



**Perspective directions of energy development  
and resource-efficient processes, equipment and technologies**

**Work program of the discipline (Syllabus)**

**Details of the discipline**

<b>Level of higher education</b>	<i>Third (educational and scientific)</i>
<b>Branch of knowledge</b>	<i>13 Mechanical engineering</i>
<b>Specialty</b>	<i>133 Industrial engineering</i>
<b>Educational program</b>	<i>Industry engineering</i>
<b>Discipline status</b>	<i>Required</i>
<b>Form of study</b>	<i>full-time (day) / full-time (evening) / part-time / remote / mixed</i>
<b>Year of preparation, semester</b>	<i>2nd year, spring semester</i>
<b>The scope of discipline</b>	<i>4 (120)</i>
<b>Semester control / control measures</b>	<i>Examination</i>
<b>Timetable</b>	<i>3 hours per week (1 hour of lectures and 2 hours of practical classes)</i>
<b>Language of instruction</b>	<i>Ukrainian</i>
<b>Information about course leader / teachers</b>	Lecturer: Prof., Dr. those. Science Zenkin Mykola Anatoliyovych tel. +38050 5476797, e-mail address nikolay_zenkin@ukr.net.
<b>Course placement</b>	<i><a href="http://ci.kpi.ua">ci.kpi.ua</a></i>

**Curriculum of the discipline**

**1. Description of the discipline, its purpose, subject of study and learning outcomes**

Today, the global trend is "greening" of the economy, ie the transition from development through consumption of natural resources and related environmental damage in the direction of increasing resource efficiency, dematerialization of production and consumption, development of additional sources of value. One of the foundations of a green economy is resource efficiency, which is one of the priorities of most countries, regardless of the amount of natural resources available to them. Transformation of the economy in the direction of resource efficiency contributes to increasing the competitiveness of business, attracting new sources of growth and job creation.

With the deepening of the integration processes of the Ukrainian economy into the world, a large number of domestic companies face the requirements and standards of new markets. Ukrainian enterprises need to modernize their production processes, improve product quality and reduce costs by increasing resource efficiency, which is especially relevant in the context of the Free Trade Agreement between Ukraine and the European Union. At the same time, for most Ukrainian enterprises the problem of limited access to new technologies and modern methods of improving production is relevant. Such techniques and tools would reduce the resource intensity of production processes, applying even low-cost measures, but for the development and implementation of these measures requires certain specific knowledge and skills of employees. Therefore,

**The subject of the discipline "Perspective directions of development of energy and resource-efficient processes, equipment and technologies »** - implementation of approaches that will ensure the implementation of modern directions of development of enterprises in the industry with the use of modern equipment and technologies based on energy and resource conservation.

To a large extent, the solution to this problem will be determined by the level of training of specialists working in the field of mechanical engineering, including state energy management institutions, research institutions, organizations and enterprises.

To successfully solve the problem of implementing energy and resource efficient processes, specialists must be free to own and process information, be able to solve complex problems of providing production with modern equipment and technologies, taking into account the environmental and economic components.

**The purpose of the discipline "Perspective directions of development of energy and resource efficient processes, equipment and technologies"**

The purpose of studying this discipline is to form in graduate students a set of knowledge in the field of modern technologies, scientific developments, equipment and processes, taking into account their energy efficiency and resource efficiency.

In accordance with the purpose of training doctors of philosophy in this specialty requires strengthening the competencies formed in graduate students:

- ability to critically analyze, evaluate and synthesize new and complex ideas;
- ability to develop and implement projects, including own research;
- based on determining the state of energy and resource efficiency of the enterprise and the analysis of negative impacts on the production system, the ability to offer modernization of equipment and new technologies in order to achieve maximum economic and positive environmental effect.

According to the requirements of the program of the discipline "**Perspective directions of development of energy and resource-efficient processes, equipment and technologies »**, students after mastering it must demonstrate the following program learning outcomes:

- to know the priority state directions of development of science, equipment and technologies in professional and related fields;
- know the main directions of state policy in the field of energy saving, energy efficiency and energy independence;
- be able to formulate and test hypotheses, use appropriate evidence to substantiate the conclusions, in particular the results of theoretical analysis and experimental studies of ways to activate the man-made environment;
- professionally process, analyze, summarize and scientifically substantiate the scientific results of research on the production of the latest theoretical positions and innovative energy and resource efficient solutions.

