Ministry of Education and Science of Ukraine

National Aerospace University
"Kharkiv Aviation Institute"

Department 202 «Theoretical Mechanics, Engineering and Robotic Systems»

APPROVED

Acting Head of Scientific
Methodical Committee

_____ M.S. Romanov

«30» _____August_____2021

WORKING PROGRAM OF COMPULSORY ACADEMIC DISCIPLINE

"Engineering Mechanics (Theoretical Mechanics and Theory of Mechanisms and Machines) (Term ProjectP)"/ТЕОРЕТИЧНА МЕХАНІКА ТА ТЕОРІЯ МЕХАНІЗМІВ І МАШИН (КУРСОВИЙ ПРОЕКТ)(іноземною мовою)

(name of academic discipline)

Fields of study: 13 «Mechanical Engineering»,
27 «Transport Services»
Specialities: 134 «Aviation and Aerospace Technologies»,
272 «Aviation Transport»

Educational programs: «Airplanes and helicopters»,
«Design and production of constructions from composite materials»,
«Production technologies of aircrafts»,
«Aircraft engines and power plants»,
«Satellites, engines and power plants»
«Maintenance service and repair of aircrafts and aircraft engines»
«Супутники, двигуни та енергетичні установки. Інженерно технічний переклад)»

Full-time tuition
Level of higher education: bachelor's (first cycle)

Kharkiv 2021

Working program of academic discipline “Engineering Mechanics (Theory of Mechanisms and Machines) (TP)” is for students of program subject areas 134 «Aviation and Aerospace Technologies» and 272 «Aviation Transport»
Educational programs: «Airplanes and helicopters»
«Design and production of constructions from composite materials»,
«Production technologies of aircrafts»,
«Aircraft engines and power plants»,
«Satellites, engines and power plants»
«Maintenance service and repair of aircrafts and aircraft engines»
«Супутники, двигуни та енергетичні установки. Інженерно технічний переклад)»

June, 25, 2021 - 8 p.

Developers:
Olga Kladova, Associate Professor of Department «Theoretical Mechanics, Engineering and Robotic Systems», PhD _____
Anna Kuznetsova, Associate Professor of Department «Theoretical Mechanics, Engineering and Robotic Systems», PhD _____

Working program was approved at the meeting of Department 202 «Theoretical Mechanics, Engineering and Robotic Systems»
Minutes #11 – June 30, 2021

Head of Department, DSc, Professor_____ O.O. Baranov

1. Description of the discipline

<table>
<tr><td rowspan="2">Characteristics</td><td rowspan="2">Branch of science, specialization, academic degree</td><td>Description of the discipline</td></tr>
<tr><td>full-time tuition</td></tr>
<tr><td>Credits – 2</td><td rowspan="3">Fields of study:
13 «Mechanical Engineering»,
27 «Transport Services»</td><td>Compulsory</td></tr>
<tr><td>Modules – 1</td><td rowspan="2">Academic year:</td></tr>
<tr><td>Thematic modules – 1</td></tr>
<tr><td rowspan="3">Individual research assignment «Design and analysis of mechanisms of aircraft engineering»</td><td rowspan="3">Specialities:
134 «Aviation and Aerospace Technologies»,
272 «Aviation Transport»</td><td>2021/ 2022</td></tr>
<tr><td>Semester</td></tr>
<tr><td>4th</td></tr>
<tr><td>Total number of academic hours – 32/60</td><td rowspan="3"></td><td>Lectures, a.h.</td></tr>
<tr><td rowspan="6">Number of weekly academic hours for full-time tuition:
auditorium – 1
independent work – 2,75</td><td>-</td></tr>
<tr><td>Practices, seminars, a.h.</td></tr>
<tr><td rowspan="3">Level of higher education:
bachelor’s (first cycle)</td><td>32</td></tr>
<tr><td>Laboratory activities, a.h.</td></tr>
<tr><td>-</td></tr>
<tr><td rowspan="6"></td><td>Independent work, a.h.</td></tr>
<tr><td>28</td></tr>
<tr><td>Individual task, a.h.</td></tr>
<tr><td>-</td></tr>
<tr><td>Form of examination</td></tr>
<tr><td>credit with grade</td></tr>
</table>

Note: ratio between classroom hours and student independent work hours for full-time education is equal: 16/44=0,37

2. The objective and outcomes of the course

2. The objective and outcomes of the course

The **objective** of the course is learning of methods of kinematic and dynamic analysis and synthesis of mechanisms to gain experience and practical skills in solving problems related to research mechanisms and components of aviation equipment.

