

<b>Name of subject</b>	<b>Hydrogen technologies (ECTS 4)</b>
<b>Subject/module code</b>	VT2204
Science taught semester (s).	2 <sup>nd</sup> semester
Responsible teacher	Nazarov Furkat, PhD., senior teacher.
Education language	Uzbek
Connection to the curriculum	Elective
Training hours (this including independent education)	<b>Total hours-120</b> <b>Audience Training hours – 36</b> Lecture training hour – 18 Practical training hour – 18 <b>Independent education -84 hours</b>
ECTS	4
The purpose and tasks of subject / learning outcomes	<p><b>The purpose of teaching the subject is</b> To provide students with modern theoretical knowledge and practical skills in hydrogen energy technologies, to introduce them to methods of hydrogen production, storage, transportation and use, and to prepare them to design environmentally safe and sustainable energy systems. The subject also aims to prepare students to conduct independent analysis and research within the framework of hydrogen economy, energy policy, safety standards and technological innovations.</p> <p><b>The objective of the course</b> “Hydrogen technologies” to provide students with in-depth theoretical knowledge and solid practical skills in advanced areas of hydrogen energy and technologies; to analyze technologies for the production, storage, transportation and use of hydrogen in accordance with modern environmental and economic requirements, as well as to prepare them to conduct independent research and innovative design activities.</p> <p>Learning Outcomes:</p> <ol style="list-style-type: none"> <li>1. Understands the scientific basis of hydrogen technologies;</li> <li>2. Demonstrates practical hydrogen production, storage, and use;</li> <li>3. Knows the basics of design, modeling, and security;</li> <li>4. Can make a scientific or practical contribution to the development of green energy;</li> </ol>
Course content (topics)	<p><b>I. Main Theoretical Part (Lecture Sessions)</b>  Topics:</p> <ol style="list-style-type: none"> <li>1. Hydrogen Energy: Introduction and Basic Concepts.</li> <li>2. Physicochemical properties of hydrogen.</li> <li>3. Hydrogen production methods (steam reforming, pyrolysis, electrolysis).</li> <li>4. Electrolysis Technologies: Green Hydrogen Production.</li> <li>5. Thermochemical and biological production methods.</li> <li>6. Hydrogen storage technologies: gaseous, liquid and metal hydrides.</li> <li>7. Fuel Cells: Types, Operating Principle.</li> <li>8. Hydrogen applications in automotive, aviation, and industry.</li> <li>9. Hydrogen strategies in developing countries.</li> </ol> <p><b>II. Instructions and recommendations for organizing laboratory exercises.</b>  Laboratory work is not included in the curriculum</p> <p><b>III. Practical training instructions and recommendations</b>  The instructor's preparation for a practical session begins with the study of initial documents (such as the curriculum, topic schedule, etc.) and concludes with the development of a detailed lesson plan. The instructor must have a clear understanding of the objectives and tasks of</p>

	<p>the practical session, as well as the amount of work each student is expected to perform. Methodological guidelines serve as the primary instructional document for instructors in preparing and conducting practical sessions. The purpose of the practical session is to facilitate the comprehension of theoretical material, the acquisition of practical skills, the ability to consciously apply knowledge in academic and professional activities, and the development of critical thinking and confidence in forming personal viewpoints.</p> <p><i>Recommended Practical Topics:</i></p> <ol style="list-style-type: none"> <li>1. Experiment on obtaining hydrogen by electrolysis.</li> <li>2. Assembling and running a fuel cell model.</li> <li>3. Hydrogen storage and measurement methods.</li> <li>4. Working with a gas analyzer in safety conditions.</li> <li>5. Study of the physicochemical properties of hydrogen.</li> <li>6. Analysis of hydrogen production methods.</li> <li>7. Fuel cells and their operating principles.</li> <li>8. Integration of hydrogen and renewable energy sources.</li> </ol> <p><b>IIV. Independent learning and practical exercises</b></p> <p>Independent learning competency helps students to develop self-improvement skills and increase the efficiency of their professional activities. Students perform independent tasks on their mobile devices under the guidance of a teacher, either in traditional or electronic form.</p> <p>Recommended topics for practical exercises:</p> <ol style="list-style-type: none"> <li>1. Hydrogen is the clean fuel of the future.</li> <li>2. Advantages and disadvantages of hydrogen as an energy source.</li> <li>3. Hydrogen production through electrolysis technology.</li> <li>4. Hydrogen fuel cells and their operating principle.</li> <li>5. Hydrogen storage and transportation technologies.</li> <li>6. Integrating hydrogen into energy systems.</li> <li>7. Environmental advantages of hydrogen energy.</li> <li>8. Towards a carbon-neutral economy: the role of hydrogen.</li> <li>9. Hydrogen and the Sustainable Development Goals.</li> <li>10. Hydrogen economy: development prospects and global competition.</li> <li>11. Hydrogen policy in countries around the world (Germany, Japan, Saudi Arabia, South Korea).</li> <li>12. Prospects for the development of hydrogen energy in Uzbekistan.</li> <li>13. Hydrogen in industry: iron production, chemical industry, etc..</li> <li>14. Integration of hydrogen and renewable energy sources.</li> </ol>
Exam form	Written
Teaching/learning and examination requirements	<p>Complete mastery of theoretical and methodological concepts and practical knowledge of the discipline, the ability to correctly reflect the results of analysis, independently reason about the processes being studied and carry out tasks in the current, intermediate forms of control and independent work, pass written work on the final control.</p> <p>When drawing up final exam questions, deviations from the content of the discipline program are not allowed. The bank of final exam questions for each discipline is discussed at the meeting and approved by the head of the department.</p> <p>No later than 1 week before the start of the final control, tickets signed by the head of the department, enclosed in an envelope, are sealed by the Dean's office and opened 5 minutes before the start of the exam in the presence of students. Final exam duration is 80 minutes. Answers to final exam questions are recorded in copybooks with the seal of the Dean's office. After completion of the final work, the work is immediately encrypted by a representative of the Dean's office, and the copybooks are handed over to the commission for verification. From the moment of completion of the final exam, a period of 72 hours is allotted</p>

