MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aviation University
Aerospace Faculty
Department of Applied Mechanics and Materials Engineering

AGREED

Dean of the Air Navigation, Electronics and Telecommunications Faculty

_____ Serhii ZAVHORODNII

«24» 09 2022

APPROVED

Vice-rector for Academics

_____ Anatolii POLUKHIN

«30» 09 2022

Quality Management System

COURSE TRAINING PROGRAM
on
"Mechanics"

Educational and Professional Program: "Piloting and Navigation Equipement Complexes"
Field of study: 17 "Electronics and Telecommunications"
Specialty: 173 "Avionics"

Form of training	Semester	Total (hours / ECTS credits)	Lectures	Practicals	Labs	Self-study	Home works	Term Paper	Form of semester control
Full-time:	3	120/ 4,0	17	17	17	69	-	-	Graded Test 3s
Part-time:	4	120/ 4,0	4	4	4	108	C/w 4s	-	Graded Test 4s

Index: CB-2-173-1/22-3.3
Index: CB-2-173-1з/22-3.3

The Course Training Program on "Mechanics" was developed on the basis of Educational and Professional Program «Piloting and Navigation Equipement Complexes», Curriculum № CB-2-173-1/22 and Extended Curriculum ECB-2-173-1/22 for the "Bachalor" educational degree specialists training for the Specialty 173 «Avionics» and corresponding normative documents.

Developed by:
Associate Professor
of Applied Mechanics and
Materials Engineering Department _____ Oleksandr BASHTA

Senior Lecturer of Applied Mechanics
and Materials Engineering Department _____ Inna SEMAK

Discussed and approved by Department of Applied Mechanics and Materials Engineering, Minutes №_8_ of "_26_" ___09___ 2022.

Head of the Department _____ Oksana MIKOSIANCHYK

Discussed and approved by the Graduate Department for the Specialty 173 «Avionics», Educational and Professional Program «Piloting and Navigation Equipement Complexes» – Avionics Department, Minutes №_15_ of "_26_" ___09___2022.

Guarantor of the Educational
and Professional Program _____ Oleksii CHUZHA

Head of the Department _____ Yurii HRYSHCHENKO

Vice Rector on International
Collaboration and Education

_____ Iryna ZARUBINSKA
"_29_ _09_____2022

Document level – 3b
The planned term between revisions – 1 year
Master copy

Contents:

INTRODUCTION

The Course Training Program on "Mechanics" is developed based on the "Methodical guidance for the subject course training program", approved by the order № 249/од, of 29.04.2021 and corresponding normative documents, international training programs for aviation professionals, in particular those coordinated by ICAO (International Civil Aviation Organization), EASA (European Aviation Safety Agency) and corresponding regulatory documents.

1. EXPLANATORY NOTE
1.1. Place, objectives, tasks of the subject
This discipline is the theoretical basis of the knowledge and skills that form the aviation profile of a specialist in the field of aircraft design and maintenance, required for design, manufacturing and maintenance of airplanes and helicopters.

Main target to study the discipline is the formation of future specialists' knowledge on structure, kinematics and dynamics of modern standard mechanisms and machines, bases of calculations, design and operation of electromechanical systems and their elements in the process of design of production, operation and repair.

The tasks of the discipline:
mastering the general principles of the study of the structure, kinematics and dynamics of mechanisms and machines, the basics of calculation and design of parts and components of general purpose, which are found in various electromechanical systems and industries.

