Course title	Structure and Properties of Engineering Materials (ECTS 4)
Subject/module code	MMTX2304
Semester(s) in which the course is taught	3rd semester (2026–2027 academic year)
Assigned instructor	Pirnazarov I., associate professor, Department of Engineering Communications
Language of instruction	Uzbek
Course type	Compulsory
Study workload (including independent study)	**Total workload – 120 hours** **Contact hours – 48** Lecture hours – 24 Laboratory hours – none Practical class hours – 24 **Independent study – 72 hours** Course project – none
ECTS	4
Course aims and objectives / learning outcomes	**The main aim of teaching the "Structure and Properties of Engineering Materials" course is to develop students' professional competencies in understanding the relationship between the atomic and crystal structure, microstructure and properties of engineering materials (metals and alloys, polymers, ceramics, composites, as well as construction and thermal insulation materials) and the methods used to process them, and in selecting materials on a scientific basis for heat and gas supply and ventilation systems.** **The objectives of the course are that the student:** – studies the classification of materials, atomic structure and the types of interatomic bonding; – masters the analysis of crystal lattices, crystal defects and diffusion processes; – acquires the methods for determining the mechanical, physical and chemical properties of materials; – learns to use phase diagrams, including the iron–carbon diagram; – knows the designation (grading) and fields of application of steels, cast irons, non-ferrous metals, polymers and composite materials; – masters the corrosion of materials and the methods of protecting them; – is able to select materials for engineering communications (pipes, fittings, thermal insulation) on a sound basis. **Prerequisites: (FIZ11204) Physics; (OM11210) Higher Mathematics; (QKIM1204) Construction Chemistry; (CHGMG11208) Descriptive Geometry and Engineering Graphics.** **Learning outcomes:** **Knowledge:** 1. Knows the classification of engineering materials, their atomic and crystal structure and crystal defects. 2. Knows the mechanical, physical and chemical properties of materials and the methods for determining them. 3. Knows phase diagrams, the fundamentals of heat treatment and the designation systems for materials (EN, ISO, AISI). **Skills:** 4. Performs calculations related to crystal lattice parameters, diffusion and the results of mechanical tests. 5. Determines the phase and structural composition of alloys using the lever rule. 6. Calculates the strength, thermal expansion and corrosion rate of pipe materials. **Competencies:** 7. Selects and justifies materials appropriate to the operating

	conditions of heat and gas supply and ventilation systems. 8. Proposes technical solutions for protecting materials against corrosion and heat losses.
Course content (topics)	**I. Main theoretical section (Lectures) – 24 hours** **Topic 1: Introduction. Classification of materials. (2 hours)** Purpose and objectives of the course and its importance for engineering communications. Classification of materials: metals, ceramics, polymers, composites, semiconductors and advanced materials. [1, 3, 4] **Topic 2: Atomic structure and interatomic bonding. (2 hours)** Electron configuration and the periodic table. Ionic, covalent and metallic bonds; van der Waals and hydrogen bonds. [1, 2] **Topic 3**: Crystal structure of solids. (2 hours)** Crystal lattice, unit cell, crystal systems and Bravais lattices. [1, 2, 4] **Topic 4**: Imperfections in crystal structure and diffusion. (2 hours)** Point defects (vacancies, interstitial atoms); substitutional and interstitial solid solutions. [1, 2, 4] **Topic 5: Mechanical properties of materials. (2 hours)** Stress and strain. Elastic deformation, Hooke's law, modulus of elasticity, Poisson's ratio. [1, 3, 4] **Topic 6: Failure of materials. (2 hours)** Ductile and brittle fracture. Fundamentals of fracture mechanics: stress intensity factor and fracture toughness. [1, 3] **Topic 7: Phase (equilibrium) diagrams. (2 hours)** Concepts of phase, component and system. [1, 4] **Topic 8: Steels, cast irons and non-ferrous metals. (2 hours)** Classification and designation of steels (EN 10027, AISI/SAE). [1, 2, 4] **Topic 9: Polymer materials and composites. (2 hours)** Molecular structure of polymers, degree of polymerisation, crystallinity. Thermoplastics, thermosets and elastomers. [1, 2, 3] **Topic 10: Ceramics, glass and construction materials. Physical properties of materials. (2 hours)** Structure and properties of ceramic materials; refractory materials (for boiler furnaces). [1, 3] **Topic 11: Corrosion and protection of materials. Materials