The **task** of the course is to provide students with the knowledge and skills to design and research the mechanisms and machines and to explore the topics of kinematics and dynamics of machinery in respect to the synthesis of mechanisms in order to accomplish desired motions or tasks, and also the analysis of mechanisms in order to determine their dynamic behavior.

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

C02. Ability to communicate in a foreign language.

C06. Ability to generate new ideas (creativity).

C07. Ability to make informed decisions.

C08. Ability to learn and master modern knowledge.

C11. Ability to use theories of flight dynamics and control in the design of rocket and space technology.

C15. Ability to design and test elements of rocket and space technology, its equipment, systems and subsystems.

Program learning outcomes:

PLO02. Fluent in oral and written foreign language on professional matters.

PLO06. Have the skills of self-study and autonomous work to improve professional skills and solve problems in a new or unfamiliar environment.

PLO11. Have the skills to determine the loads on the structural elements of rocket and space technology at all stages of its life cycle.

PLO16. Apply modern methods of design, construction and production of elements and systems of rocket and space technology in professional activities.

PLO20. Understand and justify the design features and basic aspects of work processes in systems and elements of rocket and space technology.

Interdisciplinary connections: Physics, Theoretical Mechanics, Machine Elements, Higher Mathematics, Applied Mechanics, Construction Mechanics.

3. Course Content

Thematic Module №1. Carrying out term project «Synthesis and analysis of lever mechanism and planetary gearing».

1. Synthesis and structural analysis of lever mechanism.

2. Kinematical analysis of lever mechanism by graph-analytical method. Construction of combined velocity diagrams and combined acceleration diagrams.

3. Force analysis of lever mechanism. Determination of reactions in kinematic pairs of lever mechanism and balancing force (balancing moment) by Bruevich's method.

4. Dynamical analysis of mechanism. Determination of energy and mass characteristics.

5. Determination of motion law of mechanism links. Construction of diagrams.

6. Design of planetary gearing. Kinematic analysis of planetary gearing by analytical method.

7. Construction of linear and angular velocity diagrams of planetary gearing.

8. Analysis of qualitative indicators of involute gearing: transverse contact ratio, specific sliding, geometry coefficient of specific pressure. Selection of optimal variant of gear. Construction of diagrams of qualitative indicators.

9. Execution of explanatory and calculation report.

4. Course arrangement

Names of Modules and Topics	Number of hours					
	full-time tuition					
	total	namely				
		lec	pr	lab	ind	i.w.
1	2	3	4	5	6	7
Module 1						
Thematic Module 1. Carrying out term project «Synthesis and analysis of lever mechanism and planetary gearing»						
TOPIC 1. Synthesis and structural analysis of lever mechanism.	5		2			3
TOPIC 2. Kinematical analysis of lever mechanism by graph-analytical method. Construction of combined velocity diagrams and combined acceleration diagrams.	8		4			4
TOPIC 3. Force analysis of lever mechanism. Determination of reactions in kinematic pairs of lever mechanism and balancing force (balancing moment) by Bruevich's method.	7		4			3
TOPIC 4. Dynamical analysis of mechanism. Determination of energy and mass characteristics.	7		4			3
TOPIC 5. Determination of motion law of mechanism links. Construction of diagrams.	5		2			3
TOPIC 6. Design of planetary gearing. Kinematic analysis of planetary gearing by analytical method.	9		6			3
TOPIC 7 Construction of linear and angular velocity diagrams of planetary gearing.	7		4			3
TOPIC 8. Analysis of qualitative indicators of involute gearing: transverse contact ratio, specific sliding, geometry coefficient of specific pressure. Selection of optimal variant of gear. Construction of diagrams of qualitative indicators.	7		4			3
TOPIC 9. Execution of explanatory and calculation report.	5		2			3
Totally for thematic module 1	**60**		**32**			**28**
Totally for term	**60**		**32**			**28**

