Subject data sheets

Foundational and Materials Science Subfield Subjects

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Contents

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Lecturers teaching the foundation and specialized courses:

Andrea Ádámné Major PhD, Gyula Bagyinszki PhD, Csaba Balázsi DSc, Katalin Balázsi PhD, Emőke Bardóczyné Székely PhD, Hamuda Hosam Bayoumi CSc, Károly Belina CSc, Rita Bodáné Kendrovics PhD, Ákos Borbély PhD, Judit Borsa CSc, Zsuzsanna Czégény PhD, János Dusza DSc, Gabriella Farkas PhD, Viktor Gonda PhD, Mariann Halász PhD, Richárd Horváth PhD, Zsolt József Horváth DSc, Zoltán Hózer DSc, Zoltán Juvancz DSc, Éva Kiss, DSc, Szilvia Klébert, PhD, László Koltai, PhD, Tünde Kovács, PhD, Krisztina László, DSc, Mária Marosné Berkes, PhD, Gergely Márton, PhD, Balázs Mikó, PhD, Ákos Nemcsics, DSc, Sándor Pekker, DSc, László Péter, DSc, Péter Petrik, DSc, Péter Pinke, PhD, Mihály Réger, DSc, Tamás Réti, DSc, Endre Ruszinkó, DSc, Gusztáv Schay, PhD, Abdul Shaban, CSc, András Stirling, DSc, Erzsébet Takács, DSc, Márta Takács, PhD, Judit Telegdi, DSc, Péter Tóth, PhD, András Zachár, PhD

The details of the lecturers can be found on the doktori.hu website.

1. Foundational subjects

1.1 General Materials Science

Course title:
1.1.1 Physical chemistry of surfaces
Credit value: 6
Course coordinator and instructor: Krisztina László
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: Basic knowledge of physical chemistry/thermodynamics

Course description:
The aim of the course is to explore the laws governing interfacial phenomena. To introduce the properties of solid surfaces (e.g., contact catalysts, semiconductors, foams, membranes) that are of fundamental importance to materials science. The role of interfaces; the laws governing processes occurring at interfaces; characterization of interfaces. Course content: The concept of surface/interface, general definitions, classification of interfaces. Thermodynamics of interfaces, surface energy, surface tension, homogeneous and heterogeneous surfaces, flat and curved surfaces. Wetting of solid surfaces. S/G boundary surface phenomena: adsorption, physisorption and chemisorption, additional phenomena (swelling), measurement of adsorption/desorption, adsorption hysteresis, types of adsorption isotherms and their interpretation, processing of adsorption data: specific surface area, pore size distribution, surface energy models: Langmuir, BET, potential models, t-method surface requirement and critical size. S/L interfacial phenomena: non-ionic and ionic systems, unrestricted and restricted mixing liquids, adsorption isotherm types and their interpretation. Kinetics of interfacial processes, sorption - desorption, surface coverage, surface diffusion. Adsorption heat and methods of determination, immersion and flow calorimetry. Particle size analysis: size range and method, types of distribution curves. The concept of surface fractals, their role and methods of determination. Applications: the role of surfaces in materials science and environmental phenomena, heterogeneous catalysis - the LH and ER models, interfacial nanoreactors, Pressure/Thermal Swing Adsorption, production of new types of sorbents, their applications (e.g., nanotubes, hydrogen storage, etc.), new results.

List of the 2-5 most important required readings with bibliographic data:
- László Krisztina: Physical Chemistry of Surfaces, electronic notes, 2011.
- Somorjai, G. A.: Introduction to Surface Chemistry and Catalysis. Wiley, New York, 1994.
- Gregg, S. J.; Sing, K. S. W.: Adsorption, Surface Area and Porosity. Academic Press, London, 1982.
- Siderius, D. W.; Evans, J. D.; Iacomi, P.; Vanduyfhuys, L.; Van Speybroeck, V.; Bon, V.; Kaskel, S.: Best-Practice Reporting for Porous Materials Adsorption Data. Angewandte Chemie International Edition, 64(44) (2025) e202513606. https://doi.org/10.1002/anie.202513606
- Low, M.-Y. (Ashlyn); Barton, L. V.; Pini, R.; Petit, C.: Analytical Review of the Current State of Knowledge of Adsorption Materials and Processes for Direct Air Capture. Chemical Engineering Research and Design, 189 (2023) 745-767. https://doi.org/10.1016/j.cherd.2022.11.040