selection. (2 hours)** Chemical and electrochemical corrosion, the galvanic series; forms of corrosion (uniform, pitting, intergranular, stress corrosion cracking). [1, 3] **Topic 12: Quality control and standardisation of materials. (2 hours)** Non-destructive testing methods: visual and dimensional, ultrasonic, radiographic, magnetic particle and liquid penetrant testing. ** Topics drawn from the curricula of universities ranked in the TOP-300 (MIT, 3.091 "Introduction to Solid-State Chemistry"). **II. Guidelines and recommendations for practical classes – 24 hours** Practical classes are calculation-based: each student completes an individual variant of the assignment, processes the data, presents the

	results in tables and graphs, and defends a report on the work. The purpose of practical classes is to consolidate theoretical knowledge and to develop the skills needed to apply it when selecting and evaluating materials for heat and gas supply and ventilation systems. **Recommended practical topics (2 hours each):** 1. Calculating the lattice parameters, atomic packing factor and theoretical density of metals. 2. Determining the Miller indices of crystallographic directions and planes. Calculating interplanar spacing and the diffraction angle using Bragg's law. 3. Calculating the equilibrium concentration of vacancies. Determining the carburising time of steel on the basis of Fick's laws. 4. Processing tensile test results: determining the modulus of elasticity, yield and tensile strengths, percentage elongation and reduction of area (ISO 6892-1). 5. Determining the hardness of materials by the Brinell and Vickers methods; evaluating the relationship between hardness and tensile strength. 6. Calculating impact toughness (Charpy method). Determining the critical stress and critical crack size from fracture toughness. 7. Analysing the iron–cementite phase diagram. Determining the phase and structural composition of steel using the lever rule. 8. Reading steel designations (EN 10027). Calculating critical points, selecting a heat-treatment schedule and assessing weldability using the carbon equivalent. 9. Calculating the strength of metal and polymer pipes (SDR, MRS, PN); determining the thermal elongation of pipes. 10. Calculating the corrosion rate by the mass-loss method. Determining the mass of a sacrificial anode on the basis of Faraday's law. 11. Selecting thermal insulation materials. Calculating heat loss from an insulated pipe and the efficiency of the insulation. 12. Calculating the modulus of elasticity and density of composite materials using the rule of mixtures. Selecting materials on the basis of Ashby performance indices. **III. Laboratory classes** Laboratory classes are not provided for in the curriculum of this course. **IV. Independent study – 72 hours** Independent study develops students' ability to learn autonomously, to work with scientific and technical literature, standards and electronic resources, and to apply the knowledge gained in professional activity. Assignments are completed under the teacher's guidance in traditional or electronic form. **Topics recommended for independent study:** 1. History of the development of materials science and its modern trends. (6 hours) 2. Modern methods of materials research (SEM, TEM, X-ray diffractometry). (6 hours) 3. Allotropy and its importance in engineering (the examples of iron, titanium and tin). (6 hours) 4. Crystallisation of metals and methods of controlling grain size. (6 hours) 5. Non-destructive testing methods for materials (ultrasonic, radiographic, magnetic, liquid penetrant). (6 hours) 6. Heat-resistant steels for boiler and heating network pipes (P235GH, 16Mo3, etc.). (6 hours) 7. Alloy and stainless steels and their designation according to EN and AISI. (6 hours) 8. Applications of copper and aluminium alloys in heat exchangers

	and air ducts. (6 hours) 9. Joining technologies for polymer pipes (butt fusion welding, electrofusion, press fittings). (6 hours) 10. Modern thermal insulation materials and the energy efficiency of buildings. (6 hours) 11. Corrosion protection of underground pipelines (insulating coatings, electrochemical protection). (6 hours) 12. Case study: selecting a material for a specific engineering system component using the Ashby method and preparing a presentation. (8 hours) **V. Teaching technologies and methods** – interactive and visual (multimedia) lectures; – interactive case studies (practical tasks on materials selection); – calculation-based practical classes (individual variants); – "Brainstorming", "Cluster" and "Insert" methods; – work in small groups and presentations; – use of the electronic resources of MIT OpenCourseWare and DoITPoMS (University of Cambridge).
