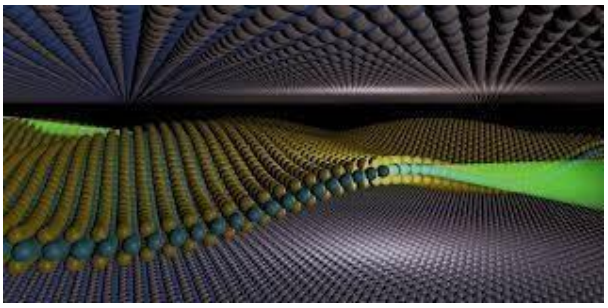
Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Applied Radio Electronics

[RE-10] ELECTRONIC MATERIALS



Work program of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	G - Engineering, manufacturing, and construction
Specialization	G5 - Electronics, electronic communications, instrument engineering, and radio engineering
Educational program	All
Discipline status	Elective (F-catalog)
Form of higher education	Full-time
Year of training, semester	Available for selection starting from the 2nd year, fall semester
Scope of the discipline	4 credits (Lectures 16 hours, Practical classes 30 hours, Laboratory work 74 hours)
Semester Control/control measures	Credit
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian
Information about the course coordinator/teachers	Lectures: Nepochatych Y. V., Labs: Nepochatych Y. V., Independent work: Nepochatych Y. V.
Course location	

Curriculum

1. Description of the course, its purpose, subject matter, and learning outcomes

The discipline "Electrical and Radio Materials" belongs to the cycle of professional training and is a primary component of the set of disciplines that prepare students for their future design, engineering, and technological activities.

The purpose *of teaching the discipline is to develop students' abilities to:* •

assess the operating conditions of the material;
- *draw up requirements for the material in accordance with its operating conditions;*

- *make an informed choice of materials in accordance with their purpose, operating conditions, and technology.*

***Subject** of the discipline: properties of electrical and radio materials, their parameters, and the influence of various factors on them. The discipline provides specific knowledge and understanding of the effects of various technological and operational factors on the properties of materials, the characteristics of their behavior in different production and use conditions, and, if necessary, the mechanisms for purposeful modification of material properties.*

***Program learning outcomes**:*

***knowledge**:*

- *composition and structure of materials;*
- *properties of materials;*
- *the influence of external factors on the properties of materials;*
- *parameters and possibilities of using materials;*
- *classification of materials, material grades;*

***skills**:*

- *link the properties of a material to its composition, structure, production technology, and shaping;*
- *predict the dependence of material properties on operating conditions;*
- *measure material parameters.*

Experience:

- *use a combination of knowledge and skills to select materials for use in radio-electronic devices.*

***Program learning outcomes from the educational program**:*

PLO 4: explain the results obtained from measurements in terms of their significance and relate them to the relevant theory;

PLO 18: find, evaluate, and use information from various sources necessary for solving professional tasks, including reproducing information through electronic search;

PLO 28: apply methods and means of influencing the parameters of the physical environment;

PLO 31: apply ... the latest materials in the design of radio-electronic equipment for intelligent systems.

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

Interdisciplinary connections:

To study the discipline, students need to master the sections "electricity" and "magnetism" in physics, as well as the necessary knowledge of mathematics (to the extent taught in the first year), chemistry (at least to the extent of the school course), and the basics of circuit theory.

The knowledge gained is provided by the disciplines: "Electronics Components, Mechatronics, Design of Intelligent Radio-Electronic Equipment, Elements of Intelligent Radio-Electronic Equipment, Radio-Electronic Equipment Manufacturing Technology
Radio-Electronic Equipment Production Technology," "Electronic Equipment Production Technology: Assembly, Installation, Adjustment, Control, and Testing Technologies."

