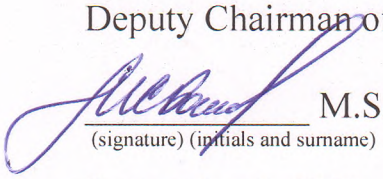
Ministry of Education and Science of Ukraine
National Aerospace University
"Kharkiv Aviation Institute"

Department № 202
"Theoretical mechanics, mechanical engineering and robotic systems"

APPROVED
Deputy Chairman of the EMC 1



_____ M.S. Romanov
(signature) (initials and surname)

September 1, 2021

THE WORK PROGRAM Of COMPULSORY EDUCATIONAL DISCIPLINE

DESIGN OF MACHINE ELEMENTS
(name of academic discipline)

Branch of knowledge: 13 "Mechanical Engineering", 27 "Transport"
(code and name of the field of knowledge)

Specialties: 134 "Aviation and rocket and space technology", 272 "Aviation transport"
(code and name of the specialty)

Educational programs: "Airplanes and helicopters", "Aircraft engines and power plants", "Design and manufacture of structures made of composite materials", "Aircraft production and repair technologies", "Aircraft engines and power plants", "Maintenance and repair of aircraft and aircraft engines", "Satellites, engines and power plants. Engineering and technical translation", "Rocket and space complexes"

Form of study: full-time

Level of higher education: first (bachelor's)

Kharkiv 2021

Developer:

Koveza Yu. V., Associate Professor 202, Ph.D.
(surname and initials, position, academic degree and academic title) (signature)

The work program was considered at the meeting of the department №202 – "Theoretical mechanics, mechanical engineering and robotic systems"
(name of the department)

Minutes № 11 of June 30, 2021

Head of Department Ph.D., Professor - O.O. Baranov
(scientific degree and academic title) (signature) (initials and surname)

1. Description of the discipline

<table>
<tr><td>Name of indicators</td><td>Field of knowledge, specialty, educational program, level of higher education</td><td>Characteristics of the discipline
(full-time education)</td></tr>
<tr><td>Number of credits - 5</td><td rowspan="11">Areas of knowledge

13 "Mechanical Engineering",
27 "Transport"

Specialties

134 "Aviation and rocket and space technology",
272 "Air transport"

Educational programs

"Airplanes and helicopters", "Aircraft engines and power plants", "Design and manufacture of structures from composite materials", "Technologies for the production and repair of aircraft", "Maintenance and repair of aircraft and aircraft engines", "Aircraft engines and power plants", "Satellites, engines and power plants. Engineering and Technical Translation", "Rocket and Space Complexes "

Level of higher education:

first (bachelor's)</td><td>COMPALSORY</td></tr>
<tr><td>Number of modules - 2</td><td>Academic year</td></tr>
<tr><td>Number of content modules - 2</td><td>2021/2022</td></tr>
<tr><td>Individual task "Designing a mechanism with a screw-nut transmission"
_____</td><td>Semester</td></tr>
<tr><td>The total number of hours is 72/150</td><td>5th</td></tr>
<tr><td rowspan="7">Number of weekly hours for full-time study:
classroom - 5/4
independent student work - 4,875</td><td>Lectures [1)]</td></tr>
<tr><td>40 hours</td></tr>
<tr><td>Practical, seminar[1)]</td></tr>
<tr><td>16 hours</td></tr>
<tr><td>Laboratory [1)]</td></tr>
<tr><td>16 hours</td></tr>
<tr><td>Individual work</td></tr>
<tr><td>78 hours</td><td>Type of control</td></tr>
<tr><td colspan="2"></td><td>modular control
exam</td></tr>
</table>

The ratio of the number of hours of classroom classes to independent work is: for full-time study - (72/78) = 0.923.

[1)] The classroom load can be reduced or increased by one hour depending on the class schedule.

2. The purpose and objectives of the discipline

Goal is study of methods of design and calculation of mechanical engineering parts.

Task is study of the basics of calculations and design, criteria for the efficiency of parts and components of machines, mastering the methods of calculation of various parts, acquaintance with modern design methods.

