
Total with regard to the course	27	0	41	108

Topics of exemplary practical work

No.	Topic of practical (seminar) work
1	Moment of a force about a given point. Varignon's theorem. Loads and equilibrium conditions for statically determined and stable rigid body in two dimensions (in plane). Steps to solve the reactions from the constraints of a statically determined and stable rigid body.
2	Moment of a force about a given axis. Loads and equilibrium conditions for statically determined and stable rigid body in three dimensions. Steps to solve the reactions from the constraints of a statically determined and stable rigid body.
3	Kinematics of the particle. Velocity and acceleration.
4	Kinematics of the rigid body. Translation motion. Rotational motion about a fixed axis. Velocity and acceleration.
5	Relative motion of the particle. Composition of the velocities in the relative motion of a particle. Composition of the accelerations in relative motion of the particle.
6	Plane motion. Instantaneous center of rotation (ICR). Velocity and acceleration.
7	Dynamics of the absolute motion of the particle. The first and the second general problems of dynamics. Dynamics of the free particle and dynamics of the constrained particle.
8	Theorem of the motion of the center of mass.
9	Theorem of the linear momentum. Theorem of the linear momentum conservation.
10	Theorem of the angular momentum. Theorem of the angular momentum conservation.
11	Theorem of the kinetic energy. Mechanical energy conservation.
12	Dynamics of the plane motion.
13	D'Alembert's principle.

Topics of exemplary laboratory practice

No laboratory practice

5. ORGANIZATIONAL AND PEDAGOGICAL CONDITIONS

5.1. EDUCATIONAL TECHNOLOGIES USED FOR COMPETENCES FORMATION

Holding lectures in the discipline is based on the active method of training in the process of which students are not passive but active participants of the lesson answering questions of the teacher. Teacher's questions are aimed at activating the process of learning material as well as at the development of logical thinking. The questions stimulating associative thinking and connecting new material with the previous one are identified by the teacher in advance.

Practical lessons are hold by realization of the method based on active training: problem areas are determined, groups are formed. The following aims are pursued in the process of practical education: use of definite disciplines knowledge and creative methods in solving problems and decision-making; students' skill-building of teamwork, interpersonal communication and development of leadership skills; consolidation of the basic theoretical knowledge.

Interactive lectures, group discussions, role-playing games, training sessions, and analysis of situations and simulation models are used in academic studies.

5.2. STUDENTS' MANUAL FOR THE COURSE STUDY

Learning the course students are recommended to fulfill the following positions:

1. Learning of the discipline should be done systematically.
2. After learning one of the course unit with the help of the text-book or lecture notes it is recommended to reproduce in memory the basic terms, definitions, notions of the unit.
3. Special attention should be paid to the reports on practical studies and individual complex tasks for self-work.
4. The topic of questions studied individually is given by the teacher at the lectures. Also the teacher refers to the literary resources (first of all, to the newly published in periodicals) in order the students understand the problems touched on the lectures in detail.