3. Contents of the academic discipline

Names of sections and topics	Number of hours				
	Total	including			
		Lectures	Practical (seminar)	Laboratory (computer workshop)	SRC
1	**2**	**3**	**4**	**5**	**6**
Topic 1. *General provisions. Classification of electrical and radio materials*	*14*	*8*			*6*
Topic 2. *Dielectrics*	*46*	*18*		*8*	*20*
Topic 3. *Magnetic materials*	*24*	*6*		*8*	*10*
Topic 4. *Conductive materials*	*12*	*4*		*2*	*6*
Modular test	*4*				*4*
Home test	*14*				*14*
Preparation for the test	*6*				*6*
Total hours	**120**	**36**		**18**	**66**

4. Teaching materials and resources

Recommended reading

Basic

1. Poplavko, Yu. M. Physical Materials Science: Textbook / Yu. M. Poplavko, S. O. Voronov. — Kyiv: Internet Publishing House of the National Technical University of Ukraine, 2015. — 699 p.
2. Materials for Radioelectronic Equipment and Telecommunication Systems. Lecture Course: Textbook / Igor Sikorsky Kyiv Polytechnic Institute; comp.: A. P. Miroshnychenko, G. V. Ivannik.

— Electronic network educational publication — Kyiv: Igor Sikorsky KPI, 2022. — 242 p.

3. Electrical Engineering Materials: Lecture Course. Part 1. Dielectric materials. [Electronic resource]: textbook for students of all forms of education majoring in 141 "Electric Power Engineering, Electrical Engineering, and Electromechanics" / Igor Sikorsky Kyiv Polytechnic Institute; compiled by: V.M. Kyrylenko, K.V. Kyrylenko. V.M. Golovko. — Electronic text data (1 file: 6.698 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2021. — 224 p.
4. Lyshuk V. V. Electrical and Radio Materials: Textbook / V. V. Lyshuk. — Lutsk: 2016. — 324 p.
5. Leontiev V. O. Electrical Engineering Materials: Textbook / V. O. Leontiev, S. V. Bevz, V. A. Vidmish. — Vinnytsia: VNTU, 2013. — 122 p.
6. Lecture course on the subject "Electrical, Radio, and Acoustic Materials" for bachelors majoring in 6.050803 "Acoustics" [Electronic resource] / NTUU "KPI"; compiled by V. S. Didkovsky, S. A. Naida,

O. V. Bogdanov. — Electronic text data (1 file: 1.7 MB). — Kyiv: NTUU "KPI", 2012. — 190 p.

7. Shvets, E. Y. Materials and Components of Electronics: Textbook / E. Y. Shvets, I. F. Chervonyi, Yu. V. Golovko — Zaporizhia: ZDIA, 2011. — 278 p.
8. Electrical and Radio Materials: Laboratory Practicum [Electronic resource]: textbook for students majoring in 172 "Electronic Communications and Radio Engineering" / Igor Sikorsky KPI; compiled by: Yu. V. Nepochatykh. — Electronic text data (1 file: 1.17 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. — 72 p.
9. Methodological guidelines for completing homework assignments, calculations and graphs,

and
tests in the discipline "Materials Science of Radio Electronic Devices" for students majoring in "Design and Technology of Radioelectronic Devices" of all forms of training / compiled by V. A. Bidenko, S. V. Ogurtsov, M. F. Bogomolov. — Kyiv: KPI, 1990. — 32 p.

Additional

10. Bovsunovsky A.P. Electrical engineering materials: a brief reference guide / A.P. Bovsunovsky. — Kyiv: NUHT, 2012. — 36 p.

11. DSTU 2843-94. Electrical engineering. Basic concepts. Terms and definitions. [Effective from 1996-01-01]. Official publication. Kyiv: DP "UkrNDNC", 1994. 36 p.

12. DSTU 2725-94. Magnetic materials. Terms and definitions. [Effective from 1995-07-01]. Official publication. Kyiv: DP "UkrNDNC", 1994. 34 p.

13. DSTU 2815-94. Electrical and magnetic circuits and devices. Terms and definitions. [Effective from 1996-01-01]. Official publication. Kyiv: DP "UkrNDNC", 1994. 58 p.

