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

Department № 403“Composite Structures and Aviation Materials”
(department title)

APPROVED BY

Project team leader / Head of SMC
_____ Shevtsova M.A.

«____»_____2020

GRADUATING PROGRAM OF EDUCATIONAL DISCIPLINE

Experimental testing of composite structures
(title of the discipline)

Branch of knowledge: 13 "Mechanical Engineering"
(code and title of brunch of knowledge)

Specialty: 134 "Aerospace Engineering"
(code and title of specialty)

Educational program: Design and Manufacturing of Composite Constructions
(title of educational program)

Level of higher education: first (Bachelor)

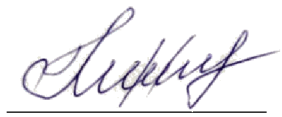
Kharkiv – 2020

Graduating program Experimental testing of composite structures

For students of specialty:134 "Aerospace Engineering".
Educational program:Design and Manufacturing of Composite Constructions

«___» _____ 2020, _– 11 pages.

Program was developed by associate professor of 403 dept., associate professor
(surname and initials, position held, scientific rank, academic rank)

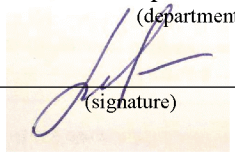


_____ S..M. Purhina ____
(signature) (initial and surname)

Program was approved by department of Composite Structures and Aviation Materials

Protocol № _1_from «31» 08. 2020.

Head of department ofComposite Structures and Aviation Materials, Ph.D, associate professor
(department title, head of department scientific rank and academic rank)



_____ M.A. Shevtsova____
(signature) (initial and surname)

1. Description of educational discipline

<table>
<tr><td rowspan="2">Indicators</td><td rowspan="2">Branch of knowledge, Specialty, Educational program, Level of higher education</td><td>Characteristics of educational discipline</td></tr>
<tr><td>Daily form of studying</td></tr>
<tr><td>Кількістькредитів – 4</td><td rowspan="11">Branch of knowledge
13 "Mechanical Engineering"
(code and title of brunch of knowledge)

Specialty
134 "Aerospace Engineering"
(code and title of specialty)

Educational program:Design and Manufacturing of Composite Constructions
(title of educational program)

Level of higher education
first (Bachelor)</td><td>General vocational training cycle</td></tr>
<tr><td>Modules – 2</td><td>Years of studying:</td></tr>
<tr><td>Substantial modules – 3</td><td>2020/2021</td></tr>
<tr><td>Individual scientific-researchtask
_____
(title)</td><td>Semester</td></tr>
<tr><td rowspan="2">Total hours – 150</td><td>8-rd</td></tr>
<tr><td>Lectures²⁾</td></tr>
<tr><td rowspan="2">Weekly rate for daily form of studying¹⁾ (hours):
auditoria – 3
self-studying –6</td><td>24hrs</td></tr>
<tr><td>Practical, seminar classes²⁾</td></tr>
<tr><td>- hrs</td></tr>
<tr><td>Laboratory classes²⁾</td></tr>
<tr><td>24hrs</td></tr>
<tr><td>Self-studying</td></tr>
<tr><td>102hrs</td></tr>
<tr><td>Control type:</td></tr>
<tr><td>exam</td></tr>
</table>

Notes.

[1)]The ratio between auditoria classes to self-studying and individual studying (hours): for daily form of studying – 48/102.

[2)]Auditory load may be reduced or increased by one hour, depending on the schedule of classes.

2. Objective and tasks of the subject

Objectiveof this course is to study the test methods of composite elements, equipment and testing equipment; and basic methods of experimental data processing.

Taskis study some skills to determine the actual physical and mechanical characteristics (FMC) of the composite material, their dependence on technological factors and changes in environmental conditions. Studyofequipmentand facilities for experiments.Mastering the methods of mathematical analysis of the obtained data.

As result of studying students have to:

know:

- methods and means of static tests of composite samples;
- methods and means of special tests of composite samples;
- methods of processing the results of experimental research.

have ability:

- identify samples for different tests;
- determine the loading conditions of products, their units and elements;
- process the results of experiments
- about standard and non-standard equipment for testing.

3. Graduating program

Module 1

Substantialmodule 1.Methods and means of static tests of composite samples.