	<p>for checking and posting the results on the electronic platform.</p> <p>The teacher who taught the students in this discipline is not involved in the process of conducting the exam and checking the students' answers.</p> <p>Student(s) who are dissatisfied with the final exam results may submit a written or oral appeal within 24 hours of the publication of the final exam results. Complaints submitted after 24 hours from the publication of the final exam results will not be accepted.</p>
Scope of assessment criteria and procedure	<p><b>CURRENT CONTROL</b></p> <p>Purpose: Determining and assessing the student's level of knowledge, practical skills, and competencies on course topics.</p> <p>Instructions: The student's activity in daily classes is assessed through the student's mastery of course topics, as well as constructively interpreting and analyzing the educational material, developing module-specific skills, acquiring practical skills (in terms of quality and the specified number) and competencies, solving problem situations aimed at applying professional practical skills, working in a team, preparing presentations, etc.</p> <p>Current control form: Activity in lessons Preparing educational materials Working with sources within the subject Using educational technologies Working in a team Preparing presentations Working with projects.</p> <p><b>MIDTERM CONTROL</b></p> <p>Purpose: Assessing the student's knowledge and practical skills and level of mastery of lecture material after completing the relevant section of the course.</p> <p>Form and procedure of intermediate control: Midterm examination is held during the semester during the training sessions after the completion of the relevant module of the curriculum of the subject. Midterm examination is held once in written form within the framework of this subject. Midterm examination questions cover all topics of the subject.</p> <p><b>INDEPENDENT LEARNING</b></p> <p>Purpose: Independent learning is aimed at fully covering the content of this course, expanding the theoretical knowledge acquired, and establishing independent learning activities for students.</p> <p>Form and procedure of independent education: independent work assignments are completed in the form of an educational project, presentation, case study, problem solving, information search, digest, colloquium, essay, article, abstract, etc. Completed assignments for independent study are placed in the electronic system and checked based on the anti-plagiarism program and evaluated by the subject teacher.</p> <p>In this case, the uniqueness of the completed assignment should not be less than 60%, otherwise the assignment will not be accepted for assessment. The number of independent work assignments, depending on the nature of the subject, should not be less than 3 for one subject (module). Independent work assignments account for 60% of the points allocated for current and intermediate control.</p> <p><b>FINAL CONTROL</b></p> <p>Purpose: The final examination is held at the end of the semester to determine the level of mastery of the student's theoretical knowledge and practical skills in the relevant subject. The final examination is held at a specified time according to the examination schedule created by the Registrar's Office on the electronic platform.</p> <p>Requirements: The student must have passed the current control, intermediate control and independent learning assignments by the deadline for the final control type in the relevant subject. A student who has not passed the current control, intermediate control and independent</p>