Educational content

5. Methodology for mastering the academic discipline (educational component)

Lectures

No	Lecture topic and list of main questions (list of teaching aids, references to literature, and assignments for independent study)
1	**Topic 1. General provisions. Classification of electrical and radio materials. Lecture 1. Parameters of electrical and radio materials.** *List of main issues:* The relationship between the properties, composition, and structure of materials. Macroscopic parameters of electrical and radio materials. Parameters characterizing losses. [3, pp. 14–16, 21–31; 4, pp. 15–19, 200–211; 5, pp. 130–144; 6, pp. 213–225]. *Assignments for independent study:* Elements of zone theory of solids. [1, pp. 9-15, 4 pp. 9-15, 19-26].
2	**Topic 1. General provisions. Classification of electrical and radio materials. Lecture 2. Classification of electrical and radio materials** *List of main questions:* Classification of materials according to their reaction to the influence of electric and magnetic fields. Consideration of criteria for dividing materials into dielectrics, semiconductors, and conductors. [1, pp. 12-15; 3, pp. 10-14; 4, pp. 7-9; 5, pp. 5-10; 6, pp. 25-34]. *Assignments for independent study:* Classification of materials according to their aggregate state. Plasma. [1, pp. 22-30; 3, pp. 47-52, 232].
3	**Topic 1. General provisions. Classification of electrical and radio materials. Lecture 3. Classification of electrical and radio materials.** *List of main questions:* Classification by reaction to changes in the amplitude of electromagnetic influence. Classification by reaction to sinusoidal electromagnetic influence. Classification by reaction to changes in frequency. Classification by reaction to the direction of electromagnetic influence. [3, pp. 46-47; 4, pp. 188-189; 5, pp. 5-10]. *Assignment for independent study:* Phase of a complex system. Crystalline and non-crystalline phases. [2, pp. 7-11; 3, pp. 27-31; 4, pp. 15-19; 5, pp. 8-10].

4	**Topic 1. General provisions. Classification of electrical and radio materials.** **Lecture 4. Classification of electrical and radio materials.** *List of main questions:* Classification of electrical and radio materials according to the orderliness of their structure. Crystallization. Amorphous and glassy states of materials. Types of glass-like materials. [2, pp. 24-32, 508-514; 3, pp. 192-193, 205-207; 4, pp. 243-244; 5, pp. 195-196]. *Assignment for independent study:* Schematic diagram of the technology for manufacturing sieves. [1, pp. 167–168; 2, pp. 512–514; 3, pp. 205–207; 4, pp. 250–252; 5, pp. 199–200].
5	**Topic 2. Dielectrics.** **Lecture 5. Polarization of dielectrics.** *List of main questions:* Macroscopic parameters of dielectrics. Microscopic parameters of dielectrics. Mechanisms and models of polarization of dielectrics. Mechanical models of elastic and thermal polarization. [6, pp. 7-16, 42-55; 7, pp. 40-49]. *Assignment for independent study:* Equivalent circuit of a dielectric in which different polarization mechanisms exist. [1, pp. 17-18; 3, pp. 39-40; 4, pp. 183-184].
6	**Topic 2. Dielectrics.** **Lecture 6. Polarization of dielectrics.** *List of main questions:* Electronic elastic polarization. Ionic elastic polarization. Polar axis — an element of symmetry in polar crystals. Dipole elastic polarization. [1, pp. 18-19; 3, pp. 40-42; 4, pp. 184-185; 5, pp. 114-116; 6, pp. 93-108]. *Assignment for independent study:* Dipole elastic polarization in pyroelectrics. [6, p.106, 172-174].
7	**Topic 2. Dielectrics.** **Lecture 7. Polarization of dielectrics.** *List of main questions:* Dipole thermal polarization. Ion thermal polarization. Electron thermal polarization. [1, pp. 19-21; 3, pp. 42-45; 4, pp. 185-187; 5, p. 116; 6, pp. 117-132]. *Assignments for independent study:* Migration, or volume charge, polarization. [1, p.21; 3, p.45; 4, p.188; 5, pp.116-117; 6, pp.50-51, 54, 86].
8	**Topic 2. Dielectrics.** **Lecture 8. Polarization of dielectrics.** *List of main questions:* The relationship between macroscopic and microscopic parameters of dielectrics. Features of polarization of nonpolar dielectrics. Mosotti's formula. Polarization catastrophe. [6, pp. 42-46, 85-88, 93-104, 132-135, 137-142; 5, pp. 208-215]. *Assignment for independent study:* Review the lecture material.
9	**Topic 2. Dielectrics.** **Lecture 9. Polarization arising without the influence of an electric field.** *List of key issues:* Types of polarization arising without the influence of an electric field. Pyroelectrics. Ferroelectrics. Phase transitions of the 1st and 2nd kind in substances. Domain structure. Domain walls. Hysteresis. Main polarization curve. Parameters of ferroelectrics. Influence of frequency and temperature. [1, pp. 27-29, 55-56; 4, pp. 261-273, 278-281; 5, pp. 208-222, 241-245; 6, pp. 167-169, 172-176, 185-196, 350-354]. *Assignments for independent study:* Residual polarization. Electrets. Conditions for the formation of electrets. Classification of electrets. [3, pp. 58-60; 4, pp. 281-283; 5, pp. 267-272; 6, pp. 182-185].