1.2. Program learning outcomes
As a result of studying the discipline the student must acquire the following skills:
– modern engineering methods of calculations for strength, rigidity and stability;
– basics of experimental and theoretical methods for studying stresses and strains;
– computational calculation methods for solving engineering problems;
– the main types of mechanisms and machines used in various fields of technology;
– principles of construction of mechanisms and machines and features of their functioning;
– general methods of structural, kinematic and dynamic study of different types of mechanisms;
– methods of choice of materials and allowable stresses;
– methods of calculations of standard parts and mechanisms of aircraft equipment;
– stages of development of design documentation and the content of individual stages of design.
– develop engineering models and diagrams of structural elements;
– independently carry out design and verification calculations of structural elements with different types of deformations.
– develop a rational scheme of the mechanism;
– perform design calculation of individual parts and components for tensile strength, compression, bending, shear and torsion, as well as dynamic loads;

– solve separate problems of designing of mechanisms under the set initial conditions;

– form a technical task for the design of mechanisms and to determine the initial data.

1.3. Acquired competences

As a result of studying the discipline, the student must acquire the following competencies:

- the ability to solve complex specialized and practical problems related to the development, production and certification of aerospace and rocket technology, which involves the application of theories and methods of physics, mathematics and engineering, is characterized by complexity and uncertainty.
- ability to generate new ideas (creativity).
- ability to make informed decisions.
- ability to learn and master modern knowledge.
- ability to evaluate the technical and economic characteristics of avionics systems and devices.
- ability to develop and implement measures to diagnose, verify the performance and predict the reliability of avionics systems, troubleshooting and failures of avionics components, analyze the causes of their occurrence, develop and implement measures to prevent them.

1.4. Interdisciplinary Connections

The subject is based on following subjects, as: "Higher Mathematics", "Physics", "Electrical and radio engineering basics of avionics", and is the basis for the study of further disciplines, namely: "On-board information display and registration systems (ATA 25/44/46)"; "On-board automatic flight control systems (ATA 22)"; "Aircraft design and functional systems (ATA 21 / 26-30 / 32/35/36/38)"; "Instrumentation equipment and complexes of integrated avionics (ATA 31/42)"; "Maintenance and repair of avionics (ATA 45)".

2. COURSE TRAINING PROGRAM ON THE SUBJECT

2.1. The subject content

Educational material constructed according to the module principle and consists of two modules, namely: **Module №1 «Fundamentals of theoretical mechanics and strength of materials», Module №2 «Basics of machine elements»** which is logically completed, relatively independent, integral parts of the subject, learning of which involves modular control works and analysis of the results of its implementation.

2.2. Modular structuring and integrated requirements for each module

Module №1 "Fundamentals of theoretical mechanics and strength of materials"

Know:

-general methods of calculating individual parts and components for tensile, compressive, bending, shear and torsional strength, as well as dynamic loads;
-main types of mechanisms and machines used in various fields of technology and principles of construction and features of their operation;
-methods of material selection, allowable stresses and calculation of typical parts and mechanisms of electromechanical systems;
- methods of development of design documentation and the content of individual stages of design.

Learning outcomes:
-perform a kinematic study of gear mechanisms;
-determine the gear ratio of simple, complex and planetary gears;
-calculation of the strength of typical mechanical transmissions and mechanisms of electromechanical systems;
- perform design calculations for the strength of standard parts and assemblies in tension, compression, bending, shear and torsion, as well as under dynamic loads.

Topic 1. General issues of strength of materials.
Basic definitions. Basic hypotheses. Objects of study. Classification of external loads. Internal forces. Section method. Types of simple deformations of a bar. Deformations and stresses.

Topic 2. Tension and compression.
Normal forces and stresses. Hooke's law. Tension diagram. Permissible stresses. Fundamentals of strength calculations. Moving the cross sections of the beam. Calculations for rigidity.

Topic 3. Fundamentals of the theory of stress and strain.
The main stresses. Types of stress. Linear stress state. Flat stress state. Theories of strength. Landslide. Net shift.

Topic 4. Geometric characteristics of flat sections.
Basic definitions. Moments of inertia of the simplest sections. The main axes, the main moments of inertia.

Topic 5. Bending.
Bending. Calculation of flexural strength.

