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

Renewable Energy Sourses
Department

# ELECTROTECHNICAL MATERIALS

## Work program of the discipline (Syllabus)

### Details of the academic discipline

| Level | ***Bachelor*** |
|---|---|
| **Branch of knowledge** | *14 Electrical engineering* |
| **Speciality** | *141 Electric Power Engineering, Electrical Engineering and Electromechanics* |
| **Educational and Professional Program** | *ENERGY MANAGEMENT AND ENERGY EFFICIENT TECHNOLOGIES* |
| **Discipline status** | *Normative* |
| **Form of education** | *full-time (day)* |
| **Year of training, semester** | *1st year, autumn semester* |
| **Scope of the discipline** | *90 hours / 3 ECTS credits*<br>*(lectures - 36 hours, laboratory classes - 18 hours, IWS - 36 hours)* |
| **Semester control/ control measures** | *Final test, module control work (MCW)* |
| **Lessons schedule** | *http://roz.kpi.ua/* |
| **Language of teaching** | *Ukrainian* |
| **Information about head of the course / teachers** | Lecturer: Kateryna Kyrylenko, PhD, Associate Professor, katakyr20@gmail.com; +38(067) 508-55-75 (Telegram) - during working hours.<br>Consultations: every Thursday, 16:00-17:00<br>Laboratory supervisor: Oleksandr Melnyk, Assistant, oa.melnyk@kpi.ua; +38(068) 623-74-35, @oamelnyk (https://t.me/oamelnyk) - during working hours.<br>Consultations: every Thursday, 16:00-17:00 |
| **Placement of the course** | https://classroom.google.com/c/NTUwMDU1OTY3NTMy?cjc=qxhwbcv |

### Curriculum of the discipline

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

*The program of educational discipline "Electrotechnical materials" is compiled in accordance with the professional educational programme "Energy management and energy-efficient technologies" of first (bachelor) level higher education level of the specialty 141 - Electric power, electrical engineering and electromechanics.*

*Modern electric power and electrotechnical equipment, high and low voltage power transmission lines, electrophysical and electrotechnological equipment cannot be qualitatively designed and constructed without the use of electrotechnical materials and cannot be efficiently produced and operated without knowledge of the properties and features of the application of these materials. The main tasks of modern electrotechnical materials science: to develop new and increase the efficiency of the use of existing electrotechnical materials in electric power, electrical engineering and electromechanics, in particular by increasing the specific power of electrical equipment; reduce electricity losses during its transmission in overhead and cable lines and during the operation of electrical machines and devices; ensure accident-free and safe work when servicing electrical equipment.*

*The study of the discipline "Electrotechnical materials" contributes to the understanding of the processes occurring in electrotechnical materials and helps to determine the possibilities of using materials in electric power, electrical engineering and electromechanics and the efficiency of operation and operational reliability of electrical equipment.*

***The purpose of mastering the discipline*** *is to form knowledge about properties and criteria for the selection of electrical materials depending on the principle of operation, design and conditions of use of the equipment and to form a specialist capable of performing the work of a researcher, designer, technologist and operator of electric power, electrotechnical, electromechanical, electrophysical and testing equipment for the production, transformation, transportation, distribution and use of electric energy, ensuring the high quality of this equipment in the process of design and production, and in the process operation, efficient use, qualified maintenance and reliability..*

***The subject of the discipline****: 33classification of electrical materials according to purpose, properties and composition; physical processes that occur in electrotechnical materials under the influence of electromagnetic fields, the relationship of the properties of electrotechnical materials with the chemical composition, structure and modes of technological processing, the dependence of the properties, characteristics and parameters of materials on temperature, characteristics of voltage and field intensity, mechanical stresses, pressure, humidity, radiation, chemical and other external factors; methods of testing and measuring the main electrical, magnetic, and physical-mechanical parameters of electrical engineering materials; criteria for the rational technical and economic selection of electrical materials in the design and repair of electrical and electrical equipment, taking into account the effect of operational and external factors on it.is patterns and trends in industrial energy consumption, principles of production management as an energy and environmentally friendly system.*

***Competencies:*** *(GC7) Ability to work in a team; (PC3) Ability to solve complex specialized tasks and practical problems related to the operation of electrical systems and networks, the electrical part of stations and substations, and high-voltage equipment; (PC5) Ability to solve complex specialized tasks and practical problems related to the operation of electric machines, devices and automated electric drives; (PC6) Ability to solve complex specialized tasks and practical problems related to the problems of production, transmission and distribution of electric energy.*
***Programme learning outcomes:*** *(PLO7) To carry out the analysis of processes in electric power, electrotechnical and electromechanical equipment, relevant complexes and systems.*

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

*Preliminary successful mastering of knowledge and skills in the following disciplines is required general knowlege in Mathematics, Physics and Chemistry.*

