Міністерство освіти і науки України
Національний аерокосмічний університет ім. М. Є. Жуковського
«Харківський авіаційний інститут»

Кафедра проектування літаків і вертольотів (№ 103)

ЗАТВЕРДЖУЮ

Керівник проектної групи
_____ О.Г. Гребеніков
(підпис) (ініціали та прізвище)

«31» серпня 2020 р.

РОБОЧА ПРОГРАМА ВИБІРКОВОЇ НАВЧАЛЬНОЇ ДИСЦИПЛІНИ

Інтегроване проектування літаків та вертольотів
(назва навчальної дисципліни)

Галузь знань: 13 «Механічна інженерія»
(шифр і найменування галузі знань)

Спеціальність: 134 «Авіаційна і ракетно-космічна техніка»
(код і найменування спеціальності)

Освітня програма: «Літаки і вертольоти»
(найменування освітньої програми)

Форма навчання: денна

Рівень вищої освіти: другий (магістерський)

Харків 2020 рік

Робоча програма «Інтегроване проектування літаків та вертольотів»
(назва дисципліни)
для студентів за спеціальністю: 134 «Авіаційна і ракетно-космічна техніка»
освітньою програмою: «Літаки і вертольоти»

«31» 08 2020 р., 13 с.

Розробники: Гребеніков О.Г., завідувач каф. № 103, д.т.н., професор
Урбанович В.А., доцент каф. №103
Трубаєв С.В., доцент каф. №103, к.т.н.
(прізвище та ініціали, посада, науковий ступінь та вчене звання) (підпис)

Робочу програму розглянуто на засіданні кафедри проектування літаків та вертольотів
(назва кафедри)

Протокол № 1 від "31" 08 2020 р.
Завідувач кафедри д.т.н., професор О.Г. Гребеніков
(науковий ступінь та вчене звання) (підпис) (ініціали та прізвище)

1. **Description of discipline**

<table>
<tr><td rowspan="2">Name of indicators</td><td rowspan="2">regarding the knowledge, training direction (specialty, specialization) of higher education</td><td>Characteristics discipline</td></tr>
<tr><td>full-time education</td></tr>
<tr><td rowspan="2">Number of credits - 4</td><td>areas of knowledgeb
13 "Mechanical Engineering"
(code name)</td><td rowspan="2">Cycle
training</td></tr>
<tr><td rowspan="3">Profession
134 "Aviation and rocket and space technology"
(code and name)

Educational program
"Aircraft and helicopters"
(name)</td></tr>
<tr><td>number of modules - 1</td><td>Academic year:</td></tr>
<tr><td>Number of content modules - 1</td><td>2019/2020</td></tr>
<tr><td>Individual task
Methods of integrated design of aviation equipment
(title)</td><td></td><td>Semester</td></tr>
<tr><td>General number of hours - 120
number of classroom hours * /
total number of hours - 48/120</td><td rowspan="4">Level of higher education:
third (educational-scientific)</td><td>2nd</td></tr>
<tr><td rowspan="3">Number of weekly hours for full-time study:
classroom - 5
independent student work - 10</td><td>Lectures</td></tr>
<tr><td>24 hours.</td></tr>
<tr><td>Practical, seminar</td></tr>
<tr><td></td><td>16 hours.</td></tr>
<tr><td></td><td>Laboratory</td></tr>
<tr><td></td><td>-</td></tr>
<tr><td></td><td>Independent work</td></tr>
<tr><td></td><td>80 hours.</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td>exam</td></tr>
</table>

The ratio of the number of hours of classroom classes to independent work is:
for full-time study - 40/80.

2. Purpose and objectives of the discipline

Aim - the purpose of studying the discipline "Integrated design of aircraft and helicopters" is to teach students knowledge about the methodology of integrated design and modeling of aircraft and helicopters, their units and systems, equipment, assemblies, master geometry, space distribution model and analytical design standards using computer integrated systems. Acquire knowledge in the field of design of prefabricated units of regulated durability. Gain the necessary skills in the field of integrated design of aircraft and helicopters and master:

a) methods of research and calculations in determining the characteristics and parameters of prefabricated aircraft structures, taking into account the given resource;
b) methods of integrated design and modeling of aircraft units using computer systems.

