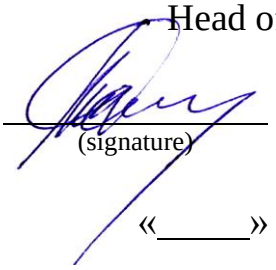
MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aerospace University
"Kharkov Aviation Institute"

Aircraft engine design department (№ 203)

APPROVED
Head of project team



_____ *Oleksandr Bilohub*
(signature) (first and last name)

«_____» _____ 2020

SYLLABUS OF AN ACADEMIC DISCIPLINE

FUNDAMENTALS OF AEROSPACE ENGINEERING
(name of academic discipline)

Field of education *13 «Mechanical Engineering»*
(code and name of a field of education)

Field of study *134 «Aviation and Spacecraft Technologies»*
(code and name of field of study)

Educational program *Aircraft engines and power plants*
(code and name of educational program)

Form of training *Day studies*

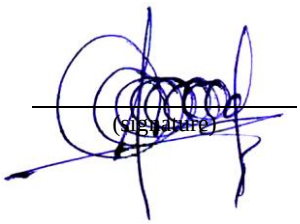
Level of higher education *First (bachelor)*

Kharkiv 2020

Working program *Fundamentals of Aerospace Engineering*
(name of academic discipline)
for students of a field of study *134 «Aviation and Spacecraft Technologies»*
educational program *Aircraft engines and power plants*

« *1* » June 20*20* *p.*

Person, who developed the syllabus *DSc, Prof., SR, Vasyl Loginov* (signature)
(author, job, academic degree and rank)



Working program was approved at the meeting of the department
Aircraft Engine Design
(department)

Minutes № 1 dated « 30 » August 2020

Head of department *Dr. Sc., Professor* *Sergiy Yepifanov*
(academic degree and rank) (signature) (first and last name)

1. Description of the discipline

<table>
<tr><td>Characteristics</td><td>Branch of science, specialization, academic degree</td><td>Description of the discipline
(full-time tuition)</td></tr>
<tr><td rowspan="2">Credits – 4,5</td><td>Field of education:
13
«Mechanical Engineering»</td><td rowspan="2">Variable</td></tr>
<tr><td>(cipher and name)</td></tr>
<tr><td>Modules – 1</td><td rowspan="5">Field of study:
134
«Aviation and spacecraft technologies»</td><td>Academic year:</td></tr>
<tr><td>Semantic modules – 2</td><td>2020 / 2021</td></tr>
<tr><td>Individual task</td><td rowspan="3">Semester</td></tr>
<tr><td></td></tr>
<tr><td>(title)
Total number of academic hours – 64* / 135</td></tr>
<tr><td rowspan="10">Number of academic hours for full-time tuition:

auditorium – 4

independent work – 4,4</td><td>(cipher and name)</td><td>1-th</td></tr>
<tr><td rowspan="9">Educational program

Airplanes and helicopters
(cipher and name)

Higher education:

<u>First (Bachelor)</u></td><td>Lectures *</td></tr>
<tr><td>32 a.h.</td></tr>
<tr><td>Practices, seminars *</td></tr>
<tr><td>32 a.h.</td></tr>
<tr><td>Laboratory activities *</td></tr>
<tr><td>-</td></tr>
<tr><td>Independent work</td></tr>
<tr><td>71 a.h.</td></tr>
<tr><td>Form of examination</td></tr>
<tr><td>credit</td></tr>
</table>

The ratio of hours of classes to independent work is: for full-time education – 64 / 71.

* *Auditory load can be reduced or increased by one hour, depending on the schedule of classes.*

2. Goals and purposes of discipline

Goal: formation of initial knowledge and ideas about the current state and prospects of aviation science, engineering and technology.

Task: study of the basic characteristics of aviation and rocket technics, aviation and the principles of rocket propulsion technology of aircraft and rocket technology.

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

General competencies: Ability to work both independently and in a team with representatives of other professional groups. Ability to make informed decisions in normal and special situations and implement them correctly. Ability to learn and master modern knowledge.