## **2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)**

Study of the discipline «**Promising directions for the development of energy and resource efficient processes, equipment and technologies**» is based on the principles of integration of various knowledge acquired by graduate students during the bachelor's and master's degree in the study of natural sciences and engineering. Discipline «**Promising directions for the development of energy and resource efficient processes, equipment and technologies**» is a fundamental basis that should provide solving complex problems in the field of development of modern energy and resource efficient processes, use of modern equipment and technologies and is aimed at deep rethinking of existing and creation of new holistic knowledge and professional practice.

## **3. The content of the discipline**

**Section 1. Basic energy saving measures. Current state and world trends in energy saving. Energy independence as a component of Ukraine's national security.**

Topic 1. Types and sources of energy in Ukraine and the world. Promising energy sources, renewable energy sources.

Topic 2. Energy strategy of Ukraine for the period up to 2030, energy saving strategy in Ukraine as components of national security of Ukraine

### **Section 2. Low-waste and non-waste technological processes. Efficient use of water. Reduction of production wastewater and their treatment.**

Topic 3. Negative impact of outdated technologies and equipment on the environment. Replacement of technologies and equipment with modern, energy efficient and environmentally friendly ones. Economic feasibility of replacing obsolete equipment.

### **Section 3. Reduction of waste generation and their utilization. Sources of waste in production. Sources of air pollution.**

Topic 4. The main provisions of the laws of Ukraine on environmental protection. Sources of waste generation in production, ways to reduce waste and safe and efficient waste management. Organization and support of waste processing.

**Section 4.** Effective use of materials. Classification of raw materials. The choice of raw materials and its quality. Eco-industrial parks and innovation clusters.

Topic 5. Current trends and directions of effective use of materials. Rapid Prototyping Technologies.

Topic 6. Surface strengthening of parts as a way to extend their service life. Modern chemical technologies and energy efficiency. Modern methods of processing used materials.

Topic 7. Eco-industrial parks and innovation clusters: purpose, efficiency, economic feasibility.

### **Section 5. Resource-efficient and clean production as a tool for the transition to a "green" economy.**

Topic 8. Integrated resource-efficient technologies in the world and prospects for their development in Ukraine. Goals and benefits of resource efficient and clean production.

**Section 6.** Introduction of resource efficient and clean production (RES) in the industrial sector. Priority areas of RECHV assessment. Search for resource-efficient solutions. SUBSTANCE APPROACHES.

Topic 9. RECHV-assessment: analysis of material flows, analysis of equipment, analysis of energy flows, analysis of water efficiency. Selection and ecological and economic substantiation of RECH measures. Ecological, economic, technical assessment of the proposed implementations of energy-, resource-efficient processes, equipment and technologies.

## **4. Training materials and resources**

### **Basic literature**

1. Vorfolomeev AV Fundamentals of resource efficiency of enterprises. Teaching. manual. - K. : 2018. - 52 p.
2. Dzyadkevich Yu.V. Economic bases of resource saving. Tutorial. - Ternopil: Vector, 2015. - 76 p.
3. Energy strategy of Ukraine for the period up to 2030. Approved by the order of the Cabinet of Ministers of Ukraine dated 24.07.2013 № 1071.
4. Tsybka M. Resource efficient and clean production. Teaching. manual / M. Tsybka, K. Romanova, A. Vorfolomeev. - K. : 2017. - 84 c.

### ***Additional literature***

5. Law of Ukraine "On Environmental Protection". - K., 1991.
6. Law of Ukraine "On Energy Conservation" - Bulletin of the Verkhovna Rada of Ukraine, 1994, №30, Art. 283.
7. Energy saving installations and environment / Under. ed. prof. Malyarenko VA / Textbook. - M. : ХГАГХ, 2002. - 738 c.

8. Dzhedzhula, VV Energozberezhennia promyslovykh pidpriemstv: metodologiya formuvannia, mekhanizm upravlinnia [Energy saving of industrial enterprises: methodology of formation, management mechanism]. - Vinnytsia: VNTU, 2014. - 346 p.
9. Deyneko VA Energy management and energy saving. Method. manual for self. work stud. / State Academy of Light Industry of Ukraine, National Technical University of Ukraine "KI". - K .: 1995. Book 5 Efficient use of thermal energy. - 59 p.
10. Energy saving strategy in Ukraine: Analytical and reference materials in 2 volumes: General principles of energy saving / Ed. V.A. Zhovtyansky, MM Kulika, B.S. Moans. - K .: Akadempriodika, 2006. - T.1. - 510 s.
11. Bobovich BB Processing of production and consumption wastes / B.B. Bobovych, VV Renewable energy sources in local facilities / Yu.I. Yakymenko, Ye.I. Sokol, V.Ya. Жуйков, Ю.С. Peterger, OL Ivanin. - Kyiv: IPC "Polytechnic", 2001. - 114 p.
12. Sibikin Yu.D. Energy saving technology: textbook / Yu.D.Sibikin, M. Yu. Sibikin.- M .: Forum. 2005.- 348 p.