Tasks - the main tasks of studying the discipline "Integrated design of aircraft and helicopters" are to provide students with knowledge of modern methods of design, construction and modeling of aircraft and helicopters of a given resource using computer integrated systems CAD / CAM / CAE; basic provisions of the Air Code of Ukraine, Airworthiness standards of aircraft and helicopters, certification of aircraft, basic principles of operation in CAD / CAM / CAE systems, basic requirements for the creation of "Standard Specification" for aircraft and manuals for maintenance and operation.

As a result of studying the discipline the student must

***know*:**

- modern technologies of design, construction and modeling of aircraft and helicopters;
- the place of computer integrated systems in the production of aircraft and helicopters;
- methods of modeling elements of aircraft and helicopters using the CAD / CAM / CAE system Siemens NX;
- modern requirements for flight safety under conditions of fatigue life of the glider;
- fatigue resistance characteristics of aviation materials;
- ways to ensure the resource of aircraft structures;
- methods of calculating the durability of structural elements with a stress concentrator, typical mobile and fixed connections;
- methods of ensuring the fatigue quality of typical prefabricated units of airplane and helicopter;
- methods of ensuring a given durability and survivability characteristics;
- methods of restoring the bearing capacity of glider and helicopter elements with fatigue cracks;
- methods of creating design and operational documentation in electronic form;

***be able to*:**

- create mathematical models of the outer surface of the aircraft and helicopter;
- create computer models of aircraft and helicopter construction elements;
- correctly calculate the impact of structural and technological parameters on the durability of structural elements and their connections;
- to choose constructive parameters of power elements, knots and their connections providing the set durability and durability at a minimum of weight and constructive and technological restrictions;
- to model power elements, their connections and prefabricated compartments of units using the CAD / CAM / CAE system Siemens NX;

***have an idea*:**

- about modern computer integrated systems;
- about the place of computer integrated systems in the system of design, production and operation of aircraft;
- principles and methods of CALS technologies.
- about perspective constructive-technological methods of providing a resource and operational survivability of a design of the glider of the plane and the helicopter;
- about methods of automation of calculation and design of designs of the plane and the helicopter taking into account fatigue;
- about scientific problems of providing a resource, maintainability, tightness and quality of an external surface of designs of the plane and the helicopter;

- about mathematical modeling and creation of analytical standards of the plane and the helicopter;
- about the place of computer integrated systems in the system of design, production and operation of airplanes and helicopters.

Interdisciplinary links: the discipline is based on the knowledge gained in the study of disciplines: General structure of ARCT objects, Aerodynamics, Strength, Design of elements and units of ARCT, General design of aircraft and helicopters, Technology of aircraft production.

3. Curriculum

Content module 1.

Methodology of integrated design and modeling of prefabricated aircraft structures of regulated durability

TOPIC 1. The state of the problem of designing prefabricated aircraft structures regulated durability.
General issues of fatigue. Characteristics of fatigue resistance of structural irregularities. Analysis of design methods for prefabricated aircraft structures. Analysis of design methods taking into account the fatigue of shear bolted joints of prefabricated aircraft structures of regulated durability. Analysis of methods of designing riveted joints of prefabricated structures of aircraft of regulated durability. Analysis of methods for delaying the growth of fatigue cracks in prefabricated thin-walled structures of aircraft. Fatigue resistance of typical elements of aircraft structures.

TOPIC 2. The concept and scientific basis of the methodology of integrated design and achievement of regulated durability of prefabricated aircraft structures using CAD / CAM / CAE systems.
The concept and principles of integrated design of prefabricated aircraft structures. Method of analysis of influence of constructive-technological parameters on characteristics of volume stress-strain state of models of elements of regular zones of prefabricated structures of aviation equipment by means of CAD \ CAE ANSYS system. Fatigue resistance characteristics of typical elements of regular zones of prefabricated aircraft structures. Method for predicting fatigue life of holes with a hole. A method for predicting the durability of shear joints made with axial and radial tensions of hexagon bolts.