Special (professional) competencies: Ability to use the propositions of hydraulics, aero- and gas dynamics to describe the interaction of bodies with gaseous and hydraulic environment. Ability to assign optimal materials for structural elements of aerospace engineering. Ability to design and test elements of aerospace engineering, its equipment, systems and subsystems.

Program learning outcomes: To explain the influence of design parameters of elements of aerospace engineering on its flight performance. Have an idea of the methods of ensuring the stability and controllability of aerospace engineering. To apply modern methods of design, construction and production of elements and systems of aerospace engineering in professional activities. To understand and justify design features and basic aspects of workflow in systems and elements of aerospace engineering. To have skills in the development of technological processes, including the use of computer-aided design of the production of structural elements and systems of aerospace engineering. To understand how operational factors affect the design of aircraft, engines and their systems. To have a basic knowledge on organization of maintenance and repair of aircraft. To have basic knowledge to ensure compliance of aviation equipment with the requirements of regulatory and technical documentation and standards of airworthiness and flight safety.

Interdisciplinary sounds: thermodynamics and heat exchange, physics, theory and development of blade machines, theory of repeated-reactive engines, hydrodynamics.

3. Course content

Module 1

Semantic module 1

TOPIC 1. History and prospects of development of aviation and rocket-space technology.

Introduction. Subject of study and discipline tasks. Place of discipline in the curriculum. Recommended books. The first inventors of the aircraft and flights in the atmosphere. Aircraft development in the early twentieth century. The main stages of the development of aviation and rocket and space technology. Causes of appearance of special disciplines. Problems and tasks of interdisciplinary design of aircraft and power plants. Prospects for the development of aviation and rocket and space technology.

TOPIC 2. International standard atmosphere and main characteristics of aircraft.

International standard atmosphere. Basic parameters and characteristics of the atmosphere. International system of units. Range of heights and flight speeds of aircraft. Classification of aircraft on the principle of flight and destination. Schematic layout of the aircraft. The concept of power plant of the aircraft. Basic geometric and aerodynamic parameters and characteristics of airplanes and unmanned aerial vehicles. Polar of wings and aircraft. Aerodynamic quality of the aircraft. Load acting on the aircraft. Design of airplanes and unmanned aerial vehicles. The concept of the system of automatic control of aircraft, the control and mechanization of the elements of the airframe.

Modern information technologies for designing aircraft and power plants. Classification of helicopters by appointment. Basic geometric and aerodynamic characteristics of helicopters. Aerodynamic forces and moments, lifting force and principles of its creation. Helicopter construction. Rocket-space complexes. Realization of rocket-dynamic and ballistic flight principles. Space Missiles: Classification and Design. Missiles for military use. Modern anti-missile systems.

TOPIC 3. The basic requirements and principles of the creation of aircraft and power plants.

The concept of the equation of the existence of the aircraft. Requirements for modern of the aircrafts. Modern information technologies for the creation of aircraft and their propulsion systems. Principles of technical and economic justification of the characteristics of the aircraft. The flight profile of the aircraft and the main stages of flight: cruise flight, set altitude and lowering, take-off and landing, aerobatics. Principles of integration of power plant and airframe of airplane. Determination of the required thrust force of the engine at different stages of the flight of the aircraft. Range and duration of flight. The concept of the generation of aircraft.

Modular testing

Semantic module 2

TOPIC 4. Heat engines of aircraft.

Classification of heat engines for aircraft, regions of use and limitation. Piston engines: principle of operation, thermodynamic cycles, design diagrams. Ways of providing power to the piston engines. Transition from piston engines to air-breathing. The concept and principle of the aviation power plant operation. Determination of the propulsion power of an air-breathing engine. Ramjet engine motors, operating principle and application area. Gas turbine engines: work principle and regions of use. The loads affecting the elements of the gas turbine engines. Structural and layout diagrams of the gas turbine engines. Features of the working process turboprop and turboshaft engines. Main systems of gas turbine engines: fuel, automatic control, lubrication and cranking. Fuel and lubricants for gas turbines. Generations of aviation engines. The concept of working processes and regions of use of rocket engines. Thermodynamic cycles and types of rocket engines. Determination of the propulsion power of rocket engines. Principle diagrams of liquid and solid propellant rocket engines, their advantages and disadvantages. Types of fuel rocket engines.