6. LIST OF TEACHING MATERIALS AND INFORMATION SUPPLY FOR STUDENTS' SELF WORK IN THE DISCIPLINE

6.1. PAPER-BASED COURSEWARE

Sl.№	Bibliographic entry (author, title, mode of publication, place, publishing house, year of publication, number of pages)	Number of copies in the library
	1. Basic literature	
1	Targ S.M. Theoretical mechanics short course. – M.: Higher School, 2002-2009, 416 p. (in Russian)	736
2	Digest of tasks for course work on theoretical mechanics (ed. by A.A. Yablonsky). – M.: Integral-Press, 2007, 367 p. (in Russian)	717
3	Mescherskiy I.V. Theoretical mechanics tasks. – SPb.: Lan, 2002–2012, 448 p. (in Russian)	790
4	Nikitin N.N. Theoretical mechanics course. – SPb.: Lan, 2010, 2011, 607 p. (in Russian)	60
5	Mohyedin M.Z. Theoretical Mechanics [Electronic resource]. – Springer Heidelberg Dordrecht: London, New York, 2010, 413 p. URL: https://www.pdfdrive.com/theoretical-mechanics-theoretical-physics-1-e156672251.html (date of the application: 01.12.2020).	
6	Deleanu D. Theoretical mechanics. Theory and applications. – Konstantsa: Editura Nautica, 2012, 295 p. Doi: 10.13140/RG.2.1.1786.1842	
	2. Additional literature	
	2.1. Educational and scientific literature	
1	Yablonsky A.A., Nikiforova V.M. Theoretical mechanics course. – SPb.: Lan, 2002, 2004, 764 p. (in Russian)	123
2	Mohyedin M.Z. Theoretical Mechanics [Electronic resource]. – Springer Heidelberg Dordrecht: New York, 2015, 188 p. URL: https://www.researchgate.net/publication/333237181_Theoretical_Mechanics (date of the application: 01.12.2020).	
	2.2. Standardized and Technical literature	
	not provided	
	3. Students' manual in mastering discipline	
	not provided	
	4. Teaching and learning materials for students' self work	
	not provided	

6.2. ELECTRONIC COURSEWARE

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet/local net; authorized free assess)
Basic literature	Mohyedin M.Z. Theoretical Mechanics. – Springer Heidelberg Dordrecht: London, New York, 2010, 413 p.	URL: https://www.pdf-drive.com/theoretical-mechanics-theoretical-physics-1-e156672251. html (date of the application: 01.12.2020).	Internet; free access
Basic literature	Deleanu D. Theoretical mechanics. Theory and applications. – Konstantsa: Editura Nautica, 2012, 295 p.	Doi: 10.13140/RG.2.1. 1786.1842	Internet; free access
Additional literature	Mohyedin M.Z. Theoretical Mechanics. – Springer Heidelberg Dordrecht: New York, 2015, 188 p.	URL: https://www.rese-archgate.net/publication/ 333237181_Theoretical_ Mechanics (date of the application: 01.12.2020)	Internet; free access

6.3. LICENSE AND FREE DISTRIBUTED SOFTWARE USED IN THE COURSE EDUCATIONAL PROCESS

Type of Software	Software branding
OS	Windows 10 (Azure Dev Tools for Teaching)
Office Applications	Adobe Acrobat Reader DC
General purpose application software	Microsoft Office Visio Professional 2016 (Azure Dev Tools for Teaching)
General purpose application software	WinRAR (license №879261.1493674)

6.4. MODERN PROFESSIONAL DATA BASES AND INQUIRY SYSTEMS USED IN THE COURSE EDUCATIONAL PROCESS

Branding	Reference to information resource
Scopus database	https://www.scopus.com/
Web of Science Database	https://www.webofscience.com/
Scientific electronic library database (eLIBRARY.RU)	https://elibrary.ru/
Scientific Library of the Perm National Research Polytechnic University	https://lib.pstu/
Lan Electronic Library System	https://e.lanbook.com/
Electronic library system IPRbooks	https://www.iprbookshop.ru/
Information resources of the Network ConsultantPlus	https://www.consultant.ru/
Company database EBSCO	https://www.ebsco.com/

7. LOGISTICS OF THE COURSE EDUCATIONAL PROCESS

Type of classes	Name of the necessary basic equipment	Number of units
Lectures	Multimedia set (laptop and projector)	1
Practice work	Multimedia set (laptop and projector)	1

8. FUND OF THE COURSE EVALUATING TOOLS

Ministry of Science and Higher Education of the Russian Federation

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FUND OF ESTIMATING TOOLS

For students' midterm assessment in the discipline
"Theoretical mechanics"
Supplement to the Academic Course Working Program

Training program	21.03.01 Oil and Gas Engineering
Direction (specialization) of educational program	Oil and Gas Engineering
Graduate qualification	Bachelor's degree
Graduate academic chair	Oil and Gas Technology
Form of study	Full-time studies