According to the requirements of the educational-professional program, students must achieve the following competencies:

- the ability to make informed decisions;
- the ability to the element's strength calculations;
- ability to design and test elements of aviation and rocket and space technology, its equipment, systems and subsystems;
- the ability to develop and implement technological processes of production of elements and objects of aviation and rocket and space technology;
- skills of using information and communication technologies and specialized software in training and professional activities.

Program learning outcomes:

- have the skills to determine the loads on the structural elements of aviation and rocket and space technology at all stages of its life cycle;
- to apply in professional activity modern methods of design, construction and production of elements and systems of aviation and rocket and space technology;
- to calculate the stress-strain state, to determine the bearing capacity of structural elements and the reliability of aerospace and rocket systems.

Prerequisites: "Descriptive geometry", "Engineering and computer graphics", "Interchangeability and standardization", "Mechanics of materials and structures", "Theoretical mechanics", "Theory of mechanisms and machines".

Co-requisites: "General Principles of Rational Design", "Design of Machine Elements (TP)", production practice and writing a bachelor's thesis.

3. The program of the discipline

Module 1. Basics of calculations and design

Content module 1. Connections of machine parts, screw and gears

Topic 1. Introduction. Basic concepts of the discipline "DME"

The role of mechanical engineering in the economy and development of the state. Brief information on the history of development of methods for calculating parts and components of machines.

Course structure. The main provisions used in the calculations and design. Basic concepts, classification of parts and components

Criteria of element working capacity. Materials for general and special purpose parts. Load in machines. Strength at constant stresses. Strength at alternating stresses. The concept of rigidity, vibration resistance, heat resistance and wear resistance in machines.

Topic 2. Detachable joints

Purpose of threaded connections. Types of threads. Distribution of forces between turns of pair "screw-nut". Types of destruction of elements of threaded joints. Calculation of thread turns.

Static strength threaded joints. Calculation of bolts loaded with axial and transverse forces under the condition of admissibility and inadmissibility of joint opening.

Dynamic strength of threaded joints. Basic calculation cases. Means to increase the strength of threaded connections of aerospace products.

Calculation of groups of bolted joints at different load options. Features of calculation of group threaded joints of aerospace technology.

Keys and splines joints. Types and bases of calculations. Types of centering and landing.

Topic 3. Permanent joints

The use of permanent joints in aerospace engineering.

Riveted joints. Types and classification. Distribution of forces between rivets. Calculation of single rivets and group riveted joints.

Types of welds. Stress concentration in welds and methods to increase their strength. Calculation of connections loaded with force and torque.

Topic 4. Power screws

Screw-nut transfers in aircraft control mechanisms and process equipment. Purpose and calculation of "screw-nut" transfers with sliding and rolling friction.

Topic 5. Transmission mechanisms

Transmission mechanisms, their purpose, classification and drive structure in mechanical engineering and aerospace engineering. Mechanical transmissions and their characteristics.

Classification, purpose, areas of use of gears. The nature and types of teeth damage.

Forces acting in the engagement of different types of gears. Design loads on the tooth.

Gear materials, thermal and chemical-thermal hardening of teeth. Transmission accuracy.

Calculation of contact strength. Calculation of gears bending. Features of calculations of gears at nonstationary loadings.

Allowable stresses for calculating the contact and bending endurance. Gear efficiency.

Modular control

Content module 2. Helical gears, bevel gears, wave and worm gears. Rotational units.

Topic 6. Features of calculation of different types of transfers

Features of calculations on the strength of helical and bevel gears, features of calculations of high-speed aviation gears.

Wave transmissions. Areas of use of wave gears. Structure and principle of operation. Types of wave generators. Performance criteria and materials for transmissions. Design and verification calculations.

Worm gears. Classification, purpose, areas of use. Principles of worm transmission. Types of damage. Efficiency. Forces in gearing. Worm and gear calculations. Materials and allowable stresses.

Topic 7. Shafts and axles

Purpose and nature of work. Design and check calculations of the strength of shafts and axles.

