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| <b>Fan name</b>                                       | <b>Electrical technical materials (ECTS 5)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Subject/module code                                   | ETM2405                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Science taught semester (s).                          | 4 <sup>th</sup> semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Responsible teacher                                   | Akhmedov Abdurauf, Senior teacher.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Education language                                    | Uzbek                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Study to the program connection                       | Elective                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Training hours (this including independent education) | <b>Total hours - 150.</b><br><b>Auditory training hours - 60.</b><br>Lecture training hours - 30<br>Laboratory training hours - 15<br>Practical training hours - 15<br><b>Independent education -90 hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| ECTS                                                  | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| The purpose and tasks of subject / learning outcomes  | <p><b>The purpose of teaching the subject is</b> to prepare specialists who can practically apply the elements of electrical engineering, micro- and nanoelectronics. This subject provides initial information about the properties of materials used in various electrical devices, as well as their basic operating principles.</p> <p><b>The task of the subject</b> is to form theoretical and practical knowledge in students on the in-depth study of the base of "Electrical Technical Materials" and the analysis of their main properties from a physical, mechanical, chemical, and technological perspective.</p> <p><b>Learning outcomes:</b></p> <ol style="list-style-type: none"> <li>1. Knowledge of the importance of electrical engineering materials science and to have a skill.</li> <li>2. Electrical engineering materials, Semiconductor microelectronic devices have the skills to use nanoelectronic materials to be.</li> <li>3. The development of electrical engineering materials, widely used in the electrical engineering industry must have knowledge and skills about its application.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Course content ( topics )                             | <p><b>I. Home Theoretical Part (Lecture Sessions)</b></p> <p><b>Topic 1:</b> Introduction. The role of electrical materials in modern electrical engineering. Aggregate states of matter. Defects in crystals. Point and line defects</p> <p><b>Topic 2:</b> Polarization of dielectrics.</p> <p><b>Topic 3:</b> Electrical conductivity of dielectrics</p> <p><b>Topic t 4:</b> Energy losses in dielectrics. Calculation of the dissipation angle <math>\delta</math> or tangent of this angle <math>\text{tg}\delta</math> in dielectrics. Dissipations in gases, liquids and solid dielectrics. Nonpolar dielectric dissipation. Dissipation in polar liquids. Dependence of energy dissipation in liquid dielectrics on viscosity. Dielectric dissipation in a solid with an ionic structure. Dielectric dissipation in ferroelectrics</p> <p><b>Topic 5:</b> Breakdown of dielectrics. Breakdown voltage of dielectrics. Dielectric strength of dielectrics. Electrical strength of air. Electrical strength of liquid dielectrics. Breakdown of solid dielectrics. Electrical breakdown of macroscopically homogeneous dielectrics; electrical breakdown of inhomogeneous dielectrics; thermal breakdown; electrochemical breakdown.</p> <p><b>Topic 6:</b> Electrical engineering materials – Electrical properties of dielectrics</p> <p><b>Topic 7:</b> Thermal characteristics of electrical technical materials</p> <p><b>Topic 8:</b> Physicochemical characteristics of electrical materials<br/> Mechanical characteristics of electrical materials. Wetting of dielectrics.</p> |

Humidity of materials. Moisture absorption of dielectrics. Mechanical properties of dielectrics. Physical properties of dielectrics. Protection of insulation from moisture. Thermal properties of dielectrics. Effect of high- energy radiation on dielectric properties.

**Topic 9:** Solid polymer dielectrics.

Solid polycondensation dielectrics

**Topic 10:** Plastics. Electroceramic materials. Capacitor ceramic materials.

**Topic 11:** Piezoelectric materials Glass and ceramics Mica and high-frequency dielectrics based on it

**Topic 12:** Basic properties of metallic conductive materials. Pure metals and alloys used in electrical engineering

**Topic 13:** Conductor materials with relatively low electrical resistance.

**Topic 14:** Castings with high electrical resistivity. Winding and electrical installation wires. Cable and wire marking.