Year (-s): 1 **Semester (-s):** 2

Workload:
in credits: 5 CU
in hours: 180 h

The form of midterm assessment:
Grading test 2 semester

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Fund of estimating tools for midterm assessment of students' learning the subject **"Theoretical mechanics"** is the part (supplement) to the academic course working program. Fund of estimating tools for midterm assessment of students' learning the discipline has been developed in accordance with the general part of the fund of estimating tools for midterm assessment of the basic educational program which determines the system of the midterm assessment results and criteria of putting marks. Fund of estimating tools for midterm assessment of students' learning the subject determines the forms and procedures of monitoring results and midterm assessment of the subject leaning by the students.

1. LIST OF CONTROLLED RESULTS OF STUDYING DISCIPLINE, OBJECTS OF ASSESSMENT AND FORMS OF CONTROL

According to the Academic Course Working Program mastering course content is planned during one semester (the second semester of curriculum) and is divided into three educational modules. Classroom activities, lectures and practical work as well as students' self-work are provided for every module. In the frames of mastering course content such competences as *to know, to be able, to master* pointed out in the ACWP are formed. These competences act as the controlled results of learning the discipline "Theoretical mechanics" (Table 1.1).

Monitoring of the acquired knowledge, abilities and skills is made in the frames of continuous assessment, progress check and formative assessment in the process of studying theoretical material, reports on laboratory works and during examination. Types of control is given in Table 1.1

Table 1.1 – List of controlled results of learning the discipline

Controlled results of learning the discipline (KAS)	**Type of control**					
	Continuous assessment		**Progress check**		**Formative assessment**	
	T	**AC**	**PWR**	**CW**		**Test**
1	**2**	**3**	**4**	**5**	**6**	**7**
Acquired knowledge						
K.1 Knows the basic concepts, axioms and theorems of mechanics;	T	AC				
K.2 Knows methods of finding reactions in the equilibrium system of rigid bodies; the kinematic characteristics of the motion of the particle and the rigid body;	T	AC				
K.3. Knows the differential equations of motion of the particle and the rigid body relative to the inertial and non-inertial coordinate system.	T	AC				
Acquired abilities						
A.1 Is able to make and solve the equilibrium conditions for statically determined and stable rigid body under influence of some force system;			PWR1-2	CW1		

1	2	3	4	5	6	7
A.2 Is able to determine the speed and acceleration of the particle and the rigid body performing translational, rotational and plane motion;			PWR3-6	CW2		
A.3. Is able to solve the first and the second general problems of dynamics, to use the general theorems of dynamics and basic principles.			PWR7-10	CW3		
Mastered skills						
S.1 Masters the skill of studying the equilibrium conditions of the rigid body under influence of some force system;			PWR1-2	CW1		+
S.2 Masters the skill of solving problems in kinematics of the particle and the rigid body;			PWR3-6	CW2		+
S.3 Masters the skill of making and solving differential equations of motion of the particle and the rigid body; the skill of using the basic provisions and methods of mechanics that are necessary to studying the disciplines of the professional cycle.			PWR7-10	CW3		+

T – Express test; AC – colloquium (discussion of theoretical material, academic conference); PWR – report on practical work; CW –control work; TQ – theoretical question; PT – practical task; CT – complex task of grading test.

Final assessment of the learned discipline results is the midterm assessment which is made in the form of test taking into consideration the results of the running and progress check.