10	**Topic 2. Dielectrics.** **Lecture 10. Polarization arising without the influence of an electric field.** *List of main questions:* Piezoelectric polarization. Direct and inverse piezoelectric effects. Electrostriction. Single-crystal and ceramic piezoelectric materials. [4, pp. 273-278; 5, pp. 227-241; 6, pp. 169-172]. *Assignments for independent study:* Application of active dielectrics. Capacitors. Pyroelectric sensors, pyroviscous sensors. Temperature stabilization. Piezoelectric motors. Piezoelectric transformers. [4, pp. 268–273, 276–278, 282–283].
11	**Topic 2. Dielectrics.** **Lecture 11. Electrical conductivity of dielectrics.** *List of main questions:* Displacement current and sheet resistance. Key parameters characterizing the electrical conductivity of dielectrics. Types of current carriers and mechanisms of conductivity in dielectrics. Dependence of the conductivity of dielectrics on temperature; comparison with semiconductors. [1, pp. 30-41; 4, pp. 193-200; 5, pp. 122-130; 6, pp. 25-26, 196-208]. *Assignments for independent study:* Specific volume and surface resistivity of dielectrics. The effect of moisture on the electrical conductivity of solid dielectrics. [1, pp. 42-43; 3, pp. 62-64, 69-72; 4, pp. 194-195].
12	**Topic 2. Dielectrics.** **Lecture 12. Electrical strength of dielectrics.** *List of main questions:* Definition of the concept of "dielectric breakdown." Types of breakdown. Factors affecting breakdown voltage. Mechanism of electronic breakdown. Avalanche. Streamer. Influence of temperature, pressure, frequency. [1, pp. 58-69; 3, pp. 89-101; 4, pp. 211-220; 5, pp. 144-150; 6, pp. 317-327]. *Assignments for independent study:* Electrothermal breakdown. Electrochemical breakdown. [1, pp. 69-73; 3, pp. 101-105; 4, pp. 220-224; 5, pp. 150-153; 6, pp. 339-350].
13	**Topic 2. Dielectrics.** **Lecture 13. Types of dielectrics.** *List of main questions:* High-frequency and low-frequency dielectrics. Spatial and linear polymers. Composite powder plastics. Layered plastics. Inorganic glass. The effect of the chemical composition of glass on its properties. Alkali-free glass. Alkali glass without heavy oxides. Alkali glass with a high content of heavy oxides. Sital. Features of manufacturing technology. Structure of sital and its properties. Installation and capacitor sital. [1, pp. 101-126, 148-155, 160-165; 3, pp. 121-141, 147-153, 169-207; 4, pp. 225-240, 243-252; 5, pp. 172-184, 188-200]. *Assignments for independent study:* Ceramics. Features of manufacturing technology. Structure of ceramics and its properties. Types of ceramics. Installation and capacitor ceramics. [1, pp. 168-175; 3, pp. 207-230; 4, pp. 252-260; 5, pp. 200-204].
14	**Topic 3. Magnetic materials.** **Lecture 14. Physical processes in magnetic materials and their properties.** *List of main questions:* Classification of substances by magnetic properties. The nature of ferro- and ferrimagnetism. Classification of strong magnetic materials. Hysteresis loop. Initial and main magnetization curves. Parameters of strong magnetic materials. Magnetization by an alternating field. [1, pp. 267-275; 3, pp. 352-360, 363; 4, pp. 296-324; 5, pp. 273-285]. *Assignment for independent study:* Air gap in an open magnetic circuit. [5, pp. 286-287].