Shaft calculations for stiffness and oscillations. Materials and construction of shafts and axles. Design and technological ways to increase the durability of shafts and axles. Features of the design of the shafts of aerospace technology.

Topic 8. Rolling and bearings

Areas of use. Classification and design of bearings. Accuracy, kinematics, friction losses. Types of damage. Materials. Choice of bearings on static and dynamic loading capacity. Speed of rolling bearings. Designs of bearing units of aviation and space equipment.

Sliding bearings. Areas of use and design. Materials. Types of Friction. Boundary friction bearings and basics of their calculation.

Hydrodynamic and hydrostatic bearings. Calculations of fluid friction bearing characteristics.

Topic 9. The main types of mechanical couplings

Purpose, characteristics and classification of couplings. Permanent, elastic and compensating couplings. Controlled and self-controlled couplings. Safety couplings.

Modular control

4. The structure of the discipline

Names of meaningful modules and topics	Number of hours				
	Total	Including			
		lec.	pr.	lab.	ind.
1	2	3	4	5	6
Module 1					
Content module 1. Connections of machine parts, screw and gears					
Topic 1. Introduction. Basic concepts of the "DME"	3	2	-	-	1
Topic 2. Detachable joints	14	4	4	2	4
Topic 3. Permanent joints	11	4	-	4	3
Topic 4. Power screws	14	2	2	-	10
Topic 5. Transmission mechanisms	18	6	2	2	8
Modular control	2	2	-	-	-
Total on the content module 1	**62**	**20**	**8**	**8**	**26**
Content module 2. Helical gears, bevel gears, wave and worm gears. Rotational units.					
Topic 6. Features of calculation of different types of transfers	21	6	6	3	6
Topic 7. Shafts and axles	12	4	-	2	6
Topic 8. Rolling and sliding bearings	16	4	2	3	7
Topic 9. The main types of mechanical couplings	7	4	-	-	3
Modular control	2	2	-	-	-
Tootal on the content module 2	**58**	**20**	**8**	**8**	**22**
Module 2					
Individual task "Designing a mechanism with a screw-nut transmission"	30	-	-	-	30
Total hours	150	40	16	16	78

5. Topics of practical classes

#	Name topics	Number of hours
1	Determining the size of bolts in a group bolted connection	2
2	Calculation of pre-tightened bolted connection	2
3	Screw-nut transmission design	2
4-5	Calculation of gears	6
6	Design of gear wheel	2
7	Calculation and design of support units	2
	Total	16

6. Topics of laboratory classes

#	Topics Name	Number of hours
1	Properties of materials	2
2	Experimental analysis of stress distribution in longitudinal fillet welds	2
3	Calculation of prestressed bolt joint	2
4	Experimental analysis of forces in bolts	2
5	Determination of gear efficiency	2
6	Determination of the efficiency of the planetary gearbox	2
7	Determination of critical shaft speed	2
8	Study of the design and symbols of rolling bearings	2
	Total	16

8. Independent work

#	Work Name	Number of hours
1	Introduction. Basic concepts of the discipline "DME" (Topic 1)	2
2	Detachable joints (Topic 2)	3
3	Permanent joints (Topic 3)	3
4	Power screws (Topic 4)	10
5	Transmission mechanisms (Topic 5)	8
6	Features of calculation of different types of transfers (Topic 6)	6
7	Shafts and axles (Topic 7)	6
8	Rolling and sliding bearings (Topic 8)	5
9	The main types of mechanical couplings (Topic 9)	5
10	Individual task "Design of a unit with a screw transmission"	30
	Total	78

9. Individual tasks

#	Task Name	Number of hours
1	"Designing a mechanism with a screw-nut transmission" (topics 2,4)	30

10. Teaching methods

Classroom lectures, practical and laboratory classes, individual consultations (if necessary), independent work of students on the materials published by the department (manuals), competitions.

11. Methods of control

Current control, written or test module control, final control in the form of a written exam or in the form of a test.

