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

Department of Space Technology and Non-Conventional Energy Sources (No. 402)

"I APPROVE"

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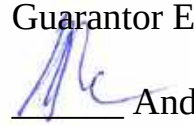

_____ Andriy POGUDIN

« » _____2025

SYLLABUS OF THE MANDATORY COURSE
ACADEMIC DISCIPLINE

« Design wind turbines »

Area of knowledge: 14 "Electrical Engineering"

Specialty: 141 "Electrical Power Engineering, Electrical Engineering and Electromechanics"

Educational programs: "Non-traditional and renewable energy sources"

Level of higher education : first (bachelor's degree)

The syllabus is effective from 01.09.2025

Kharkiv – 2025

Developer:

Senior Lecturer, Department of
Space Technology and Non-Conventional Energy Sources (No. 402) _____
Maksym NAKAZNENKO

The syllabus of the academic discipline was considered at the meeting of the Department of Space Technology and Non-Conventional Energy Sources

Protocol No. __1__ dated "28" __August_____ 2025

Acting Head of the Department, Ph.D., Associate Professor _____ Yuriy SHEPETOV

Agreed with the representative of education seekers:

_____ _____ Olexander LISIN
(signature) (first name and last name)

1. General information about the teacher

Full name: Nakaznenko Maksym Mykolayovych
Position: Senior Lecturer, Department of Space Technology and Non-Conventional Energy Sources
Academic degree: -
Academic title: -
List of disciplines taught: "Computer methods for calculating rocket and space technology structures" "Systems for automated design of aircraft engines and power plants" « Design wind turbines » "Operation of unconventional energy installations" "Integrated energy plants with non-traditional energy sources"
Areas of scientific research: - Design and calculation of power plants with renewable energy sources; -Modeling of thermal regimes of microsatellites ; -Non-traditional energy sources;
Contact information: m.nakaznenko@khai.edu

2. Description of the academic discipline

Form of education	Daily
Semester	7th
Language of instruction	Ukrainian
Type of discipline	Required
Course volume: ECTS credits/number of hours	Full-time: 5 ECTS credits / 150 hours (64 classroom hours, of which: lectures – 32, practical – 16; laboratory work-16, SRH – 86)
Types of educational activities	Lectures, practical (seminar) classes, laboratory work, independent work,
Types of control	Current control, module control, performance of calculation work, semester control - exam
Prerequisites	"Electrical equipment of power plants", "Electrical stations, networks and systems"
Co-requisites	Information control systems and complexes of NEU
Post-requisites	« Design wind turbines -KP»

3. Purpose and objectives of the academic discipline, lists of competencies and expected learning outcomes

The purpose of the academic discipline is: *to acquire professional knowledge in the design and construction basics of wind power plants and their components.*

Task – *mastering theoretical knowledge and practical skills in calculating the loads acting on the rotor blades of wind power plants, choosing the design and production technologies of wind power plant blades.*

Competencies acquired:

Integral competence : *The ability to solve specialized tasks and solve practical problems during professional activities in the field of electrical power engineering, electrical engineering and electromechanics or in the process of learning, which involves the application of theories and methods of physics and engineering sciences and are characterized by complexity and uncertainty of conditions.*

General Competencies (GC)

After completing this program, the student will be able to:

Ability for abstract thinking, analysis and synthesis.

Ability to apply knowledge in practical situations.

Special competencies:

After completing this program, the student will be able to:

Ability to solve complex specialized tasks and practical problems related to the operation of non-traditional and renewable energy facilities.

Ability to solve complex specialized tasks and practical problems related to the problems of production, transmission and distribution of electrical energy at non-traditional and renewable energy facilities.
Ability to develop designs for electrical power, electrical engineering and electromechanical equipment for non-traditional and renewable energy facilities in compliance with the requirements of legislation, standards and technical specifications.