*The results of the study of the discipline "Electrotechnical matherials" are necessary for "Technical Mechanics", "Fundamentals of Metrology and Electrical Measurements", "Electric Drive"*

## 3. The content of the discipline

***Electrotechnical matherials.***

***Section 1. Introduction*** *The place and role of the discipline in the training of electrical engineering bachelors. Definition of electrical engineering terms. General information about the structure of substances, electrical materials and their classification according to various criteria.*

***Topic 1.*** *General information about electrical materials.*
***Topic 2.*** *Basic information about the structure of the substance.*

***Section 2. Dielectric materials.*** *Polarization and electrical conductivity of dielectrics, dielectric losses, breakdown of dielectrics, physicochemical, mechanical and radiation properties of dielectrics. Basic dielectric materials.*

***Topic 3.*** *Classification of dielectrics*
***Topic 4.*** *The polarization of matter.*
***Topic 5.*** *Conductivity of dielectrics.*
***Topic 6.*** *Dielectric losses.*
***Topic 7.*** *Dielectric breakdown.*
***Topic 8.*** *Breakdown of gases.*
***Topic 9.*** *Breakdown of liquid dielectrics.*
***Topic 10.*** *Breakdown of solid dielectrics.*
***Topic 11.*** *Non-electric properties of dielectrics.*
***Topic 12.*** *Insulating materials for energy and electrical engineering.*

***Section 3. Conductive materials.*** *Classification and main properties of conductor materials. Conductive materials for various electrical applications.*

***Topic 13.*** *Basic properties of conductors.*
***Topic 14.*** *Conductive materials with high conductivity.*
***Topic 15.*** *High electrical resistivity alloys.*

***Section 4 Semiconductor materials.*** *General review of the main properties of semiconductors, as well as information about the main semiconductor materials.*

***Topic 16.*** *General characteristics of semiconductor materials.*
***Topic 17.*** *Semiconductor materials for some applications.*

***Section 5. Magnetic Materials.*** *Basic information about magnetic properties of materials. The processes in magnetic materials. Magnetization of ferromagnetic materials. Magnetosensitive and magnetohard materials.*

***Topic 18.*** *General characteristics of magnetic materials.*
***Topic 19****. Magnetic materials in electrical engineering.*

## 4. Training materials and resources basic (textbooks, manuals) literature

***Basic literature***


1. *Електротехнічні матеріали: Курс лекцій. Частина 1. Діелектричні матеріали. [Електронний ресурс]: навч. посіб. для здобувачів ступеня бакалавра за освітніми програмами «Електричні станції», «Електричні системи і мережі», «Електротехнічні пристрої та електротехнологічні комплекси», «Нетрадиційні та відновлювані джерела енергії», «Електричні машини і апарати», «Електромеханічні системи автоматизації, електропривод та електромобільність», «Управління, захист та автоматизація енергосистем» спеціальності 141 «Електроенергетика, електротехніка та електромеханіка», уклад.: В. М. Кириленко, К.В. Кириленко. В.М. Головко – Київ : КПІ ім Ігоря Сікорського, 2021. – 224 с. Доступ: https://ela.kpi.ua/handle/123456789/45608*
2. *Електротехнічні матеріали. Курс лекцій. Частина 2. Напівпровідникові, провідникові і магнітні матеріали [Електронний ресурс] : навчальний посібник для студентів спеціальності 141 – Електроенергетика, електротехніка та електромеханіка / КПІ ім. Ігоря Сікорського ; уклад.: К. В. Кириленко, В. М. Кириленко, В. М. Головко. – Електронні текстові дані (1 файл 2.9 Мбайт). – Київ : КПІ ім Ігоря Сікорського, 2023. – 109 с. – Назва з екрана. Режим доступу: https://ela.kpi.ua/handle/123456789/57250*
3. *Електротехнічні матеріали: лабораторний практикум [Електронний ресурс]: навчальний посібник для здобувачів ступеня бакалавра спеціальності 141 «Електроенергетика, електротехніка та електромеханіка» / КПІ ім. Ігоря Сікорського ; уклад.: В. М. Кириленко, К. В. Кириленко, М. О. Будько. – Електронні текстові дані (1 файл: 2,71 Мбайт). – Київ : КПІ ім Ігоря Сікорського, 2022. – 74 с. – Назва з екрана. Режим доступу: https://ela.kpi.ua/handle/123456789/48371*

*4. Електротехнічні матеріали: оформлення звітів з лабораторних робіт [Електронний ресурс] : навчальний посібник для студентів спеціальності 141 - Електроенергетика, електротехніка та електромеханіка / КПІ ім Ігоря Сікорського ; уклад.: К. В. Кириленко, В. М. Кириленко. – Електронні текстові дані (1 файл: 1,34 Мбайт). – Київ : КПІ ім Ігоря Сікорського, 2022. – 23 с. – Назва з екрана. Режим доступу: https://ela.kpi.ua/handle/123456789/48385*