### ***Information resources on the Internet***

13. Law of Ukraine "On the basis of national security" / Verkhovna Rada of Ukraine [Electronic resource]. - Access mode: <http://zakon4.rada.gov.ua/laws/show/964-15>.
14. Energy strategy of Ukraine for the period up to 2030 [Electronic resource] .– Access mode: <http://zakon4.rada.gov.ua/laws/show/n0002120-13>.
15. Ministry of Environmental Protection and Natural Resources of Ukraine - <https://mepr.gov.ua/>
16. Industrial ecology. Community of Environmentalists -<http://www.eco.com.ua/>
17. Professional Association of Ecologists of Ukraine (PAEU) - <https://paeu.com.ua/>
18. Principles and practices of resource-efficient production: a guide to better business [http://recpc.kpi.ua/images/eap\\_green/printed\\_materials/RECP-Prim-er-2017.pdf](http://recpc.kpi.ua/images/eap_green/printed_materials/RECP-Prim-er-2017.pdf)
19. Guide to implementing methods of resource-efficient and cleaner production [http://www.recpc.org/wp-content/uploads/2018/02/Posibnik\\_Cen-trREChV\\_14-05-17\\_Prew.pdf](http://www.recpc.org/wp-content/uploads/2018/02/Posibnik_Cen-trREChV_14-05-17_Prew.pdf)
20. Handbook of Best Practices for Improving Resource Efficiency [http://www.recpc.org/wp-content/uploads/2018/02/Katalog\\_2017\\_view-3.pdf](http://www.recpc.org/wp-content/uploads/2018/02/Katalog_2017_view-3.pdf)
21. Resource efficient and clean production: textbook. manual .: [Electronic resource]. - Access mode:<http://recpc.kpi.ua>

## Educational content

### 5. Methods of mastering the discipline (educational component)

#### Lectures

*Lectures are aimed at:*

- providing modern, holistic, interdependent knowledge of the discipline «**Promising directions for the development of energy and resource efficient processes, equipment and technologies**», the level of which is determined by the target setting for each specific topic;
- providing creative work of postgraduate students together with the teacher during the lecture;
- education of postgraduate students of professional and business qualities and development of their independent creative thinking;
- formation of the necessary interest in graduate students and providing direction for independent work;
- reflection of methodical processing of material (selection of the main provisions, conclusions, recommendations, clear and adequate to their formulations);
- use for demonstration of visual materials, combination, if possible, with demonstration of results and samples;
- teaching research materials in clear and high-quality language with observance of structural and logical connections, explanation of all newly introduced terms and concepts;
- accessibility for perception by this audience.

<i>N<sup>o</sup> s / n</i>	<i>The title of the lecture topic and a list of main issues (list of teaching aids, references to the literature and tasks on VTS)</i>	<i>Hours</i>
1	<p><b>Types and sources of energy in Ukraine and the world. Promising energy sources, renewable energy sources.</b></p> <p>Analyze literature data on existing types and sources of energy in Ukraine and the world. Know the basics of energy management and existing means of energy production: chemical power sources, heat pumps, biofuels, energy cogeneration systems). Understand the principles of energy efficiency. Energy efficient lighting.</p> <p><i>Literature:</i> [1] p. 18-32; [2] c. 12-30.</p> <p><i>Tasks on VTS.</i> Identify the most promising energy sources, renewable energy sources. Analyze the possibility of using solar energy (solar collectors, solar power plants), wind energy, centralized and dispersed power supply systems</p>	2
2	<p><b>Energy strategy of Ukraine for the period up to 2030, energy saving strategy in Ukraine as components of national security of Ukraine</b></p> <p>Sources and consumers of water resources in production. Know the basic information about the quality characteristics of water. Understand the principles of efficient use of water resources.</p> <p>The main tasks and principles of reducing the volume of wastewater at the enterprise and their treatment. The main types of wastewater at the enterprise, and methods of wastewater treatment. Ecological thinking regarding wastewater reduction.</p> <p><i>Literature:</i> [3] p. 118-214; [4] c. 206-218; [18].</p> <p><i>Tasks on VTS.</i> Analyze the possibilities of negative impact of outdated technologies and equipment on the environment. Identify the possibility of replacing technologies and equipment with modern, energy efficient and environmentally friendly.</p>	2

