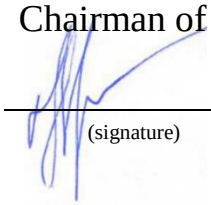
Ministry of Education and Science of Ukraine
National Aerospace University
"Kharkiv Aviation Institute"

Department *Aircraft engine design (№ 203)*

APPROVED

Chairman of the ScMC #1



Serhii Nyzhnyk
(signature) (first and last name)

« *30* » *08* 2023

SYLLABUS OF A MANDATORY ACADEMIC DISCIPLINE

SYSTEMS OF AIRCRAFT POWER PLANTS

(name of academic discipline)

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

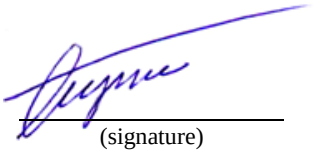
Field of study *134 «Aerospace Engineering»*
(code and name of field of study)

Educational program *Design, operational diagnostics, maintenance and repair of aircraft engines and power plants*
(code and name of educational program)

Form of study: full-time

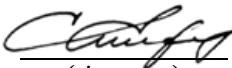
Academic degree: *First (Bachelor)*
(academic degree)

Kharkiv 2023

Person, who developed the syllabus — *Bezuglyi Serhii, senior lecturer* (author, position, academic degree and rank)  (signature)

The syllabus was approved at the meeting of the department
Aircraft Engine Design
(department)

Minutes № *1* dated « *28* » *August* 2023.

Head of the department *DSc., Professor* (academic degree and rank)  (signature) *S. Yepifanov* (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>Credits – 5.5</td><td>Field of education:
13 «Mechanical Engineering»
(cipher and name)</td><td>Mandatory</td></tr>
<tr><td>Modules – 2</td><td rowspan="3">Field of study:

134
«Aviation and spacecraft technologies»
(cipher and name)</td><td>Academic year:</td></tr>
<tr><td>Semantic modules – 2</td><td>2023 / 2024</td></tr>
<tr><td>Individual task
Calculation-graphic work
«Designing of Engine Main Fuel Pump»
(title)</td><td>Semester</td></tr>
<tr><td rowspan="3">Total number of academic hours – 72*/165</td><td rowspan="6">Educational program:
Design, Operational Diagnostics, Maintenance and Repair of Aircraft Engines and Power Plants
(name)</td><td>7-th</td></tr>
<tr><td>Lectures *</td></tr>
<tr><td>40 a.h.</td></tr>
<tr><td rowspan="2">Practices, seminars *</td></tr>
<tr><td>8 a.h.</td></tr>
<tr><td rowspan="2">Number of academic hours for full-time tuition:
auditorium – 4.5
independent work – 5.81</td><td>Laboratory activities *</td></tr>
<tr><td>24 a.h.</td></tr>
<tr><td>Independent work</td><td rowspan="2">Higher education:
First (Bachelor)</td></tr>
<tr><td>93 a.h.</td></tr>
<tr><td>Form of examination</td></tr>
<tr><td>Exam</td></tr>
</table>

The ratio of hours of classes to independent work is: for full-time education - 72 / 93.

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

2. Goals and purposes of discipline

The course **aims** to give knowledge and skills, which are necessary to make an analysis of systems and assemblies of aviation power plants, their operation. The discipline also gives an overview of their specifics.

Task of discipline. This course provides studying of aircraft of main systems power plants with GTE (fuel, oil, starting, deicing, firefighting systems and drives) and structure of their main components units (pumps, fuel and oil nozzles, starters etc.).

After studying this course student must

know:

– the conditions systems and assemblies of AEs and PPs operate at;
– typical and prospective schemes of assemblies and systems of PPs;
– generic schemes of fuel supplying, lubricating, starting, deicing, firefighting systems and drives.

be able to:

– choose the systems and assemblies of AEs and PPs, find, analyze and substantiate their schemes and parameters.