15	**Topic 3. Magnetic materials.** **Lecture 15. Soft magnetic materials for low, high, and ultra-high frequencies.** *List of key questions:* Requirements for magnetically soft materials. High-purity iron (electrolytic and carbonyl) and technically pure iron. Silicon electrical steel. Textured steel. Low-coercivity alloys (permalloy, alcyfer). [1, pp. 275–281; 3, pp. 364–371; 4, pp. 326–333; 5, pp. 287–295]. *Assignments for independent study:* Special-purpose magnetic materials (materials with a rectangular hysteresis loop, magnetostrictive materials). [1, pp. 281-283; 3, pp. 384-388; 4, pp. 344-349; 5, pp. 304-313, 327-329].
16	**Topic 3. Magnetic materials.** **Lecture 16. Soft magnetic materials for low, high, and ultra-high frequencies.** *List of main questions:* Ferrites. Production of ferrites. Magnetic and electrical properties of ferrites. Applications of ferrites. Magnetodielectrics. [1, pp. 283-289; 3, pp. 371-384; 4, pp. 333-344; 5, pp. 295-304]. *Assignments for independent study:* Magnetically hard materials (manufacturing technology features and types) [1, pp. 291-298; 3, pp. 388-396; 4, pp. 349-358; 5, pp. 317-327].
17	**Topic 4. Conductive materials.** **Lecture 17. Classification and basic properties of conductive materials.** *List of main issues:* Classification of conductive materials. Specific resistance of conductors. Effect of deformation and temperature. Specific resistance of alloys. Thermal conductivity of conductors. Thermoelectric force. [1, pp. 186-197; 3, pp. 231-250; 4, pp. 27-45, 52-55; 5, pp. 11-19]. *Assignments for independent study:* Thermal conductivity of conductors. Temperature coefficient of linear expansion. [1, pp. 195-197; 3, pp. 249, 251; 5, pp. 18-20].
18	**Topic 4. Conductive materials.** **Lecture 18. Types of conductive materials.** *List of main questions:* Highly conductive materials. Superconductors and cryoconductors. High-resistance alloys. Alloys for thermocouples. [1, pp. 198-213, 219-223; 3, pp. 240-243, 252-260, 283-289; 4, pp. 56-74; 5, pp. 20-30, 36-40]. *Assignments for independent study:* Tensometric alloys. Contact materials. Solders and fluxes. [1, pp. 223-226; 3, pp. 280-282; 4, pp. 85-86; 5, pp. 40-43].

Laboratory classes

The main purpose of laboratory classes:

- *to test acquired theoretical knowledge in practice;*
- *acquiring skills in working with measuring instruments and equipment;*
- *mastering methods of measuring parameters and recording characteristics;* • *acquiring skills in evaluating experimental data and drawing conclusions.*

No.	Name of laboratory work (computer workshop)	Number lecture hours
1	**Topic 2. Dielectrics.** **Laboratory work No. 4**. Investigation of piezoelectrics. [8, pp. 34–49]. *Independent work assignment:* prepare a report on the work and prepare answers to the control questions. [8, p. 49].	4
2	**Topic 2. Dielectrics.** **Laboratory work No. 5**. Investigation of ferroelectrics. [8, pp. 50–61]. *Independent work assignment:* prepare a report on the work and prepare answers to the test questions. [8, p. 61].	4

3	**Topic 3. Magnetic materials.** **Laboratory work No. 6**. Investigation of the dispersion of magnetic permeability of ferrites (4 hours). [8, pp. 62–70]. *Independent work assignment:* prepare a report on the work and prepare answers to the test questions. [8, p. 70].	4
4	**Topic 3. Magnetic materials.** **Laboratory work No. 2**. Investigation of the effect of elastic deformations on the properties of magnetically soft materials. [8, pp. 17–23]. *Independent work assignment:* prepare a report on the work and prepare answers to the test questions. [8, p. 23].	4
5	**Topic 4. Conductive materials.** **Laboratory work No. 3**. Electrical conductivity of radio engineering materials. Complete sections: 3.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4. [8, pp. 24–33]. *Independent work assignment:* write a report on the work and prepare answers to the test questions. [8, p. 33].	2

6. Independent work

Students complete the tasks assigned for independent study. In addition, students complete a home test (HT). The purpose of this work is to reinforce the lecture material, broaden their horizons in the field of materials science, and develop skills in solving practical problems and grapho-analytical constructions. Homework assignment options are outlined in the methodological guidelines [9] (100 options). Each student receives an individual option consisting of 4 tasks and theoretical questions. Tasks are given to students in the 6th week. The 16th week is the last week for completing the calculation and graphic work.

