National Technical University of Ukraine
Igor Sikorsky Kyiv Polytechnic Institute "

Department of
Electromechanical Systems
Automation and Electrical
Drives

ELECTROMOBILITY

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	*First (undergraduate)*
Discipline	*14 "Electrical engineering"*
Specialty	*141 "Electric power engineering, electrical engineering and electromechanics"*
Educational program	*Electromechanical automation systems, electric drive and electric mobility*
Discipline status	*Discipline of professional and practical training (mandatory)*
Form of education	*Daytime*
Year of training, semester	*4th year, fall semester/3rd year, fall semester*
Scope of the discipline	*56 hours of lectures / 18 practical hours classes / MKR/RGR / 5 ECTS credits*
Semester control/ control measures	*test*
Class schedule	*http://rozklad.kpi.ua*
Language of teaching	*Ukrainian*
Information about the head of the course / teachers	Lecturer: *Ph.D. , Assoc. Mykola Vasyliovych PUSHKAR, 0675088258*
Placement of the course	https://do.ipo.kpi.ua/course/view.php?id=4808

Program of study discipline

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

The program of the study discipline "ELECTROMOBILITY" was compiled in accordance with the educational program "Electromechanical systems of automation, electric drive and electromobility " of bachelor's training in specialty 141 - Electric power, electrical engineering and electromechanics.
The purpose of the educational discipline *is to study the design of the main types of electric cars and other electric vehicles (city transport, unmanned aerial vehicles, sea and river transport), the basis of the theory of electric mobility .*
The content of *the credit module includes theoretical information on the structure of electric vehicles of various types, the structure of electric drives and the main technological schemes of modern electric vehicles.*
The subject of the educational discipline *is advanced technologies in electric vehicles, the basics of electromechanical energy conversion in electric vehicles.*
Program learning outcomes:
PR05. Know the basics of electromagnetic field theory, methods of calculating electric circuits and be able to use them to solve practical problems in professional activities.

PR06. Apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities.
PR07. To carry out the analysis of processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and systems.
PR08. Choose and apply suitable methods for the analysis and synthesis of electromechanical and electric power systems with given indicators.
PR18. Be able to learn independently, acquire new knowledge and improve skills in working with modern equipment, measuring equipment and application software.
PR22. Know and understand the basics of coordinate transformation and the principles of frequency and vector control of electromechanical systems.
PR25. Know ways to improve the efficiency of algorithms for controlling electric drives, electromechanical systems, the basics of electromobility theory .
PR27. To know the equation of motion of an electric drive for different types of masses; methods of calculating the mechanical part of the electric drive; methods of controlling DC and AC motors; methods of selecting electric motors by power.

Professional competences:

K17. The ability to develop projects of electric power, electrotechnical and electromechanical equipment in compliance with the requirements of legislation, standards and specifications.
K19. Awareness of the need to increase the efficiency of electric power, electrotechnical and electromechanical equipment.
K20. Awareness of the need to constantly expand one's own knowledge of new technologies in electric power, electrical engineering and electromechanics.
K21. The ability to quickly take effective measures in emergency (emergency) situations in electric power and electromechanical systems.
K22. The ability to use mathematical methods and methods of the theory of automatic control in the study of linear and nonlinear systems, conduct analysis of quality indicators, synthesize regulators, compile and analyze structural diagrams of automatic control systems.
K25. The ability to perform calculations of the mechanical part of the electric drive, mechanical transients, calculate the parameters of DC and AC motors, perform their modeling and analysis.
K27. Ability to solve complex practical problems related to energy conversion in renewable sources and electric transport.

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

To successfully master the discipline, the student must have basic knowledge of the theory of structural materials, electric machines and devices, theoretical electrical engineering, theory of automatic control, theory of electric drive, control of electric drives. Competences, knowledge and skills acquired in the process of studying the credit module enable students and future specialists to independently solve complex practical problems related to energy conversion in electric transport.

3. Content of the academic discipline

The discipline is structurally divided into 4 ***sections , namely*** *:*

Section 1 THEORY OF ELECTROMOBILITY

Topic 1 Concept of electric mobility , History of electric transport
Topic 2 Reasons for using electric cars, ecological aspects of electric transport.
Topic 3 Classification of electric vehicles and hybrids

Chapter 2 ELECTRIC TRANSPORT

Topic 4 Design of modern trolleybuses and electric buses
Topic 5 Design of modern trams and subway cars, railway transport. Electric funicular.
Topic 6 Electric bicycles and electric scooters . Personal electric transport.
Topic 7 Electromechanical transmission. Design of electric transmission of ships. Azipod system .