Topic 1.Introduction.The purpose and objectives of the course.The main types of mechanical tests.Features of tests of composite samples. Characteristics determined during tests of composite samples. Types of samples. Influence of technological factors. Testing of composite components.

Topic 2.Instruments for measuring displacements.Mechanical strain gauges.Optical and electrical devices.Other ways to measure displacements.

Topic 3.Statistical calculation of test results.Organization and planning of the experiment.

Topic 4.Tensile tests.Shape and dimensions of samples.Equipment.Loading of flat samples at different angles to the direction of reinforcement. Tensile tests of annular specimens.

Topic 5.Compression tests.Shape and dimensions of samples.Equipment.Methods of loading.Requirements for methods of attaching samples. Compression of flat and ring samples.

Topic 6.Testing of samples for shear. Methods of studying shear resistance. Torsion of thin-walled pipes.Distortion of the plate.Rotation of a square plate.

Topic 7.Testing of samples for three-point bending. Test methods and

calculation of results. Equipment.Sample parameters.Limits of use.Testing of samples for four-point (pure) bending. Test methods and calculation of results. Equipment.Sample parameters.Modular control.

Substantial module 2.Methods and means of special tests of composite samples

Topic 8.Testing of samples at high and low temperatures.Determination of the coefficient of linear thermal expansion of the composite. Test methods and calculation of results. Equipment.Sample parameters.

Topic 9. Fatigue test samples. Methods of testing and processing the results.Equipment.Sample parameters and non-standard test equipment.Tests of samples for creep and long-term strength. Test methods and calculation of results. Equipment.Sample parameters.

Topic 10.Chemical tests, aging, optical tests, electrical.Modular control.

Module 2.

Substantial module 3. Static tests of assemblies, units and products from composites

Topic 11.Testing of three-layer structures with honeycomb tensile filler.Features of testing methods and processing of results.Equipment.Sample parameters.

Topic 12.Defining the parameters of the connecting layer.Short beam method.Determination of the pliability of fasteners.

Topic 13.Statement of the problem for testing aircraft units.Features of load modeling.Laboratories of static tests of aircraft and their equipment.

Topic 14.Statement of the problem for testing aircraft units.Features of load modeling.Modular control.

Module 3.

Exam on the above topics.

4. The subject arrangement

Substantial modules and topics	Hours for Daily form				
	Total	including			
		L	pr	lab	s.s
1	2	3	4	5	6
Module 1					
Substantial module1. Experiment and preliminary calculation of experimental data					
Topic 1. Introduction to the course	5	1	–	–	4
Topic 2. Displacement measuring devices.	5	1	–	–	4
Topic 3. Calculation of testing results	8	2	–	–	6
Topic 4. Tensile tests	7	1	–	2	4
Topic 5. Compression tests	7	1	–	2	4
Topic 6. Shear tests	8	2	–	2	4
Topic 7. Bending tests	10	2	–	2	6
Module control	2	–	–	2	–
Total in substantial module 1	**52**	**10**	–	**10**	**32**
Substantial module2. Methods and means of special tests of composite samples					
Topic 8. Testing of samples at high and low temperatures.	10	2	–	–	8
Topic 9. Fatigue test samples. Tests of samples for creep and long-term strength.	12	2	–	2	8
Topic 10. Chemical tests, aging, optical tests, electrical	16	2	–	4	10
Module control	2	–	–	2	–
Total in substantial module 2	**40**	**6**	**–**	**8**	**26**
Module 2 **Substantial module 3.** Static tests of assemblies, units and products made of composites					
Topic 11. Testing of three-layer structures with honeycomb tensile filler.	16	2	–	2	12
Topic 12. Defining the parameters of the connecting layer. Short beam method. Determination of the pliability of fasteners.	14	1	–	2	10
Topic 13. Statement of the problem for testing aircraft units. Laboratories of static tests of aircraft and their equipment.	12	1	–	–	10
Topic 14. Statement of the problem for testing aircraft units.	14	2	–	–	12
Module control	2	–	–	2	–
Total in substantial module 3	**58**	**6**	–	**6**	**44**
Total hours	**148**	**22**	–	**24**	**102**
Module 3					
Individual task	–	–	–	–	–
Exam	2	2	–	–	–
Total hours	**150**	**24**	–	**24**	**102**

