National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Department of the Electrical Engineering Automation & Mechatronic Complexes (EEAMC)

ENGINEERING AND TECHNICAL REGULATION IN THE FIELD OF PRODUCTION AND USE OF HYDROGEN

Working program of the academic discipline (SYLLABUS)

Details of the academic discipline

Level of higher education	***Second (master's)***
Branch of knowledge	*14 Electrical engineering*
Specialty	*141 Power engineering, electrical engineering and electromechanics*
Educational program	*of intelligent electrotechnical and mechatronic complexes* ***Certificate program**: Engineering and automation of hydrogen energy systems and technologies*
Discipline status	*Selective*
Form of education	*Full-time (day)/remote*
Year of training, semester	*1 year of study, spring semester*
Scope of the discipline	*(36 hours - lectures , 18 hours - practical , 96 IWS)*
Semester control/ control measures	*Exam, MKW*
Lessons schedule	*http://roz.kpi.ua/*
Language of teaching	*Ukrainian*
Information about the head of the course / teachers	Lecturer: *Doctor of Sciences (Technical), Professor, Boichenko Sergii,* *tel . 093-457-01-13,* *E- mail: boichenko.sergii@lll.kpi.ua, chemmotology 1 @gmail.com*[1] Practical / Seminar : *Doctor of Sciences (Technical) , Professor, Boichenko Sergii*
Placement of the course	*Link to the remote resource:* *Google classroom:* https://classroom.google.com/c/NTg1OTI2OTkzMjU4 ; *https://campus.kpi.ua/*

Program of educational discipline

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

The discipline "Engineering and technical regulation in the field of production and use of hydrogen", like other special disciplines, performs both basic general educational and developmental and general educational functions, the essence of which is the formation of integrated knowledge and skills necessary for future creative engineering activities of a specialist in hydrogen energy systems and technologies.

The main goal of teaching the educational discipline "Engineering and technical regulation in the field of hydrogen production and use" is to study the regulatory, legal, technical and technological basis, engineering foundations in the field of hydrogen production and use.

The subject of the academic discipline is technical regulation in the field production and use hydrogen.

Program competences: The main task of the educational discipline is the acquisition of professional skills by students on the basis of practical and theoretical materials regarding the basic methodology and technology of organizing the rational use of hydrogen in energy and as a motor fuel.

Program learning outcomes :

use the legal, normative, technical, technological base, theoretical knowledge to solve practical engineering tasks of rational application of technological processes of hydrogen production, its accumulation and storage; automate technological processes; to establish the relationship between the physico-chemical, operational and environmental properties of hydrogen; analyze technological processes, optimize them through automation; determine the most important, optimal technological parameters and justify optimal technological processes, as well as operational conditions for the rational use of hydrogen and form the infrastructure for the rational operation of technological equipment .

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

Pre-requisites: the discipline is based on students' knowledge of the basic concepts of physics, mathematics, economics, philosophy, sociology, ecology and professional training disciplines, aimed at acquiring the skills of a systematic approach to studying and solving current and prospective problems of energy, rational use of energy resources and engineering and technological techniques in solving specific practical situations, as well as the ability to correctly assess the local and remote consequences of management and engineering decisions regarding the use of hydrogen.

Post-requisites. Competences that will be acquired by students during the study of this discipline should be applied by them during the execution of the master's thesis, as well as future engineering tasks in the field of energy, in particular, electrical engineering, renewable energy sources, alternative methods of generating electricity, alternative energy in general, etc.

3. Content of the academic discipline

Part 1. Regulatory, technological and organizational principles of engineering support for the production and use of hydrogen :

Topic 1.1. Bases and basics of engineering. Basic terms and concepts.

Topic 1.2. Trends in the development of hydrogen technologies in industries.

Topic 1.3. The concept of the roadmap for the development of hydrogen energy in Ukraine for the period up to 2035.

Topic 1.4. Legal regulation of the hydrogen industry: European and world experience.

Topic 1.5. The legislative base and the basics of technical regulation in the field of hydrogen production and use.

Part 2. Modern technologies of hydrogen production and use:

Topic 2.1. Technology of production of electric energy by fuel cells. Hydrogen technology of electricity storage.

Topic 2.2. The technology of obtaining hydrogen by electrolysis using the energy of the wind, the sun, and the earth.

Topic 2.3. Metal hydride hydrogen storage technologies.

Topic 2.4. Innovative and technologies for using hydrogen in industry and the transport sector.