Chapter 3 ELECTRIC CARS

Topic 8 Basic elements of electric cars
Topic 9 Transmission configuration of modern electric cars
Topic 10 Full HEV hybrids
Topic 11 Plug - in hybrids
Topic 12 Rechargeable vehicle (BEV). Electric vehicle with increased range (RXBEV). Electric car with fuel elements (FCBEV)
Topic 13 Accumulators of modern electric cars
Topic 14 Charging batteries for electric cars. Standards of charging stations and modes of operation.
Topic 15 Recovery and storage of electric energy in electric transport

Chapter 4 Aircraft with electric engines

Topic 16 Electric aircraft, unmanned aerial vehicles powered by electric traction.
Topic 17 Quadcopters and helicopters, main nodes and schemes of modern UAVs

4. Educational materials and resources

Main information resources:

1. *Iqbal Husain. Electric and Hybrid Vehicles Design Fundamentals. CRC Press, London 2021, 498 p.*
2. *Hnatov, A. V. Infrastructure electric vehicles in : lecture notes [Electronic resource] / A. V. Hnatov, Sh. V. Argun; Ministry of Education and Science of Ukraine , Kharkiv . national automob .-dor. Univ. - Kharkiv , 2021. - 142 p.*
3. *Construction and dynamics electric rolling stock: a textbook / C. V. Panchenko, M. M. Babaev , V. S. Blindyuk and others . – Kharkiv : UkrDUZT , 2018. – Part 1. 280 p.*
4. *Hnatov, A. V. Progressive automotive technologies transport i : lecture notes [Electronic resource] / A. V. Hnatov; Ministry of Education and Science of Ukraine , Kharkiv . national automob .-dor. Univ. - Kharkiv , 2020. - 185 p.*
5. *Islam, Md Rabiul. Emerging Power Converters for Renewable Energy and Electric Vehicles: Modeling, Design, and Control. CRC Press, London 2021, 419 p.*
6. *Ashok Kumar L., Albert Alexander S. Power Converters for Electric Vehicles. CRC Press, London 2021, 273 p.*
7. *Rolling stock urban electric transport. Mechanical part : teach manual / V. Kh. Daleka, M. V. Hvorost, V. I. Skurikhin , D. I. Skurikhin . ; Kharkiv . national city university household - va named after O. M. Beketova. – Kharkiv : XNUMX named after O. M. Beketova, 2018. – 388p.*
8. *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design / [E. Mehrdad, Y. Gao, A. Emadi and etc.]. - United States of America: CRC Press, 20 1 4. - 424 p .*

9. *Supporting literature*

1. *Electronic and microprocessor equipment cars : training help / Yu.I. Pindus , R.R. A whirlwind – Ternopil : TNTU, 2016. – 209 p.*
2. *Basov, H. G. Development of electric motor-car rolling stock [Text]: educ . guide . Part 2 / H. G. Basov, S. I. Yatsko . – Kharkiv : Apex+, 2005. – 248 p.*
3. *Theory and design rolling stock of high-speed transport: Textbook / S. V. Panchenko, O. B. Babanin , A. O. Kagramanyan and others . - Kharkiv : UkrDUZT , 2018. - 362 p.*
4. *MC Falvo, IS Bayram, "EV charging stations and modes: International standards "- 2014, pp . 1064-1139.*

Methodical literature

Educational content

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

Lecture classes

No s/p	*The name of the topic of the lecture and a list of main questions (a list of didactic tools, references to the literature and tasks on the SRS)*
1	***Section 1 THEORY OF ELECTROMOBILITY*** *Concept of electric mobility , History of electric transport*
2	*Reasons for using electric cars, ecological aspects of electric transport.*
3	*Classification of electric vehicles and hybrids*
4	*Design of modern trolleybuses and electric buses. Trolleybuses*
6	*Design of modern trolleybuses and electric buses. Electric buses*
7	*Design of modern trams and subway cars. Trams*
8	*Design of modern trams and subway cars. Subway*
9	*Design of modern trams and subway cars. Electric funicular (lecture- excursion)*
10	*Design of modern high-speed electric trains*
11	*Electric bicycles and electric scooters .*
12	*Personal electric transport*
13	*Electromechanical transmission*
14	*Construction of electric transmission of ships. Azipod system .*
15	*The main elements of electric cars*
16	*configuration of modern electric vehicles*
17	Full HEV hybrids
18	*Plug-in hybrids*
19	*Battery powered vehicle (BEV). Electric vehicle with increased range (RXBEV). Fuel cell electric vehicle (FCBEV)*
20	*Accumulators of modern electric cars*
21	*Charging batteries for electric cars. Standards of charging stations and modes of operation.*
22	*Recovery and storage of electric energy in electric transport*
23	*Electric plane, unmanned aerial vehicles powered by electric traction.*