2. TYPES OF CONTROL, STANDARD CONTROL TASKS AND SCALES OF LEARNING RESULTS ASSESSMENT

Continuous assessment of the academic performance is aimed at maximum effectiveness of the educational process, at monitoring students' specified competencies formation process, at increase of learning motivation and provides the assessment of mastering the discipline. In accordance with the regulations concerning the continuous assessment of the academic performance and midterm assessment of students taught by the educational programs of Higher education – programs of the Bachelor's Course, Specialists' and Master's Course the next types of students' academic performance continuous assessment and its periodicity is stipulated in PNRPU:

– acceptance test, check of the student's original preparedness and his correspondence with the demands for the given discipline learning;

– continuous assessment of mastering the material (the level of mastering the component "to know" defined by the competence) at every group studies and monitoring of lectures attendance;

– interim and progress check of students' mastering the components "to know" and "to be able" of the defined competences by computer-based or written testing, control discussions, control works (individual home tasks), reports on laboratory works, reviews, essays, etc.

Discipline progress check is conducted on the next week after learning the discipline module, while the interim control is made at every monitoring during the discipline module study;

– interim assessment, summarizing of the current students' performance at least once a semester in all disciplines for every training program (specialty), course, group;

– retained knowledge control.

2.1. CONTINUOUS ASSESSMENT OF EDUCATION

Continuous assessment of learning is made in the form of discussion or selective recitation (express test) on every topic. According to the four-point system the results of assessment are put into the teachers' note-book and are considered in the form of integral mark in the process of the midterm assessment.

2.2. PROGRESS CHECK

For the complex assessment of the acquired knowledge, abilities and skills (Table 1.1) progress check is carried out in the form of practical work presentations and midterm control works (after learning every discipline module).

2.2.1. Presentation of laboratory work

It is planned 10 practical works all in all. Standard topics of practical works are given in ACWP and in the following table.

No.	Topic of practical (seminar) work
1	Equilibrium conditions for rigid body in two dimensions.
2	Equilibrium conditions for rigid body in three dimensions.
3	Kinematics of the particle.
4	Kinematics of the rigid body.
5	Relative motion of the particle.
6	Kinematics of the plane motion.
7	Dynamics of the particle motion.
8	Theorem of the angular momentum.
9	Theorem of the kinetic energy.
10	Dynamics of the plane motion.

Presentation of practical work is made by the student individually or by the group of students. Standard scale and criteria of assessment are given in the general part of FET of the educational program.

2.2.2. Midterm control work

According to ACWP 3 midterm control works (CW) is planned to be realized after learning the educational modules of the discipline by the students.

The first CW is realized with respect to the module 1 "Statics", the second CW – with respect to the module 2 "Kinematics", and the third CW is realized with respect to the module 3 "Dynamics".

Standard tasks of the first CW:

A simple crane is represented as in the figure. Calculate the forces from the two rods *MA* and *MB* which connect the punctual pulley to the vertical wall. It is known that the pulley is without friction and the ideal string has at one end a weight *G* that has to lift and at the other end is wrapped on the drum of an engine.

Standard tasks of the second CW:

One disc having the radius $R = 40$ cm performs a rotation motion about its fixed center with constant angular velocity $\omega = 0, 5\ s^{-1}$. Determine and represent, at a given instant, the velocities and accelerations of ends of two perpendicular diameters and finally represent the distribution of velocities on the two diameters.

Standard tasks of the third CW:

One bullet *P* by mass m is launched from the height *H* with the horizontal initial velocity in the gravitational field. Determine the position in which the bullet arrives on the surface of the ground and its velocity in the same instant knowing that the motion is performed without the resistance of the air.

Standard scale and criteria of the results of the midterm control work assessment are given in the general part of FET of the educational program.

2.3. FULFILLMENT OF THE COMPLEX INDIVIDUAL SELF-WORK TASK

Individual complex task for the students is used for assessment their skills and abilities acquired in the process of learning the discipline in which the course project or course paper is not stipulated.

Standard scale and criteria of assessment of the individual complex task presentation are given in the general part of FET of the educational program.

2.4. MIDTERM ASSESSMENT (FINAL CONTROL)

Admission for midterm assessment is made according to the results of continuous assessment and progress check. Preconditions for admittance are successful presentation of all practical works and positive integral estimation with respect to the results of continuous assessment and progress check.