TOPIC 3. The method of integrated design and achievement of regulated durability of shear bolted joints of prefabricated aircraft structures.
Integrated analysis of the impact of bolt installation technology and load level on the characteristics of local VAT in the elements of a two-section single-row countersunk bolted connection using the ANSYS engineering analysis system. Analysis of the influence of bolt installation technology and load level on the characteristics of local VAT in the elements of a two-threaded three-row secret connection. Research of durability of models of typical secret bolted connections. Method of calculating the distribution of forces between rows in shear bolted joints of aircraft structures using the ANSYS engineering analysis system. A method for predicting the influence of structural and technological parameters of shear countersunk bolted joints on their durability. Methods of creating computer models of bolted joints of prefabricated aircraft structures using the Siemens NX system.

TOPIC 4. New design and technological solutions for shear bolted joints of prefabricated aircraft structures.
Increase of durability of connections by application of bolts with a three-conical countersunk head. Application of an adhesive layer for increase of durability of secret connections with local tension. The use of unloading holes to increase the durability of bolted joints. Use of unloading gaskets to increase the durability of shear bolted joints. Ways to increase the durability of joints of prefabricated panels with a socket profile. Increasing the durability of single-cut joints on a solid profile by local thickening of the pads in the area of the extreme row.

TOPIC 5. The method of integrated design and achievement of regulated durability of shear riveted joints of prefabricated thin-walled structures of aircraft.

Method of integrated design and modeling of typical riveting joints of prefabricated aircraft structures. Method of designing riveted joints of cladding of a given durability at the stage of sketch design. Methods of analysis of the influence of design and technological parameters on the characteristics of the local VAT riveting connection. Methods for calculating the distribution of forces between the rows of shear riveting joints. The method of studying the influence of size deviations formed during the manufacture of rivets and making holes for their installation, on the distribution of radial tension in the thickness of the package after the riveting process. Methods for predicting the influence of structural and technological parameters of concealed riveting joints on their durability.

TOPIC 6. New design and technological solutions for shear riveting joints of prefabricated thin-walled structures of aircraft.

Structural and technological methods of increasing the fatigue life of single-cut riveting joints by unloading the extreme rows. Rivets for high-resource concealed riveted joints. Concealed rivet with conical compensator and efficiency of its application in typical connections. The method and technology of riveting as a factor that increases the life of riveted joints and the quality of their outer surface.

TOPIC 7. New structural and technological methods and methods of delaying the growth of fatigue cracks to extend the life of prefabricated thin-walled structures of aircraft.

Investigation of ovalization of holes and stress-strain state in a plate with a fatigue crack. Influence of tightening of the bolts established in the apertures made in tops of a fatigue crack, on local VAT of a plate. Influence of radial tension of bolts on VAT of a plate with a fatigue crack and the openings executed on its length. Integrated methods for delaying the growth of fatigue cracks by installing bolts with radial tension and tightening at the top of the cracks. Structural and technological methods of extending the life of riveted joints of the walls of the spar.

TOPIC 8. Methods of integrated design and modeling of aircraft and helicopter units.

Methods of designing and modeling the wing, fuselage, tail, power plant, chassis, transmission, tail beam using computer integrated systems. Methods of creating master geometry, space distribution models and analytical standards of wing design elements, fuselage, tail, power plant, chassis, tail beam. Development of a computer model of an airplane and a helicopter.

TOPIC 9. Flax design tests of aircraft and helicopters.

Ground work and preparation of the experimental aircraft for the first test flight. Preparatory ground work on the plane. Flight crew training. Determination of mass, coordinates of the center of mass and moments of inertia. Ground tests and preparation of the helicopter for the first departure.

TOPIC 10. Methods of flight tests of aircraft.

Test program of the experimental aircraft. The first flight of the test aircraft. Determining the characteristics of stability and controllability of the aircraft. Determination of flight characteristics. Determination of maneuverability characteristics. Determination of takeoff and landing characteristics. Flight test of the aircraft for strength. Definition of operational restrictions. Flight tests of power plants and their systems. Flight certification tests.