3	<p><b>Negative impact of outdated technologies and equipment on the environment. Replacement of technologies and equipment with modern, energy efficient and environmentally friendly ones. Economic feasibility of replacing obsolete equipment.</b></p> <p>Sources of waste generation in production, ways to reduce waste and safe and efficient waste management. Organization and support of waste processing.</p> <p><i>Literature: [5] p. 100-125; [6] c. 1-50. [8] c. 14-20.</i></p> <p><i>Tasks on VTS.</i> The main sources of air emissions and ways to reduce air emissions. Global trends in the use of thermal energy production and measures to clean up emissions into the atmosphereair. Know the basic provisions of the laws of Ukraine on environmental protection.</p>	2
4	<p><b>The main provisions of the laws of Ukraine on environmental protection. Sources of waste generation in production, ways to reduce waste and safe and efficient waste management. Organization and support of waste processing.</b></p> <p><i>Literature: [1] p. 18-26; [12] c. 58-72; [15] c. 62-69.</i></p> <p><i>Tasks on VTS.</i> Understand the main sources of air emissions and ways to reduce emissions. Know the world trends in the use of thermal energy production and measures to clean emissions into the atmosphere. Know the basic provisions of the laws of Ukraine on environmental protection.</p>	2
5	<p><b>Current trends and directions of effective use of materials. Rapid Prototyping Technologies.</b></p> <p>Current trends and directions of effective use of materials. Rapid Prototyping technologies as a way to save resources and materials in the manufacture of machine parts and components.</p> <p><i>Literature: [5] p. 126-128; [11] c. 200-205.</i></p> <p><i>Tasks on VTS.</i> Technologies for replacing classic parts materials with modern materials with improved properties.</p>	2
6	<p><b>Surface strengthening of parts as a way to extend their service life. Modern chemical technologies and energy efficiency. Modern methods of processing used materials.</b></p> <p>Extending the service life of parts and components using resource-saving energy-intensive technologies. Methods and ways of surface hardening of delals.</p> <p><i>Literature: [4] p. 320-326; [5] c. 114-118.</i></p> <p><i>Tasks on VTS.</i> Modern methods of processing and reuse of materials.</p>	2
7	<p><b>Eco-industrial parks and innovation clusters: purpose, efficiency, economic feasibility.</b></p> <p>Basic principles of creating eco-industrial parks and innovation clusters.</p> <p><i>Literature: [5] p. 4-15; [14] c. 318-351.</i></p> <p><i>Tasks on VTS.</i> Model of eco-industrial park. Creating an innovation cluster</p>	2
8	<p><b>Complex resource-efficient technologies in the world and prospects of their development in Ukraine. Goals and benefits of resource efficient and clean production.</b></p> <p><i>Literature: [8] p. 42-56; [11] c. 326-364.</i></p> <p><i>Tasks on VTS.</i> Goals and benefits of resource efficient and clean production. Environmental and economic aspects of the introduction of modern energy and resource efficient production, equipment and technologies.</p>	2

9	<p><b>RECHV-assessment: analysis of material flows, analysis of equipment, analysis of energy flows, analysis of water efficiency. Selection and ecological and economic substantiation of RECH measures. Ecological, economic, technical assessment of the proposed implementations of energy-, resource-efficient processes, equipment and technologies.</b></p> <p>Analysis of the main divisions of the enterprise. Collection of general information on resource consumption and production. Calculation of resource consumption indicators. Data analysis. Selection of priority areas of RECH assessment.</p> <p><i>Literature: [3] p. 200-232; [5] c. 14-26.</i></p> <p><i>Tasks on VTS.</i> RECHV-assessment: analysis of material flows, analysis of equipment, analysis of energy flows, analysis of water efficiency. Selection and ecological and economic substantiation of RECH measures. Ecological, economic, technical assessment of the proposed implementations of energy-, resource-efficient processes, equipment and technologies.</p>	2
	<b>Total</b>	<b>18</b>

### Practical training

In the system of professional training of graduate students in this discipline, practical classes occupy 65% of the classroom workload. As a supplement to the lecture course, they lay and form the basis of the qualification of Doctor of Philosophy in the field of mechanical engineering, namely knowledge and ability to choose promising areas of energy and resource efficient processes, equipment and technologies. The content of these classes and methods of conducting them should ensure the development of creative activity of the individual. They develop scientific thinking and the ability to use special terminology, allow you to test knowledge, so this type of work is an important means of operational feedback. Practical classes should perform not only cognitive and educational functions, but also promote the growth of graduate students as creative workers in the field of mechanical engineering.