7. Topics of labs

Nb.	Topics	Hours
1	Production of samples for tensile, shear, compression, bending test	2
2	Determination of modulus of elasticity, Poisson's ratio, tensile strength of specimens in the tensile test using a contactless displacement recorder	2
3	Comparison of the results of the test for the rupture of fiberglass samples with different stacking structure using Student's criteria	2
4	Determination of the tensile strength for composite samples in the compression test	2
5	Comparison of strength limits for fiberglass specimens in the test for rupture of specimens with a structure of ± 45 ° and in the shear test	2
6	Testing of samples for three-point bending. Determination of strength limit. Determination of the modulus of	2
7	Determination of the influence of aggressive conditions on the tensile strength of fiberglass samples	2
8	Checking the structure of samples by calcination.	2
9	Determination of the tensile strength for composite three-layer samples in the bending test	2

8. Self-studying topics

Nb.	Topics	Hours
1	Statistical processing of experimental results (mathematical expectation, standard scattering, coefficient of variation, etc.)	8
2	Tensile testing of annular specimens using an elastic element. Compression test of annular samples by means of an elastic element. Rotationoftherings	8
3	Principles of operation and kinematic schemes of displacement meters, areas of their use	6
4	Shear tensile testing of the anisotropic plate	6
5	Shear test in the stacking plane using a four-chain articulated device	6
6	Graphoanalytical method for determining the bending modulus at three-point bending taking into account the influence of shear force	8
7	Use of the short beam method for testing samples of three-layer panels with honeycomb filler	6
8	Cutting test. Rotation of straight rods	6
9	Testing of samples at elevated and reduced temperatures. Heat resistance, methods of Vic, Martens, etc. Thefragilityofthepolymermatrix, researchmethods	8
10	Tests of samples for long-term strength, methods of implementation. Cyclic loads. Influence of temperature and aggressiveness of the environment.	6
11	Investigation of the influence of biological organisms / environment on the strength of composite samples.	8
12	Types of three-layer composite structures. Featuresofmechanicalresearch.	6

13	Determination of the pliability of microfasteners. Features of testing adhesive joints.	6
14	Electrical measuring circuits. Strain gauge equipment. Preparation and measurement of deformations using strain gauges.	6
15	Means of modeling the thermal effect on the aircraft. Means of control of temperature of a design	8

9. Individual tasks

10. Methods of studying

Conduction of auditoria lectures, labs, individual consultation (if necessary), students self-studying by materials published by department (workbooks and textbooks).

11. Methods of control

Labs passing through multiple-choice testing, written module controls, final written exams (if required).

12. Score points distribution (example for exam)

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

Current testing and self-studying														Total
Substantial module 1							Substantial module 2			Substantial module 3				
T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	100
7	7	9	7	7	7	7	7	7	7	7	7	7	7	

Estimation of theoretical knowledge.

Theoretical part (55 score points MAXIMUM)		Practical part (45 score points MAXIMUM)*
Module 1 (25 points MAX)	Exam (50 points MAX)	9 Labs (5 points MAX for each)
Module 2 (30 points MAX)		

*Note: 2 point is added in the case of ALL labs fulfilling

Estimation of practical knowledge.

Maximum score points is 5 for a ONE lab FULFILLED and PASSED.

Lab report is filled fully and correctly	Lab is fulfilled practically	Labs passing**		
		"3"	"4"	"5"
1 point	1 point	1	2	3

Note: Necessary and required conditions for labs passing is **FULLY AND CORRECTLY FILLED REPORT AND PRACTICALLY FULFILLED LABORATORY CLASS. Without mentioned conditions student gets 1 point **ONLY**.

Estimation scale: national and ECTS

Total score by all studying activities	ECTS scale	Mark by national scale	
		forexam, course project (paper), internship	for credit
90 - 100	A	excellent	passed
82 - 89	B	good	
74 – 81	C		
64 -73	D	satisfactory	
60 – 63	E		
0 – 59	FX	not passed (repassing is allowed)	not passed (repassing is allowed)

12.2. Qualitative evaluation criteria

The required amount of knowledge to obtain a positive assessment:

Basic concepts and principles of experiment planning; Methods of experimental data processing; Methods of calculating the parameters of the mathematical model of the research object, assessing their significance, as well as the adequacy of the obtained model; Methods for finding the optimal conditions and extremum of the response function. Understand the principle of basic mechanical testing, know the method of calculating mechanical characteristics using standard equipment. Understand the principle of chemical testing. Know the special tests for composite materials to verify the structure of the stacking method of calcination.