Program learning outcomes:

Know the principles of operation of bioenergy, wind energy, hydropower and solar energy plants
Select and apply suitable methods for the analysis and synthesis of electromechanical and electrical power systems in renewable energy
Solve complex specialized problems in the design and maintenance of renewable energy facilities.

4. Content of the academic discipline

Content module #1

TOPIC 1. General characteristics of wind energy.

General characteristics of wind energy. History of wind energy development. Wind energy measurements and calculations. Classification of wind turbines. General structure of wind energy installation systems. Energy characteristics of wind flow.

Lectures: *"General characteristics of wind energy in Ukraine and the world. History of the development of wind energy ", "Classification of wind turbines. General construction of wind power plant systems"*

Practical classes: " *Determination of the calculated wind speed based on measurement results. " Preliminary calculation of the dimensions of the wind turbine based on macro parameters "*

Laboratory work *: Wind flow research. Measurements and analysis*

Independent work of the student: *studying the lecture material, taking a test on the theoretical material.*

TOPIC 2. General information on aerodynamics.

Continuity equation. Bernoulli equation. Similarity criteria. Coordinate axes and aerodynamic coefficients. Center of pressure. Inductive resistance of the blade. M.E. Zhukovsky's theorem on the lifting force of blades and the work of the surface when the wind force acts on it. The work of the rotor of a bladed wind turbine. The lifting force of a rotating cylinder, the Magnus effect .

Lectures: *"Fundamentals of aerodynamics. The work of a flat surface and a cylinder in a wind flow."*

Practical classes: *"Working with databases and atlases of aerodynamic profiles. Choosing an aerodynamic profile for a wind turbine blade . "*

Laboratory work *: Study of flow around an aerodynamic profile*

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

TOPIC 3. Wind turbine rotor theories.

Theory of the ideal wind turbine by M.E. Zhukovsky. Theory of the ideal wind turbine by G.H. Sabinin. Speed. Theory of a real windmill. Processes occurring in a real rotor. Coupling equation. Torque and power of the rotor of a wind turbine. Losses of the rotor of a wind turbine . Glauert correction .

Lectures: *"Theory of the ideal wind turbine by M.E. Zhukovsky. The theory of the ideal wind turbine by G.Kh. Sabinin, "Theory of the real windmill"*

Practical classes : *"Calculation of wind turbine rotor losses."*

Laboratory work *: "Experimental study of a horizontal-axis wind turbine ."*

Independent work of the student: *studying lecture material, completing individual practical tasks and preparing for their defense, taking a test on theoretical material.*

TOPIC 4. Wind energy conversion by vertical axis wind turbines.

Aerodynamics of carousel-type wind turbines. Aerodynamics of a Savonius system wind turbine . Aerodynamics of a wind turbine with straight profiled blades.

Lectures: " *Vertical-axis wind turbines* ".

Practical classes **:** *"Preliminary calculation of a vertical axis wind turbine ".*

Laboratory work *: "Experimental study of a vertical-axis wind turbine ."*

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

TOPIC 5. Force factors acting on a wind turbine .

Aerodynamic forces. Gravitational forces. Centrifugal forces. Other factors acting on blade and wind turbine elements .

Lectures: *" Force factors acting on a wind turbine ."*

Practical exercises: *"Calculation of forces acting on blade elements"* .

Laboratory work : -

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

TOPIC 6. Efficiency of using wind energy by a wind turbine.

Regulated wind speeds. Technical indicators of the efficiency of using wind power plants . Aerodynamic characteristics wind turbines . Workers characteristics wind turbine .

Lectures: *"Energy characteristics of a wind turbine ".*

Practical classes: -

Laboratory work : -

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

Content module #2

TOPIC 7. Design of wind turbines.

Classes of wind turbines and their structural diagrams. Diagrams and structural elements of wind turbines with a horizontal axis of rotation. Diagrams and structural elements of wind turbines with a vertical axis of rotation. Wind turbine supports, types

and features. Wind turbine blade design. Materials and technology for manufacturing blades.