12. Evaluation criteria and distribution of points received by students

12.1. Distribution of points received by students (quantitative evaluation criteria)

Components of educational work	Points per one lesson (task)	Classes (tasks) quantity	Total score
Content module 1 (T1, T2, T3, T4, T5)			
1. Attendance of a class	1	20	20
2. Execution of a practical work	5	1	5
3. Calculation of an individual task	10	1	10
4. Modular control			15
Content module 2 (T6, T7, T8, T9)			
1. Attendance of a class	1	16	16
2. Execution of a practical work	5	1	5
3. Ending and defense of individual tasks	10	1	10
4. Modular control			15
5. Bonus from lecturer			4
Total for the semester			**100**

Semester exam is conducted if:

– the student's final score is less than 60 points;

– a student wants to get a better result and they refuse the score they have got.

In both cases exam is evaluated from 0 to 100 points.

The exam card includes 3 theoretical questions with the maximum number of points for each question: 40, 35, 25 (sum - 100 points).

The test task includes 30 questions with equal weight (sum - 100 points).

12.2. Criteria for evaluating student work during the semester

Satisfactory (60-74). A student should have the minimum of knowledge and skills. Must know the classification, purpose, areas of use of parts and components of general purpose in sections: detachable and non-detachable joints, types of transmissions, parts of rotating units.

Good (75 - 89). A student should know the minimum knowledge and defend all laboratory and calculation work and homework within the period specified by the teacher with a justification of the decisions and measures proposed in the works. Know the classification, purpose, design, areas of use, calculations for strength of general-purpose components.

Excellent (90-100). Prepare and defend all laboratory and calculation works and homework with a grade of "excellent". Thoroughly know all topics and be able to apply knowledge.

Grading scale: point and traditional

The sum of points	Score on a traditional scale	
	Exam, graded test	Test
90 - 100	Excellent	Graded
75 - 89	Good	
60 - 74	Satisfactory	
0 - 59	Unsatisfactory	Not graded

13. Methodical support

1. Design of machine elements [Digital resource]: tutorial / V. Dotsenko, Yu. Koveza. – Kharkiv : National Aerospace University «Kharkiv Aviation Institute», 2021. – 224 p.
2. Laboratory works on the course "Design of Machines and Mechanisms" [Text] : tutorial / V. G. Dorofeyev, Yu. V. Koveza. – Kh. : National aerospace university «Kharkov aviation institute», 2012. – 47 p.
3. Screw-nut mechanisms [Text] : tutorial / V. G. Dorofeyev, V. N. Dotsenko, Yu. V. Koveza. – Kh. : National aerospace university «Kharkov aviation institute», 2011. – 40 p.
4. Design of machine elements. Course project [Text] : tutorial / Yu. Koveza, I. Lykhosherst, S. Svitlychniy. – Kh. : National aerospace university «Kharkov aviation institute», 2014. – 180 p.

14. Recommended reading

BASIC

1. Shigley's Mechanical Engineering Design (McGraw-Hill Series in Mechanical Engineering) 10th Edition by Richard Budynas, Keith Nisbett. McGraw-Hill, 2014. – 1104 p.
2. Gupta, J. K. A Textbook of Machine Elements/ R. S. Khurmi, J. K. Gupta. – Eurasia publishing house, 2005. – 1230 p.
3. Spotts, M. F. Design of Machine Elements / Merhyle Franklin Spotts, Terry E. Shoup, Lee Emrey Hornberger. – Pearson Prentice Hall, 2004. – 928 p.
4. Threaded joints : manual / A. Y. Cherniavskyi, K. P. Msallam, Z. A. Pogorelova ; Min. of Education and Science, Youth and Sports of Ukraine, Nat. Aerospace Univ. named after N. Ye. Zhukovskiy «Kharkiv Aviation Inst.». – Kharkiv : National Aerospace University «Kharkiv Aviation Institute», 2011. – 56 p.

15. Information resources

Department websitehttps://education.khai.edu/department/202
https://k202.tilda.ws/
Youtube: 202 XAI
Google Drive:
https://drive.google.com/drive/folders/1DLAKE31GBosgfJx6X8DJJ05C0TIQ0wuG?usp=sharing