**Topic 15:** Coil and assembly wires and their classification

**Topic 16:** Classification of semiconductor materials.

**Topic 17:** Electrical properties of semiconductors. Areas of application.

**Topic 18:** Magnetic properties of materials.

Types of magnetic materials, Soft magnetic materials

**Topic 19:** Hard magnetic materials. Ferrites

**Topic 20:** Electrical insulating varnishes, enamels and compounds

**Topic 21:** Adhesives, fluxes and adhesive materials

## **II. Instructions and recommendations for organizing laboratory exercises.**

In laboratory classes, students develop practical skills and competencies in calculating and drawing tables and graphs, conducting experiments, and analyzing various indicators of processes in electrical networks and systems. The proposed topics are selected based on opportunities and conditions.

### **Recommended topics for laboratory work:**

1. Electrical conductivity of insulating materials.
2. In solid dielectrics, dielectric absorption and dielectric identifying energy waste.
3. Determination of the electrical strength of transformer oil.
4. Determination of the electrical resistance of solid dielectrics.

### **III. Practical for training instructions and recommendations**

The teacher's preparation for a practical session begins with studying the initial documents (curriculum, thematic plan, etc.) and ends with the development of a lesson plan. The teacher should have an idea of the goals and objectives of the practical session, as well as the amount of work that each student must perform.

Methodological guidelines are the teacher's main methodological document in preparing and conducting practical classes.

The goal of practical training is to understand theory and acquire skills. Its conscious application in educational and professional activities consists in developing the ability to confidently formulate one's own point of view.

### **Recommended practical topics :**

1. Dielectrics under the influence of an electric field.
2. Electrical conductivity in dielectrics.
3. Energy dissipation, breakdown in dielectrics.
4. Electrical resistance of conductive materials.
5. Conductors with high specific resistance
6. Temperature dependence of conductor resistance.
7. Conductivity in semiconductor materials.

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|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | <p>8. Properties of magnetic materials</p> <p><b>IV. Independent study and independent work.</b></p> <p>Independent learning competence serves to support students' independent self-development and increase the effectiveness of professional activities. Students perform independent work on their mobile devices under the guidance of a teacher in a traditional or electronic form.</p> <p><b>Recommended topics for independent study:</b></p> <ol style="list-style-type: none"> <li>1. Organic dielectrics.</li> <li>2. Natural resins.</li> <li>3. Artificial resins, cellulose.</li> <li>4. Textile materials.</li> <li>5. Vegetable oils, Bitumens.</li> <li>6. Waxy dielectrics.</li> <li>7. Wood and paper, Lacquered fabrics, Elastomers.</li> <li>8. Brief information about inorganic dielectrics.</li> <li>9. Glass, Ceramics, Ceramics.</li> <li>10. Mica and mica-containing materials.</li> <li>11. Asbestos, Magnetoelectrics, Piezoelectrics</li> <li>12. Conductive materials.</li> <li>13. Semiconductor: Germanium, Silicon.</li> <li>14. Magnetic materials, Ferrites.</li> </ol>                                                 |
| Student assessment     | <p>Assessment of student knowledge is based on the mastery of teaching materials (tests, assignments, written and oral work results) during the semester and final examination.</p> <p>During the Electrical technical materials course, students are assessed on a 100-point scale. Of these, 50 points are allocated to the current and intermediate results (60% of the 50 points are current control, independent study and 40% intermediate control), and 50 points are allocated to the final control result. Students whose total current and intermediate scores are less than 30 points are not admitted to the final control exam. A student who scores 30 or more points in the final control is considered to have mastered the subject.</p>                                                                                                                                                                                                                                                                                                                                                                                                      |
| Requirements for exams | <p>The student must have fully mastered the theoretical and practical concepts of the subject, be able to correctly reflect the results of the analysis. The student must have completed the tasks given in the current and intermediate forms of independent work, assessment. At the same time, he must have received the necessary points from the current, intermediate, independent education and final tests in the relevant subject within the specified time.</p> <p>A student who has not submitted current control, intermediate control and independent education tasks, as well as who has scored less than 30 points on these tasks and types of control, will not be included in the final type of control.</p> <p>Also, a student who has missed 25 or more percent of the classroom hours allocated to the subject without an excuse will be expelled from this subject, will not be allowed to take the final exam and will be considered as not having mastered the relevant credits in this subject.</p> <p>A student who fails the final exam or scores less than 30 points on this type of exam is considered academically indebted.</p> |
| Recommended Literature | <p><b>Main literature:</b></p> <ol style="list-style-type: none"> <li>1. M.T. Normurodov, V.Ye. Umirzakov va boshqalar «Elektrotexnika materiallari va qurilmalari texnologiyasi». Toshkent. «Mehnat». 2004 yil.</li> <li>2. Axmedov A.Sh., Kurbanbaeva D.U. Elektr texnika materiallari fani bo'yicha tajriba ishlarini bajarish uchun metodik ko'rsatma. -</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