Lectures: " *Classes of wind turbines and their structural diagrams. Schemes and structural elements of wind turbines with a horizontal axis of rotation", "Schemes and structural elements of wind turbines with a vertical axis of rotation. "Supports of wind power plants: types and features", " Design of wind turbine blades. Materials and technology for manufacturing blades."*

Practical classes: -

Laboratory work :-

Independent work of the student: *studying lecture material, taking a test on theoretical material.*

TOPIC 8. Electricity generation systems in wind power plants

Methods of generating electricity. Synchronous generators. Permanent magnet synchronous generators. Asynchronous generators. DC generators. Special types of generators

Lectures *: "* Generators for wind turbines, their types and features of use *."*

Practical classes: *"Working with generator documentation. Calculation and selection of generators . "*

Laboratory work *: "Testing a DC generator of independent excitation of a wind power plant ". "Testing a single-phase synchronous*
generator with permanent excitation of a wind power plant .

Independent work of the student: *studying lecture material, taking a test on theoretical material.*

TOPIC 9. Control systems and regulation of parameters of wind power plants.

Orientation of a horizontal-axis wind turbine to the direction of the wind flow. Methods of regulating the power of a horizontal-axis wind turbine. Regulation of parameters of a vertical-axis wind turbine. Principles of construction of automatic regulation, control and protection systems of wind turbines. Coordination of the powers of a wind turbine and a generator at variable
wind turbine rotation frequency

Lectures: *"Control systems and regulation of parameters of wind power plants."*

Practical classes: -

Laboratory work *: "Study of the design of a low-power wind turbine control system"*

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

TOPIC 10. Operating modes and connection diagrams of wind power plants.

Operating modes of wind power plants. Operation of wind power plants on autonomous load. Operation of wind power plants on the power system. Basic schemes

for switching on wind power plants. Schemes of electrical connections of wind power plants.

Lectures: *"Operating modes of wind power plants". "Schematics of inclusions and electrical connections of wind power plants"*

Practical classes: -

Laboratory work :-

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

TOPIC 1 1. Environmental issues in the context of wind energy.

Operating modes of wind power plants. Operation of wind power plants on autonomous load. Operation of wind power plants on the power system.

Lectures: *"Control systems and regulation of parameters of wind power plants."*

Practical classes: -

Laboratory work :-

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

TOPIC 1 2. Economic features of the use of wind energy.

General information. Capital investments. Cost of electricity production. Estimated payback period of wind farms.

Lectures: *"Economic Features of Wind Energy Use."*

Practical classes: "Calculation of the cost of electricity production "

« Estimated payback period of a wind farm »

Laboratory work : -

Independent work of the student: *studying lecture material, completing an individual practical assignment and preparing for its defense, taking a test on theoretical material.*

5. Individual tasks

Calculation work on the topic: "Aerodynamic calculation of a wind turbine blade ."

6. Teaching methods

Conducting classroom lectures, practical work, individual consultations (if necessary), independent work of students based on materials published by the department (methodological manuals).

7. Control methods

Verification and defense of practical tasks, RR, exam.

8. Evaluation criteria and distribution of points, which students receive

Table 8.1 – Distribution of points received by education seekers

Components of educational work	Points for one lesson (task)	Number of lessons (tasks)	Total points
Content module 1			
Completion and defense of practical work	2…3	6	12…18
Performing and defending laboratory work	2...3	4	8…12
Modular control	10…20	1	10…20
Content module 2			
Completion and defense of practical work	2...3	2	4…6
Performing and defending laboratory work	2...3	2	4…6
Implementation of the RR	12…18	1	12…18
Modular control	10…20	1	10…20
Total per semester			**60…100**

Semester control (exam) is conducted in case the student refuses the final control points and has admission to the exam. When taking the semester exam/credit, the student has the opportunity to receive a maximum of 100 points.