2.4.1. Midterm assessment procedure without additional evaluation testing

Midterm assessment is made in the form of grading test (differential pass). Credit on the discipline is based on the results of the previously fulfilled by the student all control works or some individual complex task on the given discipline.

Criteria of putting the final mark for the components of competences in the process of midterm assessment made in the form of test are given in the general part of FET of the educational program.

2.4.2. Midterm assessment procedure followed by evaluation testing

In definite cases (for example, in case of re-attestation of the discipline) midterm assessment in the form of the test on this discipline can be made as the card-based evaluation test. Every exam card includes theoretical questions(TQ) aimed at control of the acquired knowledge, practical tasks (PT) aimed at mastered abilities, and complex tasks (CT) aimed at control of the acquired skills of all declared competences.

The exam card is formed so that the included questions and practical tasks could estimate the level of maturity of **all** declared competences.

2.4.2.1. Standard questions and tasks the discipline testing

Standard questions for the acquired knowledge control:

The composition of velocities and the composition of accelerations in the relative motion of a particle.

Standard questions and practical tasks for the mastered abilities control:

A particle P by mass m is linked with an ideal wire without mass and having its length l by a fixed point O. The particle is in rest when the wire is vertically and at the initial instant it will have an initial horizontal velocity v_0. Knowing that the motion of the particle is performed in vertical plane under the action of its weight without any friction determine the differential equation of the motion of the particle, its velocity and the tension from the wire when this makes with the vertical direction of angle by 60°. After that, determine the value of the initial velocity v_0 as the particle to describe an entire circle.

Standard complex tasks for the acquired skills control:

Calculate velocity of the piston B of the crank mechanism when it arrives at the half of the distance between the point O and its initial position corresponding to instant when the rod and the crank are horizontal. It's known: $l_{OA} = l_{AB} = 2l$, $M_{OA} = M_{AB} = 3M$, $M_B = 2M$, $P = 4Mg$.

2.4.2.2. Scales of test assessment of educational achievements

Evaluation of discipline achievements in the form of maturity level of the components *to know, to be able, to master the* declared competences is made according to the four-point assessment scale.

Standard scale and criteria of estimating educational achievements in the process of testing for the components *to know, to be able, to master* are given in the general part of FET of educational program.

3. ASSESSMENT CRITERIA FOR COMPONENTS AND COMPETENCES LEVEL OF MATURITY

3.1. ASSESSMENT OF COMPETENCES COMPONENTS LEVEL OF MATURITY

While estimating the level of competences maturity by selective control in the process of testing it is considered that *the mark obtained for the components of the examined competence is combined with the corresponding component of all competences formed in the frames of the given academic course.*

General assessment of maturity level of all competences is made by aggregation of marks obtained by the student for each component of the formed competences taking into account the results of continuous assessment and progress check in the form of integral mark according to the four-point scale. All control results are put into the assessment sheet by the teacher according to the results of midterm attestation.

The form of the assessment sheet and requirements for its completion are given in the general part of FET of the educational program.

While making the final assessment of the midterm attestation in the form of test standard criteria given in the general part of FET of the educational program are used.

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____ _____ 20___

ACADEMIC COURSE WORKING PROGRAM

Academic course: Solids and structures
(Name)

Form of education: Full-time
(Full-time /full-time – correspondence/correspondence)

Level of higher education: Bachelor's degree
(Bachelor's program/specialist program/
Master's program)

Workload in hours (in credits): 180(5)
(Hours (CU))

Training program (degree): 21.03.01 Oil and Gas Engineering
(Code and denomination of degree)

Direction: Oil and Gas Engineering
(Title of curriculum)

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1. GENERAL PROVISIONS

1.1. GOALS AND OBJECTIVES OF THE COURSE

The goal of the course is to develop a set of knowledge in the field of engineering calculations for the strength, rigidity and stability of the elements of the structures that ensure the required reliability and safety of the products.