*5. Поплавко, Ю. М. Фізичне матеріалознавство [Електронний ресурс]: навчальний посібник / Ю. М. Поплавко, С. О. Воронов ; НТУУ «КПІ». – Електронні текстові дані (1 файл: 15,8 Кбайт). – Київ : НТУУ «КПІ», 2015. – 838 с. – Назва з екрана. Режим доступу:* https://ela.kpi.ua/handle/123456789/14029

***Additional literature***

*(optional / review)*

*6. Електротехнічні матеріали: навч. посібн. / А.С. Головченко, Д.В. Ципленков, А.А.Колб, А.В. Ніколенко; Мін-во освіти і науки України, Нац. техн. ун-т «Дніпровська політехніка» - Дніпро: НТУ «ДП», 2012. – 184 с.*

*7. Василенко І.І., Василенко Ю.І., Широков В.В. Конструкційні та електротехнічні матеріали. Навчальний посібник (рекомендовано МОН України) - Львів: «Магнолія-2006», 2018. – 242 с.*

*8. ДСТУ 2843–94. Електротехніка. Основні поняття. Терміни та визначення. (Діючий)*

*9. ДСТУ 2815-94 Електричні й магнітні кола та пристрої. Терміни і визначення. (Діючий)*

*10.ДСТУ 2725–94. Матеріали магнітні. Терміни та визначення. (Діючий)*

***Information resources***

*The literature, the bibliography of which is given with a reference, can be found on the Internet. Literature without references can be found in the library of Igor Sikorsky Kyiv Polytechnic Institute.*

*The basic literature [1-5] is recommended for reading. The connection of these resources with specific topics of the discipline is given below, in the methodology for mastering the discipline. All other literary sources are optional and are recommended to be reviewed.*

## Educational content

### 5. Methods of mastering the discipline

*The discipline includes 36 hours of lectures and 18 hours of laboratory classes, as well as a module control work (MCW), which consists of two parts (by topic) duration of 1 academic hour each.*

*Laboratory classes in the discipline are conducted to consolidate the theoretical provisions of the discipline and to acquire students' skills and experience in operating modern concepts in the field of electrotechnical material science. Based on the distribution of time for studying the discipline, nine laboratory classes are recommended (including time for the MCW).*

*Teaching methods and forms include not only traditional university lectures and seminars, but also elements of teamwork and group discussions. Active learning strategies are applied, which are determined by the following methods and technologies: problem-based learning methods (research method); personality-oriented technologies based on such forms and methods of learning as case technology and project technology; visualization and information and communication technologies, including electronic presentations for lectures. Communication with the lecturer is built through the use of the Electronic Campus information system, the Sikorsky distance learning platform based on G Suite for Education, as well as communication tools such as e-mail and Telegram. Modern information and communication and network technologies are used during training and for interaction with students to solve educational tasks.*

***LECTURE CLASSES***

| № | *The title of the lecture topic and a list of key issues*<br>*(list of teaching aids, references to literature and tasks on VTS)* |
|---|---|
| ***Section 1. Introduction*** | |
| *1* | ***Topic 1. General information about electrical materials.*** |

| № | *The title of the lecture topic and a list of key issues (list of teaching aids, references to literature and tasks on VTS)* |
|---|---|
| | ***Subject and content of the course.*** *The concept of electrical materials. The value of modern electrical engineering materials. Classification of materials in connection with their properties and areas of use. Concepts of conductor, semiconductor, dielectric and magnetic materials. Development of materials production in Ukraine and abroad. Economic indicators of the use of various materials. Review of state standards.* ***Electrotechnical terms and definitions,*** *which are necessary when studying the discipline.* *Literary references: [1, 5]* |
| *2* | ***Topic 2. Basic information about the structure of the substance.*** *The relationship between the classification of electrical materials and the aggregate state of matter. Basic information about the structure of atoms, molecules and matter. Types of chemical bonds in molecules and condensed matter. Polar and non-polar chemical bonds. The relationship between the classification of electrical materials and the chemical bond in a substance. Crystalline and amorphous structure of matter. Types of crystal lattices, defects of crystal lattices, their classification and role in the properties of matter.* *Zone theory of a solid body. Formation of energy zones during condensation of matter. Classification of electrical materials in the light of zone theory..* *Literary references: [1, 5]* |
| ***Section 2. Dielectric materials.*** | |
| *3-5* | ***Topic 3. Classification of dielectrics*** *Classifcotion of dielectrics. Structure of dielectrics. Electric charges in dielectrics and their interaction with the electric field.* ***Topic 4. The polarization of matter.*** *Dielectric permeability. Its dependence on frequency, temperature and other external factors. Methods of measuring dielectric constant. Polarization of gaseous, solid and liquid dielectrics. Linear and nonlinear dielectrics. Ferroelectrics, piezoelectrics and pyroelectrics.* ***Topic 5. Conductivity.*** *Specific volumetric conductivity. Electrical conductivity of gases, its nature and dependence on electric field strength. Electrical conductivity of liquids. Electrical conductivity of solid dielectrics. Influence of impurities. The role of humidity. Dependence on temperature. Surface conductivity. Methods of measuring specific volume and surface resistance.* ***Topic 6. Dielectric losses.*** *Total and specific losses. Scheme for replacing dielectric losses (dielectrics with losses). Nature and types of dielectric losses Dependence on frequency and temperature, aggregate state of matter and dielectric parameters. Methods of determining the tangent of the dielectric loss angle.* *Literary references: [1, 5]* |
| *6-8* | ***Topic 7. Dielectric breakdown.*** *Definition and main characteristics of breakdown. Breakdown voltage and electrical strength.* ***Topic 8. Breakdown of gases.*** *Breakdown of gases in uniform and non-uniform electric fields. Breakdown at constant and alternating voltage of low and high frequency Breakdown at pulses. Dependence of the breakdown voltage on the pressure and the size of the spark gap. Influence of humidity and temperature on the breakdown voltage of gases. Gases with increased electrical strength.* ***Topic 9. Breakdown of liquid dielectrics****. Breakdown of liquid dielectrics and the mechanism of this phenomenon. The influence of impurities on the nature of the* |