24	Quadcopters and helicopters, main nodes and schemes of modern UAVs
25	Mathematical model of a quadcopter as a control object.
26	Synthesis of the contours of the automatic control of the movement of the quadcopter in space.
27	Orientation of unmanned aerial work in space. Inertial and Global Positioning System

Practical classes

No s/p	Name of the subject of the lesson and list of main questions
1	Practical lesson No. 1 Analysis of the designs of existing electric vehicles. Calculation of the equipped and full weight, determination of the coordinates of the center of mass of the electric vehicle.
2	Practical class #2 Calculation of power and selection of an engine for an electric vehicle (simplified approach, using the example of a trolleybus) Construction and calculation of the load diagram of an electric drive of a trolleybus, checking the selected electric motor for heating, overloading capacity and starting conditions.
3	Practical lesson No. 3 Calculation of the main parameters of an electric vehicle. Resistance forces acting on an electric car. Construction of the characteristics of the change in engine power depending on the vehicle speed. Aerodynamic resistance and its influence on the electromechanical characteristics of the traction motor.
4	Practical lesson No. 4 Calculation and construction of dynamic characteristics of an electric vehicle. External speed characteristics and traction characteristics of the engine. Calculation of the dynamic factor (by mass and by coupling). Calculation and graphing of electric vehicle accelerations.
5	Practical lesson No. 5 Calculation and construction of energy characteristics of an electric car. Calculation of the consumption of electric energy for the movement of an electric vehicle. Dependence of the consumption of electrical energy on the speed of movement. Calculation of specific power consumption. Calculation of the mass of the electrochemical current source and determination of the range of the electric vehicle at different speeds.
6	Practical lesson No. 6 Calculation of the parameters of the main elements of the electromechanical system of the electric bus. Selection of batteries and supercapacitors to ensure the necessary power reserve according to the specified requirements.
7	Practical lesson #7 Calculation of power and selection of engines and quadcopter elements
8	Practical lesson #8 Study of quadrocopter control circuits in the MATLAB system. Analysis of the impact of inertia on quadcopter motion control .
9	Practical lesson No. 9 MODULAR CONTROL WORK

Student's independent work

No. z/p	Type of independent work	Number hours of SRS
1	Preparation for classroom classes	18
2	Preparation for practical classes	28
2	Preparation for MKR	4
3	Preparation for hall and ku	6
4	Implementation of RGR	22
	Together	66

Policy and control

6. Policy of academic discipline (educational component)

The system of requirements that the teacher sets before the student:

- *rules for attending classes: in accordance with Order 1-273 dated 14.09.2020, it is prohibited to evaluate the presence or absence of the winner at the classroom class, including the awarding of incentive or penalty points. According to the RSO of this discipline, points are awarded for the corresponding types of educational activity in lectures and practical classes;*
- *rules of behavior in classes: the student has the opportunity to receive points for the appropriate types of educational activity in lecture classes, provided for by the RSO of the discipline. The use of means of communication to search for information on the teacher's Google Drive, on the Internet, in a distance course on the Sikorsky platform is carried out on the condition that the teacher instructs;*
- *policy of deadlines and rescheduling: if a student did not pass or did not show up for the MKR (without a good reason), his result is evaluated at 0 points;*
- *policy on academic integrity: the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical behavior of individuals and provides a policy of academic integrity for persons working and studying at the university, which they should be guided by in their activities, including when studying and preparing control measures in the discipline "Automated electric drive";*
- *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.), it is necessary to observe generally accepted ethical norms, in particular, to be polite and limit communication to the working hours of the teacher.*

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

Current control *: RGR, MKR.*
Calendar control *: is carried out twice a semester as a monitoring of the current state of meeting the requirements of the syllabus .*
Semester control: *Exam*
Conditions for admission to the semester control *: semester rating of more than 25 points, positive assessment for RGR and MKR.*
Table of correspondence of rating points to grades on the university scale:

Number of points	*Rating*
95-100	*Perfectly*
85-94	*Very good*
75-84	*Good*
65-74	*Satisfactorily*
60-64	*Enough*
Less than 60	*Unsatisfactorily*
The conditions for admission to credit have not been met	*Not allowed*

overall rating *for work in the semester consists of points obtained for:*

1. Modular control work: *Number of MKR - 1 with a duration of 2 academic hours each. The maximum number of points per MKR is 15. The MKR evaluation criterion is as follows:*
- "excellent", complete answer (at least 90% of the required information) - 14-15 points;

- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 11-13 points;
- "satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 8-10 points;
- "unsatisfactory", an unsatisfactory answer (does not meet the requirements) or absence during the work - 0 points.