No.	Title of the topic for independent study	Number of hours of independent study
1	**Topic 1. General provisions. Classification of electrical and radio materials.** Elements of zone theory of solids. [1, pp. 9–15, 4 pp. 9–15, 19–26]. Classification of materials by aggregate state. Plasma. [1, pp. 22-30; 3, pp. 47-52, 232]. Phase of a complex system. Crystalline and non-crystalline phases. [2, pp. 7-11; 3, pp. 27-31; 4, pp. 15-19; 5, pp. 8-10]. Scheme of the technology for manufacturing sieves. [1, pp. 167-168; 2, pp. 512-514; 3, pp. 205-207; 4, pp. 250-252; 5, pp. 199-200].	*6*
2	**Topic 2. Dielectrics.** Equivalent diagram of a dielectric in which there are different polarization mechanisms. [1, pp. 17-18; 3, pp. 39-40; 4, pp. 183-184]. Dipole elastic polarization in pyroelectrics. [6, pp. 106, 172-174]. Migration, or volume charge polarization. [1, p. 21; 3, p. 45; 4, p. 188; 5, pp. 116–117; 6, pp. 50–51, 54–86]. Residual polarization. Electrets. Conditions for the formation of electrets. Classification of electrets. [3, pp. 58-60; 4, pp. 281-283; 5, pp. 267-272; 6, pp. 182-185]. Application of active dielectrics. Capacitors. Pyroelectric sensors. Piezoelectric motors. Piezoelectric transformers. [4, pp. 268-273, 276-278, 282-283]. Specific volume and surface resistivity of dielectrics. The effect of moisture on the electrical conductivity of solid dielectrics. [1, pp. 42-43; 3, pp. 62-64, 69-72; 4, pp. 194-195]. Electrothermal breakdown. Electrochemical breakdown. [1, pp. 69-73; 3, pp. 101-105; 4, pp. 220-224; 5, pp. 150-153; 6, pp. 339-350]. Ceramics. Features of manufacturing technology. Structure of ceramics and its properties. Types of ceramics. [1, pp. 168-175; 3, pp. 207-230; 4, pp. 252-260; 5, pp. 200-204].	*20*

3	**Topic 3. Magnetic materials.** Air gap in an open magnetic circuit. [5, pp. 286-287]. Special-purpose magnetic materials (materials with a rectangular hysteresis loop, magnetostrictive materials). [1, pp. 281-283; 3, pp. 384-388; 4, pp. 344-349; 5, pp. 304-313, 327-329]. Magnetically hard materials (features of manufacturing technology and varieties) [1, pp. 291-298; 3, pp. 388-396; 4, pp. 349-358; 5, pp. 317-327].	*10*
4	**Topic 4. Conductive materials.** Thermal conductivity of conductors. Temperature coefficient of linear expansion. [1, pp. 195-197; 3, pp. 249, 251; 5, pp. 18-20]. Tensometric alloys. Contact materials. Solders and fluxes. [1, pp. 223-226; 3, pp. 280-282; 4, pp. 85-86; 5, pp. 40-43].	*6*

Policy and control

7. Academic discipline policy (educational component)

Classroom sessions are mandatory.

Students are required to demonstrate their knowledge of the material covered in missed lectures during scheduled consultations.

A laboratory class missed for a valid reason must be made up by prior agreement with the instructor.

Admission to laboratory classes is granted by the teacher after an interview with the students. The defense of the report on the laboratory work is held during the next scheduled laboratory class.

The teacher conducts the defense of the calculation and graphic work after the 16th week of study according to the consultation schedule or by agreement with the students.

The rules for awarding incentive and penalty points are set out below in section 8.

8. Types of control and rating system for assessing learning outcomes

The teacher carries out ongoing assessment by communicating with students during the admission and defense of laboratory work and based on the results of the modular control work (MCW) before the second attestation. The MCW assignment consists of the questions listed in (section 9).