The required amount of skills to obtain a positive assessment:

Carry out statistical processing of experimental results (elimination of gross errors, significance of regression coefficients, assessment of the adequacy of the mathematical model, check the normality of the distribution, compare two or more samples); Be able to describe mechanical tests for tension, compression, bending and shear. Be able to make samples to obtain mechanical characteristics. Be able to describe the type and operation of basic equipment for mechanical testing.

12.3 Criteria for evaluating student work during the semester

Satisfactory (60-74). Have a minimum of knowledge and skills. Work out and

defend all laboratory work. Be able to evaluate the results of experiments. Eliminate gross errors. Calculate the mean and coefficient of variation. Compare two sets of studies. Be able to compile technical documentation for the experiment. Understand what characteristics are determined by mechanical tests for tension, compression, bending and shear. Be able to prepare samples of composite materials for mechanical tests.

Good (75 - 89). Firmly know the minimum of knowledge, perform all tasks. Demonstrate the ability to perform and defend all laboratory work within the period specified by the teacher with a justification of the decisions and measures proposed. Be able to evaluate the results of experiments. Build a histogram. Eliminate gross errors. Calculate the mean and coefficient of variation. Compare two sets of studies. Be able to compile technical documentation for the experiment. Understand what characteristics are determined by mechanical tests for tension, compression, bending and shear. Be able to prepare samples of composite materials for mechanical tests.

Excellent (90 - 100). Fully know the basic and additional material. Know all topics thoroughly. Navigate in textbooks and manuals. Unmistakably perform and defend all laboratory work within the period specified by the teacher with a detailed justification of the decisions and measures proposed in the work. Be able to evaluate the results of experiments. Build a histogram. Eliminate gross errors. Calculate the mean and coefficient of variation. Compare two or more sets of studies. Be able to compile technical documentation for the experiment. Understand what characteristics are determined by mechanical tests for tension, compression, bending and shear.Understand what characteristics are determined by mechanical tests for tension, compression, bending and shear. Be able to prepare samples of composite materials for mechanical tests. Be able to build analytical dependence for one-factor research, analyze analytical and graphical data.

13. Methodological literature sources

Lectures workbooks and textbooks:

1. https://en.wikipedia.org/wiki/Student%27s_t-testStudent's t-test
2. https://en.wikipedia.org/wiki/Coefficient_of_determinationCoefficientofdetermination
3. ASTM D3039/D3039M-08 «Standard test method for tensile properties of polymer matrix composite materials.
4. ASTM D 3410/D 3410M-03(2008) Standard TestMethodforCompressivePropertiesofPolymerMatrixCompositeMaterialswithUnsupportedGageSectionbyShearLoading.
5. ASTM D4255/D4255M-15a "Standard TestMethodfor In-Plane ShearPropertiesofPolymerMatrixCompositeMaterialsbytheRailShearMethod".
6. ASTM D7078/D7078 M—12 «Standard testmethodforshearpropertiesofcompositematerialsby V-notched railshearmethod».
7. ISO 14129:1997* Fibre-reinforcedplasticcomposites - Determinationofthe in-planeshearstress/shearstrainresponse, includingthe in-planeshearmodulusandstrength, bytheplusorminus 45 degreetensiontestmethod.

8. ASTM D790-10 "Standard testmethodsforflexuralpropertiesofunreinforcedandreinforcedplasticsandelectricalinsulatingmaterials".
9. ASTM D2990-09 «Standard testmethodsfortensile, compressive, andflexuralcreepand creep-ruptureofplastics».
10. ASTM D3479/D3479 M-12 «Standard testmethodfor tension-tension fatigueofpolymermatrixcompositematerials».
11. ASTM D542 - 14 Standard TestMethodforIndexofRefractionofTransparentOrganicPlastics.
12. ASTM D1003 - 13 Standard TestMethodforHazeandLuminousTransmittanceofTransparentPlastics.
13. ASTM C297/C297 M-04 "Standard testmethodforflatwisetensilestrengthofsandwichconstructions".

Information resources

1. Department site:www.k403.khai.edu; faculty4.khai.edu.