Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Educational Institution of Higher Education
Perm National Research Polytechnic University

APPROVED BY
Pro-rector for Academic Affairs
_____ N.V. Lobov
"25" ___11___ 2021

ACADEMIC COURSE WORKING PROGRAM

Academic course:	Theoretical Mechanics
	(Name)
Form of education:	Full-time
	(Full-time / part-time / correspondence)
Level of higher education:	Bachelor's program
	(Bachelor's program / Specialist program / Master's program)
Total labour intensiveness:	180 (5)
	(Hours (CU))
Training program (degree):	15.03.06 Mechatronics and robotics
	(Code and denomination of degree)
Direction:	Mechatronics and Robotics
	(Title of curriculum)

Perm 2021

1. General Provisions

1.1 Goals and Objectives of the Course

The goal of the course is to form professional competencies and to develop concepts in the field of theoretical mechanics; to develop skills of basic methods of mechanical motion and its mathematical modeling, methods of solving the related problems, and experience of using theoretical mechanics methods in professional activity.

1.2 Prescribed Objects of the Course

Material point and material point system; absolutely solid body and body system.

1.3 Starting Conditions

Unstipulated

2. Planned Results of the Course Training

Competence	Indicator's Index	Planned Results of the Course Training (to know, to be able to, to master)	Indicator of Attaining Competence which the planned results of training are correlated with	Means of Assessment
GPC-1	IA-1_{GPC-1}	**To know** - kinetic characteristics of a point's motion in different ways of setting motion; - basic concepts and axioms of mechanics, the conditions of equilibrium of an arbitrary system of forces, methods of calculating constraint reaction in a rest system of solids, methods of calculating their centers of gravity; - the differential equation of motion of a point relative to the inertial and non-inertial coordinate system.	**Knows** basic areas of applying mathematical methods for scientific and technical tasks solution in mechanical engineering, the aspects of scientific research systematization and mathematisation, mathematical methods for modeling designed processes, units, aids and systems of machinery production technological support in engineering practice and research; basic definitions and concepts in the sphere of reliability and diagnostic of technological systems, quantitative characteristics of reliability functioning and methods of their calculation, methods and tools of technical diagnosis and reliability evaluation of instruments and processing equipment.	Test
GPC-1	IA-2_{GPC-1}	**To be able to** - determine the velocity and acceleration of the bodies' points and the bodies themselves, which have translational, rotational	**Is able to** evaluate and present the results of mathematical modeling of objects and processes during engineering preproduction, make problem definition and solution for mathematical	Calculation and graphic works

| | | and plane motion;
- create equilibrium equations for a body under the influence of the arbitrary force system, to find positions of gravity centers of bodies;
- solve the direct and inverse dynamics of a point, to use general theorems of dynamics and basic principles. | analysis of designed situation, specific processes of machines functioning and materials processing, work up program logic for sensors maintenance and technical diagnosis; compute basic data of technological process reliability. | |
| GPC-1 | IA-3_{GPC-1} | **To master the skills** of:
- solving the kinetics of a point and a solid body;
- of analyzing the balance of a solid body under the action of a plane and spatial forces system;
- creating and solving differential equations of point and system motion;
- using the basic provisions and methods of mechanics necessary to study the disciplines of the professional cycle. | **Has mastered the skills** of using mathematical modeling for definition of technological, engineering and performance characteristics of mechanical products and facilities; estimation and presentation of results of engineering objects and processes mathematical modeling; computation of basic data of reliability and its control; analysis of technological systems reliability characteristics; drafting of measures aimed at addressing the cause of technological system failure. | 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
		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		
Grading test	9	9
Test (Credit)		
Course Project (CP)		
Course Work (CW)		
Workload in hours	**180**	**180**

4. Course contents

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
5th semester				
Unit 1. Statics.	7	0	7	36
Topic 1. Introduction to statics. Statics, basic concepts of statics. Axioms of statics. Force and force systems. Equivalence, resultant, and equilibrium. Axioms of constraint, basic types of constraint, and their reactions. Topic 2. Projections of forces and moments of forces. The projection of force on the axis and on the center. Moments of forces relative to the center and axis, their interaction. The concept of a force couple, the moment of a force couple, the equivalence and composition of a force couple. The equilibrium of a force couple. Topic 3. Equilibrium equations. Poinsot's theorem, bringing the force system to the given center, the main vector and the main moment of the force system. Equation of equilibrium for the converging, arbitrary, plane and spatial systems of forces. Topic 4. Equation of equilibrium with regard to friction forces. Friction of sliding and friction of rolling. Equilibrium with regard to friction forces.				
Unit 2. Kinematics.	10	0	10	36
Topic 5. The kinematics of a point. The kinematics of a point, point motion trajectory vector, coordinate and natural ways for point motion definition. Connection of different methods for motion definition. Topic 6. The simple motions of a rigid body. Kinematics of a rigid body. Translational motion, the translational motion theorem. Rotational motion, angular velocity, angular acceleration, velocity and acceleration of the rotating body's point. Topic 7. Complex point motion. Absolute, relative and bulk motion of a point. Velocity and acceleration addition theorem. The magnitude and direction of Coriolis acceleration, its physical significance. Topic 8. Plane-parallel motion. Plane motion, law of plane motion, independence of angular velocity from the choice of pole. Velocity of a plane figure point, velocity projection theorem, instantaneous centre of zero velocity (ICZV). Determination of a point acceleration of a plane figure by pole method.				
Unit 3. Mass point dynamics.	2	0	5	6
Topic 9. The dynamics of a point. Basic laws of material point dynamics. Inertial of frame reference. Basic forces. Differential equations for point motion in Cartesian and natural coordinate system. First and				