The exam ticket consists of two theoretical questions and a practical task. The maximum number of points for answering each theoretical question is 30 points, for completing the practical task is 40 points.

Criteria for evaluating a student's work during the semester

Required amount of knowledge to receive a positive assessment:

General characteristics of wind energy. History of wind energy development. Wind energy measurements and calculations. Classification of wind turbines. General construction of wind energy installation systems. Energy characteristics of wind flow. Continuity equation. Bernoulli equation. Similarity criteria. Coordinate axes and aerodynamic coefficients. Center of pressure. Inductive resistance of the blade. M.E. Zhukovsky's theorem on the lifting force of blades and the work of the surface under the action of wind force on it. Work of the rotor of a bladed wind turbine. Lifting force of a rotating cylinder Magnus effect . Theory of the ideal wind turbine by M.E. Zhukovsky. Theory of the ideal wind turbine by G.Kh. Sabinin. Speed. Theory of a real windmill.

Processes occurring in a real rotor. Coupling equation. Torque and power of the rotor of a wind turbine. Losses of the rotor of a wind turbine . Glauert Amendment . Aerodynamics of carousel-type wind turbines . Aerodynamics of a Savonius system wind turbine . Aerodynamics of a wind turbine with straight profiled blades . Aerodynamic forces. Gravitational forces. Centrifugal forces. Other factors acting on blade elements and wind turbines . Regulated wind speeds. Technical indicators of the efficiency of wind power plants. Aerodynamic characteristics wind turbines . Workers characteristics wind turbine . Classes of wind turbines and their structural diagrams. Diagrams and structural elements of wind turbines with a horizontal axis of rotation. Diagrams and structural elements of wind turbines with a vertical axis of rotation. Wind turbine supports, types and features. Wind turbine blade design. Materials and technology for manufacturing blades. Methods of generating electricity. Synchronous generators. Permanent magnet synchronous generators. Asynchronous generators. DC generators. Special types of generators. Orientation of a horizontal-axis wind turbine to the direction of the wind flow. Methods of regulating the power of a horizontal-axis wind turbine. Regulation of vertical-axis wind turbine parameters. Principles of constructing automatic regulation, control and protection systems for wind turbines. Coordination of wind turbine and generator capacities at variable wind turbine rotation frequency. Wind turbine operating modes. Operation of wind turbines on autonomous load. Operation of wind turbines on the power system. Basic schemes for switching on wind turbines. Schemes of electrical connections of wind power plants. Wind turbine operating modes. Operation of wind turbines on autonomous load. Operation of wind power plants on the power grid. General information. Capital investments. Cost of electricity production. Estimated payback period of wind power plants.

The required amount of skills to receive a positive assessment:

Determination of the calculated wind speed based on measurement results. Calculation of the dimensions of the wind turbine by macro parameters . Work with databases and atlases of aerodynamic profiles. Selection of the aerodynamic profile for the wind turbine blade . Calculation of the losses of the wind turbine rotor. Preliminary calculation of the vertical-axis wind turbine . Calculation of the forces acting on the blade elements. Work with generator documentation. Calculation and selection of generators. Calculation of the cost of electricity production . Estimated estimate of the payback period of the wind farm

Satisfactory (60-74). Have a minimum of knowledge and skills. Complete and defend all practical work. Demonstrate understanding of the basic principles of calculation methods.

Good (75 - 89). Acquire a minimum of knowledge and skills, complete all tasks, defend all practical work and RR within the time specified by the teacher with justification of the decisions made. Demonstrate understanding of most of the provisions of the calculation methodology.

Excellent (90 - 100) . Fully know the main and additional material. Know all topics. Be familiar with textbooks and manuals. Complete all tasks, defend all practical work within the time specified by the teacher with justification of the decisions made.

Demonstrate a high-quality understanding of all provisions of the calculation methodology.

