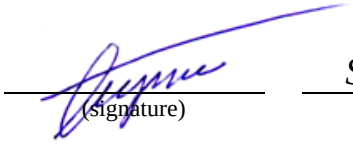
Ministry of Education and Science of Ukraine
National Aerospace University
"Kharkiv Aviation Institute"

Department *Aircraft engine design* (No. *203*)

APPROVED

Guarantor of the educational program



(signature) *Serhii BEZUGLYI* (first and last name)

"*30*" *08* 2023

SYLLABUS OF A *VARIABLE* ACADEMIC DISCIPLINE

BASICS OF TECHNICAL DIAGNOSTICS

(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*
(name of Educational program)

Form of study: full-time

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

Kharkiv 2023

Person, who developed the syllabus — *Serhii SYKHOVII, Assoc. Prof., PhD* (author, position, academic degree and rank) — (signature)

The syllabus was approved at the meeting of the department
Aircraft Engine Design (No. 203)
(department)

Minutes No. *1* dated *" 28 "* *August* 2023.

Head of the department — *DSc., Professor* (academic degree and rank) — (signature) — *Serhii 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 – 3</td><td>Field of education:
<u>13 Mechanical Engineering</u>
(cipher and name)</td><td>Variable</td></tr>
<tr><td>Modules – 2</td><td rowspan="4">Field of study:
<u>134 Aerospace Engineering</u>
(cipher and name)</td><td>Academic year:</td></tr>
<tr><td>Semantic modules – 2</td><td>2023 / 2024</td></tr>
<tr><td>Individual research task
(title)
Total number of academic hours – 54* / 90</td><td>Semester
8-th</td></tr>
<tr><td>Number of academic hours for full-time tuition:
auditorium – 4,5
independent work – 3</td><td>Educational program:
<u>Design, Operational Diagnostics, Maintenance and Repair of Aircraft Engines and Power Plants</u>
Higher education:
<u>First (Bachelor)</u></td><td>Lectures[1)]
24 a.h.
Practices, seminars[1)]
30 a.h.
Laboratory activities[1)]
–
Independent work
36 a.h.
Form of examination:
Modular control, exam</td></tr>
</table>

The ratio of hours of classes to independent work is: for full-time education - 54 / 36.

[1)] 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 students' competencies related to the basics of determining the technical condition of aircraft and aircraft engines in general, their elements and functional systems.

Tasks: formation of knowledge:

– on general concepts of technical diagnostics of aircraft and aircraft engines;

– methods of solving diagnostic problems;

– characteristics of the main elements of the diagnostic system;

– methods and means of diagnosing aircraft and aircraft engines in general, their elements and functional systems.

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

General competencies: *Ability to abstract thinking, analysis and synthesis. Ability to apply knowledge in practical situations. Knowledge and understanding of the subject area and understanding of professional activity. Ability to adapt and act in a new situation. Ability to make informed decisions. Ability to work in a team.*

Special (professional) competencies: *Ability to ensure the safety and cost-effectiveness of wind turbine flights. Knowledge and understanding of the subject area of risk management. Skills to work with regulations, reference books and other sources of information governing the activities of air transport. Ability to participate in a set of planned and preventive works to ensure the serviceability, efficiency and readiness of aircraft to effectively use them for their intended purpose. Ability to maintain technical documentation and compile established reports according to approved forms. Ability to solve problems of planning the technical operation of aircraft, operational reliability, regularity of flights. Skills to analyze the reliability of aircraft, the experience of its technical operation, planning measures to prevent aviation accidents and incidents, failures and damage to aircraft in order to maintain the airworthiness of aircraft and ensure flight safety.*

Program learning outcomes: *Ensure the safety and cost-effectiveness of aircraft flights. Analyze the risks that arise during the operation of the air transport system. Summarize information on regulatory documentation, reference literature and other sources of information governing the activities of air transport. Ensure a set of planned and preventive work on aircraft in order to maintain it ready for effective use as intended. Analyze technical documentation and established reporting according to the approved forms, including the accounting of resource and technical condition of aircraft. To plan the solution of tasks on technical operation of aircraft, operational reliability, regularity of flights, organization, information and hardware of production processes on maintenance and repair of aircraft. Analyze the reliability of aircraft, the experience of its technical operation and plan measures to prevent aviation events and incidents, failures and damage to aircraft in order to maintain the airworthiness of aircraft.*

Interdisciplinary sounds: technical operation of vessels.