4. Educational materials and resources

Basic literature:

1. Andriishyn M. P., Marchuk Y. S., Boychenko S. V. Natural gas, fuel and oil: Monograph. – Odesa: Astroprint, 2010. – 232 p.

2. Energy and technical systems. Basic provisions (ISO 13600:1997, IDT): DSTU ISO 13600-2001. K. State Standard of Ukraine. 2001. 15 p.

3. Legal regulation of energy, including nuclear, in the European Union and Ukraine. - K.: Nika-Print LLC , 2006. – 640 p.

4. Alternative energy resources: a study guide / S. V. Boychenko, A. V. Yakovleva, O. O. Vovk, Kazimyr Leyda , S. Y. Shamanskyi; in general _ edited by Professor SV Boychenko. - K.: NAU, 2021. - 397 p. (URL: https://ela.kpi.ua/handle/123456789/49236).

5. Safonova O.M. International technical regulation: training . manual / O. M. Safonova [etc.]. – Kh.: KhDUHT. - 2013. - 372 p

6. Law of Ukraine "On Metrology and Metrological Activities" No. 1314-VII of the Supreme Court dated June 5, 2014.

7. Law of Ukraine "On Standardization" No. 1315-VII BP dated 06/05/2014.

8. Law of Ukraine "On the Protection of Consumer Rights" No. 3682-XI of 15.12.1993

9. Law of Ukraine "On the Safety and Quality of Food Products" No. 2863-IU dated September 8, 2005.

10. Law of Ukraine "On technical regulations and conformity assessment" No. 124-VIII dated January 15, 2015.

11. Law of Ukraine "On Accreditation of Conformity Assessment Bodies" No. 2407111 dated May 17, 2001.

12. V. A. Malyarenko . Synopsis of lectures on the discipline "Power generation technology" / V. A. Malyarenko , S. I. Dotsenko , I. O. Temnokhud ; Hark . national _ city university _ farm named after O. M. Beketova. - Kh.: XNUMG, 2014. - 164 p.

13. Innovative practice of engineering: teaching . help _ for studies _ specialties 133 Industrial mechanical engineering, 131 Applied mechanics, 101 Ecology / KPI named after Igor Sikorskyi, editor: D.E. Sidorov – Kyiv: KPI named after Igor Sikorskyi, 2021. – 82 p. (URL: https://ela.kpi.ua/bitstream/123456789/42286/1/Sidorov.pdf).

Supporting literature:

1 . Energy security of Ukraine: methodology of system analysis and strategic planning: analyst . add . / [Sukhodolya O. M., Kharazishvili Y. M., Bobro D. G., Smenkovskyi A. Yu., Ryabtsev G. L., Zavhorodnia S. P.]; in general _ ed. O. M. Sukhodoli. – Kyiv: NISD, 2020. – 178 c.

2. Yu. Kozhedub. The basis of technical regulations of Ukraine – EU directives of a new and global approach // Legal, regulatory and metrological support of the information protection system in Ukraine. – 2005. – No. 11. – pp. 63–70.

3 . D. Korshunov. About technical regulation and types of normative documents / D. Korshunov // Standardization , certification , quality : science and technology . journal _ 1999. – 2005. – No. 4. – P.22–23.

4. Kudrya S.O., Kuznetsov M.P., Morozov Y.P., etc.// Renewable energy sources, Monograph: Edited by. S.O. Curls. - Kyiv: Institute of Renewable Energy of the National Academy of Sciences, 2020. - 392 p.

5. Fundamental aspects of renewable hydrogen energy and fuel cell technologies / edited by Yu.M. Corned beef. - K.: "KIM", 2018. - 260 p.

6. The concept of engineering - https://dspace.uzhnu.edu.ua/ pdf .

7. The concept of the roadmap for the development of hydrogen energy in Ukraine for the period until 2035 - https://ve.org.ua/index.php/journal/article/download/227/158/ .

Information resources:

1. Distance course «Engineering and technical regulation in the field of production and the use of hydrogen» - *https://classroom.google.com/c/NTYyNzYxMzcxNTE0 ;*
https://classroom.google.com/c/NTg1OTI2OTkzMjU4 (correspondence form).

Literature, the bibliography of which is provided with a link, can be found on the Internet or in the electronic library of KPI named after Igor Sikorsky. Literature, the bibliography of which does not contain references, can be found in the library or on the Internet, or in the library of the department.
Basic literature [1-3, 5-13] is mandatory for reading. All other literary sources are optional, it is recommended to familiarize yourself with them

Educational content

5. Methods of mastering an educational discipline (educational component)

The method of teaching the discipline combines visual teaching methods with explanation. Teaching is conducted in the form of lectures and laboratory (workshop) classes.