Interdisciplinary links: The course of aircraft power plants and units design is based on knowledge that is previously acquired from courses of blade machines, theory of air-breathing engines, theoretical mechanics, strength of materials, material science, gas dynamics, heat transfer, machine designing etc.

3. Course content

Module 1

TOPIC 1. *General information about aircraft PPs.* The composition of PP. Main systems. Requirements to PP. Weight indicators of PP. Stages of PP designing.

TOPIC 2. *Fuel supply system of an aircraft* (FSA). Functions and application of FSA. Requirements made to FSA. Fuels and their properties. The compositions of FSA. Schemes of FSA. The analyses of FSA. Altitude performance of FSA. Venting and supercharging FSA. Designing the scheme of emergent jettisoning and its analysis. Fuelling system. Constructive elements of FSA.

TOPIC 3. *Fuel supply system of an engine* (FSE). General information about FSE, the structure of the system. Transfer pumps. High pressure pumps of main and afterburning fuel: gear, plunger, centrifugal. Fuel nozzles. Fuel-metering sensors. Fuel filters. Tubing of fuel supplying systems.

TOPIC 4. *Lubrication system of PPs* (*oil systems OS*). Lubrication system application and requirements made for it. Aviation oils. General characteristic of OS. Structural schemes of OS: normal, reverse, normal with centrifugal air separator, short-circuited, two flow. Air separator, breather. Cooling oil, radiators. Oil tanks. Tubing, oil nozzles.

Module 2

TOPIC 5. *Units of hydraulic systems*. Schemes and design of centrifugal, gear and plunger pumps. Parameters of fuel and oil pumps. Schemes, parameters and design of fuel and oil nozzles.

TOPIC 6. *Starting system* (SS). Starting the GTE. Requirements to starting system of GTE. The variation of driving torque moment and antitorque moment during starting. Calculating starting time and required power of starter. Composition of SS. The classification of SS: electric, air, gas, gas-turbine. Ignition.

TOPIC 7. *Deicing system (DS).* An overview. Air DS. Electric DS.

TOPIC 8. *Firefighting system* (FFS). Fire prevention. External cooling and venting. Detecting overheat and fire. Allocating and extinguishing the fire.

4. Course arrangement

Names of Modules and Topics	Number of hours				
	full-time tuition				
	total	including			
		lec	pr	lab	indp
1	2	3	4	5	6
Module 1 **Semantic module 1**					
TOPIC 1. *General information about aircraft PPs.*	8	2	-	-	6
TOPIC 2. *Fuel supply system of an aircraft.*	26	8	-	4	14
TOPIC 3. *Fuel supply system of an engine.*	22	4	-	4	14
TOPIC 4. *Lubrication system of PPs* (*oil systems OS*).	31	9	8	-	14
Modular testing	1	1			
Totally for the module No 1	**88**	**24**	**8**	**8**	**48**
Module 2 **Semantic module 2**					
TOPIC 5. *Units of hydraulic systems*.	25	7	-	6	12
TOPIC 6. *Starting system*.	23	4	-	6	13
TOPIC 7. *Deicing system.*	12	2	-	2	8
TOPIC 8. *Firefighting system*.	12	2		2	8
Modular testing	1	1			
Totally for the module No 2	**73**	**16**		**16**	**41**
Individual task **Calculation-graphic work « Engine Main Fuel Pump»**	**4**				**4**
Totally for the course	**165**	**40**	**8**	**24**	**93**

5. Seminars

#	Topic	Hours
1	**---**	**0**
	Totally	**0**

6. Practical activities

№	Topic of the activity	Hours
1	Study and analysis of aircraft engine lubrication systems	6
2	Calculations of engine oil system	2
	Together	**8**

7. Laboratory activities

№	Topic of the activity	Hours
1	Fuel system of an aircraft	4
2	Fuel system of an engine	4
3	Centrifugal pumps	2
4	Gear pumps	2
5	Plunger pumps	2
6	Filters and. purifiers of hydraulic systems	4
7	Auxiliary power units and air starters	4
8	Gas turbine starters	2
	Together	**24**