Topic 6. Torsion.
Rotation of a bar of round cross section

Module 2. "Basics of machine elements"
Know:
-construction of such parts as axles, shafts, bearings, couplings and methods of their calculation;
-construction of joints with bolts, screws and studs and methods of their calculation for strength;
- design of riveted and welded joints and methods of their calculation for strength.
Learning outcomes:

-solve individual problems of designing mechanisms according to the given initial conditions;

-form a technical task for the design of parts and mechanisms for general purposes;

-stages of development of design documentation and the content of individual stages of design;

-determine the forces and moments acting on the details of the rotational motion;

-develop a rational scheme of the mechanism;

- calculate on the strength of the parts of the rotational motion;

- calculate on the strength of the connection with bolts, screws and studs;

- calculate on the strength of riveted and welded joints;

to form a technical task for the design of mechanisms and to determine the initial data.

Topic 1. Mechanical transmissions.

Purpose and classification of transmissions. Basic kinematic and power relations. General issues of calculation and design of machine parts.

Topic 2. Gearings.

General information and classification of transmissions. Elements of the theory of engagement. Gear materials. Permissible stresses.

Topic 3. Straight-toothed cylindrical gears.

Basic geometric relations. Forces in gearing of spur gears.

Calculation of contact strength. Calculation of bending of cylindrical spur gears.

Topic 4. Helical cylindrical gears.

General Information. Basic geometric ratios of helical gears. Forces in the gearing of helical gears. Features of calculation for contact strength and bending of helical gears.

Topic 5. Bevel gears.

General Information. Basic geometric relations. Equivalent wheel. Forces in the gearing of a spur bevel gear. Calculation of the contact strength of a spur bevel gear.

Topic 5. Worm gears.

General information and classification of worm gears. Basic geometric relations. Worm gear efficiency. Forces in engagement. Materials and types of destruction of worm gears. Strength calculation and thermal calculation of worm gears.

Topic 6. Shafts and axles.

General Information. Design calculation of shafts.

Topic 7. Rolling bearings and couplings.

General information and classification of rolling bearings. Practical calculation of rolling bearings. Purpose and classification of couplings.

Topic 8. Threaded joints.

General Information. Geometric parameters and calculation of the strength of threaded joints.

Topic 9. Dowels, rivets and slotted joints

General information on keyway, rivet and slotted joints. Selection and calculation of prismatic dowels. Calculation of riveted and slotted joints..

2.3. Training schedule of the subject

№	Topic	Academic hours									
		Full-time					Part-time				
		Total	Lectures	Practicals	Labs	Self-study	Total	Lectures	Practicals	Labs	Self-study
1	2	3	4	5		6	7	8	9		10
Модуль №1 "Fundamentals of theoretical mechanics and strength of materials"											
		3 semester					**4 semester**				
1.1.	General issues of material strength.	5	1			4	4,5	0,5	-		4
1.2.	Tension and compression	11	2	2	2	5	6	1	-		5
1.3.	Fundamentals of the theory of stress and strain.	9	2	2		5	5,5	0,5	-		5
1.4.	Landslide. Net shift.	9		2	2	5	7	1	-		6
1.5	Geometric characteristics of flat sections.	9	2		2	5	7	1	-		6
1.6.	Module test №1	5			1	4	-	-	-		-
Total for module №1		**48**	**7**	**6**	**7**	**28**	**30**	**4**	**-**	**-**	**26**
Модуль №2 "Basics of machine elements"											
		3 semester					**4 semester**				
2.1	Mechanical transmissions. General issues of calculation and design of machine parts.	13	2	2	2	7	14		-	1	13
2.2.	Gearings.	14	2	2	2	8	14,5		0,5	1	13
2.3.	Straight-toothed, helical, bevel, planetary gears. Worm gears.	13	2	2	2	7	14,5		0,5	1	13
2.4.	Shafts and axles.	13	2	2	2	7	14,5		0,5	1	13
2.5.	Rolling bearings and couplings.	13	2	2	2	7	13,5		0,5		13
2.6	Threaded connections. Geometric parameters and calculation of the strength of threaded joints.						8	-	-		8
2.7	Module test №2	6	-	1		5		-	-		-
2.8	Final semester test						11	-	2		9
Total for module №2		**72**	**10**	**11**	**10**	**41**	**90**		**4**	**4**	**82**
Total for the discipline		**120**	**17**	**17**	**17**	**69**	**120**	**4**	**4**	**4**	**108**