Lecture classes

No s/p	Name of the topic of the lecture and a list of main questions (reference to the literature)
1	**Topic 1.** Basic terms and concepts of engineering and technical regulation. ***Literature*** *: 1, 3, 5, 9.*
2	**Topic 2.** Bases and basics of engineering. ***Literature*** *: 2-11, add. lit. 6.*
3	**Topic 3.** Legislative basis and basics of technical regulation. ***Literature*** *: 1, 3, 5, additional years . 2,3.*
4	**Topic 4.** Trends in the development of hydrogen technologies in energy . ***Literature*** *: 4,12, add. lit. 1,4,5.*
5	**Topic 5.** Trends in the development of hydrogen technologies in transport . Examples of modern use of hydrogen in vehicles. ***Literature*** *: 4,12, add. lit. 1,4,5.*
6	**Topic 6.** The concept of a roadmap for the development of hydrogen energy in Ukraine for the period until 2035. ***Literature*** *: 12, add. lit. 1,4,5,7.*
7	**Topic 7.** Legal framework for the development of hydrogen energy . ***Literature*** *: 2, 6, 9, additional years . 2,5,7.*
8	**Topic 8.** Legal principles of hydrogen energy . ***Literature*** *: 2, 6, 9, additional years . 2,5,7.*
9	**Topic 9.** Principles of energy sector regulation. ***Literature*** *: 2,3,5,7,9, add. lit. 2,3,5,7,9.* Modular control work.
10	**Topic 10.** About technical regulation and types of normative documents. ***Literature*** *: 2,3,5,7,9, add. lit. 2,3,5,7,9.*
11	**Topic 11.** Regulatory support in the field of hydrogen use. ***Literature*** *: 2,3,5,7,9, add. lit. 2,3,5,7,9.*
12	**Topic 12.** Technology of electric energy production by fuel cells. ***Literature*** *: 2,3,5,7,9, add. lit. 2,3,5,7,9.*
13	**Topic 13.** Innovative and technologies for using hydrogen in industry and the transport sector. ***Literature*** *: 2, 6, 7, 9, add. lit. 5.7.*
14	**Topic 14.** Hydrogen technology of electricity storage. ***Literature*** *: 2, 6, 7, 9, add. lit. 5.7.*
15	**Topic 15.** Technology of obtaining hydrogen by electrolysis using wind and solar energy. ***Literature*** *: 2, 6, 7, 9, add. lit. 5.7.*
16	**Topic 16.** The technology of obtaining hydrogen by electrolysis using the energy of the earth. ***Literature*** *: 2, 6, 7, 9, add. lit. 5.7.*
17	**Topic 17.** Hydrogen storage technologies . ***Literature*** *: 2, 6, 7, 9, add. lit. 5.7.*
18	**Topic 18.** Metal hydride hydrogen storage technologies . ***Literature*** *: 2, 6, 7, 9, add. lit. 5.7.* Modular control work.

Practical classes

The main tasks of the cycle of practical classes consist in consolidating the knowledge obtained in lectures, familiarization with individual sections.

Also, for students to acquire the skills and experience to operate with modern concepts in the field of rational use of energy resources, which are necessary for the correct perception of the direction of social progress and ensuring safe conditions for the existence of humanity in the future.

No s/p	Tasks assigned to practical classes
1-2	Subject and object of the discipline. Basic terms and concepts. Practical and engineering skills and technical regulation.
3-4	Technical regulation and types of regulatory documents in the field of hydrogen use.
5-6	Examples of application of electric power production technology fuel cells. Examples of hydrogen use in vehicles
7-8	Examples of technological schemes for the production of hydrogen by electrolysis.
9	Examples of technological schemes for hydrogen accumulation.

6. Independent work of the student

The student's independent work includes such elements as preparation for current surveys, preparation for practical classes, in particular, preparation of a report and joint report, electronic short informational reports within the deadline specified by the teacher, preparation for a modular control work.

The student's independent work involves:
preparation for classroom classes - 64 hours;
preparation for the modular control work - 2 hours;
preparation for the exam - 30 hours

Control works

The purpose of conducting the modular control work (MCW) is to identify the degree of assimilation of the knowledge of the discipline by students, obtained during lectures and practical classes.

The main goal of the MKW is to form students a comprehensive idea of the organization of systematic measures of rational nature management in the context of the doctrines of sustainable development in Ukraine.