Grading scale: point and traditional

Total points	Traditional scale rating	
	Exam, differentiated test	Test
90 – 100	Perfectly	Enrolled
75 – 89	Good	
60 – 74	Satisfactorily	
0 – 59	Unsatisfactorily	Not included

9. Course Policy

Attendance at classes. Regulation of absences. The interactive nature of the course requires mandatory attendance at practical classes. Students who, under certain circumstances, cannot attend practical classes regularly must agree with the teacher during the week on a schedule for individual work-through of missed classes. Individual missed classes must be worked out at the nearest consultation within a week after they were missed. Work-through of classes is carried out orally in the form of an interview on questions specified in the class plan. In some cases, written work-through of missed classes is allowed by completing an individual written assignment.

Compliance with the requirements of academic integrity by education seekers during the study of the academic discipline. During the study of the academic discipline, education seekers must adhere to generally accepted moral and ethical norms and rules of conduct, the requirements of academic integrity stipulated by the Regulations on Academic Integrity of the National Aerospace University "Kharkiv Aviation Institute" (https://khai.edu/assets/files/polozhennya/polozhennya-pro-akademichnu-dobrochesnist.pdf). It is expected that the works of education seekers will be their original research or reasoning. The absence of references to the sources used, fabrication of sources, plagiarism, interference in the work of other education seekers are, but are not limited to, examples of possible academic dishonesty . Identification of signs of academic dishonesty in the written work of an education seeker is grounds for its non-registration by the teacher, regardless of the extent of plagiarism or deception.

Conflict resolution. The order and procedures for resolving conflicts related to corrupt actions, conflicts of interest, various forms of discrimination, sexual harassment, interpersonal relationships and other situations that may arise during training, as well as the rules of ethical behavior are regulated by the Code of Ethical Behavior at the National Aerospace University "Kharkiv Aviation Institute" (https://khai.edu/ua/university/normativna-baza/ustanovchi-dokumenti/kodeks-etichnoi-povedinki/).

10. Methodological support

1. Yakovlev O.I. Calculation and design of wind power plants with a horizontal-axis wind turbine and a synchronous generator on permanent magnets: Textbook on course design/ O.I . Yakovlev, M.O. Zatuchna , V.M. Merkushev , V.M. Pashkov . - Kh.: National Aerospace University "Kharkiv. Aviation Institute", 2001. - 130 p.
   .
2. Legoshin D.V. Calculation of the distribution of working and test loads on the blade of a large wind turbine: a manual . / [Belan N. V., Tykhevych O. O., Poltarushnikov S. A. and others]. - Kharkiv: National Aerospace University "Kharkiv. Aviation Institute " , 2006. - 59 p.
3. https://mentor.khai.edu/course/view.php?id=3288

1 1. Recommended reading

Basic

1. Inexhaustible energy. Wind energy / Kryvtsov V. S., Oleinikov A. M., Yakovlev A. I. - Textbook - Kharkiv: Khai, 2004. -158 p.
2. Fundamentals of wind energy / G. Pivnyak , F. Shkrabets , N. Neuberger , D. Tsyplenkov - Textbook. – Dnipro: Ministry of Education and Science of Ukraine, National Mining University . – Dnipro: NGU, 2015. – 335 p.
3. Syrotyuk S.V., Boyarchuk V.M., Halchuk V.P. Alternative energy sources. Wind energy – Lviv: “Magnolia-2006”, 2018. – 182p.
4. Karplyuk , V.I. Manual for studying the discipline "Aerodynamics of wind power plants" [Text] / V.I. Karplyuk , M. M. Lychagin . – D.: RVV DNU, 2008. – 56 p.

Auxiliary

1. Yakhno O.M. Wind power: design and calculation of wind turbines: Textbook /O.M. Yakhno , T. G. Taurit , N. G. Grabar // NTU “Kyiv Polytechnic Institute”, Zhytomyr State University - 2003. 256 p.

12. Information resources

1. Airfoil airfoil database Tools - – Access mode: http://airfoiltools.com/index