Objectives of the Course:

- to study of the theoretical basis and methods of calculating the strength, rigidity and stability of the elements of structures and machines;
- to be able to make calculations on the strength, rigidity and stability of typical elements of structures;
- to have the skill of determining the basic mechanical properties of materials based on standard laboratory tests.

1.2. STUDIED OBJECTS OF THE COURSE

- Engineering calculations on the strength and rigidity of frameworks, working on tension and compression, shift, torsion, bending;
- Testing methods to determine the characteristics of the strength, plasticity and elasticity of materials;
- The basics of the theory of tension and deformed state at the point of the body;
- Classical strength theories and materials plasticity criteria;
- Calculations for strength and rigidity in complex loading of products;
- Calculations on the stability of compressed rods
- Calculations for strength in the dynamic and cyclical loading of products.

1.3. STARTING CONDITIONS

Unstipulated

2. PLANNED RESULTS OF THE COURSE TRAINING

Compe-tence	**Indicator's Index**	**Planned Results of the Course Training (to know, to know how, to master)**	**Indicator of Attaining Competence which the planned results of training are correlated with**	**Means of Assessment**
1	**2**	**3**	**4**	**5**
GPC-1	**IA-1$_{gpc-1}$**	**To know** basic concepts and hypotheses used in the "Solids and structures" course. Knows basis for calculating the elements of the structures in complex types of load.	**Knows** principle features of modelling mathematical, physical and chemical processes assigned for definite technological processes.	Exam

1	2	3	4	5
	IA-2$_{gpc-1}$	**To be able to** calculate the durability, rigidity and stability of frameworks	**Is able to** use general laws of the disciplines of mechanical-engineering module; to use general laws of natural-scientific disciplines, the rules of technical drafting and plotting.	Coursework, exam
	IA-3$_{gpc-1}$	**To master the skills** to choose the optimal sizes and shapes of cross-section rods that provide the required reliability, safety and cost-effectiveness.	**Masters** basic procedures of technological and economic analysis, has the skill of drafting as a member of the creative team; participates knowledgeably in the work aimed at production processes improvement using experimental data and results of modelling; masters business interaction with maintenance department and can estimate their recommendations taking into account experimental work of the enterprise technological department.	Coursework, exam
GPC-2	**IA-1$_{gpc-2}$**	**To know** standard testing methods to determine the mechanical properties of materials. Knows the essence of the processes and phenomena that occur when materials are deformed	**Knows** vital differences in approach to the project engineering of technical facilities, systems and technological processes.	Exam
	IA-2$_{gpc-2}$	**To be able to** determine the mechanical characteristics of materials based on laboratory tests.	**Is able to** determine the demand for commercial material necessary for making the detailed design; analyze the realization of the detailed design requirements in the course of technological process; correct project data owing to his competence; estimate convergence of calculation results obtained by different procedures.	Coursework, exam
	IA-3$_{gpc-2}$	**To master the skills** of self-work in the laboratory by experimental determination of mechanical properties of structural materials	**Masters the skills of** collection and processing primary materials as assigned by the management of the project department; the skills of efficient fulfillment of the detailed design; the skills of computer work with realization of new methods and software packages.	Coursework, exam

3. FULL TIME AND FORMS OF ACADEMIC WORK

Form of academic work	Hours in all	Distribution in hours according to semesters
		Number of semester
		3
1. Holding classes (including results monitoring) in the form: 1.1.Contact classwork, including:	54	54
– lectures (L)	16	16
– laboratory work (LW)	18	18
– practice, seminars and/or other seminar-type work (PW)	18	18
– control of self-work (CSW)	2	2
– test		
1.2. Students' self-work (SSW)	90	90
2. Intermediate attestation		
Exam	36	36
Grading test		
Test (Credit)		
Course Project (CP)		
Course Work (CW)	+	+
Workload in hours	**180**	**180**

