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
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ACADEMIC COURSE WORKING PROGRAM

Academic course: Applied 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)

Workload in hours (in credits): (108)3
(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 mechanics, required for the development and operation of technical products and equipment.
The objectives of the course are:

- to study the basic models of applied mechanics and their application (material models, shapes, forces, and failures); basic methods of studying loads, movements and stress-strain state in production equipment components;
- to form the ability to perform check calculations of products and production equipment components according to the standard of performance; to use the basic techniques of experimental data processing;
- to master the skills of carrying out theoretical and experimental research for solving engineering and technical problems connected with strength evaluation of production equipment components.

1.2 Prescribed Objects of the Course

- production equipment components;
- basic types of mechanisms, parts and machine components;
- theoretical and experimental study methods of products and components of production equipment in terms of operability and reliability.

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-13	**IA-1** $_{GPC-13}$	**To know** - the basics of designing machinery, components and machine parts; - the engineering calculation fundamentals of operability and reliability at product designing; - simple types of load: tension (compression), shear, torsion, and bending; - strength, rigidity and stability calculation of production equipment parts.	**Knows** basic regulations of quality management system.	Test
GPC-13	**IA-2** $_{GPC-13}$	**To be able to**	**Is able to** apply methods of	Calculation

		- calculate strength, rigidity and stability of production equipment parts and components; - perform structural and kinematic analysis of mechanisms.	quality control in the process of designing mechatronic and robotic systems, their subsystems and definite modules.	and graphic works
GPC-13	**IA-3** $_{GPC-13}$	**To master the skills** of: - performing operability and reliability verifications of separate machines components, parts and mechanisms of production equipment; - structural and kinematic analysis of production equipment mechanisms; - calculating structural deflections under external load; - calculating basic mechanical transmission parameters.	**Has mastered the skills** of meeting the requirements of the system of products and objects quality control.	Laboratory work presentation

3 Full time and forms of academic work

Form of academic work	**Hours in all**	**Distribution in hours according to semesters**
		Number of semester
		7
1 Holding classes (including results monitoring) in the form: 1.1 Contact classwork, including:	45	45
- lectures (L)	16	16
- laboratory work (LW)	9	9
- 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)	63	63
2 Intermediate attestation		
Exam		
Grading test		
Test (Credit)	9	9
Course Project (CP)		
Course Work (CW)		
Workload in hours	**108**	**108**

4 Course contents

Name of the units with the course outline	**Full time of classroom activity in hours**	**Full time of extracurricular**

	according to the forms			work in hours according to the forms
	L	LW	PW	SSW
7th semester				
Fundamentals of modeling the material and structure mechanical behavior	8	2	4	23
Topic 1. Introduction. Basic concepts. Real structure and calculation model. Material models, body shapes, and loading. Basic hypotheses. Topic 2. External and internal forces, stress state of physical point. Method of sections. Internal power factors. Stresses. Topic 3. Mechanical characteristics of materials. Diagram of elastic-plastic material deformation under tension. Hooke's Law. Strength and deformation characteristics. Diagram of brittle materials deformation. Topic 4. Geometric characteristics of plane sections. Static moment; axial, polar and centrifugal moments of simple and complex sections inertia.				
The fundamentals of machinery mechanisms, parts and components design	8	7	14	40
Topic 5. Quality assurance at product design and construction phases. Requirements for products. Unifying quality model. Machinery and mechanisms, machine units. General classification of machines' mechanisms, parts and components. Topic 6. Engineering calculations for product design. Types of strength calculations. Requirements for products. Quality criteria for product calculation and design. Causes of operability failure and loss. Topic 7. Tension and compression. Longitudinal and transverse strain. Poisson's ratio. Stress-strain relationship. Calculations of allowable stresses and displacements. Rod systems. Internal power factor and axial movements diagram. Strength and stiffness calculation of rod systems. Topic 8. Swirling. Stress and deformations, Hooke's law at simple shear. Swirling of rods with circular cross-section. Calculation of shafts on strength and stiffness at swirling. Topic 9. Bending. Bending types. Stress and deformations at simple and transverse bending. Defining bending movements. Differential equation of the beam deflection curve. Strength and stiffness calculation. Combined bending action with torsion. Topic 10. Rod stability. Euler's formula. Yasinsky's formula. Limits of Euler's and Yasinsky formulas application. Topic 11. Improving the machines quality in calculation and design phases: steel intensity and compactability, strength balance, reduced fatigue, and unification of elements.				