List of the 2-5 most important recommended references with bibliographic data:
- Christmann, K.: Introduction to Surface Physical Chemistry. Springer-Steinkopff, Darmstadt, 1991.
- Avnir, D. (ed.): The Fractal Approach to Heterogeneous Chemistry. Wiley, Chichester, 1989.
- Mane, P. V.; Rego, R. M.; Yap, P. L.; Losic, D.; Kurkuri, M. D.: Unveiling Cutting-Edge Advances in High Surface Area Porous Materials for the Efficient Removal of Toxic Metal Ions from Water. Progress in Materials Science, 146 (2024) 101314. https://doi.org/10.1016/j.pmatsci.2024.101314
- Zhu, X.; Cui, X.; Fan, M.; Yang, Y.; Yu, Q.; Xiao, P.; Webley, P. A.; Zhao, D.: Recent Advances in Direct Air Capture by Adsorption. Chemical Society Reviews, 51(16) (2022) 6574-6651. https://doi.org/10.1039/D1CS00970B
- Siderius, D. W.; Evans, J. D.; Iacomi, P.; Vanduyfhuys, L.; Van Speybroeck, V.; Bon, V.; Kaskel, S.: Best-Practice Reporting for Porous Materials Adsorption Data. Angewandte Chemie International Edition, 64(44) (2025) e202513606. https://doi.org/10.1002/anie.202513606
Date: December 12, 2025.
Prepared by: Krisztina László

Course title:
1.1.2 Porous Materials
Credit value: 6
Course coordinator and instructor: Krisztina László
Classification of the subject: foundation subject
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: Basic knowledge of physical chemistry/thermodynamics

Course description:
The aim of the course is to familiarize students with porous systems and their characterization possibilities, which are of fundamental importance in materials science, environmental protection, and medical biology. Porous materials that are significant from the perspective of materials science, environmental protection and medical biology, their production, characterization and practical applications. Course content: Classification of porous systems (size, permeability, morphology, etc.). Overview of methods for morphological examination of porous systems (adsorption, microscopy, molecular probe methods, thermoporosimetry, Hg porosimetry, flow-through methods, etc.). General possibilities for the production of porous structural materials. Kinetic considerations. Pores in the environment: soil, solid/gas, solid/liquid, and solid/solid interaction processes in soils. Material groups: porous carbons, zeolites, clay minerals, porous polymers. Biologically relevant porous systems. Special requirements for artificial porous biomaterials; biocompatibility, biodegradability. Selective adsorption of biologically active molecules (separation technique, enrichment); an example: haemoperfusion. Biologically relevant porous systems. The structure and properties of natural bone; artificial bone materials; artificial bone materials with gradient or variable porosity. Porous scaffold materials for the regeneration of biological systems (scaffolding).

List of the 2-5 most important required readings with bibliographic data:
- László K.: Physical Chemistry of Surfaces, electronic notes, 2011.
- Gregg, S. J.; Sing, K. S. W.: Adsorption, Surface Area and Porosity. Academic Press, London, 1982.
- Schüth, F.; Sing, K.; Weitkamp, J. (eds.): Handbook of Porous Solids. Wiley-VCH, Weinheim, 2002.
- Ahmed, Y. W.; Loukanov, A.; Tsai, H.-C.: State-of-the-Art Synthesis of Porous Polymer Materials and Their Several Fantastic Biomedical Applications: a Review. Advanced Healthcare Materials, 14(26) (2025) e2403743. https://doi.org/10.1002/adhm.202403743

- Ma, Y.; Wang, Y.; Tong, S.; Wang, Y.; Wang, Z.; Sui, R.; Yang, K.; Witte, F.; Yang, S.: Porous Metal Materials for Applications in Orthopedic Field: A Review on Mechanisms in Bone Healing. Journal of Orthopaedic Translation, 49 (2024) 135-155. https://doi.org/10.1016/j.jot.2024.08.003
List of the 2-5 most important recommended references with bibliographic data:
- László K.: Physical Chemistry of Surfaces, electronic notes, 2011.
- Gregg, S. J.; Sing, K. S. W.: Adsorption, Surface Area and Porosity. Academic Press, London, 1982.
- Schüth, F.; Sing, K.; Weitkamp, J. (eds.): Handbook of Porous Solids. Wiley-VCH, Weinheim, 2002.
- Liu, X.; Fatieiev, Y.; Khashab, N. M.: Supramolecular Porous Materials for Biomedical Applications. Advanced Healthcare Materials, 14(26) (2025) e2501997. https://doi.org/10.1002/adhm.202501997
- Ahmed, Y. W.; Loukanov, A.; Tsai, H.-C.: State-of-the-Art Synthesis of Porous Polymer Materials and Their Several Fantastic Biomedical Applications: a Review. Advanced Healthcare Materials, 14(26) (2025) e2403743. https://doi.org/10.1002/adhm.202403743
Date: December 12, 2025.
Prepared by: Krisztina László