3. Course content

Module 1
Semantic module 1

TOPIC 1. Subject of study and tasks of the discipline. Place of discipline in the curriculum. Recommended Books. Operating strategies and the role of diagnostics in their provision. There was a problem estimating the status of the technical objects. Requirements for its resolution at different stages of the life cycle of aircraft engines and power plants. Functional and test diagnostics. Troubleshooting. Prognostication. History of the development of methods for assessing the technical state of aviation facilities in production, testing and operation. Operation of products according to technical condition.

TOPIC 2. Systems for diagnosing gas turbine engines. Visual display systems. Systems based on emergency flight parameters recorders. Systems based on the use of operational loggers. Systems based on airborne onboard automatic control system. Systems with onboard automatic control system. Typical

scheme of information exchange engine installation as part of an airplane information system. The main elements of diagnosis systems: meters, channels of information exchange, computing devices, recorders. Examples of specific on-board and ground-based diagnostic analysis systems. Historical retrospective of systems development.

TOPIC 3. Means of collection, transmission, processing and registration of diagnostic information. Physical principles of parameter measurement and conversion of mechanical quantities into electrical ones. Measuring systems for rotation, working temperature, fuel consumption, linear and angular displacements, vibration parameters. Signaling devices of limit values of parameters, presence of shaving in oil, etc. Analog-to-digital converters (frequency-pulse, pulse-frequency and bit-coding. Terrestrial diagnostic systems.

TOPIC 4. Description of diagnostic information by methods of probability theory and mathematical statistics. Discrete and continuous random variables. Cumulative probability and probability density functions. Typical allocations. Normal distribution law, its role in technical tasks. Basic transformations of random variables. Distribution options. Basics of mathematical statistics. Estimates and their properties. Selective distributions. Analysis of problems of direct and indirect measurements.

TOPIC 5. Theory of test of statistical hypotheses. Analysis of problems of diagnostics as problems of testing of statistical hypotheses. Errors of the first and second kind. The method of minimal average risk. The method of the minimum number of wrong decisions. The Neumann-Pearson method.

Modular testing.

Module 2
Semantic module 2

TOPIC 1. Methods of tolerance control. Tolerance control of engine parameters by limit values. Methods for determining the probability of diagnosis and assigning limit values. Tolerance control for deviations from baseline values. Method of identification of mathematical models of the normal state of objects. Determination of optimal tolerances for controlling deviations of parameters from baseline Majority methods for increasing the likelihood of control.

TOPIC 2. Trend analysis methods. Application of smoothing of information for trend analysis. Parametric and non-parametric trend criteria. Detecting the trend of engine parameters using the Hald test and the integral test.

TOPIC 3. Methods of forecasting the technical condition. Identification of predictive models. Defining confidence intervals and confidence functions. Extrapolation of results to the next time.

TOPIC 4. Methods of defect recognition. Algorithmic Troubleshooting Methods: An Empirical Approach and an Approach Based on the Use of a Mathematical Object Model. Formation of diagnostic mathematical models of aviation engines as objects of diagnosis. Identification of mathematical models. The method of diagnostic matrices. Methods of pattern recognition. Determination of probability of recognition of engine states. Determination of non-measurable parameters (thrust, etc.) taking into account the change in the technical condition of the engine. Synthesis of the measurement system for diagnosis.

TOPIC 5. Instrumental methods for diagnosing gas turbine engines. Visual-optical diagnostics of the flowing part. Endoscopes, borescopes. Examples of permissible damage to the flow part. Diagnosis of friction units by lubrication parameters and accumulation of wear products in the lubricant. Methods for determining the content of wear particles in an oil: radiation, calorimetric, spectral, ferrographic, atomic emission, atomic adsorption, atomic fluorescence. Chips and magnetic plugs. Diagnosis of the technical condition of the bearings. Capillary, luminescent and color flaw detection. Magnetic Powder, Magnetographic, Magnetoferozone and Induction Methods. Ultrasonic flaw detection.

Modular testing.

4. Course arrangement

Names of Modules and Topics	Number of hours				
	full-time tuition				
	total	total			
		lec	pr	lab	i.w.
1	2	3	4	5	6
Module 1 Semantic module 1					
TOPIC 1. Introduction to the discipline. Diagnostic tasks at different stages of the engine life cycle.	4	1	-	-	3
TOPIC 2. Systems for diagnosing objects of aviation engineering.	5	2	-	-	3
TOPIC 3. Means of collection, transmission, processing and registration of diagnostic information.	10	3	-	2	5
TOPIC 4. Description of diagnostic information by methods of probability theory and mathematical statistics.	17	3	-	10	4
TOPIC 5. The theory of testing statistical hypotheses.	12	2	-	6	4
Modular testing	1	1	-	-	-
Totally for Semantic module 1	**49**	**12**	**-**	**18**	**19**
Module 2 Semantic module 2					
TOPIC 1. Methods of tolerance control.	7	2	-	2	3
TOPIC 2. Methods of trend analysis**.**	10	3	-	4	3
TOPIC 3. Forecasting methods.	9	2	-	4	3
TOPIC 4. Methods of defect recognition.	6	2	-	-	4
TOPIC 5. Instrumental methods for diagnosing gas turbine engines.	8	2	-	2	4
Modular testing	1	1	-	-	-
Totally for Semantic module 2	**41**	**12**	**-**	**12**	**17**
Total hours for course	**90**	**24**	**-**	**30**	**36**