The main tasks of the cycle of practical classes:

- to help graduate students to systematize, consolidate and deepen theoretical knowledge in the field of modern energy and resource efficient processes, equipment and technologies;
- to teach graduate students techniques for solving practical problems, to promote the acquisition of skills and abilities to perform calculations, graphics and other tasks;
- to teach to work with scientific and reference literature and schemes;
- to form skills learn independently, ie master the methods, techniques and techniques of self-learning, self-development and self-control.

<i>N<sup>o</sup> s / n</i>	<i>The name of the topic of the practical lesson and the list of the main questions (the list of didactic support, references to the literature and tasks on VTS)</i>	<i>Hours</i>
1	<p><b>Modern problems of resource use and resource conservation in Ukraine</b></p> <p>Ecological and economic social problems of resource use. Ecological and economic efficiency of resource use</p> <p><i>Literature: [3] p. 118-214; [4] c. 206-218; [18].</i></p> <p><i>Tasks on VTS.</i> Analyze the state of resource use in the selected industry.</p>	4
2	<p><b>Energy efficient lighting.</b></p> <p>Modern lamps. Areas of application. Calculation of illumination. Disposal of used lamps.</p> <p><i>Literature: [1] p. 4-15; [3] c. 112 - 116.</i></p> <p><i>Tasks on VTS.</i> Calculate the required number of lamps to illuminate the work area when performing work of a certain level of complexity.</p>	2

3	<p><b>Economic efficiency of resource saving management</b></p> <p>The structure of technological organizational and technical measures. Economic indicators of organizational and technical measures. Methods for assessing the economic efficiency of resource conservation measures</p> <p><i>Literature: [5] p. 100-125; [6] c. 1-50.</i></p> <p><i>Tasks on VTS.</i> Methods for assessing the effectiveness of investment in resource conservation</p>	4
4	<p><b>Ecological and economic efficiency of sectoral resource-saving measures</b></p> <p>Directions for improving the assessment of environmental and economic efficiency of resource conservation.</p> <p><i>Literature: [1] p. 18-26; [12] c. 58-72; [15] c. 62-69.</i></p> <p><i>Tasks on VTS.</i> Develop a number of environmental and economic measures for the use of resource-saving technologies in a particular enterprise industry.</p>	4
5	<p><b>Rapid Prototyping Technologies.</b></p> <p>Current trends and directions of effective use of materials. Rapid Prototyping technologies as a way to save resources and materials in the manufacture of machine parts and components.</p> <p><i>Literature: [5] p. 126-128; [11] c. 200-205.</i></p> <p><i>Tasks on VTS.</i> To offer the use of the technology of layer-by-layer formation of three-dimensional objects according to their computer image for the assessment of ergonomics, visualization, product design.</p>	4
6	<p><b>Modeling of intellectual decision-making support for finding optimal ways of energy saving at machine-building enterprises</b></p> <p><i>Literature: [4] p. 320-326; [5] c. 114-118.</i></p> <p><i>Tasks on VTS.</i> Rationale and choice of methods for providing the mechanism energy saving of industrial enterprises based on the theory of fuzzy logic and linguistic variable.</p>	4
7	<p><b>Scientific and methodological bases for improving the energy efficiency of machine-building enterprises</b></p> <p>Directions of diversification and optimization of energy supply sources of machine-building enterprises.</p> <p><i>Literature: [5] p. 4-15; [14] c. 318-351.</i></p> <p><i>Tasks on VTS.</i> Evaluation of the effectiveness of the concept of optimal use of secondary energy resources of machine-building enterprises</p>	4
8	<p><b>Improvement and evaluation of the efficiency of the organizational and economic mechanism of energy saving of the machine-building enterprise</b></p> <p><i>Literature: [8] p. 42-56; [11] c. 326-364.</i></p> <p><i>Tasks on VTS.</i> To evaluate by modern means the efficiency of the functioning of the organizational and economic mechanism of energy saving of the machine-building selected enterprise of the branch.</p>	4
9	<p><b>Estimation of economic, ecological effect from realization of the concept of optimum use of power potential of the machine-building enterprise</b></p> <p>Fundamentals of the methodology of introduction of resource-efficient and environmentally friendly technologies at the enterprise; methods of planning, management and control of energy and resources.</p> <p><i>Literature: [3] p. 200-232; [5] c. 14-26.</i></p> <p><i>Tasks on VTS.</i> Features of formation of motivation of workers of the machine-building enterprises to energy saving.</p>	4
10	<p><b>Examination</b></p>	2