8. Independent work

№	Topic	Hours
1	General information about aircraft PPs	6
2	Fuel supply system of an aircraft	14
3	Fuel supply system of an engine	14
4	Lubrication system of PPs	14
5	Units of hydraulic systems	12
6	Starting system	13
7	Deicing system	6
8	Firefighting system	6
	Calculation-graphic work « Engine Main Fuel Pump»	8
	Together	**93**

9. Settlement and graphic work

Calculation-graphical work *«Engine Main Fuel Pump»*.

Stages of work:

– choosing the type of pump;
– calculations of main parameters of the pump;
– pump scheme designing, bearings types and displacement choosing;
– explanatory report drawing-up;
– defense of work.

10. Learning methods

Basic forms of learning:

- lectures;
- practical activities;
- laboratory activities;
- independent work.

Student familiarizes with basic notions and regularities, theoretical bases at lectures. They are needed when performing laboratory activities, independent task and during individual learning.

Lecture deals with single didactic problem, i.e. gives a prima facie on a problem, provides prior understanding of the presented information and states main sub problems.

The laboratory activities are based on a verbal (analytical) description of an object (systems and assemblies of GTE) and its physical representation by the special didactic materials (prepared mockups, posters, etc.). Students work in groups.

11. Questions for independent work

Module 1

1. What fuel is used in aviation gas turbine engines?
2. What fuel is used in aircraft piston engines?
3. What is not used as fuel in aircraft engines?
4. What is the mass calorific value of fuel (definition)?
5. What is the volumetric calorific value of fuel (definition)?
6. In what units is the volumetric calorific value of the fuel measured?
7. In what units is the mass calorific value of a fuel measured?
8. How does fuel density change with temperature?
9. What is the saturated vapor pressure of the fuel (definition)?
10. How does the saturated vapor pressure of a fuel change with temperature?
11. How does the kinematic viscosity coefficient of fuel change with temperature?
12. Name and describe three ways of outflow of fuel from the tank.

13. What is a two-stage pumping scheme?
14. Why is a two-stage pumping so widespread used?
15. What is the altitude performance of the fuel system (definition)?
16. What determines the altitude performance of the fuel system?
17. Write down the main condition in the fuel system altitude performance calculation.
18. What is the positive suction head (cavitation margin)?
19. What is the overpressure in the tank?
20. Why create excessive pressure in the tank?
21. How to create overpressure in the tank?
22. What types of total pressure losses in pipelines do you know?
23. How hydraulic friction losses are determined?
24. How hydraulic local losses are determined?
25. How the Reynolds number for the pipeline of circular cross section is determined?
26. What methods to increase the altitude of the fuel system are used?
27. What is the purpose of venting and pressurization of the fuel system?
28. What methods of fueling do you know?
29. What are the disadvantages of closed fueling?
30. What are the advantages of open fueling?
31. List the types of the fuel pump drives. Characterize briefly each of them.
32. What fuels are used in gas turbine engines?
33. What are the functions of fuel in gas turbine engines?
34. What is the purpose of a booster fuel pump?
35. What types of pumps are used as booster?
36. What types of pumps are used as the main ones?
37. What types of fuel pumps are used as booster ones?
38. What is the purpose of a main fuel pump?
39. The supply pressure of the engine booster pump, MPa?
40. The positive suction head of an engine booster pump, MPa?
41. What types of fuel pumps are used as the main ones?
42. The supply pressure of the main high-pressure fuel pump, MPa?
43. The positive suction head of main engine pump, MPa?
44. Which problems does the engine oil system solve?
45. What are the requirements to the oil system of an aircraft engine?
46. What are the defining properties of oils for aircraft engines?
47. What is the difference between oil systems for TJE (TFE) and TPE?
48. Perform a comparative analysis of direct and reverse schemes of oil system?
49. What are the advantages of two- and short-circuits oil systems?
50. What are the measures taken to reduce the consumption of air in the oil?
51. Why is the scavenge pumps capacity several times higher than pressure pump capacity?
52. Explain the principle of centrifugal de-aerator and centrifugal breather operation.
53. How is the oil pumped out from the engine cooled?