| № | *The title of the lecture topic and a list of key issues (list of teaching aids, references to literature and tasks on VTS)* |
|---|---|
| | *dependence of the breakdown voltage of a liquid on temperature, voltage duration, and the shape of the field.*<br>***Topic 10. Breakdown of solid dielectrics.*** *Patterns of thermal and electrical breakdown. Basics of the theory of thermal breakdown. Electrical breakdown. The dependence of the electrical strength of solid dielectrics on the shape of the field, the type of current, the frequency of the current, the duration of the voltage, and the thickness of the dielectric. Electrochemical breakdown. Breakdown of an inhomogeneous dielectric. Ionization breakdown. Breakdown on the surface of a solid dielectric. Experimental data on surface breakdown. Methods of determining the electrical strength of dielectrics.*<br>*Literary references: [1, 5]* |
| *9,10* | ***Topic 11. Non-electric properties of dielectrics.***<br>***Mechanical properties of dielectrics****: density, strength under various types of mechanical load, hardness, resistance to splitting, tear resistance, impact toughness, vibration resistance, flexibility, etc. General information on methods of determining mechanical properties.*<br>***Physico-chemical properties of dielectrics:*** *chemical resistance, moisture resistance (hygroscopicity), water resistance, water absorption, water permeability, etc. and general information about methods of their determination.*<br>***Thermal properties of dielectrics:*** *thermal conductivity, heat capacity, temperature coefficients of expansion, melting and softening temperatures; viscosity, thermal aging of dielectrics, heat resistance according to mechanical and electrical properties, resistance to thermal shocks, cold resistance, etc.*<br>***The effect of radiation on dielectrics****. Classification of ionizing radiation. Disappearing and post-effects under the influence of radiation. Critical doses of absorbed energy during irradiation.*<br>*Changes in the properties of dielectrics as a result of the environment: light resistance, atmospheric resistance and tropical resistance. Effect of biological factors on dielectrics.*<br>*Literary references: [1]* |
| *11,12* | ***Topic 12. Insulating materials for energy and electrical engineering.***<br>***Gaseous dielectric materials.*** *The use of gaseous dielectrics in electrical engineering and power engineering.*<br>***Liquid dielectrics.*** *Transformer, capacitor and cable oil, synthetic liquid dielectrics. The use of liquid dielectrics in electrical engineering and power engineering.*<br>***Solid dielectrics*** *Natural resins, bitumen, waxy dielectrics. Polymers: polyethylene, polypropylene, polystyrene, polytetrafluoroethylene, polyvinyl chloride, polyesters, polymethyl methacrylate, polyamides, polyurethanes, polyimides, phenol-formaldehyde resins, epoxy resins, organofluorine polymers, organosilicon polymers, cellulose ethers, etc. Organic films. The use of polymer dielectrics in electrical engineering and power engineering.*<br>***Plastics****. Layered and foil plastics. Elastomers. Compounds. Electrically insulating varnishes, enamels and glues. Fibrous materials: organic and inorganic, impregnated and non-impregnated. The use of plastics in electrical engineering and energy.*<br>***Monocrystalline dielectrics*** *and materials based on them for electrotechnical use. Inorganic thin and thick films.*<br>***Glass****, its classification. Oxide glass: quartz, alkaline, non-alkaline. Use of glass.* |