Course title:
1.1.3 Nanotechnology - Chemical Materials Science
Credit value: 6
Course coordinator and instructor: Éva Kiss
Classification of the subject: foundation subject
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to present the relationship between the chemical composition, structure and function of materials, and to introduce the role of nanotechnology in 1D, 2D and 3D systems and practical applications. Course content: Fundamentals of chemical materials science, the relationship between structure and macroscopic properties; the concept of nanotechnology, nanomaterials; production and functionalization of nanoparticles; characteristic properties and applications of quantum dots; colloidal drug delivery systems, their function, materials, main polymer-based types; formation and structure of self-assembled monolayers, functional monolayers, patterning with SPM; production of nanolayers and surface films and pattern formation using lithographic methods; production of Langmuir-Blodgett films, their structural characteristics and applications; production of nanostructured materials - bottom-up construction - use of association and phase separation; production of nanostructured materials – bottom-up construction – colloidal crystals, colloidal ink, electrostatic spinning; optical properties, the structure of optical fibers and a method of their production; photonic materials, structure, production; magnetic properties, classification of materials based on their magnetic properties, ferromagnetism; types of ferromagnetic materials, their characteristics; ferrimagnetic materials, superparamagnetism, giant magnetoresistance; electrical conductivity, types of materials, changes in conductivity with temperature; semiconductors and conductive devices; molecular electronics; special electrical properties of ceramics.

List of 2-5 most important required readings with bibliographic data:
- Cahn, R. W.: The Coming of Materials Science. Pergamon, Amsterdam, 2001.
- Callister, W. D.; Rethwisch, D. G.: Materials Science and Engineering: An Introduction. Wiley, Hoboken, 2020.
- Smith, W. F.; Hashemi, J.; Prakash, R.: Foundations of Materials Science and Engineering. McGraw-Hill, New York, 2021.

- Mimona, M. A.; Rimon, M. I. H.; Zohura, F. T.; Sony, J. M.; Rim, S. I.; Arup, M. M. R.; Mobarak, M. H.: Quantum Dot Nanomaterials: Empowering Advances in Optoelectronic Devices. Chemical Engineering Journal Advances, 21 (2025) 100704. https://doi.org/10.1016/j.ceja.2025.100704
- Jana, A.; Meena, A.; Patil, S. A.; Jo, Y.; Cho, S.; Park, Y.; Sree, V. G.; Kim, H.; Im, H.; Taylor, R. A.: Self-Assembly of Perovskite Nanocrystals. Progress in Materials Science, 129 (2022) 100975. https://doi.org/10.1016/j.pmatsci.2022.100975

List of 2-5 most important recommended references with bibliographic data:
- Cahn, R. W.: The Coming of Materials Science. Pergamon, Amsterdam, 2001.
- Callister, W. D.; Rethwisch, D. G.: Materials Science and Engineering: An Introduction. Wiley, Hoboken, 2020.
- Smith, W. F.; Hashemi, J.; Prakash, R.: Foundations of Materials Science and Engineering. McGraw-Hill, New York, 2021.
- Ahire, S. A.; Bachhav, A. A.; Pawar, T. B.; Jagdale, B. S.; Patil, A. V.; Koli, P. B.: The Augmentation of Nanotechnology Era: A Concise Review on Fundamental Concepts of Nanotechnology and Applications in Material Science and Technology. Results in Chemistry, 4 (2022) 100633. https://doi.org/10.1016/j.rechem.2022.100633
- Jawad, M. S.; Rahman, W. U.; Khan, M.; Faysal, A. M.: Nanomaterial Assembly Pathways: Comparative Insights into Self-Assembly and Directed Assembly Techniques. Next Materials, 10 (2026) 101422. https://doi.org/10.1016/j.nxmate.2025.101422

Date: February 23, 2026.
Prepared by: Éva Kiss

Course title:
1.1.4 Solid State Chemistry
Credit value: 6
Course coordinator and instructor: András Stirling
Classification of subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the subject in the curriculum: can be taken in semesters 1-4
Prerequisites: basic mathematics, physics, and chemistry

Course description:
The aim of the course is to familiarize students with the most important concepts and experimental and theoretical methods of solid state chemistry. Proficiency in some fundamental topics of solid state chemistry: e.g., semiconductors, insulators, heterogeneous catalysis, preparative methods. Course content: Introduction to crystal structure: symmetry, space groups, unit cell, Miller index, important structure types, lattice energy; Experimental methods: X-ray diffraction and absorption, neutron diffraction, electron microscopy methods, thermal methods; interpretation of spectra; Electronic properties: electron structure, bonding, band structure; insulators-semiconductors-metals; impurities, transistors, defect sites; Production methods: high-temperature methods, high-pressure methods, CVD, crystal growth theory; Examples: 1D, 2D, 3D carbon systems; zeolites; high-k materials; some important heterogeneous catalytic systems, adsorption and reaction kinetics on solid surfaces;.