## 6. Independent work of a graduate student

Independent work takes 70% of the time to study the credit module, including preparation for the test. The main task of independent work of graduate students is to master scientific knowledge in areas that are not included in the list of lecture questions through personal search for information, the formation of an active interest in the creative approach in educational work. In the process of independent work within the educational component, the graduate student must learn to deeply analyze modern approaches to the development and implementation of the latest energy and resource efficient processes, equipment and technologies.

### Tasks for independent work:

1. Development of the basic principles of substantiation and choice of methods of providing the mechanism of energy saving of industrial enterprises on the basis of the theory of fuzzy logic and linguistic variable.
2. Development of resource-efficient solutions for a specific enterprise in the industry and their justification.
3. Analysis of the prerequisites for resource conservation in the domestic economy.
4. Estimation of economic efficiency of realization of the concept of optimum use of secondary energy resources of the machine-building enterprises.
5. Evaluation of components in the calculation of the assessment of the economic effect of the implementation of the concept of optimal use of the energy potential of the machine-building enterprise.
6. Improving and evaluating the effectiveness of the organizational and economic mechanism of energy saving of the machine-building enterprise.
7. Development of methodological bases for assessing the effectiveness of investments in energy saving measures of industrial enterprises.
8. Analysis of modern problems of resource use in Ukraine.
9. Development of the basic principles of realization of resource-saving activity at the enterprise of branch.
10. Development of directions for improving the assessment of environmental and economic efficiency of resource conservation

## Policy and control

### 7. Course policy (educational component)

#### **Rules for attending classes and behavior in class**

Attendance is a mandatory component of assessment. Postgraduate students are obliged to take an active part in the educational process, not to be late for classes and not to miss them without good reason, not to interfere with the teacher to conduct classes, not to be distracted by actions that are not related to the educational process.

#### **Rules for assigning incentive and penalty points**

- Incentive points can be awarded by the teacher only for the performance of creative work in the discipline. But their amount may not exceed 25% of the rating scale.
- penalty points within the academic discipline are not provided.

#### **Policy of deadlines and rearrangements**

In the event of arrears of the discipline or any force majeure, graduate students should contact the teacher through available (provided by the teacher) communication channels to resolve problems and agree on an algorithm for practice.

#### **The policy of academic integrity**

Plagiarism and other forms of dishonesty are not allowed. Plagiarism includes the lack of links when using printed and electronic materials, citations, opinions of other authors. Inadmissible hints and write-

offs when writing tests, conducting classes; passing the test for another graduate student; copying of materials protected by the copyright system without the permission of the author of the work.

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute named after Igor Sikorsky". Read more: <https://kpi.ua/code>

### Policy of academic behavior and ethics

Postgraduate students must be tolerant, respect the opinion of others, formulate objections in the correct form, constructively maintain feedback in the classroom.

Norms of ethical behavior of students and employees are defined in Section 2 of the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute named after Igor Sikorsky". Read more: <https://kpi.ua/code>

## 8. Types of control and rating system for evaluation of learning outcomes (RSO)

Distribution of study time by types of classes and tasks in the discipline according to the working curriculum:

Semester	Training time		Distribution of teaching hours				Control measures		
	Loans	acad. year	Lectures	Practical	Lab. slave.	CPC	MCR	RR	Semester control
4	4	120	18	36	-	66	-	-	examination

The graduate student's rating from the credit module consists of the points he receives for his work in practical classes.

Semester control is an exam.

### System of rating (weight) points and evaluation criteria

Rating points system and evaluation criteria:

The maximum amount of points is 100. A prerequisite for admission to the exam is a rating of at least 40% of the rating scale (R), ie 40 points.