5. Practices

№	Name	Hours
1	Synthesis and structural analysis of lever mechanism.	2
2	Kinematical analysis of lever mechanism by graph-analytical method. Construction of combined velocity diagrams and combined acceleration diagrams.	4
3	Force analysis of lever mechanism. Determination of reactions in kinematic pairs of lever mechanism and balancing force (balancing moment) by Bruevich's method	4
4	Dynamical analysis of mechanism. Determination of energy and mass characteristics	4

5	Determination of motion law of mechanism links. Construction of diagrams.	2
6	Design of planetary gearing. Kinematic analysis of planetary gearing by analytical method.	6
7	Construction of linear and angular velocity diagrams of planetary gearing.	4
8	Analysis of qualitative indicators of involute gearing: transverse contact ratio, specific sliding, geometry coefficient of specific pressure. Selection of optimal variant of gear. Construction of diagrams of qualitative indicators.	4
9	Execution of explanatory and calculation report.	2
	Total	32

6. Independent work

№	Name	Hours
1	Synthesis and structural analysis of lever mechanism.	3
2	Kinematical analysis of lever mechanism by graph-analytical method. Construction of combined velocity diagrams and combined acceleration diagrams.	4
3	Force analysis of lever mechanism. Determination of reactions in kinematic pairs of lever mechanism and balancing force (balancing moment) by Bruevich's method	3
4	Dynamical analysis of mechanism. Determination of energy and mass characteristics	3
5	Determination of motion law of mechanism links. Construction of diagrams.	3
6	Design of planetary gearing. Kinematic analysis of planetary gearing by analytical method.	3
7	Construction of linear and angular velocity diagrams of planetary gearing.	3
8	Analysis of qualitative indicators of involute gearing: transverse contact ratio, specific sliding, geometry coefficient of specific pressure. Selection of optimal variant of gear. Construction of diagrams of qualitative indicators.	3
9	Execution of explanatory and calculation report.	3
	Total	**28**

7. Teaching methods

Practices; development of term project under the supervision of teacher, individual consultations; student self-study with the help of tutorials published by department.

8. Grading

Credit with grade.

9. Points distribution on term project

9.1 Points in module system

Test and individual work		Defence of project	Total points
Explanatory and calculation report	Drawings		
15	35	50	100

9.2 Qualitative evaluation criteria

The amount of knowledge required to obtain a positive assessment.

Student should know:

- classification and scope of mechanisms use;
- general methods of design and research of mechanisms;
- mathematical modeling of mechanical systems dynamics;
- methods of kinematic synthesis and analysis of mechanisms including aircraft engines units;
- methods of dynamic analysis and synthesis of mechanisms

The required amount of skills to receive a positive assessment.

The student must be able to:

- formulate a mathematical model of studied mechanical system (motion, balance);
- use modern methods of kinematic and dynamic analysis for mechanisms research;
- carry out an analysis of mathematical calculations;
- make structural analysis of mechanisms;
- project kinematic diagrams of mechanisms according to structural, kinematic and dynamic conditions;
- use mathematical methods of gear mechanisms research;
- choose rational schemes of planetary gears for aircraft engineering.

9.3 Criteria for assessing student work during the semester

Satisfactory (60-74). Have a sufficient minimum of knowledge and skills. Perform and protect all tasks included in the calculation work. Know the equilibrium conditions for different types of force systems. Know what the kinematic and dynamic equations of translational, rotational and axis rotation and plane-parallel motion. Be able to do structural analysis of mechanisms, synthesis of planetary, differential gear trains and lever mechanisms and determine mobility of mechanisms.