TOPIC 11. Air Code of Ukraine.

Terms. Aviation rules of Ukraine. Use of airspace of Ukraine. Aircraft. Aviation personnel. The crew of the aircraft. Airfields and airports. Air routes and local airlines. Aircraft flights. International flights. Air transportation. Aviation works. Protection of aviation from acts of illegal intrusion. Investigation of aviation accidents.

TOPIC 12. Standards of airworthiness of aircraft and helicopters of the transport category.

General requirements for airworthiness. Flights. Strength. Design and construction. Propulsion. Equipment. Operational restrictions and information.

TOPIC 13. Certification of civil aircraft.

Legal bases of certification. Aviation rules used in the certification of aircraft. Stages of certification of aircraft type. Features of certification of some types of aircraft. Certification of aircraft production. The main documents governing the certification of production. Stages of production certification.

4. The structure of the discipline

Names of content modules and topics	Number of hours					
	daily form of					
	all	including				
		l	p	lab	ind	s.r.
1	2	3	4	5	6	7
Content module 1. ***Methodology of integrated design of aircraft and helicopters***						
Topic 1. The ***state of the problem of designing prefabricated aircraft structures of regulated durability***	6	2	-	-	-	4
Topic 2. ***The concept and scientific bases of methodology of integrated design and achievement of regulated durability of prefabricated structures of aviation equipment using CAD / CAM / CAE systems***	12	4	-	-	-	8
Topic 3. ***Method of integrated design and achievement of regulated durability of shear bolted joints of prefabricated aircraft structures***	8	2	4	-	-	2
Topic 4. ***New design and technological solutions for shear bolted joints of prefabricated aircraft structures***	8	2	-	-	-	6
Topic 5. ***Method of integrated design and achievement of regulated durability of shear riveted joints of prefabricated thin-walled structures of aircraft***	8	1	4	-	-	3
Topic 6. ***New design and technological solutions for shear riveted joints of prefabricated thin-walled structures of aircraft***	12	1	4	-	-	7
Topic 7. ***New design and technological methods and ways to delay the growth of fatigue cracks to extend the life of prefabricated thin-walled structures of aircraft***	12	2	4	-	-	6
Topic 8. ***Methods of integrated design and modeling of aircraft and helicopter units***	24	4	-	-	-	20
Topic 9. ***Flax design tests of aircraft and helicopters***	10	2	-	-	-	8
Topic 10. ***M methods of flight tests of aircraft***	7	1	-	-	-	6
Topic 11. ***Air Code of Ukraine***	3	1	-	-	-	2
Topic 12. ***Flight standards of aircraft and helicopters of transport category***	5	1	-	-	-	4
Topic 13. ***Certification of civil aircraft***	5	1	-	-	-	4
Total in content module 1	120	24	-	16	-	80

Total hours	**120**	**24**	**-**	**16**	**-**	**80**

5. Topics of seminars

№ s / n	Name of topic	Number of hours

Not provided by the program

6. Topics of practical classes

№ s / n	Name of topic	number of hours
1	2	3
1	Design based fatigue strength of structural elements airframe with holes and haltelnymy transitions	2
2	Effect of fretting corrosion on the durability of structural elements of aluminum alloy	2
3	Effect of radial tension durability bands with holes filled bushings, screws and rivets	2
4	arising fatigue durability hinge-bolt connections	2
5	Influence of type of rivets and quantity of their numbers on durability of shear riveted connections	2
6	Influence of constructive and technological factors on debt frequency of shear bolted joints	2
7	Influence of design parameters on the durability of longitudinal joints of the wall with the edge of the spar belt	2
8	Influence of cutouts on the durability of wing panels	2
	Total	**16**

7. Laboratory topics

№ s / n	Topic name	Number of hours
	Not provided by the program	

8. Independent work

№ s / n	Title of the topic	Number of hours
	Content module 1.	
1	Achieving regulated durability of prefabricated aircraft structures as a component of its competitiveness	4
2	Development of CAD / CAM / CAE systems and the need for their use in modern design	8
3	History of durability of elements and their of machine-building constructions. Fatigue curve as a characteristic of fatigue of elements and connections. Types of fatigue curves	2
4	Review of existing design and technological solutions for mobile and fixed joints of aircraft structures to ensure regulated durability	6
5	Methods of analysis of the impact of connection technology and the level of load on the characteristics of local VAT structural elements.	3