2.4. Tasks for control (home) work (Part-time).

Control (homework) is performed in the fifth semester, in accordance with the approved guidelines, in order to consolidate and deepen the theoretical knowledge and skills of students and is an important step in mastering the material.

Control (homework) is performed on the basis of educational material submitted for independent study by students.

The specific purpose of control work (homework), depending on the variant of the task, is to perform the calculation and design of parts of gear drives mechanisms. Control (homework) work consists of calculation and graphic parts.

Execution, design and defense of the homework is carried out by the student individually in accordance with the guidelines.

Students receive tasks for homework from the methodical instructions developed by the department.

The time required to perform control work (homework) - 8 hours of independent work.

2.5. The list of questions for preparation for the final semester test (Part-time).

The list of questions and the content of tasks for preparation for the final semester test are developed by the leading teacher of the department in accordance with the work program, approved at the meeting of the department and communicated to the students.

3. BASIC CONCEPTS OF GUIDANCE ON THE SUBJECT

3.1. Teaching methods

It is recommended to use the following teaching methods during mastering the subject:

- explanatory and illustrative method;
- method of problem presentation;
- reproductive method;
- research method.

The implementation of these methods are carried out during lectures, demonstrations, self-study, work with the educational material, analysis and solution of problems.

Lectures and laboratory classes can be conducted in distance learning mode.

3.2. List of references
Basic literature

3.2.1. Vijay Kumar Jadon, Suresh Verma. (2015). Analysis and Design of Machine Elements. Second Edition. I K International Publishing house Pvt. Ltd. New Delhi.

3.2.2. R.S. Khurmij.K. Gupta. (2005). A Textbook Of Machine Design. A Textbook For The Students Of B.E. / B.Tech.,U.P.S.C. (Engg. Services); Section B Of A.M.I.E. (I)Eurasia Publishing House (Pvt.) Ltd. Ram Nagar, New Delhi-110 055.

3.2.3.   Закревський В. О. Технічна механіка: курс лекцій / В. О. Закревський. – К. : НАУ, 2005. – 280с.

3.2.4.   Закревський В.О. Механіка: навч. посібник / В. О. Закревський, М. Б. Штерн. – Київ: НАУ, 2014. – 320 с.

3.2.5.   Борозенець Г.М., Павлов В.М., Голубничій О.В.та ін. Прикладна механіка та основи конструювання: навч. посіб. К.: НАУ, 2015. – 356 с.

3.2.6.   Г.М. Борозенець, В.М. Павлов, І.В. Семак. Деталі машин./ Навчальний посібник. – К.: Видавничий дім «Кондор», 2021. – 220 с.

3.2.7.   Bashta O.V., Nosko P.L., Kornienko A.O. Mechanics. Guide to Practical Classes. – K.: NAU, 2020.– 48 p.

Additional literature

3.2.8. Singh, A. (2017). Fundamentals of Machine Design. Cambridge: Cambridge University Press.

3.2.9. Khurmi R.S. (2010). A Textbook of Applied Mechanics. S Chand & Co Ltd.

3.2.10. Mechanics. Method Guide to Doing Homework Assignments / Authors: O.V.Bashta, A.O.Kornienko, A.S.Kryzhanovskyi – K.: NAU, 2013. – 48 p.