Good (75-89). Perform and protect in the time specified in the work program all tasks that are part of the calculation work. Know the equilibrium conditions for different types of force systems. Know what the kinematic and dynamic equations of translational, rotational and axis rotation and plane-parallel motion. Be able to do kinematic analysis of lever mechanisms by means of analytical and graph-analytical methods. Show the ability to analyze the results of solving practical problems. Know and be able to put into practice methods of describing the motion (or equilibrium) of a mechanical system in generalized coordinates. Be able to create dynamic model of mechanism. Be able to determine geometrical parameters of involute gears.

Excellent (90 - 100). It is unmistakable to execute and protect with maximum marks and within the time specified by the teacher, all tasks that are part of the calculation work. Full knowledge of basic and additional material. Navigate your textbooks and guides. Be able to deduce and explain any formula and prove any theorem provided by the program. Show the ability to analyze the results of solving practical problems

National scale and ECTS grade

<table>
<tr><td rowspan="2">Total score</td><td rowspan="2">ECTS scale</td><td colspan="2">Mark on national scale</td></tr>
<tr><td>exam, course project</td><td>credit</td></tr>
<tr><td>90 – 100</td><td>A</td><td>Excellent</td><td rowspan="5">Passed</td></tr>
<tr><td>83 – 89</td><td>B</td><td rowspan="2">Good</td></tr>
<tr><td>75 – 82</td><td>C</td></tr>
<tr><td>68 -74</td><td>D</td><td rowspan="2">Satisfactory</td></tr>
<tr><td>60 – 67</td><td>E</td></tr>
<tr><td>1 – 59</td><td>FX</td><td>Fail (exam repeating is possible)</td><td>Failed (credit repeating is possible)</td></tr>
</table>

10. Procedural guidelines

1. Theoretical mechanics. Kinematics: Tutorial for self-education / V. N. Pavlenko, I. V. Bunyaeva, S. S. Vorozhko et al. – Kharkov: National Aerospace University named after N. Ye. Zhukovskiy «Kharkov Aviation Institute», 2012. – 96 p. http://library.khai.edu/library/fulltexts/metod/Pavlenko_Theoretical_Mechanics.pdf
2. Theoretical mechanics. Dynamics: Textbook / V. N. Pavlenko, I. V. Bunyaeva, S. S. Ternovskaya et al. – Kharkov: National Aerospace University named after N. Ye. Zhukovskiy «Kharkov Aviation Institute», 2013. – 184 p. http://library.khai.edu/library/fulltexts/metod/Theoretikal_Mechanik.pdf
3. http://elartu.tntu.edu.ua/bitstream/lib/26905/1/nove_TMM_angl_metod_2018-converted%20%281%29.pdf

Handout referring to the actual topics is distributed during practices.

11. Recommended literature for the course

Basic

1. F.P. Beer and E.R. Johnston, Vector Mechanics for Engineers – Statics. Dynamics, McGraw Hill Book Company, 2003.

2. J.L. Meriam and L.G. Kraige, Engineering Mechanics – Statics. Dynamics, John Wiley & Sons, 2002.

3. John J. Uicker, Jr., Gordon R. Pennock, and Joseph E. Shigley, Theory of Machines and Mechanisms, Fifth Edition – McGraw-Hill series in mechanical engineering, 2017.

Auxiliary

1. R.S. Khurmi, J.K. Gupta, Theory of Machine - Eurasia Publishing House, 2015.

2. Thomas Bevan, The Theory of Machines – CBS Publishers and Distributors, 2016.

3. The Theory of Machines by Robert Ferrier McKay – Edward Arnold, London, 2017.

4. C.H. Jensen, J.D. Helsel, Engineering Drawing And Design. - McGraw-Hill Science, 7th Edition, 2015.

5. J. A. Collins, H. R. Busby, G. H. Staab, Mechanical Design of Machine Elements and Machines. - Wiley, 2nd Edition, 2018.

12. Information sources

PhD Kladova https://mentor.khai.edu/course/view.php?id=5186
PhD Kuznetsova https://mentor.khai.edu/course/view.php?id=6744