Policy and control

7. Policy of academic discipline (educational component)

During the course, students are obliged to adhere to the general moral principles and rules of ethical behavior specified in the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute".

Violation of the Code of Academic Integrity of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute" is a serious violation, even if it is unintentional. The code is available at the link: https://kpi.ua/code.3 .

In particular, adherence to the Code of Academic Integrity means that all work on exams and tests must be done individually. During independent work, students can consult with teachers and other students, but must solve tasks independently, guided by their own knowledge, abilities and skills. References to all resources and sources (for example, in reports, independent papers or presentations) should be clearly identified and properly formatted. In the case of joint work with other students on individual tasks, you should indicate the degree of their participation in the work.

Academic Integrity: The policy and principles of academic integrity are defined in section 3 of the Code. Norms of ethical behavior: Norms of ethical behavior of students and employees are defined in section 2.

Requirements for a student of the discipline:

- attending lectures and laboratory classes is a mandatory component of studying the material, the teacher records attendance at classes;
- the teacher uses *Google classroom* for teaching the material of the current lecture, additional resources, laboratory work, practical classes, etc.;
- the teacher uses his own presentation material at the lecture; who teaches at *Google* after the lecture *classroom* from the relevant discipline, where there is a flow of students;
- during lectures, it is forbidden to distract the teacher from presenting the material to students, all questions, clarifications, etc. students ask at the end of the lecture in the time allotted for this;
- The MCR is completed in a practical session and sent to *Google classroom or teacher's e-mail* ;
- in accordance with the "Code of Honor" of the MKW, RR, Tests and Reports students perform independently;
- incentive points are awarded for: active participation in lectures; preparation of reviews of scientific works; presentations on one of the topics, creation of educational and methodical materials ;
- penalty points are issued for: late submission of MKW, rewriting of MKW.

Google course open on the device from which he works *classroom* on the "Sikorsky" platform (the access code to the course is provided at the first lesson according to the schedule). Syllabus ; lecture material; tasks for each practical session; MKR options; methodical recommendations for practical work; variants of the credit test are posted on the "Sikorsky" platform and in the "KPI Electronic Campus " system.

All students, without exception, are obliged to comply with the requirements of the Regulations on the Academic Plagiarism Prevention System at the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute".

Students who have scored during the semester the number of points (R ≥ 60 points) can get a grade without a credit test. In case of a desire to increase the grade, the student completes a credit test, based on the results of which a grade is assigned.

Students who scored a rating in the discipline Rc < 60 during the semester are required to write a final test.

For participation in the All-Ukrainian Olympiad (competition of scientific works), a student is awarded 5 (I round) or 10 (II round) points. For writing an article and publishing it, the student is awarded 10 points (publication included in Scopus or Web of Science) or 6 points (professional edition of Ukraine). 3 points for publication of report abstracts at a scientific conference. The total amount of incentive points cannot exceed 10 points.

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

Current control: URL: https://kpi.ua/document_control.

Surveys at lectures, participation in seminars, reports (presentations), joint reports, MKW.

Calendar control: conducted twice a semester as a monitoring of the current state of meeting the syllabus requirements . The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the corresponding calendar control.

Semester control: Exam.

The size of the RS scale is 100 points, which is formed during the semester based on the results of the following works:

– survey during lectures (18 points);

– active work in a practical session (participation in the seminar) (9 practical sessions × 2 points = 18 points);

– preparation of a report (presentation) and presentation at a seminar (19 points for 1 report);

– joint report (rebuttal) at the seminar (3 practical classes × 3 points = 9 points);

– writing MKW (2 parts × 18 points = 36 points).

$$RC_{(max)} = 18\ 1 + 9\ 2 + 19 + 3\ 3 + 36 = 100 \text{ points .}$$

The survey is conducted directly during the lecture session. A complete answer is valued at 1 point, the absence of an answer - 0 points.

Active participation in the practical session (participation in the work of the seminar) is assessed at 2 points, less active participation, incorrect questions and comments that indicate the student's unpreparedness for the class reduce the grade for the work in the seminar to 1 point or to 0 points.

Tasks within the framework of the practical session are evaluated in 2 points according to the following criteria: "excellent" – a fully completed task (at least 90% of the required information), the computer workshop was completed with the necessary modeling and answers to questions - 2 points; "good" - the task is sufficiently completed (at least 75% of the required information), the computer workshop is completed with the necessary modeling and answers to questions, but there are minor inaccuracies - 1 point; "satisfactory" - the task is incompletely completed (at least 60% of the required information), the computer workshop is completed with the necessary modeling and answers to questions, but there are some errors - 0.5 points; "unsatisfactory" - the practice was not completed - 0 points.