4. COURSE OUTLINE

Name of the units with the course outline	Full time of classroom activity in hours according to the forms			Full time of extracurricular work in hours according to the forms
	L	LW	PW	SSW
Semester 3				
Tension and compression, shear and torsion, geometric characteristics of flat sections The goals and objectives of the Solids and structures. concept of strength, rigidity, stability. Identification of internal force factors. Mechanical characteristics of materials. Moments of inertia of the simplest figures. Analysis of internal force factors for shear and torsion.	6	6	6	35
Straight bending. The concepts of bending. Types of bend. Determining the stresses and deformations of bending.	6	6	6	30
A stress-strain state at the point of the body, complex strength, fatigued strength of materials, stability of compressed rods. Components of a stress-strain state at the point of the body. Potential deformation energy. Types of complex load. Mechanical characteristics of fatigue resistance. Effect of rod conditions on critical force.	4	6	6	25
Total with regard to semester	16	18	18	90
Total with regard to the course	16	18	18	90

Topics of exemplary practical work

Sl.№	Topic of practical (seminar) work
1	Calculating the strength and definition of deformations of rod systems that work on tension and compression.
2	Determining the geometric characteristics of planar sections.
3	Calculations for strength and rigidity at torsion.
4	Identify internal force factors when bending. Building a diagram of internal force factors. Calculating the beam for strength by normal stress.
5	A complete test of the strength of the I-beam.
6	Determining deformations when bending.
7	Analysis of a planar stress-strain state at the point of the body.
8	Calculations for strength in complex resistance: asymmetric bend, bend with torsion.
9	Calculating shafts to resist multi-cycle fatigue. The calculation for the stability of the centrally compressed rod.

Topics of exemplary laboratory practice

Sl.№	Topic of laboratory work
1	Testing for stretching plastic and fragile materials. Identify the basic characteristics of the strength and plasticity of the material.
2	Testing for compression of plastic and fragile materials. Experimental definition by tendometrical characteristics of the material: the Jung module and the Poisson coefficient.
3	Determining the shear modulus of elasticity on the results of the test on the torsion of the thin-walled tube.
4	Experienced definition of deformations when bending in the specified sections of the beam.
5	Experienced definition of the movements of the console beam at the asymmetric bend.

5. ORGANIZATIONAL AND PEDAGOGICAL CONDITIONS

5.1. EDUCATIONAL TECHNOLOGIES USED FOR COMPETENCES FORMATION

Holding lectures in the discipline is based on the active method of training in the process of which students are not passive but active participants of the lesson answering questions of the teacher. Teacher's questions are aimed at activating the process of learning material as well as at the development of logical thinking. The questions stimulating associative thinking and connecting new material with the previous one are identified by the teacher in advance.

Practical lessons are held by realization of the method based on active training: problem areas are determined, groups are formed. The following aims are pursued in the process of practical education: use of definite disciplines knowledge and creative methods in solving problems and decision-making; students' skill-building of teamwork, interpersonal communication and development of leadership skills; consolidation of the basic theoretical knowledge.

Laboratory classes are based on an interactive learning method in which students communicate not only with the teacher but also with each other. At the

same time, students ' activity in the learning process dominates. The teacher's place in interactive classes is reduced to orienting students ' activities to achievement of the goals of studies.

Interactive lectures, group discussions, role-playing games, training sessions, and analysis of situations and simulation models are used in academic studies.

5.2. STUDENTS' MANUAL FOR THE COURSE STUDY

Learning the course students are recommended to fulfill the following positions:

1. Learning of the discipline should be done systematically.

2. After learning one of the course units with the help of the text-book or lecture notes it is recommended to reproduce in memory the basic terms, definitions, notions of the unit.

3. Special attention should be paid to the reports on practical studies, laboratory works and individual complex tasks for self-work.