5. Laboratory topics

No.	Name	Hours
1	Measurement error	2
2	Use of mathematical models in diagnosis	4
3	Determination of parameters of distribution laws	6
4	The theory of testing statistical hypotheses	6
5	Methods of tolerance control	2
6	Methods of trend analysis	4
7	Assessment of the belonging of two samples to the same population	4
8	Methods of visual control	2
	Total	**30**

6. Independent work

No.	Name	Hours
1	Operating concepts of aviation technology	2
2	Diagnostics systems for gas turbine engines	2
3	Means of measurement of parameters of gas turbine engines	5
4	Fundamentals of probability theory	2

5	Basics of mathematical statistics	3
6	Methods for testing statistical hypotheses	4
7	Methods of admission control of gas turbine engines	3
8	Methods of trend analysis	3
9	Forecasting methods	4
10	Methods for detecting defects in gas turbine engines	4
11	Instrumental methods for diagnosing gas turbine engines	4
Total		**36**

7. Learning methods

Basic forms of learning:

- lectures;
- practical works;
- laboratory works;
- individual task;
- independent work.

Lecture gives to student basic conceptions, bases of theory, relations which necessary to prepare for laboratory works, practical works and individual task.

Lecture solves one didactic problem only – gives primary knowledge about subject of topic, formulates main problems.

Laboratory and practical works are based on verbal (analytic) description of the object (engine, unit or component) and its material presentation using special didactic materials (mockups, posters, drawings etc.). During laboratory works, team-based approach of students work is applied.

Main form of learning is independent work. It cannot be done without preliminary knowledge given in lecture. During independent work, students study lecture material, prepare to laboratory and practical works, make calculation-graphic task and term project.

8. Questions for independent work

Module 1
Semantic module 1

1. Subject of study and tasks of discipline.
2. Operating strategies and the role of diagnostics in their provision.
3. The problem of assessing the condition of technical objects.
4. Requirements for its resolution at different stages of the life cycle of aviation engines and power plants.
5. Functional and test diagnostics.
6. History of the development of methods for assessing the technical condition of aircraft facilities in production, testing and operation.
7. Operation of products according to technical condition.
8. Systems for diagnosing gas turbine engines.
9. Visual display systems.
10. Systems based on the emergency flight parameters recorders.
11. Systems based on the use of operational registrars.
12. Systems based on an airborne on-board automatic control system.
13. On-board automatic control systems.
14. Typical scheme of information exchange engine installation as part of an all-aircraft information system.
15. The main elements of diagnosis systems: meters, channels of information exchange, computing devices, recorders.

16. Physical principles of parameter measurement and conversion of mechanical quantities into electrical ones.

17. Systems of measurement of rotation, temperature of a working body, fuel consumption, linear and angular movements, parameters of vibration. Signaling devices of limit values of parameters, presence of shaving in oil, etc.

18. Analog-to-digital converters (frequency-pulse, pulse-frequency and bit-coding).

19. Description of diagnostic information by methods of probability theory and mathematical statistics.

20. Discrete and continuous random variables. Cumulative probability and probability density functions. Typical allocations. Normal distribution law, its role in technical tasks.

21. Fundamentals of mathematical statistics. Estimates and their properties. Selective distributions.

22. Formation of diagnostic mathematical models of aviation engines as objects of diagnosis.

23. Method of identification of mathematical models of the normal state of objects.

24. The theory of testing statistical hypotheses.

25. Analysis of problems of diagnostics as problems of testing of statistical hypotheses.

26. Errors of the first and second kind.

27. The method of minimum average risk.

28. The method of the minimum number of erroneous decisions.

29. Neumann-Pearson method.

Module 2

Semantic module 2

1. Methods of tolerance control.
2. Tolerance control of engine parameters by limit values.
3. Methodology for determining the probability of diagnosis and assigning limit values.
4. Tolerance control for deviations from baseline values.
5. Determination of optimal tolerances for controlling deviations from the baseline values
6. Majority methods of increasing the likelihood of control
7. Trend analysis methods
8. Application of smoothing of information for trend analysis.
9. Parametric and non-parametric trend criteria.
10. Detecting the trend of engine parameters using the Hald's criterion and the integral criterion
11. Methods of defect recognition.
12. Algorithmic Troubleshooting Methods: An Empirical Approach and an Approach Based on the Use of a Mathematical Object Model.

a. thirteen.