Graduate students who scored less than 0.6 R during the semester, as well as those who want to increase the overall rating, perform a test. In this case, all points obtained by them during the semester are canceled. Test tasks contain questions that relate to different sections of the credit module. The list of questions to be submitted for semester control is given in Section 9.

The evaluation system consists of two components:

Home - designed to assess current control activities during the semester;

Examination - designed to assess individual questions (tasks) in the exam.

The size of the starting component is -50 points, the size of the examination component - 50 points.

Starting points are formed as the sum of rating points received by the applicant as a result of current control measures and incentive points.

After evaluating the answers of the graduate student to the exam, the teacher summarizes the starting points and points for the exam.

*Performing tasks in practical classes.*

The weight score in practical classes is 1 - 8 to 5 points, 9 - 10 points.

*Criteria for evaluating the implementation of a practical task*

<i>Completeness and signs of task performance</i>	<i>Bali</i>	
<i>The task is completed in full</i>	5	10
<i>Minor shortcomings under paragraph 1</i>	4	8-9
<i>Late performance of the task</i>	3	7
<i>Untimely performance of the task, shortcomings under item 1</i>	2	2-6
<i>Poor task performance</i>	1	1
<i>Failure to complete the task</i>	0	0

Thus, the rating semester scale of the initial assessment of the credit module is:

$$R = 8 * 5 + 1 * 10 = 50 \text{ points}$$

According to the results of educational work for the first 7 weeks, the "ideal graduate student" must score 40 points. At the first certification (8th week) the graduate student receives "credited" if his current rating is at least 20 points. At the second certification (14th week) the graduate student receives "credited" if his current rating is not less than 40 points.

The maximum amount of points is 100. A prerequisite for admission to the exam is a rating of at least 40% of the rating scale (R), ie 40 points.

Graduate students who scored less than 0.6 R during the semester, as well as those who want to increase the overall rating, perform a test. In this case, all points obtained by them during the semester are canceled. Test tasks contain questions that relate to different sections of the credit module. The list of questions to be submitted for semester control is given in Section 9.

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Starting points are formed as the sum of rating points received by the applicant as a result of current control measures and incentive points.

After evaluating the answers of the graduate student to the exam, the teacher summarizes the starting points and points for the exam.

To obtain an examination grade, the sum of all rating points obtained during the semester and the points obtained in the exam R is transferred according to the table:

<i>Scores</i>	<i>Rating</i>
95 ... 100	perfectly
85 ... 94	very good
75 ... 84	fine
65 ... 74	satisfactorily
60 ... 64	enough
RD < 60	unsatisfactorily
Admission conditions are not met	not allowed

## 9. Additional information on the discipline (educational component)

### An approximate list of questions that are submitted for semester control

1. Name the main provisions of Ukraine's energy strategy until 2030.
2. Name the types and sources of energy for industrial enterprises.
3. Name the main global environmental problems of mankind.
4. Name the Sustainable Development Goals.
5. Define resource-efficient and clean production.
6. Name the main energy saving measures.
7. Give a formula for calculating the energy intensity of production.
8. Specify the share of fossil energy sources in the structure of energy consumption.
9. Name the main types of renewable energy sources.
10. Name the main methods of stimulating renewable energy.
11. Name the organizational and economic prerequisites for the development of energy saving in Ukraine.
12. Name the principles of modeling intellectual decision support for finding optimal ways to save energy in machine-building enterprises.
13. What is a "green" economy?
14. What is a "green" industry?
15. Explain the meaning of the term "green tariff".
16. What is the Paris Climate Agreement about?
17. Classification of natural factors and processes of human impact on the environment.
18. The concept of resource conservation and principles of implementation of resource-saving activities.
19. Functions and components of resource saving.
20. Resource saving factors.
21. Directions and types of resource saving.