Teaching the credit module "Electrical and Radio Materials" involves the following learning outcome assessment rating system (LOAS).

The student's rating for the credit module is made up of points (on a 100-point scale) that they receive for:

1. completion and defense of 4 laboratory works;

2. a modular control work (MCW);
3. home control work (HCW).

Rating (weighted) point system and assessment criteria

1. Laboratory works

Weighted score — 10. The maximum number of points for all laboratory works is: 10 points × 4 = 40 points.

Each laboratory assignment is evaluated based on:

a) preparedness for work:

- fluency in theoretical material, availability of a prepared protocol 4 points;

- poor command of theoretical material 2 points;
- unpreparedness for work -1 point;

b) completion of laboratory work:

- report formatted according to requirements 4 points;

- work completed with errors or sloppily 2 points;

- work not completed -1 point;

c) defense of the work:

- complete answer during defense 2 points;

- incomplete answer during defense 0 points;

- work defended on a day other than the day of completion and the following lab day 0 points.

2. Modular control

Weighting — 20 points.

Assessment criteria:

- "Excellent," the topic of the assignment is fully disclosed (at least 90% of the required information) 20–18 points;

- "Good," sufficiently complete answer (at least 75% of the required information), or complete answer with inaccuracies 17–15 points;

- "Satisfactory," incomplete answer (at least 60% of the required information), there are errors 14–10 points;

- "unsatisfactory," unsatisfactory answer (does not meet the requirements for "satisfactory") 0 points.

3. Homework assignment

Weighting —

40. Assessment

criteria:

- "excellent," all requirements for the assignment have been met 40–35 points

- "good," almost all requirements for the assignment have been met, or there are minor errors34–28 points;

- "Satisfactory," there are shortcomings in meeting the requirements for the work and certain errors 27– 22 points;

- "sufficient," there are noticeable shortcomings in meeting work requirements and errors 21–10 points;

- "unsatisfactory," does not meet the requirements for "sufficient," many errors 0 points;

- for each week of delay in submitting the calculated work for review -

1 point. Penalty points for:

-denial of admission to laboratory work due to unsatisfactory initial control... -1 point;

-failure to complete laboratory work. ....-1 point;

-absence from laboratory classes without a valid reason..... ..-2 points;

-for each week of delay in submitting the calculated work for review...-1

point. The total number of penalty points shall not exceed 10 points. Bonus

points for:

-preparation of a summary for the competition ..... 8 points;

-preparation of a report..... 10 points;

-improvement of teaching materials ..... 8 points.

The total number of incentive points shall not exceed 10 points.

The rating scale is R = 100 points.

Calculation of the rating scale (R)

The sum of the weighted points for control measures (items 1-3) during the semester is:

R = 40 + 20 + 40 = 100 points.

Conditions for a positive interim assessment

- To receive a "pass" on the first interim assessment (week 8), the student must score at least 10 points ("ideal" student – 20 points).
- To receive a "pass" on the second interim assessment (week 14), the student must earn at least 30

points (an "ideal" student earns 60 points).

The maximum number of points is 100. A prerequisite for admission to the exam is the completion of all laboratory work and calculation work. To receive a credit for the credit module "automatically," you must have a rating of at least 60 points and complete all laboratory work and calculation work.

Students who have a rating of less than 60 points at the end of the semester, as well as those who want to improve their grade, must complete a credit test. In this case, the points for the test should be added to the points for the homework test, and this rating is final. The test consists of four questions from different sections of the work program from the list provided in paragraph 9 of this program.

For each question, the student can receive points in accordance with the assessment system:

–"excellent", complete answer (at least 90% of the required information) 15–13 points;

–"good", sufficiently complete answer (at least 75% of the required information, possible inaccuracies) 12–10 points;

–"satisfactory", incomplete answer (at least 60% of the required information, possible errors) 9–7 points;

–"unsatisfactory", unsatisfactory answer 0 points.

The sum of points for the student's academic activity to receive a credit for the credit module "automatically", or the sum of points for the homework test and the credit test should be converted into a credit grade according to the table:

Table of correspondence between rating points and grades on the university scale

Number of points	Grade
100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

9. Additional information on the discipline (educational component)

List of questions to check the level of mastery of the educational material for modular control and for semester control.