| № | *The title of the lecture topic and a list of key issues (list of teaching aids, references to literature and tasks on VTS)* |
|---|---|
| | *Electrotechnical ceramics: electrotechnical porcelain, capacitor ceramics, etc. The use of ceramic dielectrics in electrical engineering and power engineering.* *Literary references: [1, 5]* |
| | ***Section 3. Conductive materials.*** |
| *13,14* | ***Topic 13. Basic properties of conductors.*** *General characteristics of conductive materials. Classification of conductive materials. Specific resistance of metals and alloys. Thermoelectric power. Dependence of electrical properties of metals on external factors.* *Conductive materials for various electrical applications.* ***Topic 14. Conductive materials with high conductivity*** *Conductor copper. Its properties and applications. Conductor bronzes and brasses. Aluminum, its properties and applications. Aluminum-based conductor alloys.* *Silver, gold, platinum, palladium.* *Superconductors and cryoconductors. Use of high conductivity materials in wires and cables.* ***Topic 15. High electrical resistivity alloys.*** *General requirements and classification of conductor alloys by application. Thermocouple materials. Alloys for technical resistors. Heat-resistant alloys. Refractory metals and alloys. Alloys for various applications. Contact materials. Iron, bimetals. Solders and fluxes. Non-metallic conductors.* *Literary references: [2]* |
| | ***Section 4. Semiconductor materials*** |
| *15,16* | ***Topic 16. General characteristics of semiconductor materials.*** *General information and classification. The main parameters that characterize the properties of semiconductor materials (type of conductivity, band gap, mobility of charge carriers, etc.), dependence of parameters on material temperature, current frequency.* *P-n junction in semiconductors. Contact phenomena at the semiconductor-metal interface. The use of semiconductor materials for diodes, transistors, thermistors, photoresistors, tensor resistors, varistors, Hall sensors, for thermocouples and other technical uses. Integrated circuits. Semiconductor photomodules for solar energy. Advantages of semiconductor devices.* ***Topic 17. Semiconductor materials for some applications.*** *Germanium and silicon. Compounds $A^{IY}B^{IY}$ ; $A^{III}B^{YI}$, $A^{II}B^{YI}$. ; Multiphase semiconductor materials. Oxide semiconductors, silicon carbide. A general overview of the technology of obtaining and processing semiconductor materials.* *Literary references: [2]* |
| | ***Section 4. Magnetic materials.*** |
| *17,18* | ***Topic 18. General characteristics of magnetic materials.*** *Classification of magnetic materials. Magnetization of magnetic materials. Basic characteristics in static fields. Static and reversible magnetic permeability. Dynamic hysteresis loop. Dynamic, amplitude and complex magnetic permeability. Magnetic losses, their calculation and ways to reduce these losses. Curie points of magnetic materials. The influence of chemical composition, structure, mechanical processing and heat treatment on the magnetic properties of materials.* ***Topic 19. Magnetic materials in electrical engineering****.* *Magnetosensitive materials for magnetic conductors. Characteristics of the hysteresis loop. Low-frequency soft magnetic materials with high saturation induction, technical* |

| № | *The title of the lecture topic and a list of key issues (list of teaching aids, references to literature and tasks on VTS)* |
|---|---|
| | *iron, electrolytic iron, carbonyl iron, electrotechnical steel, permendur. Low-frequency magnetosensitive materials with high magnetic permeability (permalloy, alsifer). High-frequency soft magnetosensitive materials: magnetodielectrics and magnetosensitive ferrites. Features of the use of magnetosensitive materials in electrical equipment.*<br>*Magnetohard materials for permanent magnets and magnetic memory.*<br>*Characteristics of the hysteresis loop. Specific magnetic energy. Stability of permanent magnets. Steels hardened to martensite. Non-malleable (cast) ferromagnetic materials based on the iron-aluminum system. Plastically deformed (malleable) ferromagnetic alloys. Alloys based on rare earths elements. Special ferromagnets. Magnetostrictive metals and alloys. Materials for magnetic recording of information. Thermomagnetic materials. Magnetic materials with a rectangular hysteresis loop. Magnetic films. Other magnetic materials. Aging of magnetic materials*<br>*Literary references: [2]* |