TOPIC 5. Life cycle of the aircraft.

The concept of the life cycle of aircraft. Features of the aircraft engine life cycle. Uniform standard design documentation. Aviation rules. Certification documents. Appointments and types of engine tests. System of technical operation of aircraft. The concept of innovative projects and their risk assessment.

Modular testing

4. Course arrangement

Names of Modules and Topics	Number of hours				
	full-time tuition				
	total	namely			
		lec	pr	lab.	i.w.
1	2	3	4	5	6
Module 1 **Semantic module 1**					
TOPIC 1. History and prospects of development of aviation and rocket-space technology.	10	2	-	-	8

TOPIC 2. International standard atmosphere and main characteristics of aircraft.	22	4	6	-	12
TOPIC 3. The basic requirements and principles of the creation of aircraft and power plants.	31	6	5	-	20
Modular testing	1	-	1	-	-
Totally for Semantic module 1	**64**	**12**	**12**	**-**	**40**
Semantic module 2					
TOPIC 4. Heat engines of aircraft.	37	12	10	-	15
TOPIC 5. Life cycle of the aircraft.	33	8	9	-	16
Modular testing	1	-	1	-	-
Totally for Semantic module 2	**71**	**20**	**20**	**-**	**31**
Totally hours for course	**135**	**32**	**32**	**-**	**71**

5. Topics of practical study

№	Name of topics	Hours
1	Determination of the main characteristics of aircraft.	2
2	Analysis of the design and systems of airplanes and unmanned aerial vehicles.	4
3	Analysis of the design and systems of helicopters of different purposes.	4
4	Analysis of the equation of the existence of aircraft and determination of take-off mass of the aircraft.	4
5	Determination of the required engine thrust force at different stages of the flight.	4
6	Determination of the design and assembly scheme of aircraft engines and main systems for various purposes.	4
7	Determination of trust of power plant of aircraft with gas turbine engine.	6
8	Analysis and determination of the cost of the flight time of the aircraft engine.	4
	Totally hours for course	**32**

6. Independent work

№	Name of topics	Hours
1	History and prospects of development of aviation and rocket-space technology.	8
2	International standard atmosphere and main characteristics of aircraft.	12
3	The basic requirements and principles of the creation of aircraft and power plants.	20
4	Heat engines of aircrafts.	15
5	Life cycle of the aircrafts.	16
	Totally hours for course	**71**

7. Learning methods

Basic forms of student training: training sessions, practical training, independent work, control activities.

The lecture is an element of the course of study, which covers the main theoretical material of the discipline. The lectures give systematic bases of scientific knowledge and practical experience

on separate topics, reveals the state and prospects of the development of the aviation and rocket industry of science and technology, focuses on the most complex and topical issues of educational material. The lectures provide detailed consideration by students of certain theoretical provisions of the discipline. The student is given the basic concepts on the themes, the fundamentals of theory and law, which are necessary for preparation for the implementation of practical works, seminars, independent work, as well as the execution of individual tasks.

During *practical training* students develop the skills and practical application of theoretical positions by individually executing the corresponding formulated tasks by students. Practical work is based on the students' performance of calculations of the main parameters and characteristics of aircraft and engines of power plants.

Independent work of students is the main way of mastering the educational material. It is carried out with the purpose of working out and assimilation of educational material, consolidation and deepening of knowledge, skills and abilities; execution of calculation-graphic work, preparation of the abstract, preparation for future classes and control measures; the formation of students of the culture of intellectual labor, autonomy and initiative in the search and acquisition of knowledge. During independent work, students profoundly study lecture material, prepare for practical works and seminars, perform settlement and graphic work.

8. Methods of control

During the study of discipline, the following types of control are used: current, modular and semester. ECTS requirements must be met when applying control measures.

Current control is carried out on all types of training sessions. The main purpose of the current control is to provide feedback between the teacher and the students in the learning process, to check the readiness of the students for the implementation of the following educational tasks, and to ensure the management of their learning motivation. The information obtained during the current control is used to correct methods and methods of training, as well as for the independent work of students. Current control is carried out in the form of oral questioning or written express control during conducting of training sessions, speeches of students at the discussion of questions at seminars, as well as in the form of computer testing. The results of the current control (current progress) are the main information during the conduct of the test (modular control) and are taken into account in determining the final score from this discipline.