second problem of the point dynamics. Solving the second problem of the point dynamics.				
Unit 4. General dynamical systems theory.	7	0	14	24
Topic 10. Introduction to mechanics of system. The dynamics of the mechanical system. External and internal forces. Properties of internal forces. The mass of the system. The geometry of the masses. The center of the system masses and its coordinates. Topic 11. Theorem of the change in momentum and the motion of the mass center. Theorem of the mass center motion. Momentum of material point and system, the impulse of force. Theorem of the change in momentum of material point and system. Conservation of momentum of the system and the velocity of the system mass center Topic 12. Theorem of the kinetic moment. The moment of point inertia, solid body and system. Theorem of the moments of inertia relative to parallel axes. Radius of inertia. Inertia moments of simple bodies. Theorem of the point motion moment and the kinetic moment of the system. Differential equation of body rotation. Corollaries of the theorem. Topic 13. Theorem of changing kinetic energy. Kinetic energy of a point, system and solid body, and its calculation. Work and power of force. Private cases of calculating work. Potential forces, potential energy, and conservative mechanical systems. The work and power of the force applied to a rotating body. Theorem of changing the kinetic energy of a material point and a system in an integrated or differential form. Topic 14. Application of the general theorem to the dynamics of a solid body. Dynamics of plane-parallel motion. Differential equations of plane body motion in Cartesian and natural coordinate system. Basic solutions. Topic 15. D'Alembert's principle. The force of inertia of the material point. The main vector and the main moment of inertia. D'Alembert's principle for the material point and system.				
Unit 5. The elements of analytic dynamics.	1	0	5	6
Topic 16. Basics of analytical dynamics. Analytical record of constraint and its brief classification. Concepts of actual and possible moves. Principle of virtual displacements. Fundamental equation of dynamics.				
Total with regard to 5th semester	**27**	**0**	**41**	**108**
Total with regard to the course	**27**	**0**	**41**	**108**

Topics of exemplary practical works

№	Topic of practical works
1	Statics of converging plane force system.
2	Statics of arbitrary plane force system.
3	Statics of arbitrary spatial force system.

4	Static friction.
5	Kinematics of a point.
6	The translational and rotational motion of a solid body.
7	Compound motion point. Velocity.
8	Compound motion point. Acceleration.
9	Plane motion of a rigid body. Velocity. Method of ICZV.
10	Plane motion of a rigid body. Velocity. Method of a pole.
11	Plane motion of a rigid body. Acceleration.
12	Dynamics of a point. The force, a function of time or velocity.
13	Dynamics of a point. The force, a function of velocity or coordinates.
14	The masses center of the system. Theorem of the masses center motion.
15	Conservation of the masses center of the system.
16	Moment of a rigid body inertia.
17	Principle of kinetic moment of the system.
18	Gyrodynamics of a rigid body.
19	The dynamics of plane movement of a rigid body.
20	Theorem of kinetic energy change in differential form.
21	Theorem of kinetic energy change in integral form.
22	Law of full energy conservation.
23	D'Alembert's principle.
24	Principle of virtual displacements.

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 formulated 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.

5.2. Students' Manual for the Course Study

Learning the course, it is advisable for students to implement the following recommendations:

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 the basic terms, definitions, notions of the unit from memory.
3. Special attention should be paid to the reports on practical studies and individual complex tasks for self-work.
4. The topics list for individual study is given by the teacher at the lectures. The teacher also provides students with literary sources (first of all, new ones in the periodical scientific literature) for a more detailed under-standing of the issues presented at the lectures.

6. List of Teaching Materials and Information Supply for Students' Self work in the Discipline

6.1 Paper-based courseware

№	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	Rakisheva Z.B., Sukhenko A.S. Textbook on Theoretical Mechanics. 2nd ed.: 2017. 354 p.	
2.	Merrill George Arthur Elementary Text-book of Theoretical Mechanics. (Kinematics and Statics). Nobel Press, 2012. 204p.	
2 Additional literature		
2.1 Educational and scientific literature		
1	Cora S. Lüdde, Reiner M. Dreizler Theoretical Mechanics. Theoretical Physics 1. Springer: 2010. 411 p.	
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	Theoretical-mechanics	https://docplayer.net/14931020-Theoretical-mechanics.html	internet, free access

6.3 License and Free Distributed Software used in the Course Educational Process

Type of Software	Software branding
Operating systems	Windows 10 (Azure Dev Tools for Teaching)
Office applications	Microsoft Office Professional 2007, license 42661567

6.4 Modern Professional Databases and Inquiry Systems Used in the Course Educational Process

Branding	Reference to information resource
Scientific Library of Perm National Research Polytechnic University	http://lib.pstu.ru/

Lan' Electronic library system	https://e.lanbook.com/
IPR books Electronic library system	http ://www.iprbookshop.ru/
Information resources of the Network ConsultantPlus	http://www.consultant.ru/

7. Logistics of the Course Educational Process

Type of classes	Name of the necessary basic equipment	Number of units
Lecture	Projector	1
Practical class	Personal computer	10

8. Fund of the Course Evaluating Tools

Described in a separate document