***LABORATORY CLASSES***

| № | *Name of the topic of the practical class and a list of key questions (links to information references)* |
|---|---|
| *1* | ***Study of electrical conductivity of solid dielectrics.***<br>*The purpose of the work is to investigate the influence of the composition and structure of the material and environmental factors on the values of specific bulk - ρv and surface - ρs resistances of solid dielectrics.*<br>*Literary references: [1,3,4]* |
| *2* | ***Study of polarization of solid dielectrics***<br>*The purpose of the work is to investigate the influence of the composition and structure of the material and external conditions on the polarization of solid dielectrics.*<br>*Literary references: [1,3,4]* |
| *3* | ***Study of dielectric losses in solid dielectrics.***<br>*The purpose of the work is to study the mechanisms of dielectric losses and the regularities of the influence of external factors on the dielectric losses of solid dielectrics**.***<br>*Literary references: [1,3,4]* |
| *4* | ***Study of electrical strength of dielectrics.***<br>*The purpose of the work is to investigate the general regularities of the breakdown of gaseous and liquid dielectrics.*<br>*Literary references: [1,3,4]* |
| *5* | ***Modular control work, Part I***<br>*Literary references: [1]* |
| *6* | ***Research of electrical conductivity of semiconductors.***<br>*The purpose of the work is to investigate the effect of temperature on the electrical conductivity of semiconductor resistors, thermistors and positrons, to determine the width of the forbidden band and the temperature coefficient of resistance of semiconductor materials.*<br>*Literary references: [2,3,4]* |
| *7* | ***Study of the properties of conductive materials****.* |

| № | Name of the topic of the practical class and a list of key questions (links to information references) |
|---|---|
| | *The purpose of the work is to investigate the effect of temperature on the electrical conductivity of conductive materials with high specific conductivity and high specific resistance; determine the specific thermal EMF of conductor thermocouples.* *Literary references: [2,3,4]* |
| *8* | ***Study of the properties of ferromagnetic materials.*** *The goal of the work is to learn to determine the main characteristics of ferromagnetic materials.* ***Module control work*** *Literary references: [2,3,4]* |
| *9* | ***Modular control work, Part II*** *Literary references: [2]* |

## 6. Independent work of the student

| № | Type of independent work | Number of hours of IWS |
|---|---|---|
| *1* | *Preparing for classroom lessons* | *9* |
| | *Carrying out calculations based on primary data obtained in laboratory classes, writing protocols of laboratory work, studying theoretical material* | *17* |
| *2* | *Preparing for the MCW* | *4* |
| *3* | *Preparing for the Final test* | *6* |

## Policy and control

## 7. Policy of the discipline (educational component)

*The system of requirements that the teacher puts before the student:*

- *rules of attendance: in accordance with Order 1-273 of 14.09.2020, it is prohibited to assess the presence or absence of the applicant in the classroom, including the accrual of incentive or penalty points. According to the RSO of this discipline, points are awarded for the relevant types of educational activity in lectures and practical classes.*

*At the beginning of each class, both lecture and practical, the student must have the Zoom application installed on the device from which he or she is working (in the case of distance learning), and the course "Electrotechnical matherials" on the Sikorsky platform (the course access code is provided at the first lesson according to the schedule). Silabus; lecture material; workshop; assignments for practical classes; options for module tests; express tests to be completed during lectures; a list of questions for the exam is available on the Sikorsky platform and in the KPI Electronic Campus system.*

- *rules of behavior in the classroom: the student has the opportunity to receive points for the relevant types of learning activities in lectures and practical classes provided for by the discipline's RSO. The use of communication tools to search for information on the teacher's Google Drive, on the Internet, in a distance course on the Sikorsky platform is subject to the instruction of the teacher;*

- *rules for the protection of individual tasks: both individual protection of laboratory work and collective protection (as part of a team, determined at the first laboratory session) are allowed. In both cases, the individual answers of each student to control questions for laboratory work are evaluated;*

- *rules for awarding incentive and penalty points: incentive and penalty points are not included in the main RSO scale, and their total does not exceed 10% of the maximum number of points. The total amount of incentive points cannot exceed 10 points.*

- *deadlines and retakes policy: each student is responsible for meeting the deadlines for completing tasks within the schedule of classroom classes in the discipline. The mandatory control measure of assessment for admission to the exam is the MCW. A student who, for a valid reason (sick leave, academic mobility, etc.), has not written an MCW, has the right to do so during regular consultations with the teacher according to the schedule. The procedure for retaking the semester control is determined by the general rules of the university[1].*

- *policy on academic honesty: 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 persons and provides for a policy of academic honesty for persons working and studying at the university, which they should be guided by in their activities, including when studying and passing control measures in the discipline "Energy Management. Part 1". Teachers and students studying this discipline are committed to comply with the provisions of the Code of Honor adopted by the University[2];*

- *when using digital tools for communication with the lecturer (mobile communication, e-mail, correspondence on forums and social networks, etc.), it is necessary to follow generally accepted ethical standards, in particular, to be polite and limit communication to the lecturer's working hours.*

***Inclusive education.*** *The learning of knowledge and skills in the discipline can be accessible to most people with special educational needs, except for students with severe visual impairments that do not allow them to complete tasks using personal computers, laptops, and/or other technical tools.*

***Study in a foreign language.*** *In the process of completing tasks, students may be recommended to refer to English references.*