	<p>learning assignments, as well as who has received a score in the range of "0-29.9" for these assignments and control types, is not included in the final control type. Also, a student who has missed 25 percent or more of the classroom hours allocated to a subject without a reason is excluded from this subject and is not included in the final control type and is considered not to have mastered the relevant credits in this subject. A student who has not passed or was not included in the final control type and has received a score in the range of "0-29.9" for this type of control is considered to be an academic debtor.</p> <p>Final control form: The final examination in this subject will be conducted in written form. If the final examination is conducted in written form, the requirements for assessment must also be reflected.</p>				
Criteria for assessing student knowledge	5 grade	100 points		Assessment criteria	
	5	90-100	Excellent	When a student is considered to be able to make independent conclusions and decisions, think creatively, observe independently, apply the knowledge he has gained in practice, understand, know, express, and narrate the essence of the subject, and have an idea about the subject.	
	4	70-89,9	Good	When the student is considered to be able to observe independently, apply the knowledge he has gained in practice, understand, know, express, and narrate the essence of the subject, and has an idea about the subject.	
	3	60-69,9	Satisfactory	When the student is found to be able to apply the knowledge he has gained in practice, understands, knows, can express, and narrate the essence of the subject, and has an idea about the subject.	
	2	0-59,9	Unsatisfactory	When it is determined that the student has not mastered the science program, does not understand the essence of the subject, and does not have an idea about the science.	
Course assessment criteria and procedure	Assessment type	Total points allocated	Control (task) form	Distribution of points	Qualifying score
	Current assessment	30 points	System tasks	20 points (divided by the number of tasks)	18 points
			Student activity (in seminars, practical, laboratory classes)	10 points	
	Midterm assessment	20 points	Supervision: Written work	10 points	12 points
			System tasks	10 points (divided by the number of tasks)	
	Final assessment	50 points	Written assignment (5 questions)	50 points (10 points per question)	30 points
* Note: 60% of the points allocated for current and intermediate					

	control are allocated to independent work assignments. Independent work assignments are evaluated as system assignments through the electronic platform.
Recommended Literature	<p><b>Main literature:</b></p> <ol style="list-style-type: none"> <li>1. Gupta, R. B. Hydrogen Fuel: Production, Transport, and Storage. CRC Press. 2008</li> <li>2. Turner, J. A. A Realizable Renewable Energy Future. Science, 305(5686), 972–974.2004</li> <li>3. Sorensen, B. Hydrogen and Fuel Cells: Emerging Technologies and Applications. Elsevier Academic Press. 2005</li> <li>4. Larminie, J., &amp; Dicks, A. Fuel Cell Systems Explained. 2nd Ed. John Wiley &amp; Sons. 2003</li> <li>5. Ramazonov, M., &amp; G‘aybullayev, A. Vodorod olish usullari va uning tasnifi. O‘zbek ilmiy jurnali, openscience.uz.2024</li> <li>6. Yartys, V. A., Materials for hydrogen-based energy storage – past, recent progress and future outlook. Journal of Alloys and Compounds, 817, 153261.2020</li> <li>7. International Energy Agency (IEA).The Future of Hydrogen: Seizing today’s opportunities. Paris: IEA.2021</li> <li>8. Techtitute Professional Master’s Degree in Hydrogen Technology.2024 <a href="http://www.techtitute.com">www.techtitute.com</a></li> </ol> <p><b>Additional literature:</b></p> <ol style="list-style-type: none"> <li>9. Mirziyoyev Sh.M. Yangi O‘zbekistonda erkin va farovon yashaylik. –T.: “TASVIR nashriyot uyi”, – 2021.– 50 b.</li> <li>10. Mirziyoyev Sh.M. Milliy taraqqiyot yo‘limizni qati‘yat bilan davom ettirib yangi bosqichga ko‘taramiz .–T.:“O‘zbekiston”, 2017–592 b</li> <li>11. Decree of the President of the Republic of Uzbekistan dated January 28, 2022 No. PF-60 “On the Development Strategy of New Uzbekistan for 2022-2026”.</li> <li>12. Aalto University Master's Programme in Hydrogen and Electric Systems – Curriculum 2024–2026. 2024 <a href="http://www.aalto.fi">www.aalto.fi</a></li> <li>13.Birmingham University. Hydrogen, Fuel Cells and Their Applications MSc. <a href="http://www.birmingham.ac.uk">www.birmingham.ac.uk</a> 2024</li> <li>14.TH Rosenheim University Master of Hydrogen Technology. <a href="http://www.th-rosenheim.de">www.th-rosenheim.de</a> 2024</li> <li>15.Cyber Leninka. Vodorod ishlab chiqarish usullarining tahlili. cyberleninka.ru 2023</li> <li>16.Slibrary. Piroliz usulida chiqindilardan vodorod olish texnologiyasi. 2023 <a href="http://www.slibrary.uz">www.slibrary.uz</a></li> <li>17.Bard, A. J., &amp; Faulkner, L. R. Electrochemical Methods: Fundamentals and Applications. Wiley 2001.</li> </ol> <p><b>Internet sites:</b></p> <ol style="list-style-type: none"> <li>18. <a href="http://www.gov.uz">www.gov.uz</a> –Government portal of the Republic of Uzbekistan.</li> <li>19. <a href="http://www.catback.ru">www.catback.ru</a> – international scientific articles and educational materials website.</li> <li>20. <a href="http://www.google.ru">www.google.ru</a> – international educational materials search website.</li> <li>21. <a href="http://www.ziyonet.uz">www.ziyonet.uz</a> – national educational materials search website.</li> <li>22. <a href="http://www.lex.uz">www.lex.uz</a> – national database of legal documents and information.</li> <li>23. <a href="http://www.catback.ru">www.catback.ru</a> – scientific articles and educational materials.</li> </ol>