Toshkent: TDTU, 2005.

3. Ахмедов А.Ш., Курбанбаева Д.У. Методическое руководство к выполнению лабораторных работ по курсу Электротехнические материалы. -Ташкент: ТГТУ, 2005.

4. Ahmedov A.Sh. Elektr texnika materiallar. O'quv qo'llanma, - Toshkent: TDTU, 2006.

5. Герасимов А.Н., Губанович А.Г., Климкович П.И. Лабораторная работа (Практика) по дисциплине «Электротехнические материалы». Минск-2004

6.A.R. West . R.H. Mitchell . P. Shiv Halasyamani M. Kunz & I.D. Brown . A. Safari, R.K. Panda, V.F. Janas. Dielectric Materials. Chemistry 754, 2002.

7.T.K. Basak. Electrical engineering materials. New Age International, Nil edition. USA, 2009.

8.Sattarov S.A., Mustafakulov A.A.,Siddikov I.X. va b. “Alternativ energiya manbalari”, Jizzax-2021.

9.Sillaev A.X., Bedriskiy I.M., Boltaev O.T. Elektrotexnika materiallari. Darslik, Toshkent-2017.

10. Mustafakulov A.A., Xudayberdiev O., Mustafakulov A. Elektrotexnika materiallari, Toshkent, «Turon-ikbol»-2015.

11.Mustafakulov A.A.”Elektr texnik materiallar”. Darslik, Toshkent-2022.

**Additional literature:**

12. Mirziyoyev Sh.M. Yangi O'zbekistonda erkin va farovon yashaylik. –T.: “TASVIR nashriyot uyi”, – 2021.– 50 b.

13. Mirziyoyev Sh.M. Milliy taraqqiyot yo'limizni qati'yat bilan davom ettirib yangi bosqichga ko'taramiz .–T.:“O'zbekiston”, 2017–592 b

14. O'zbekiston Respublikasi Prezidentining 2022-yil 28-yanvardagi PF-60-son “2022-2026 yillarga mo'ljallangan Yangi O'zbekistonning taraqqiyot strategiyasi to'g'risida”gi Farmoni.

15.Prof. Ramesh Chandra PrustyDepartment of EE & EEE Veer Surendra Sai University of Technology (Formerly UCE, Burla), Electrical engineering materials, 2014.

16.Roy McWeeny Professore Emerito di Chimica Teorica, Universita di Pisa, Pisa (Italy) More physics: Electric charges and fields – electromagnetism.2011

**Internet resources:**

17. [www.ziyounet.uz](http://www.ziyounet.uz) – national educational materials search site.

18. [www.gov.uz](http://www.gov.uz) – Government portal of the Republic of Uzbekistan.

19.[www.google.com](http://www.google.com) – international educational materials search site.

20.[www.energystrategy.ru](http://www.energystrategy.ru) – “Energy Policy and Strategy” information portal

21. [www.twirpx.com](http://www.twirpx.com) – international educational materials search site.