Modular control of knowledge, skills, and skills of students is carried out after studying the logically completed part (content module) of the curriculum. Modular control is conducted in the form of oral questioning or testing. The results of module control are additional information during the offset and are taken into account when determining the final score from this discipline.

Semester control is conducted in the form of a score in the amount of study material defined by the work program of the discipline. The form of semester control is written.

Semester 1 – *test (credit)*.

Questions for students to work independently
Module 1

1. The main stages of development of aviation and space rocket technology.
2. International standard atmosphere. Basic parameters and characteristics of the atmosphere.
3. International system of units. Principles of transfer of quantities.
4. Range of altitudes and flight speeds of aircraft.
5. Classification of aircraft by the principle of flight and destination.
6. Layout scheme of aircraft.
7. The concept of powerplant of aircraft.

8. Basic geometric and aerodynamic parameters and characteristics of aircraft and unmanned aerial vehicles.

9. Lifting force and principles of its creation for aircraft.

10. Load acting on the aircraft.

11. Design of aircraft and unmanned aerial vehicles.

12. Classification of helicopters by purpose.

13. Basic geometric and aerodynamic characteristics of helicopters.

14. Aerodynamic forces and moments, lift and principles of its creation for helicopters.

15. Design of helicopters.

16. Space rocket complexes.

17. Implementation of rocket dynamics and ballistic flight principles.

18. Space rockets: classification and design.

19. Missiles for military use.

20. Modern missile systems.

21. The concept of the equation of existence of the aircraft.

22. Requirements for modern of aircraft.

23. Modern information technologies of creation of aircraft and their power plants.

24. Principles of feasibility study of the characteristics of aircraft.

25. Aircraft flight profile and main stages of flight: cruise flight, altitude and descent, takeoff and landing, flight.

26. Principles of integration of the power plant and airframe of aircraft.

27. Determination of the desired engine thrust at different stages of the aircraft flight.

28. Flight range and duration.

29. The concept of the generation of aircraft.

Module 2

30. Classification of heat engines for aircraft, scope and limitations.

31. Piston engines: principle of operation, thermodynamic cycles, circuit diagrams.

32. Ways of providing power to piston engines.

33. Transition from piston engines to air-jet engines.

34. The concept and principle of operation of an aircraft power plant.

35. Determination of the driving force of an air jet engine.

36. Direct current engines, operating principle and scope.

37. Gas turbine engines: principle of operation and scope.

38. Design and layout schemes of the GTE.

39. Features of workflow of turboprop and turbocharged engines.

40. The main systems of gas turbine engines: fuel, automatic control, lubrication and start-up.

41. Generation of aircraft engines.

42. The concept of workflows and areas of use of rocket engines.

43. Thermodynamic cycles and types of rocket engines.

44. Determination of the driving force of rocket engines.

45. Schematic diagrams of liquid and solid propellant rocket engines, their advantages and disadvantages.

46. Application of heat engines on the aircraft.

47. Concept of life cycle of aviation engineering.

48. Features of the life cycle of an aircraft engine.

49. The only standard design documentation.

50. Information technologies of design of aviation power plants.

51. Aviation rules.
52. Certification documents.
53. Purpose and types of engine tests.
54. System of technical operation of aircraft.
55. The concept of innovative projects and their risk assessment.

9. Testing

The course material is divided into 5 topics, which are combined into one module.

Addition of module 1 - on the 9th week (once).

The student is allowed to take the module, provided that he has completed all kinds of required works, provided on topics.

Registration of practical works - in writing, protection - orally.

Homework protection term is 10 weeks. Delayed homework protection per week - minus 2 points, 2 weeks - minus 4 points.

Semester 1 – *test (credit).*

10. Evaluation criteria and distribution of the points that the students get

10.1 Distribution of the points that the students get (quantitative evaluation criteria)

Components of educational work	Points for one lesson (task)	Number of lessons (tasks)	Total number of points
Work at lectures	0…0,5	4	0…2
Execution and defense of practical works	3…5	8	24…40
Modular testing	36…58	1	36…58
Total for semester			**60…100**

The semester control (test) is carried out in case of student's refusal of the points of the current testing and in the presence of admission to the test. Admission to the credit is granted subject to the completion and delivery of all practical work, as well as the completion and successful protection of homework.