Student assessment	Student assessment is based on the level of mastery of the learning materials during the semester and final assessment (calculation assignments, tests, and written and oral work). Throughout the "Structure and Properties of Engineering Materials" course, students are assessed on a 100-point scale. Of this total, 50 points are allocated to current and midterm assessment (60% of these 50 points for ongoing assessment and independent study, and 40% for the midterm assessment), while 50 points are allocated to the final assessment. Students whose combined current and midterm score is below 30 points are not admitted to the final examination. A student who obtains 30 or more points in the final assessment is considered to have passed the course. **Assessment criteria:** **a) A grade of "5" (excellent) requires the student to:** – fully explain the essence and content of the course; – present topics in a scientific and logically consistent manner, without scientific errors or inaccuracies; – have a clear understanding of the theoretical and practical importance of the course material; – demonstrate the ability to think independently and freely within the scope of the course; – give clear and correct answers to the questions asked; – complete all practical assignments fully and without errors; – be able to apply theoretical knowledge in various situations and reach systematic conclusions. **b) A grade of "4" (good) requires the student to:** – understand the essence and content of the course and present topics scientifically and logically without errors; – understand the practical importance of the course content; – complete the given tasks and assignments within the scope of the syllabus; – give correct answers to the questions asked; – complete independent study assignments in full. **c) A grade of "3" (satisfactory) requires the student to:** – have a general understanding of the course; – cover the topics within a narrow scope, allowing some errors in presentation; – complete independent study assignments; – give incomplete answers to questions. **d) A grade of "2" (unsatisfactory) is given in the following cases:**

	– the student did not prepare for classes; – independent study assignments for the course were not completed; – assignments were found to have been copied from others; – serious errors and inaccuracies were made in answers; – the student does not know the course material.
Examination requirements	To earn the credits, the student must have fully mastered the theoretical and methodological concepts of the course, be able to present the results of calculations correctly and reason independently about the processes studied; complete all practical class assignments and defend the reports on them; complete the tasks and assignments given in the current and midterm assessment; and submit the final assessment assignment. Students who do not submit current assessment, midterm assessment and independent study assignments, or who score fewer than 30 points for these assignments and assessment components, are not admitted to the final assessment. Furthermore, a student who, without a valid reason, misses 25 percent or more of the contact hours allocated to the course will be withdrawn from the course, will not be admitted to the final examination, and will be considered not to have earned the relevant credits for the course. A student who fails the final examination or receives a score in the range of "0–29.9" for this examination is considered to have an academic debt.
Recommended literature	**Main literature:** 1. Ergashev D.U. et al. Materialshunoslik va konstruksion materiallar [Materials Science and Structural Materials]. Textbook. – Tashkent, 2021. 2. Qahhorov S.Q., Rahmatov I.I., Muxamedov Sh.M. Materialshunoslik (Materialshunoslik va konstruksion materiallar) fanidan amaliy mashg'ulotlar [Practical Classes in Materials Science (Materials Science and Structural Materials)]. Study guide. – Tashkent, 2022. 3. Callister W.D., Rethwisch D.G. Materials Science and Engineering: An Introduction. 10th ed. – Hoboken (NJ): John Wiley & Sons, 2018. – 992 p. 4. Askeland D.R., Wright W.J. The Science and Engineering of Materials. 7th ed. – Boston: Cengage Learning, 2016. – 896 p. **Additional literature:** 5. Mirboboyev V.A. Konstruksion materiallar texnologiyasi [Technology of Structural Materials]. Textbook. – Tashkent, 2003. 6. Nosirov I. Materialshunoslik [Materials Science]. Textbook. – Tashkent, 1994. 7. Domone P., Illston J. (eds.). Construction Materials: Their Nature and Behaviour. 4th ed. – London: Spon Press (Taylor & Francis), 2010. **Internet resources** 8. https://ocw.mit.edu/courses/3-091-introduction-to-solid-state-chemistry-fall-2018/ – MIT OpenCourseWare, 3.091 "Introduction to Solid-State Chemistry". 9. https://ocw.mit.edu/courses/3-032-mechanical-behavior-of-materials-fall-2007/ – MIT OpenCourseWare, 3.032 "Mechanical Behavior of Materials". 10. https://www.doitpoms.ac.uk – University of Cambridge, DoITPoMS interactive teaching and learning resources in materials science.