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

***Current control:*** *express controls at lectures, MCW, completion of tasks in laboratory classes, protection of laboratory works.*
***Calendar control:*** *conducted twice a semester as a monitoring of the current state of fulfillment of the requirements of the syllabus.*
***Semester control: final test.***

*1. The student's rating in the discipline is calculated from 100 points and consists of points that the student receives for:*

- *express tests in lectures (10 points);*
- *completion and defense of 7 laboratory tasks in laboratory classes (70 points);*
- *writing an MCW (20 points).*

*2. Criteria for awarding points:*

*2.1 Express controls in lecture classes: weighted score - 10. The maximum number of points for express controls is 2 points * 5 express controls = 10 points.*

*Express control is carried out in the form of tests that the student performs directly at the lecture, 5-10 minutes before the end of the lesson. At the end of the lesson, the tests are closed and cannot be rewritten*

[1] *Regulations on the current, calendar and semester control of learning outcomes at Igor Sikorsky Kyiv Polytechnic Institute (Annex 1 to Order No. 7-137 of August 0, 2020). URL: https://kpi.ua/document_control*
[2] *Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute". URL: https://kpi.ua/code.*

*or completed at home. The test contains six questions and several answers to each of them, one of which is correct. Each correct answer is worth 0.4 points.*

*2.2 Laboratory work (preparation for laboratory work, conducting experiments, drawing up a report and defending laboratory work).*

*Weighted score – 10. (Preparation of a report on laboratory work - 5 points, defense of laboratory work – 5 points)*

*The maximum number of rating points: 10x7=70*

*Evaluation criteria:*

*- timely and complete performance of laboratory work (completely prepared report on the work performed, satisfactory design of the calculation and graphic part, full analysis of the results and meaningful conclusions based on the results of the work), comprehensive answers to the questions of the question, a clear definition of all concepts and physical quantities 10 points*

*– minor errors in the calculation and graphic part or incomplete answers to questions of 7-9 points*

*– Incomplete or incorrect performance (missing tasks, significant errors in calculations, incorrect answers to questions) 4...6 points*

*2.3. Writing a module control work: the weighting score for one MCW is 10. The maximum score for two MCWs is 20 points.*

*During the semester, one module control work is conducted, which is divided into two one-hour works, for each of which the following assessment criteria are established:*

*- full answer to theoretical questions, tasks solved correctly - 9-10 points*

*- answer to theoretical questions with minor flaws, minor errors in solving tasks - 6-8 points*

*- answer to theoretical questions with significant shortcomings, significant errors in solving tasks - 4-6 points*

*- unsatisfactory answer to theoretical questions, incorrect solution of tasks – 0…3 points*

*3. Calendar control: is conducted twice a semester as a monitoring of the current state of fulfillment of the requirements of the syllabus. 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 relevant calendar control.*

*4. Semester control: assessment*
*The maximum amount of points for work in the semester is 100 points. The condition for admission to the final test is to complete of 7 laboratory tasks and write a module control work.*
*Students who did not score 60 points during the semester or who wish to improve their grade perform a credit test on the subject of the credit module, while the student's initial rating is canceled, and the grade for the credit test is the final grade for the discipline. The credit task contains 3 credit questions, which are determined by the teacher and correspond to the list of questions given in additional information on the discipline.*

| *Method of evaluation* | *Amount* | *The minimum grade in points* | *Maximum score in points* |
|---|---|---|---|
| *Express controls on the materials of lectures* | *5* | *5* | *10* |
| *Completion of tasks in laboratory classes* | *7* | *28* | *70* |
| *MCW* | *2* | *0* | *20* |
| *Final rating* | | *60* | *100* |

*Table of correspondence between rating points and grades on the University scale:*

| *Number of points* | *Grade* |
|---|---|
| *100-95* | *Perfect* |
| *94-85* | *Very good* |
| *84-75* | *Fine* |
| *74-65* | *Satisfactorily* |
| *64-60* | *Enough* |
| *less than 60* | *Unsatisfactorily* |
| *Admission conditions aren't met* | *Not allowed* |

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

*The list of questions submitted for semester control.*

*1. General characteristics of the fields of application of electrical engineering materials*

*2. The relationship between the types of chemical bonds in molecules and condensed matter and the properties of electrical engineering materials*

*3. The main provisions of the zone theory of solids and the classification of electrical materials within the framework of this theory.*

*4. Polarization of dielectrics. The main physical and technical parameters that characterize polarization.*

*5. The main types and mechanisms of polarization, their features. Classification of dielectrics by types of polarization.*

*6. Features of spontaneous polarization and its dependence on temperature and frequency.*

*7. Dependence of the dielectric constant of dielectrics with different structures on temperature and frequency.*

*8. Dielectric permeability of mixtures of two or more dielectrics that do not form chemical compounds with each other.*