1. *Classification of electrical and radio materials according to their reaction to changes in the amplitude of electromagnetic influence.*
2. *Classification of electrical and radio materials according to their reaction to sinusoidal electromagnetic influence.*
3. *The glassy state of matter is a type of amorphous state. Purely amorphous state.*
4. *Residual polarization. Electrets. Classification of electrets.*
5. *Active dielectrics. Use of active dielectrics.*
6. *Types of polarization that occur without the influence of an electric field.*
7. *Initial polarization curve, main polarization curve.*

8. *Electrical breakdown of dielectrics. Types of electrical breakdown.*
9. *Streamer mechanism of electronic breakdown in gaseous dielectrics.*
10. *Ionic and molionic electrical conductivity of dielectrics.*
11. *Pyroelectrics. Ferroelectrics (classification, properties).*
12. *Classification of materials according to their behavior in an electric field.*
13. *Classification of materials according to their behavior in a magnetic field.*
14. *Dependence of the dielectric permeability of polar dielectrics on temperature.*
15. *Migration (volume-charge) polarization.*
16. *The effect of moisture on the electrical conductivity of dielectrics.*
17. *Mechanical models of elastic and thermal (relaxation) polarizations.*
18. *The nature of the electrical conductivity of solid dielectrics.*
19. *Limit and partial hysteresis loops. Material parameters determined by the limit hysteresis loop.*
20. *Piezoelectric effect. Applications of piezoelectrics.*
21. *Dipole elastic polarization.*
22. *Clausius–Mossotti formula. "Polarization catastrophe."*
23. *Ionic thermal polarization.*
24. *Isotropy, anisotropy, quasi-isotropy, texture.*
25. *Polarization of dielectrics. Main parameters characterizing it.*
26. *Electrical conductivity of liquid dielectrics.*
27. *Complex dielectric permeability of dielectrics. Parameters characterizing energy losses in dielectrics.*
28. *High-resistance iron-based alloys.*
29. *Magnetization curve. Types of magnetization curves.*
30. *High-resistance copper-based alloys.*
31. *Mechanisms of electrical conductivity of dielectrics. Types of current carriers in dielectrics.*
32. *Basic magnetization curve. Magnetic permeability.*
33. *Electronic electrical conductivity of dielectrics.*
34. *Superconductors and cryoconductors.*
35. *Dependence of semiconductor electrical conductivity on temperature.*
36. *The effect of temperature on the magnetic properties of antiferromagnets, ferrimagnets, and ferromagnets.*
37. *Temperature coefficient of linear expansion of conductors (TC_l , α_l). Relationship between TC_R and TC_l .*
38. *Domain structure of ferroelectrics. Energy criterion for the emergence of domain structure.*
39. *Specific resistance of alloys.*
40. *Basic requirements for magnetically soft materials. The effect of heat treatment on their properties.*
41. *Specific resistance of metals. Effect of temperature and deformation on the specific resistance of metals.*
42. *Classification of conductive materials.*
43. *Ferro- and ferrimagnets.*
44. *Piezoelectric polarization. Model of piezoelectric polarization.*
45. *Types of magnetic losses.*
46. *Permalloy.*
47. *The relationship between macroscopic and microscopic parameters of a dielectric.*
48. *Electrical insulation ceramics.*
49. *Magnetically soft and magnetically hard materials.*
50. *Main features of thermal (relaxation) polarization. Types of thermal polarization.*
51. *High-frequency organic dielectrics.*
52. *Basic properties and types of dielectric glass and silicates.*
53. *Features of the elastic polarization mechanism. Electronic elastic polarization.*
54. *Basic properties of ferrites and their applications.*
55. *Types of polarization of dielectrics arising under the influence of an electric field.*
56. *Electrothermal breakdown in solid dielectrics.*

Description of material, technical, and informational support for the discipline

Five laboratory works are proposed to familiarize students with certain properties of metal conductors, passive and active dielectrics, ferro- and ferrimagnets that these materials exhibit under the action of an electromagnetic field.

Work program for the academic discipline (syllabus):

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Approved by the PRE Department (Minutes No. 06/2025 dated 06/24/2025)

Approved by the methodological commission of the faculty/research institute (protocol No. 06/2025 dated 25.06.2025)