During the semester credit the student has the opportunity to get a maximum of 100 points. The scorecard consists of five theoretical questions. Theoretical questions are divided as follows: first question topic 1; the second question is topic 2; third question - topic 3; fourth question - topic 4; fifth question - topic 5.

When answering theoretical questions, a question about a practical task can be asked. It relates to the analysis of the design and systems of aircraft engines installed on aircraft of various purposes as an important component of engineering training. The maximum score for each question is 20.

10.2 Qualitative evaluation criteria

In order to receive a positive assessment, a student must

know:

– history and prospects of development of aviation and rocket and space technology;

– concept of work processes of piston, air-jet and rocket engines of aircraft, their range of altitudes and flight speeds;

– basic requirements and principles for the creation of aircrafts and power plants;

– approaches to determining the required thrust of the engine at different stages of the aircraft flight;

– the concept of the life cycle of an aircraft engine, the impact of production technologies and the system of technical operation of aircraft;

be able:

– make a sketch drawing of the design scheme of the air-jet engine and the aircraft powerplant;

– use terminology in the field of design, construction and production of aircraft engines and rocket technology;

– determine the thrust of the propulsion system of a gas turbine engine.

10.3 Criteria for assessing student work during the semester

Satisfactory (60-74). Have the necessary minimum of knowledge and skills. Practice and protect all practical work. Pass content modules with a positive evaluation. Be able to explain the working processes of piston, air-jet and rocket engines of aircraft, their range of altitudes and flight speeds. Know the basic requirements and principles for the creation of aircraft and power plants. Explain the basic approaches to determining the desired thrust of the engine at different stages of the aircraft flight. To be able to make a sketch drawing of the design scheme of an air-jet engine and the aircraft powerplant.

Good (75-89). Firmly master a minimum of knowledge and skills. Practice and protect all practical work. Pass content modules with a positive evaluation. Be able to explain the working processes of piston, air-jet and rocket engines of aircraft, their range of altitudes and flight speeds. Know the basic requirements and principles for the creation of aircraft and power plants. Explain the basic approaches to determining the desired thrust of the engine at different stages of the aircraft flight. Know the concept of the life cycle of an aircraft engine, the impact of production technologies and the system of technical operation of aircraft. To be able to make a sketch drawing of the design scheme of an air-jet engine and the aircraft powerplant.

Excellent (90-100). Fully master the knowledge and skills of the discipline. Practice and protect all practical work. Pass content modules with a positive evaluation. Be able to explain the working processes of piston, air-jet and rocket engines of aircraft, their range of altitudes and flight speeds. Know the basic requirements and principles for the creation of aircraft and power plants. Explain the basic approaches to determining the desired thrust of the engine at different stages of the aircraft flight. Know the concept of the life cycle of an aircraft engine, the impact of production technologies and the system of technical operation of aircraft. To be able to make a sketch drawing of the design scheme of an air-jet engine and the aircraft powerplant. Know the approaches to determining the desired thrust of the engine at different stages of the aircraft flight. Be able to determine the required thrust for takeoff aircraft.

Grade scales: national and ECTS

<table>
<tr><td rowspan="2">Grade scale</td><td colspan="2">National scale</td></tr>
<tr><td>For exam, course project (work), practice</td><td>For test</td></tr>
<tr><td>90-100</td><td>“excellent”</td><td rowspan="3">Passed</td></tr>
<tr><td>75-89</td><td>“good”</td></tr>
<tr><td>60-74</td><td>“satisfactory”</td></tr>
<tr><td>0-59</td><td>“non-satisfactory”</td><td>Not passed t</td></tr>
</table>

11. Methodological support

1. Methodical manuals on discipline (power point presentations, posters etc.)
2. Mock-up of aircraft and rocket engines.
3. Training prototypes of airplanes and helicopters.
4. Methodical instructions for performance of the calculation-graphic work on the topic "Determination of required thrust force of the engine at different stages of the flight aircraft".
5. Methodical aids of the department on related subjects of discipline.