6	Existing rivets for high-resource concealed riveted joints Structural and technological methods for extending the life of riveted joints of thin-walled structures	7
7	Methods of delaying the growth of fatigue cracks in aircraft structures.	6
8	Methods for predicting fatigue life of units of aircraft structures. Methods of increasing the durability of joints in units. Methods of designing riveted joints of cladding of a given durability. Progressive rivets and their use in the assembly of aircraft units Methods of designing riveted joints of cladding of a given durability.	20
9	Preparation of the test aircraft for the first test flight. Preparatory ground work on aircraft and helicopters during flight design tests	8
10	Characteristics of stability and controllability, which are confirmed during flight tests of aircraft.	6
11	General and specific requirements of the Air Code for aircraft and helicopters	2
12	Structure and composition of the Aviation Rules used in the certification of aircraft. Familiarization with the structure and composition of the Aviation Rules (AP-21, AP-25, AP-27, AP-36, AP-39, etc.)	4
13	Basic documents governing the certification of production. Stages of production certification.	4
	Total	**80**

9. Individual tasks

1. Research of influence of constructive-technological factors on durability of typical constructive irregularities. Creation of a model of space distribution and analytical standards of structural elements of given zones of aircraft units. Preparation for the diploma project.

2. Creation of a master geometry of the surface of the aircraft, the design of which was performed during training in the specialty, which will be part of the diploma project.

10. Teaching methods

Conducting classroom lectures, practical work, individual consultations (if necessary), independent work of students on materials published by the department (manuals) and leading aviation organizations, use of Internet materials and electronic materials posted on the website of the department, the first round Olympiads in the specialty.

11. Methods of control

Conducting current control, written modular control, final control in the form of an exam.

12. Evaluation criteria and distribution of points received by students

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

Components of educational work	Points for one lesson (task)	Number of classes (tasks)	Total number of points
Content module 1			
Work on lectures	0… 1	16	0… 16
Execution and defense of practical works	0 .. .4	8	0 ... 32
Modular control	0… 52	1	0… 52
Total per module 1			**0… 100**

Semester control (examination) is carried out in case of refusal of the student from points of current testing and in the presence of admission to examination. During the semester exam the student has the opportunity to receive a maximum of 100 points.

The ticket for the exam consists of four questions. The maximum number of points for answering each question is 25 points.

12.2. Qualitative evaluation criteria The
required amount of knowledge to obtain a positive assessment:

- modern technologies for the design, construction and modeling of aircraft and helicopters;
- the place of computer integrated systems in the production of aircraft and helicopters;
- methods of modeling elements of aircraft and helicopters using the CAD / CAM / CAE system Siemens NX;
- modern requirements for flight safety under conditions of fatigue life of the glider;
- fatigue resistance characteristics of aviation materials;
- ways to ensure the resource of aircraft structures;
- methods of calculating the durability of structural elements with a stress concentrator, typical mobile and fixed connections;
- methods of ensuring the fatigue quality of typical prefabricated units of airplane and helicopter;
- methods of ensuring a given durability and survivability characteristics;
- methods of restoring the bearing capacity of glider and helicopter elements with fatigue cracks;
- methods of creating design and operational documentation in electronic form ;.

The required amount of skills to obtain a positive assessment: to

- create mathematical models of the outer surface of the aircraft and helicopter;
- create computer models of aircraft and helicopter construction elements;
- correctly calculate the impact of structural and technological parameters on the durability of structural elements and their connections;
- to choose constructive parameters of power elements, knots and their connections providing the set durability and durability at a minimum of weight and constructive and technological restrictions;
- to model power elements, their connections and prefabricated compartments of units using the CAD / CAM / CAE system Siemens NX;

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 practical work. Know: general issues of fatigue; concepts and principles of integrated design; methods of creating computer models of connections; the method of designing riveted joints of a given durability at the stage of sketch design; constructive-technological methods of increase of a resource of riveted connections of walls of a spar; methods of creating analytical standards of aircraft and helicopter design elements; ground and air test program; stages of certification and general provisions of the Air Code of Ukraine.