Module 2

1. Name plunger pump parts.
2. Name gear pump parts.
3. Name centrifugal pump parts.
4. List the requirements for fuel injectors.
5. What is the difference between evaporating and spray nozzles?
6. Explain scheme and operating principle of jet fuel nozzles.
7. Explain scheme and operating principle of centrifugal fuel nozzle (swirler).
8. Explain scheme and operating principle of the dual-channel two-nozzle swirler.
9. How to determine the fuel mass flow through the fuel nozzle?
10. What is the difference between ground and in-flight startup?
11. What is the reason of preliminary rotor acceleration at startup?
12. Explain character in which torques are varied during engine startup.
13. Which kind of rotor is preferable to be accelerated in multi-shaft engine startup and why?
14. Name the types of starting systems.
15. Describe the air starting system.
16. Describe the solid propellant starting system.
17. Describe the starting system with combustion chamber.
18. Describe the liquid monopropellant starting system.
19. Describe the electric starting system.
20. Describe the starting system with direct compressed air supply onto the turbine blades.
21. Describe the gas turbine starting system.
22. What kind of starting systems has the least mass?
23. How is the combustion chamber ignited? Why the external source of energy is required?
24. Draw the constructive scheme of high-voltage constrained sparking plug. How much voltage it needs?
25. Draw the constructive scheme of a surface discharge sparking plug. How much voltage it needs?
26. Compare the surface discharge sparking plug with the high-voltage constrained one.
27. At which flight conditions there is a risk of engine icing?
28. What elements of the engine must be protected from icing?
29. What types of anti-icing systems do you know? Name their advantages and disadvantages.
30. What is the purpose of the thermostat in anti-icing system?
31. How to protect propeller blades against icing?
32. What design measures reduce the likelihood of an engine fire?
33. Why is the engine compartment vented?
34. What is the purpose of the firewalls? Where are they located?
35. How is an engine fire detected?
36. How to detect engine overheating?
37. How fire extinguishing is organized?

12. Testing

The course is divided into two modules:

1. Fuel and oil systems.
2. Units of hydraulic systems. Starting, deicing, firefighting systems.

Module 1 is passed during 10-th week (one attempt), module 2 – 16-th week (one attempt).

Before passing modulus, student must make all laboratory, practical works, and independent work of this modulus.

Execution of laboratory works – in writing form, defense – orally.

Term of the home task defense – 14-th week. Delay of defense on one week – 2 points minus;

2 weeks – 4 points minus.

Semester 7 – examination.

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

12.1 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
Module 1			
Work at lectures	0…0.5	12	0…6
Execution and defense of laboratory (practical) works	1…2	8	8…16
Modular testing	24…32	1	24…32
Module 2			
Work at lectures	0…0.5	12	0…6
Execution and defense of laboratory (practical) works	1…2	4	4…8
Modular testing	24…32	1	24…32
Total for semester			**60…100**

Semester testing (examination) is held in case the student gives up points of modular testing and is permitted to the examination. The permission is given if the student has finished and passed all laboratory and practical works and also successfully defended the home task.

Maximum total score of the examination is 100 points.

The examination card is composed of four theoretical questions. The theoretical questions are distributed as follows:

the first question is on aircraft fuel system (Module 1);

the second is on oil system (Module 1);

the third question is on units on hydraulic systems (Module 2);

the fourth question is on starting system + deicing or firefighting system (Module 2).

Maximum number of points for each question is 25.