3.3. Internet Information resource

3.3.1 http://nau.edu.ua/ua/menu/science/instutional-repository.html

3.3.2. https://er.nau.edu.ua/handle/NAU/43244

3.3.3. https://er.nau.edu.ua/handle/NAU/40475

3.3.4. https://er.nau.edu.ua/handle/NAU/45798

3.3.5. https://er.nau.edu.ua/handle/NAU/40147

3.3.6. https://web.njit.edu/~vitaly/HONORS111/notes111h.pdf

3.3.7. http://giacr.ac.in/notes/Diploma/engg_mechanics.pdf

3.3.8. http://www.nptelvideos.in/2012/12/design-of-machine-elements.html

4. RATING SYSTEM OF KNOWLEDGE AND SKILLS GRADE

4.1. Grading of individual types of student work done in points in accordance with table 4.1.

Table 4.1

Kind of Academic Activities	Max Grade		Kind of Academic Activities	Max Grade	
	Full-time	Part-time		Full-time	Part-time
	3 s	4 s		3 s	4 s
Module №1 «Fundamentals of theoretical mechanics and strength of materials»			**Module № 2 «Basics of machine elements»**		
Doing and defence of practical and lab works	25 (sum)	20	Answers to theoretical questions during lectures	25 (sum)	20 (sum)
			Doing and defence of	20	-

			practical and lab works		
		-	Execution and defending of control (home) work (part-time)	-	30
For carrying out a module test №1, a student must receive not less	*15*	–	*For carrying out a module test №2, a student must receive not less*	15	
			Final semester test of Part-time	-	**30**
Carrying out a module test №1	15	–	Carrying out a module test №2	15	–
Total for the module №1	**40**	--	**Total for the module №2**	**60**	
Total for module №1, №2				**100**	**100**
Total for the Subject				**100**	

4.2. Completed types of educational work are credited to the student, if he received a positive rating for them.

4.3. The sum of rating assessments received by the student for certain types of completed academic work is the current modular rating assessment, which is recorded in the module control.

4.4. The final modular rating obtained by the student based on the results of the course defense and defense in points, on the national scale and ECTS scale is entered in the module control, as well as in the study card, individual student curriculum and Diploma Supplement, for example, as follows: ***92 / Excellent / A, 87 / Good / B, 79 / Good / C, 68 / Sat./D, 65 / Sat./E, etc.***

4.5. The final semester rating is converted into a grade on the national scale and the ECTS scale.

4.6. The final semester rating in points, on the national scale and the ECTS scale is entered in the test report, study card and individual curriculum of the student (record book), for example, as follows: ***92 / Excellent / A, 87 / Good / B, 79 / Good / C, 68 / Sat./D, 65 / Sat./E, etc.***

4.7. The Total Grade for the subject is equal to the average grade from Total Semester Grades with its further transformation into national scale and ECTS system.

The Total Grade is recorded to the Diploma Appendix

(Ф 03.02 – 01)

АРКУШ ПОШИРЕННЯ ДОКУМЕНТА

№ прим.	Куди передано (підрозділ)	Дата видачі	П.І.Б. отримувача	Підпис отримувача	Примітки

(Ф 03.02 – 02)

АРКУШ ОЗНАЙОМЛЕННЯ З ДОКУМЕНТОМ

№ пор.	Прізвище ім'я по-батькові	Підпис ознайомленої особи	Дата ознайом- лення	Примітки

(Ф 03.02 – 04)

АРКУШ РЕЄСТРАЦІЇ РЕВІЗІЇ

№ пор.	Прізвище ім'я по-батькові	Дата ревізії	Підпис	Висновок щодо адекватності

(Ф 03.02 – 03)

АРКУШ ОБЛІКУ ЗМІН

№ зміни	№ листа (сторінки)				Підпис особи, яка внесла зміну	Дата внесення зміни	Дата введення зміни
	Зміненого	Заміненого	Нового	Анульо- ваного			

(Ф 03.02 – 32)

УЗГОДЖЕННЯ ЗМІН

	Підпис	Ініціали, прізвище	Посада	Дата
Розробник				
Узгоджено				
Узгоджено				
Узгоджено				