Good (75 - 89). To acquire a minimum of knowledge and skills, to perform all tasks, to defend all practical works in the term stipulated by the teacher with the substantiation of the accepted decisions. Analyze design methods taking into account durability and methods of growth retardation of fatigue cracks; results of researches of fatigue of bolted connections. To know constructive-technological means of increase of fatigue durability of riveted connections; methods of design and modeling of aircraft and helicopter units using computer integrated systems; flight certification test program; general requirements for airworthiness standards.

Excellent (90 - 100). Fully know the basic and additional material. Know all topics. Navigate in textbooks and manuals. Be able to analyze modern technologies of integrated design, construction and modeling of joints of structural elements of aircraft and helicopters, taking into account fatigue. Be able to analyze the means of ensuring the regulated durability of aircraft and helicopters.

Unmistakably perform and defend all practical work within the period specified by the teacher with a detailed justification of decisions and draw conclusions.

scale: point and traditional

Sum of points	GradingGrading according to the traditional scale	
	Exam, differentiated test	Credit
90 - 100	Excellent	Credited

75 - 89	Good	
60 - 74	Satisfactory	
0 - 59	Unsatisfactory	Not credited

13. Methodical support

Lecture notes and literature in the library, methodical office and in electronic form on the server of the department of aircraft and helicopter design (the list is given below in section 14 of this program).

14. Recommended Books

Basic:

1. Машиностроение. Encyclopedia Airplanes and helicopters. Book 1 / Ed. advice: KV Frolov et al. - M .: Mechanical Engineering. T. IV-21. Aerodynamics, flight dynamics and durability. / GS Büshgens, JA Azarov, G.A. Amiryants et al .; Under common. ed. GS Buschgens. 2002. - 800 p.
2. Mechanical engineering. Encyclopedia / Ed. Type: KV Frolov (lecturer), Etc. Airplanes and helicopters. T. IV-21. Design, construction and systems of aircraft and helicopters. Book 2 / A.M. Matveenko, AI Akimov, MA Akopov et al .; Under common. ed. AM Matveenko. 2004. - 752 p.
3. Fundamentals of general design of aircraft with gas turbine engines: Textbook. allowance in 2 hours / Balabuev PV, Bychkov SA, Grebenikov AG, Zheldochenko VN, Kobylyansky AA, Myalitsa AK, Ryabkov VI, Tseplyaeva T .P. - H .: Nat. aerospace XAI University, 2003. - Part 1 - 454 p. - Part 2 - 390 p.
4. Principles of designing airplanes with gas turbine engines / PV Balabuyev, SA Bichkov, AG Grebenikov, VN Zjeldochenko, AA Kobilyanskiy, AK Myalitsa, VI Ryabkov, TP Tseplyaeva. - Study Guide. - Kharkiv: National Aerospace University «Kharkiv Aviation Institute», 2013. - 731 p.
5. Methodology of integrated design and modeling of prefabricated aircraft structures / AG Grebenikov. - H .: Nat. aerospace XAI University, 2006. - 532 p.
6. Methodology of integrated designing and modeling of aircraft assembly structures / OG Grebenikov. - Kharkiv: National Aerospace University «Kharkiv Aviation Institute», 2010. - 414 p.
7. Eger SM, Liseytsev NK, Samoilovich OS Fundamentals of automated aircraft design: Textbook. manual for students of aviation specialties of universities. - M .: Машиностроение, 1986. - 232 с.
8. Проектирование самолетов: Учебник для вузов / C.M. Eger, WF Mishin, NK Liseytsev and others; Under. ed. SM Eger. - 3rd ed., Reworked. and ext. - M .: Mashinostroenie, 1983. - 616 p.
9. CALS (Continuous Acquisition and Life cycle Support) in aircraft construction / Bratukhin AG, Davydov Yu.V., Eliseev Yu.S., Pavlov Yu.B., Surov VI; Ed. AG Bratukhina - M .: MAI Publishing House, 2000. - 304 p.
10. Theory and practice of passenger aircraft design, Ed. GV Novozhilova. - Moscow: Nauka Publishing House, 1976. - 435 p.
11. Design of heavy single-propeller helicopters and their transmissions: a textbook: in 2 hours / AG Grebenikov, AM Gumenny, AI Dolmatov, VN Dotsenko, Yu. V. Dyachenko, SV Epifanov , Ya. S. Karpov, ED Kovalev, LI Losev, SE Markovich, VT Sikulsky, SV Trubaev, VA Udovenko, VV Usik, V A. Urbanovich, MN Fedotov; under ed. VS Krivtsova. - Kh .: KHAI, 2007. - 2 h.
12. Design of helicopters / VS Кривцов, Я.С. Karpov, LI Losev. - Textbook. - Kharkiv: Nat. aerospace University "Kharkov. Aviation Institute", 2003. - 344 p.
13. Aircraft design: Lab. practicum / AG Гребеников, A.A. Kobylyansky, VN King, WN Zheldochenko, VA Urbanovich, EV Bricklayer. - H .: Nat. aerospace University "XAI", 2002. - 176 p.
14. Uniform standards for the airworthiness of civil aircraft. - M .: Mashinostroenie, 1985. 470 s.
15. Resistance of fatigue of structural elements / AZ Воробьев, Б.И. Olkin, VN Stebenev et al. - M .: Mechanical Engineering, 1990. - 240 p.
16. Information technologies in science-intensive mechanical engineering: Computer support of industrial business / Under. common ed. AG Bratukhina. - К .: Техніка, 2001. - 728 с.
17. Krivov GA, Matvienko VA, Afanasyev LF World aviation at the turn of the XX-XXI centuries. Industry, markets - K. 2003. - 296 p.: Ill. 87.
18. Fundamentals of computer modeling using an integrated system CAD / CAM / CAE / PLM UNIGRAPHICS NX / AG Гребеников, С.В. Удовиченко, А.М. Гуменный, В.В. Парфенюк, В.А. Никифоров, С.В. Воронов. - Study. allowance. - Kharkiv: Nat. aerospace University ”Kharkiv. aviation. Inst. ”, EDS PLM SOLUTIONS, ANTO“ KNK ”, 2004. - 198 p.
19. Fundamentals of computer modeling using an integrated system CAD / CAM / CAE / PLM UNIGRAPHICS NX / AG Гребеников, С.В. Удовиченко, А.М. Гуменный, В.В. Парфенюк, В.А. Никифоров, С.В. Воронов. - Study. Lab manual. workshop. - Kharkiv: Nat. aerospace University ”Kharkiv. aviation. Inst. ”, EDS PLM SOLUTIONS, ANTO“ KNK ”, 2005. - 104 p.

20. NX for the designer-machine builder [Text] / P.S. Goncharov, M.Yu. Ельцов, C.Б. Korshikov et al. M .: DMK Press, 2010. - 504 p.
21. Danilov, Yu. Practical use of NX [Text] / Yu. Danilov, I. Artamonov. - M .: DMK Press, 2011. - 332 p.
22. Analysis of the stress-strain state of aircraft structures using the ANSYS system: Textbook. allowance at 2 o'clock / A.G. Гребеников, С.П. Светличный, B.H. King, WN Anpilov - H .: Nat. aerospace XAI University, CADFEM GmbH, ANTO KNK, 2002. - Part 1 - 310 p.
23. Integrated design of helicopters of transport category [Text]: textbook: in 3 hours / A.G. Гребеников, Н.И. Москаленко, B.A. Urbanovich, et al .; under ed. VA Boguslaeva. - H.: Nat. aerospace Univ. NE Zhukovsky "Kharkov. aviation. in-t ». - Zaporozhye: ed. JSC MOTOR SICH, 2016. - Part 1. - 411 p .; - Part 2. - 454 p .; - Part 3. - 419 p.
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15. Information resources

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