2. Practical classes . *The maximum number of points for all practical classes is 2 points * 9 classes = 18 points.*

At practical classes, students together with the teacher solve tasks according to the subject of the practical class. After each practical session, students receive a homework assignment that must be solved and submitted to the teacher for review before the start of the next session (usually this is 2 weeks, but sometimes this time can be changed by the teacher in some specific cases).

Evaluation criteria

- the homework was solved correctly and passed within 2 weeks after the practical lesson - 2 points;
- the homework was solved correctly, but it was submitted more than 2 weeks after the practical lesson - 1 point;
- the homework was solved with minor errors and passed within more than 2 weeks after the practical lesson - 0.5 points;
- the homework is solved with significant errors - it is returned for revision.

3 . Estimated graphic work. *According to the work study plan, each student performs a calculation and graph work*
The maximum number of points for completing the RGR is 17 and consists of the maximum points for design – 5 , for protection – 12 .
0.5 points are deducted for each day of late submission of the RGR for verification the maximum number of points that can be obtained for RGR, but not more than 5.
Evaluation criteria
For registration:
- compliance with registration requirements - 5 points;
- slight deviation from the requirements for registration - 4 points;
- significant deviation from the registration requirements - 3 points;
- RGR is not properly executed - 0 points and is returned for processing.
For protection:
- understanding of the presented material, complete answers to questions for the defense - 10-12
points;
- understanding of the presented material, full answers to questions for defense with some inaccuracies - 7-9 points;
incomplete answers to defense questions - 5-6 points ;
- the work is completed with significant errors, the student cannot give an answer to protection - 0 points.
Calendar control is based on the current rating. A condition for a positive assessment is the value of the student's current rating of at least 50% of the maximum possible at the time of assessment.

The form of semester control is an exam

The maximum number of points is 50.
A necessary condition for admission to the exam is a positive assessment for the MKR, execution and defense of calculation and graphic work, a starting rating of at least 25 points.

The examination paper consists of answers to three theoretical questions and one practical task.
Evaluation criteria of the exam
Each theoretical question is worth 10 points, and the practical question is worth 20 points.
The evaluation system of theoretical questions:
- "excellent", complete answer (at least 90% of the required information) - 9-10 points;
- "good", sufficiently complete answer (at least 75% of the required information), or complete an answer with minor inaccuracies - 8 points;
- "satisfactory", incomplete answer (at least 60% of the required information) and insignificant errors - 6-7 points;
- "unsatisfactory", an unsatisfactory answer (does not meet the requirements for 6 points) - 0 points.
Evaluation system of the practical task:
- "excellent", complete problem-free solution - 18-20 points;
- "good", complete solution of the task with insignificant inaccuracies - 15-17 points;
- "satisfactory", the task was completed with certain shortcomings - 12-14 points;
- "unsatisfactory", task not completed - 0 points.
Evaluation criteria for credit test work
- "excellent", complete answer, at least 95% of the required information (complete, error-free solution of the task) - 95 - 100 points;
- "very good", sufficiently complete answer, at least 85% of the required information or minor inaccuracies (complete solution of the task with minor inaccuracies) - 85-94 points;
- "good", sufficiently complete answer, at least 75% of the required information or minor inaccuracies (complete solution of the task with minor inaccuracies) - 75-84 points;
- "satisfactory", incomplete answer, at least 65% of the required information and some errors (the task was completed with certain shortcomings) - 65-74 points;
– "enough", incomplete answer, but at least 60% of the required information and some errors (the task was completed with significant shortcomings) - 60 - 64 points;
- "unsatisfactory", the answer does not meet the conditions for "satisfactory" - 0 points.

Certificates of completion of distance or online courses on the relevant subject may be credited subject to the fulfillment of the requirements specified in *Order No. 7-177 dated 01.10.2020 On approval of the regulation on recognition in KPI named after Ihor Sikorskyi of learning results acquired in non-formal/ informal education*

Working program of the academic discipline (syllabus):

Compiled by M.V. Pushkar, associate professor of the Department of Automation of Electromechanical Systems and Electric Drives of the FEA.

Approved by the Department of Automation of Electromechanical Systems and Electric Drives of the FEA (Protocol No. 15 dated 13.06.2024)

Agreed by the Methodical Commission of the faculty [1](protocol No. 10 dated 06/20/2024)

[1]Methodical council of the university – for general university disciplines.