4. The topic of questions studied individually is given by the teacher at the lectures. Also the teacher refers to the literary resources (first of all, to the newly published in periodicals) in order the students understand the problems touched on the lectures in detail.

6. LIST OF TEACHING MATERIALS AND INFORMATION SUPPLY FOR STUDENTS' SELF WORK IN THE DISCIPLINE

6.1. PAPER-BASED COURSEWARE

Sl.№	Bibliographic entry (author, title, mode of publication, place, publishing house, year of publication, number of pages)	Number of copies in the library
1	2	3
	1. Basic literature	
1	C. Ross, J. Case, A. Chilver, Strength of Materials and Structures, Oxford, Butterworth-Heinemann, 2003, 706 p.	1
	2. Additional literature	
	2.1. Educational and scientific literature	
1	R.K. Bansal, Engineering Mechanics and Strength of Materials, New Dehli, Laxmi Publications, 2044, 881p.	1
2	Sobotka Z. Rheology of Materials and Engineering Structures. Prague : Academia, 1984. 548 p.	1
3	Proceedings of the 7th Israeli-Russian Bi-National Workshop "The Optimization of Composition, Structure and Properties of Metals, Oxides, Composites, Nano- and Amorphous Materials", Perm, August, 4-11, 2008 / Perm, 2008. 207 p.	1
4	Beer F. P., Johnston E. R. Mechanics for Engineers. Statics : Statics. 4th ed New York : McGraw-Hill Book Company, 1987. 448 p.	1

1	2	3
5	Emel'yanycheva E. A., Abdullin A. Fundamentals of Chemical Engineering of Hydrocarbon Processing. SPb, 2018. 95 p.	1
6	Bonnelle J. P., Delmon B., Derouane E. Surface Properties and Catalysis by Non-Metals. Dordrecht : D. Reidel Publishing Company, 1983. 562 p.	1
7	Rajasekaran S, Sankarasubramanian G Essentials of Engineering Mechanics. 2 ed New Delhi : Vikas Publ. House PVT LTD, 2006. [658 p.]	1
2.2. Standardized and Technical literature		
3. Students' manual in mastering discipline		
4. Teaching and learning materials for students' self work		

6.2. ELECTRONIC COURSEWARE

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet/local net; authorized free access)
Additional literature	International Journal of Solids and Structures	*https://www.journals.elsevier.com/international-journal-of-solids-and-structures*	Internet
Additional literature	Latin American Journal of Solids and Structures	*https://www.lajss.org/index.php/LAJSS*	Internet
Additional literature	Strength of Materials	*https://www.springer.com/journal/11223*	Internet

6.3. LICENSE AND FREE DISTRIBUTED SOFTWARE USED IN THE COURSE EDUCATIONAL PROCESS

Type of Software	Software branding
OS	Windows 10 (Azure Dev Tools for Teaching)
Office Applications	Adobe Acrobat Reader DC
Office Applications	Microsoft Office

6.4. MODERN PROFESSIONAL DATABASES AND INQUIRY SYSTEMS USED IN THE COURSE EDUCATIONAL PROCESS

Branding	Reference to information resource
Scopus database	https://www.scopus.com/
Web of Science Database	https://www.webofscience.com/
Scientific electronic library database (eLIBRARY.RU)	https://elibrary.ru/

Branding	Reference to information resource
Scientific Library of the Perm National Research Polytechnic University	https://lib.pstu/
Lan Electronic Library System	https://e.lanbook.com/
Electronic library system IPRbooks	https://www.iprbookshop.ru/
Information resources of the Network ConsultantPlus	https://www.consultant.ru/
Company database EBSCO	https://www.ebsco.com/

7. LOGISTICS OF THE COURSE EDUCATIONAL PROCESS

Type of classes	Name of the necessary basic equipment	Number of units
Lab equipment class	Models and stands for laboratory work	25

8. FUND OF THE COURSE EVALUATING TOOLS

In the separated file