A report on a given topic is usually accompanied by a presentation (up to 10 slides).

Evaluation criteria: "excellent": creative disclosure of the task, fluency in the material, appropriate presentation materials - 18-19 points; "good": in-depth disclosure of the task, relevant information - 14-16 points; "satisfactory": reasonable disclosure of the task - 10-12 points; "unsatisfactory": the topic is not disclosed - 0 points.

During the semester, each student acts as a co-speaker (opponent) three times.

Evaluation criteria: "excellent": fluency in the material, reasoned and reasoned questions, remarks and comments - 3 points; "good": good mastery of the material - 2 points; "satisfactory": weak mastery of the material - 1 point; "unsatisfactory": the student does not master the material, does not participate in the work - 0 points.

During the semester, one MKW is held, consisting of two parts. Each part of the MKW contains three complex questions of the theoretical, calculation or open type, valued at 6 points. The MKW part contains three questions to which the student must provide a written answer.

MKW (2 parts) is conducted directly during the lecture session, in the presence of the teacher, in the form of a written work, 18 points (each). At the end of the class, the MKW is handed in and cannot be rewritten or completed at home. MKW is sent to *Google classroom or teacher's e-mail.*

Students who have met all the admission requirements and have a rating of 60 or more points receive a rating corresponding to the rating without additional tests. The sum of the rating points received by the student during the semester is transferred to the final grade according to the table. If the sum of points is less than 60, but the practical and MKW have been completed and credited, the student completes credit work. In this case, the sum of the points for the practical, MKW and final work is transferred to the final grade according to the table. A student who received more than 60 points in the semester, but wants to improve his result, can take part in credit work. In this case, the final result consists of the points obtained on the assessment work and points for practical and MKW. The credit work is estimated at 63 points. The control task of this paper consists of two theoretical questions from the list provided in the appendix to the syllabus and a practical question. Each question and task is evaluated at 21 points according to the following criteria: "excellent" - a complete answer (at least 90% of the required information), appropriate justifications and a personal opinion are provided - 21 - 19 points; "good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies - 18 - 16 points; "satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotype" level and containing some errors - 15 - 13 points; "unsatisfactory" - unsatisfactory answer - 0 points.

To assign grades to the examination report, the rating is converted into traditional and ECTS grades according to the table

Scores	Rating
100–95	Perfectly
94–85	Very good
84–75	Fine
74–65	Satisfactorily
64–60	Enough
Less than 60	Unsatisfactorily
MKR is not included	Not allowed
RGR is not included	Not allowed

9. Additional information on the discipline (educational component)

The list of theoretical questions submitted for Current, Calendar and Semester control is given in *Google classroom.*

Distance Learning:

Distance learning in this academic discipline is allowed on the basis of general decisions of the university due to force majeure circumstances.

Inclusive education:

This discipline can be taught to most students with special educational needs, except for students with severe visual impairments that do not allow them to complete tasks with the help of personal computers, laptops and/or other technical means.

Learning a foreign language:

Given the specifics of the academic discipline, some concepts and educational material can be studied in English (in fragments).

Taking into account the student-centered approach, at the request of students, it is allowed to study individual topics with the help of appropriate English-language electronic resources.

Extracurricular activities:

Consultations (individual and group) on this academic discipline and independent work of students can be carried out with prior consent in the scientific laboratory, in the scientific and technical library of the university and/or at home, respectively. The educational material provided for assimilation by the student in the process of independent work is submitted to the final control together with the educational material that was studied during classroom training sessions.

At the beginning of the semester, the teacher informs students/students about the possibility of taking appropriate free (or paid) courses at their discretion on the subject of the academic discipline. After the student receives an official certificate of completion of the relevant courses, the teacher has the right to credit the relevant part of the course (or the course as a whole). The applicant can choose an online course independently or on the recommendation of a teacher. 1 hour of the course is valued at 1 point. The maximum number of hours that can be credited for the results of non-formal education is 12 hours, accordingly the maximum number of points for such results is 12 points.

Working program of the academic discipline (SYLLABUS):

Compiled by: Doctor of Sciences (Technical), Professor, Boichenko Sergii V.

Approved: by the department of the **EEAMC** scientific and educational institute of energy saving and energy management (protocol № 17 dated May 31, 2023).

Adopted: by the methodological council of the scientific and educational institute of energy saving and energy management (protocol № 9 dated 06.22.23).