12.2 Qualitive evaluation criteria

To get positive mark, the student must

know:

- purpose of main PP systems (fuel, oil, starting, deicing, firefighting) and requirements to them;
- purpose and components of an aircraft fuel system;
- purpose and components of an engine fuel system;
- properties of aviation fuels;
- ways of fuel supply from fuel tanks;
- altitude performance of fuel and oil systems;
- fuelling methods;
- types and structure of pumps used;
- application properties of oil system;
- structure of oil systems;
- used oils;
- types and structure of starting systems;
- the way torque moments change during starting;
- purpose and structure of deicing systems;
- purpose and structure of firefighting systems;

know how to:

- choose type of fuel supply system;
- calculate altitude capacity of fuel and oil systems;
- choose type and parameters of oil and fuel pumps;
- choose type and parameters of oil system depending on engine type;
- provide fire extinguishing;
- protect engine elements against icing.

12.2 Criteria of the student evaluation during semester

Satisfactory (60-74). The student must have the required minimum of knowledge. He must finish and pass all laboratory and practical works, pass modular testing with positive mark. He must know purpose and structure of fuel, oil, and starting, deicing and firefighting systems. He must identify systems components and methods of their efficiency improvement, explain main functions of accessories, their structure, name main parts of an accessories and explain its shape.

Good (75-89). The student must be proficient in minimum knowledge. He must finish and pass all laboratory and practical works, pass modular testing with positive mark. Know main trends in turbine engine power plants development, confidently identify type of accessory. He must explain principles and methods of power plant systems operation improving, accessory parts unloading, and choosing optimal operational and design parameters of components; explain altitude performances off aircraft systems and methods of their analysis.

Excellent (90-100). He must finish and pass all laboratory and practical works, pass modular testing with excellent mark (one or two modules with “good” mark and minimum 80 points are permitted). Know main and additional material in full scale. Explain influence of flight altitude, flight velocity on systems efficiency. Know influence of the operational mode and flight conditions on the system efficiency. Successfully identify type of component, name its parts and methods of their junction using a drawing or mockup. Explain the problem of fuel and oil stability (absence of cavitation) and methods of this problem solution. Name loads that act impellers, plungers, gears and casings at different operation conditions; explain loads and torques applied to rotor at starting process. Know basic materials which the main engine units’ parts are made from.

Grade scales: national and ECTS

Grade scale	National scale	
	For exam, course project (work), practice	For test
90-100	"excellent"	Passed
75-89	"good"	
60-74	"satisfactory"	
0-59	"non-satisfactory"	Not passed t

13. Methodological support

1. Didactic materials (manuals, Power point presentations, posters etc.).
2. Mockups of pumps, fuel nozzles, starters in 103, 124, 122 rooms and hall of Motor building.
3. Tutorials for different topics of the course.
4. https://mentor.khai.edu/enrol/index.php?id=4443

14. Recommended literature for the course

Main

1. Bezuglyi, S. Systems and Units of Aircraft Power Plants [Text]:/ S. Bezuglyi, S. Yepifanov, R. Tzukanov. – Kh. : KhAI, 2015. - 100 p.

2. Bezuglyi, S. Components of Aircraft Power Plant Systems [Text]: lect. summary / S. Bezuglyi, F. Sirenko, M. Shevchenko. – Kharkov: National Aerospace University «Kharkov Aviation Institute», 2016. – 104 p.

Additional

Bezuglyi, S. Designing of Aircraft Gear Pumps [Text] : tutorial / S. Bezuglyi. – Kharkiv : National Aerospace University «Kharkov Aviation Institute», 2021. – 44 p.

15. Information sources

1. Bases of Aerospace Engineering.
2. Introduction to Specialty.
3. Theoretical mechanics.
4. Mechanics of Materials and Constructions.
5. Bases of Aerospace Engineering Objects Designing.
6. Theory of Air-breathing Engines.
7. Blade Machines.
8. Bases of Aero Engines and Power Plants Designing.