22. Assessment of ecological and economic efficiency of resource conservation.
23. Ecological - economic efficiency of resource-saving measures at the microeconomic level.
24. Ecological and economic efficiency of sectoral resource-saving measures.
25. Directions for improving the assessment of environmental and economic efficiency of resource conservation.
26. Structure of technological organizational and technical measures of energy saving.
27. Economic indicators of organizational and technical measures.
28. Methods for assessing the economic efficiency of energy saving measures.
29. Methods for evaluating the effectiveness of investments in energy saving.
30. Prerequisites for resource conservation in the domestic economy.
31. Resource-saving transformations in the modern economy.
32. Ecological, economic and social problems of resource use.
33. Ecological and economic efficiency of resource use.
34. Intensity of resource use.
35. Areas of resource-saving activities in Ukraine.
36. Explain what is a circular economy?
37. Which UN organizations care most about the state of the environment in the world?
38. Tell us about the international agreements of UNIDO and UNEP.
39. What is necessary for the effective functioning of the enterprise?
40. List the five main benefits of the introduction of SALW and what is their essence?
41. For what purpose is RECH used in enterprises?
42. What are the main environmental problems that are solved with the help of things?
43. What are raw materials and how are they classified?
44. What is the quality of raw materials?
45. Define the concept of "energy management".
46. Where is water used in enterprises?
47. Name the indicators of water quality.
48. What is wastewater?
49. What are the methods of wastewater treatment?
50. What is industrial waste?
51. What are the sources of waste generation at the enterprise?
52. Name the main steps of RECHV implementation in the enterprise.
53. How is the analysis and data collection performed at the enterprise?
54. What is SALW assessment?
55. How is the analysis of material flows performed?
56. What is the material balance of the enterprise?
57. Name the reasons for the loss of materials in enterprises.
58. What is energy balance?
59. Name the causes of energy losses in enterprises.
60. Name the causes of water loss in enterprises.
61. List and explain the directions of RECH options.
62. What is the purpose of the environmental and economic justification of the options of RECHV?
63. Formulate the essence of the organizational and economic mechanism of energy saving of industrial enterprises.
64. Formulate the methodological principles of economic and energy survey of the enterprise.
65. What is the place and what is the role of energy saving in the management system of industrial enterprises.
66. Describe the current state of development of the domestic energy market.
67. How to assess the energy efficiency of machine-building enterprises.
68. Formulate methodological bases for assessing the effectiveness of investments in energy saving measures of industrial enterprises.
69. Name the features of investing in energy saving measures of industrial enterprises.
70. Formulate the basic principles of substantiation and choice of methods for ensuring the mechanism of energy saving of industrial enterprises on the basis of the theory of fuzzy logic and linguistic variable.
71. Name the areas of diversification and optimization of energy sources of machine-building enterprises.
72. Estimation of economic efficiency of realization of the concept of optimum use of secondary energy resources of the machine-building enterprises.
73. What are the financial costs of industrial enterprises for thermal modernization of buildings and structures.
74. List the components when calculating the assessment of the economic effect of the implementation of the concept of optimal use of energy potential of the machine-building enterprise.
75. Name the features of the formation of motivation of employees of machine-building enterprises to save energy.

76. Improving and evaluating the effectiveness of the organizational and economic mechanism of energy saving of the machine-building enterprise.
77. Explain the reason for the larger capacity of lithium-based chemical power sources compared to other chemical power sources.
78. Justify the reason for using lithium ions in chemical power sources instead of pure lithium.
79. Explain the term "memory effect". Name the main methods of biofuel processing.
80. Name the advantages of pellets over conventional firewood.
81. Indicate the substances that can be obtained from the process of gasification of carbonaceous substances.
82. Name the cheapest raw materials for ethanol production.
83. Name the main substances that are part of biogas.
84. Name the main disadvantages of ethanol when used as a motor fuel.
85. Give the names of agricultural plants from which biodiesel is made. Give the advantages of thermal power plants compared to thermal power plants.
86. Name the reason for the expediency of using low-power thermal power plants in rural areas.
87. Specify the difference between closed-loop and open-loop settings.
88. Give the principle on which the operation of the fuel cell is based.
89. Name the main components of fuel cells.
90. Name the main types of fuel cells.
91. List the advantages and disadvantages of Rapid Prototyping
92. List the factors that reduce the efficiency of conversion of solar energy into heat and electricity.
93. What are secondary energy resources?
94. Specify the type of dependence of specific wind power on its speed.
95. Name the main types of wind turbines.
96. Name the main advantages of wind turbines with a vertical axis of rotation.
97. Give the dependence of the speed of rotation of the windmill on the number of blades.
98. Specify the function performed by the multiplier.
99. Name the methods of adjusting the power of the windmill when the wind speed changes.

***Work program of the discipline (syllabus):***

***Folded*** Prof., Dr. those. Science Zenkin Mykola Anatoliyovych

**Approved** at the meeting of the Department of Machines and Apparatus of Chemical and Oil Refining (Protocol № 26 of 19 June 2021)

**Agreed** metodic commission of the Faculty of Engineering and Chemistry (Protocol № 11 of June 25, 2021)