*9. Main classes of active dielectrics, features of their polarization and areas of application.*

*10. Electrical conductivity of solid dielectrics. The influence of external factors on volume and surface resistivity, methods of their measurement.*

*11. Electrical conductivity of gases, independent and independent conductivity of gases, saturation current in gases.*

*12. Dielectric losses, mechanisms of dielectric losses, total and specific losses, angle of dielectric losses.*

*13. Substitution schemes for a dielectric with losses, vector diagrams and expressions for tg for them and the possibility of applying substitution schemes.*

*14. Types of dielectric losses depending on the structure and properties of dielectrics.*

*15. Influence of external factors on dielectric losses.*

*16. General characteristics of the dielectric breakdown phenomenon. Types of breakdown.*

*17. Physics of electrical breakdown in a uniform field.*

*18. Effect of electronegativity of gases on their electrical strength.*

*19. Dependence of electrical strength of gases on pressure and distance between electrodes. Paschen's law.*

*20. Theory of thermal breakdown of dielectrics.*

*21. Influence of dielectric characteristics and external factors on breakdown voltage during thermal breakdown.*

*22. Partial discharges in dielectrics and characteristics of their intensity.*
*23. Features and patterns of ionization breakdown.*
*24. Moisture, hygroscopicity, wettability, moisture permeability of dielectric materials and their influence on the operational characteristics of insulation.*
*25. Classes of heat resistance of electrical insulation, temperature index and profile of heat resistance of insulating materials.*
*26. The effect of radioactive irradiation on the electrical, mechanical and thermal properties of dielectrics.*
*27. Practical value of thermal conductivity, heat resistance, resistance to thermal shock and temperature coefficient of expansion of electrical insulating materials.*
*28. Characteristics of electrical insulating properties of air and other gaseous dielectrics.*
*29. Natural and synthetic liquid electrical insulating materials, their properties, features and main areas of application.*
*30. Classification of solid dielectrics according to various criteria, features and areas of application of solid dielectrics.*
*31. Properties and areas of application of micas (muscovite and phlogopite). The main groups of mica-based materials, their properties and areas of application.*
*32. Electrically insulating glass and materials based on it.*
*33. The most important types of ceramic electrical insulating materials and their areas of application.*
*34. Classification and areas of application of polymer dielectrics and plastics.*
*35. Basic polymeric dielectric materials, their properties and applications.*
*36. Elastomers, their properties and applications.*
*37. Lacquers, enamels and compounds, their properties and applications.*
*38. Fibrous electrical insulating materials (organic and inorganic), their properties and applications.*
*39. General characteristics of active dielectrics.*
*40. General characteristics of conductive materials and their application.*
*41. Basic properties of conductive materials.*
*42. Conductive materials of high conductivity: properties and applications.*
*43. Conductive materials of high resistance: properties and applications.*
*44. Thermocouple materials: properties and applications.*
*45. Solders and conductor materials for electrical contacts: properties and applications.*
*46. Superconducting and cryoresistive materials: properties and applications.*
*47. General characteristics and classification of semiconductors.*
*48. The influence of external factors on the electrical conductivity of semiconductors.*
*49. Thermoelectric phenomena in semiconductors and their applications.*
*50. Magnetoelectric phenomena in semiconductors and their applications.*
*51. P-n junction in semiconductors, its properties and applications.*
*52. Magnetic properties of matter and general classification of magnetic materials.*
*53. Magnetosensitive materials, their properties and applications.*
*54. Magnetohard materials, their properties and applications.List of topics to be submitted for semester control:*
*The list of questions submitted for semester control is posted in the distance learning course.*

*A higher education applicant has the opportunity to take an online course(s) on one or more topics provided by the syllabus of the discipline. The applicant can choose an online course independently or on*

*the recommendation of a teacher. The applicant's rating may include certificates of completion of full-time or distance learning courses on the subject of the course on the platforms Prometheus, Coursera, etc. The procedure for recognition through validation of learning outcomes acquired in non-formal/informal education by applicants of all levels of higher education studying at Igor Sikorsky Kyiv Polytechnic Institute is set out in the Regulations on the recognition of learning outcomes acquired in non-formal/informal education at Igor Sikorsky Kyiv Polytechnic Institute (approved and enacted by order of 09.05.2023 № HOH/157/2023).*

*For self-study, relatively simple questions are offered, which in most cases are descriptive in nature, designed to broaden students' horizons and repeat materials studied in other disciplines and are directly related to the discipline.*

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

**Prepared by:**

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*Kateryna Kyrylenko*

**Approved by** the Renewable Energy Sourses Department (protocol № 14 from May 24, 2024.).

**Approved by** the Methodological Council of Educational and Scientific Faculty of Electric Power Engineering and Automatics (protocol № 10 from June 20, 2024).