12. Recommended literature for the course

Main

1. Yepifanov, S. Major units of aircraft gas turbine engines: Tutorial [Text] / S. Yepifanov, Y.Shoshin, Y. Gusev. – Kharkov.: National Aerospace University "Kharkov Aviation Institute", 2013. – 101 p.

2. Yepifanov, S. Afterburners and exhaust systems of turbine engines: Tutorial [Text] / S. Yepifanov, Y.Shoshin, V. Chygryn. Kharkov.: National Aerospace University "Kharkov Aviation Institute", 2014. – 32 p.

3. Garkusha, A. General structure of aircraft engines and power plants [Text] / A. Garkusha, F. Sirenko. – Kharkov.: National Aerospace University "Kharkov Aviation Institute", 2014. – 76 p.

4. Hunecke, K. Jet engines. Fundamentals of theory, design and operation [Text] // K. Hunecke. – 6-th impression/ - Osceola.: Motorbooks IP&W, 2003. – 241 p.

5. Boyce, M.P. Gas turbine engineering handbook [Text] / M.P. Boyce. - 3-rd ed. – Gulf Professional Publishing. – 2006. – 936 p.

6. Shoshin, Yu. Basic technical data of Soviet, Ukrainian and Russian cruise engines of aircraft [Text] / Yu. Shoshin, F. Sirenko. – Kharkov.: National Aerospace University "Kharkov Aviation Institute", 2015. – 65 p.

Additional

1. World Air Forces 2015. Special report / Flight International. – Flightglobal insight, 2015. – 36 p.

2. Jane's. Aero–Engines [Text] / Jane's // Edited by Bill Gunston OBE, FRAeS, March, 2010. – 950 p.

13. Information sources

1. Global Market Forecast: Growing Horizons 2017-2036 // Airbus - [Electronic resource]. – Mode of access : http://www.aircraft.airbus.com/market/global-market-forecast-2017-2036/.
2. Airbus: aircraft families // Airbus - [Electronic resource]. – Mode of access : http://www.aircraft.airbus.com/aircraftfamilies/.
3. Current Market Outlook 2017-2036 // Boeing - [Electronic resource]. – Mode of access : http://www.boeing.com/commercial/.
4. Bombardier Business and Commercial Aircraft // Bombardier - [Electronic resource]. – Mode of access : http://www.bombardier.com/en/aerospace.html.
5. Embraer: Challenge. Create. Outperform // Embraer - [Electronic resource]. – Mode of access : https://embraer.com/global/en.
6. Sukhoi Company (JSC): Airplanes // Sukhoi - [Electronic resource]. – Mode of access : http://www.sukhoi.org/eng/planes/.

7. Russian aircraft corporation: last news // Migavia - [Electronic resource]. – Mode of access : http://www.migavia.ru/index.php/en/production/new-unified-family-of-the-fighters.

8. Antonov gliders and airplanes / Before produced, experimental modely, gliders of O.K. Antonova // Antonov - [Electronic resource]. – Mode of access : http://www.antonov.com/aircraft/antonov-gliders-and-airplanes.

9. Ilyushin Aviation Complex PJSC: Aircraft manufacture // Ilyushin - [Electronic resource]. – Mode of access : http://ilyushin.org/aircrafts/.

10. Zaporozhye Machine-Building Design Bureau Progress State Enterprise named after Academician A.G.Ivchenko: Aviation Engines // Ivchenko-progress - [Electronic resource]. – Mode of access : http://ivchenko-progress.com/?page_id=52&lang=en.

11. Aircraft engines // Motorsich - [Electronic resource]. – Mode of access : http://www.motorsich.com/eng/products/aircraft/.

12. Digital Solutions at GE Aviation: engine and digital systems // GE Aviation - [Electronic resource]. – Mode of access : https://www.geaviation.com/.

13. Creating the future of power: Products & Services // Rolls-royce - [Electronic resource]. – Mode of access : https://www.rolls-royce.com/products-and-services.aspx.

14. The excellent information integrator leading the industry // AVIC - [Electronic resource]. – Mode of access : http://www.avic.com/en/forbusiness/militaryaviationanddefense/index.shtml.