Total with regard to 7th semester	**16**	**9**	**18**	**63**
Total with regard to the course	**16**	**9**	**18**	**63**

Topics of exemplary practical works

№	Topic of practical works
1.	Measure internal forces by cross-section
2.	Defining the geometry of the plane sections
3.	Calculation of a plane hinge-bar system
4.	Defining the cross-sectional dimensions of the shoulder shank at central tension (compression)
5.	Stem calculation for strength and stiffness at torsion
6.	Strength calculation for permanent joint
7.	Strength calculation for threaded joint
8.	Calculation of fixed beam for plane bending strength
9.	Defining vertical bending movements

Topics of exemplary laboratory works

№	Topic of laboratory works
1.	Uniaxial tension diagram of elastoplastic material. Definition of material mechanical properties.
2.	Definition of the basic transmission parameters. Standardized machine parts in reductor designs.
3.	Definition of torsional shear modulus.
4.	Deflection definition of beam with two-legged stirrups.
5.	Study of compressed rod stability with great flexibility.

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.

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, 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	Rajput R.K. A Textbook of Applied Mechanics. Laxmi Publications, 2015.	
2	Polyakhov N.N., Tovstik P.E., Yushkov M.P., Zegzhda S.A. Rational and Applied Mechanics. – Springer International Publishing, 2021, pp.520.	
3	Awrejcewicz J., Koruba Z. Classical Mechanics: Applied Mechanics and Mechatronics. Springer Science+Business Media, LLC 2012.	
	2 Additional literature	
	2.1 Educational and scientific literature	
1	Smith C.B. Applied Mechanics for Engineers: The Commonwealth and International Library: Mechanical Engineering Division. Elsevier Science, 2013.	
2	Case J., Chilver A.H., Rocc C.T.F. Strength of Materials and Structures: An Introduction to the Mechanics of Solids and Structures. Elsevier Science, 2013.	
3	Glendinning E.H., Glendinning N. Oxford English for Electrical and Mechanical Engineering. Oxford Univ. Press, 2010.	
	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	Rational and Applied Mechanics	https://archive.org/details/rationalandappl00woodgoog/page/n29/mode/2up	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
General purpose application software	Dr.Web Enterprise Security Suite, PNRPU, 2017

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/
Springer Nature e-books database	http:/link.springer.com/ http://www.springerprotocols.com/ http://materials.springer.com/ http://zbmath.org/ http://npg.com/
Web of Science database	http://www.webofscience.com/
Wiley Journals database	http://onlinelibrary.wiley.com/
Scientific electronic library database (eLIBRARY.RU)	https://elibrary.ru/
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
Laboratory class	Torsion-testing machine MI40KU	1
Laboratory class	UKI-10M testing machine (for fatigue testing of metals at the cantilever bending of a rotating sample)	1
Laboratory class	Set of reductors for studying reduction gear box and worm gears	15
Laboratory class	Models of mechanisms structure	21
Laboratory class	Personal computer	1
Laboratory class	Devices for simulation of teeth cutting and drawing profiles by form-generating method of mechanisms and machinery theory.	5
Laboratory class	Installations produced by Rosuchpribor Russian Scientific Production Association for mechanical testing: - TMT 01 "Study of a plane concurrent forces system", - TMT 02 "Study of a plane arbitrary forces system", - TMT 03 "Defining reactions at the beam ends", - TMT 04 "Defining the center of gravity of plane figures", - TMT 05 "Body of rotation balancing", - TMT 11/14 "Defining the torsional shear modulus and main stresses during torsional and combined bending and twisting operations", - TMT 12"Defining the linear and angular movements of	9

	cross sections of a static beam", - TMT 13 "Defining the deflection in unsymmetrical bending", - TMT 15 "Demonstration of longitudinal-transverse bending of flexible rod"	
Lecture	Projector	1
Lecture	Laptop	1
Practical class	Desks	21

8 Fund of the Course Evaluating Tools

Described in a separate document