13. The method of diagnostic matrices. Methods of pattern recognition.
14. Determination of probability of recognition of engine states.
15. Determination of parameters which are not measured (drafts, etc.) taking into account the change of the technical condition of the engine
16. Instrumental methods of diagnosing gas turbine engines.
17. Visual-optical diagnostics of the flow part. Endoscopes, borescopes.
18. Examples of permissible damage to the flow part.
19. Diagnosis of friction units by lubrication parameters and accumulation of wear products in the lubricant.
20. Methods for determining the content of wear particles in an oil: radiation, calorimetric, spectral, ferrographic, atomic emission, atomic adsorption, atomic fluorescence.
21. Capillary, luminescent and color flaw detection.
22. Magnetic Powder, Magnetographic, Magnetoferozone and Induction Methods.
23. Ultrasonic flaw detection.

9. Testing

The material of the discipline is divided into two content modules:

1. Means of gathering diagnostic information. Methods of statistical decisions.
2. Admission control methods and trend analysis.

Module 1 is passed during the 6th week (once), module 2 is passed during the 12th week (once).

Before passing modulus, student must finish and submit all laboratory and practical works of this modulus.

Reports on laboratory works – in writing form, defense – orally.

Semester 8 - Exam.

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
Module 1 Semantic module 1			
Work at lectures	0…0,5	6	0…3
Execution and approval of laboratory (practical) works	3…5	4	12…20
Modular testing	18…27	1	18…27
Module 2 Semantic module 1			
Work at lectures	0…0,5	6	0…3
Execution and approval of laboratory (practical) works	3…5	4	12…20
Modular testing	18…27	1	18…27
Total for course			**60…100**

The semester control (exam) is carried out in case of refusal of the student from the points of the current testing and if there is admission to the exam. Admission to the exam is granted subject to completion and completion of all laboratory work.

During the semester exam the student can get a maximum of 100 points.

The exam ticket consists of two questions from the first and second module.

The maximum score for each question is 20.

10.2 Qualitative evaluation criteria

In order to receive a positive assessment, a student must

know:

- Basic means of information gathering;
- Methods of statistical decisions;
- Trend analysis methods.

be able:

- use mathematical models for diagnosis;
- determine limit values of measurement parameters for transition from one state to another;
- use information theory.

10.3 Criteria of the student evaluation during semester

Satisfactory (60-74). Have the necessary minimum of knowledge and skills. Work out and protect all labs. Pass a unit test with a positive evaluation. Know the basic methods of diagnosis. Be able to use statistical decision methods.

Good (75-89). Know all the requirements that are required for a satisfactory assessment. Know how to collect information. Know and apply methods of tolerance control and trend analysis.

Excellent (90-100). Excellent to know all requirements for Systems for diagnosing objects of aviation engineering. Know the methods of probability theory and mathematical statistics and be able to apply them. Know the methods of detecting defects and be able to apply them. Know the methods of non-destructive diagnosis and be able to apply them.

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

11. Methodological support

1. Didactic materials (visual aids).
2. Calculation and control programs PC:
   - "Mathematical model of GTE" (Models);
   - "Indicators of reliability of diagnosis of GTE" (Rapid);
   - "Errors of measurement activities" (Project).
   - "Modeling of statistical data by Monte Carlo method" (isnos);
3. Methodical working of departments 203 with calculation methods and variants of tasks.

12. Recommended literature for the course

Main

1. The Jet engine [Text] // The Technical Publications Department of RR plc. – Derby, England. – 1996. – 278 p.
2. Treager, I. E. Aircraft gas turbine engine technology [Text] / I. E. Treager. – 3-rd ed. – Glencoe/McGraw-Hill. 2001. – 677 p.
3. Hunecke, K. Jet engines. Fundamentals of theory, design and operation [Text] / K. Hunecke. – 6-th impression. - Osceola.: Motorbooks IP&W, 2003. – 241 p.
4. Boyce, M.P. Gas turbine engineering handbook [Text] / M. P. Boyce. - 3-rd ed. – Gulf Professional Publishing. – 2006. – 936 p.

Additional

1. Синтез систем управления и диагностирования газотурбинных двигателей [Текст] /С. В. Епифанов, Б. И. Кузнецов, И. Н. Богаенко и др. – К. : Техніка, 1998. – 312 с.