List of 2-5 most important required readings with bibliographic data:
- Woodward, P. M.; Karen, P.; Evans, J. S. O.; Vogt, T.: Solid State Materials Chemistry. Cambridge University Press, Cambridge, 2021. ISBN 9780521873253.

- Fahlman, B. D.: Materials Chemistry. 4th ed., Springer, Cham, 2023. https://doi.org/10.1007/978-3-031-18784-1
- Portillo-Vélez, N. S.; Moreno, N.; Rojas, S.: Benefits and Complexity of Defects in Metal-Organic Frameworks. Communications Materials, 5 (2024) Article 91. https://doi.org/10.1038/s43246-024-00691-1

List of the 2-5 most important recommended references with bibliographic data:
- Woodward, P. M.; Karen, P.; Evans, J. S. O.; Vogt, T.: Solid State Materials Chemistry. Cambridge University Press, Cambridge, 2021. ISBN 9780521873253.
- Fahlman, B. D.: Materials Chemistry. 4th ed., Springer, Cham, 2023. https://doi.org/10.1007/978-3-031-18784-1
- Ibach, H.; Luth, H.: Solid-State Physics. 5th ed., Springer, Berlin, 2009.
- Portillo-Vélez, N. S.; Moreno, N.; Rojas, S.: Benefits and Complexity of Defects in Metal-Organic Frameworks. Communications Materials, 5 (2024) Article 91. https://doi.org/10.1038/s43246-024-00691-1
Date: January 12, 2026.
Prepared by: András Stirling

Course title:
1.1.5 Introduction to Plasma Chemistry
Credit value: 6
Course coordinator and instructor: Szilvia Klébert
Classification of the course: foundation course
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to introduce plasma chemistry technologies and provide the necessary theoretical background. Course content: Plasma technology is used in almost all areas of industry today (light industry, chemical industry, heavy industry, microelectronics, energy, etc.). The course provides an insight into the main trends in plasma chemistry, such as material synthesis (creation of powder and bulk materials), surface modification of different types of materials, layer separation, and the kinetics of plasma-assisted gas-phase reactions. It provides comprehensive knowledge of different plasma sources, types of electrical discharges, elementary plasma chemistry reactions, their kinetics and thermodynamics. It introduces the main reactor types and configurations through numerous application examples.

Fridman, A.: Plasma Chemistry. Cambridge University Press, New York, 2008.
Fridman, A.; Kennedy, L. A.: Plasma Physics and Engineering. Taylor & Francis, New York, 2004.
Okubo, M.: Nonthermal Plasma Surface Modification of Materials. Springer Nature Singapore, Singapore, 2023. DOI: 10.1007/978-981-99-4506-1.
Bertin, M.; Leitao, E. M.; Bickerton, S.; Verbeek, C. J. R.: A review of polymer surface modification by cold plasmas toward bulk functionalization. Plasma Processes and Polymers, 21(5) (2024) e2300208. DOI: 10.1002/ppap.202300208.
Komuro, A.: A review of streamer discharge-induced plasma chemistry at atmospheric pressure: Key mechanisms and future perspectives. Journal of Electrostatics, 137 (2025) 104087. DOI: 10.1016/j.elstat.2025.104087.
List of the 2-5 most important recommended references with bibliographic data:
Fridman, A.: Plasma Chemistry. Cambridge University Press, New York, 2008.
Fridman, A.; Kennedy, L. A.: Plasma Physics and Engineering. Taylor & Francis, New York, 2004.

Kim, H. T.; Jung, C. M.; Kim, S. H.; Lee, S.-Y.: Review of Plasma Processing for Polymers and Bio-Materials Using a Commercial Frequency (50/60 Hz)-Generated Discharge. Polymers, 15(13) (2023) 2850. DOI: 10.3390/polym15132850.
Bogaerts, A.; Centi, G.; Hessel, V.; et al.: Perspectives and Emerging Trends in Plasma Catalysis: Facing the Challenge of Chemical Production Electrification. ChemCatChem, 17(7) (2025) e202401938.
Li, S.; Arun, P.; van den Bogaard, H.; van Raak, T.; Liu, C.; Gallucci, F.: A review of experimental approaches, trends and opportunities in plasma-based gas conversion research. Frontiers of Chemical Science and Engineering (2025).
Date: December 11, 2025.
Prepared by: Szilvia Klébert

Course name:
1.1.6 Fracture Mechanics
Credit value: 6
Course coordinator and instructor: Tünde Kovács
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
To familiarize students with the causes of crack formation, methods of detection, and ways of prevention in terms of both material selection and structural design. Study of the toughness behavior of materials, analysis of the fracture process, stable and unstable crack propagation. Fracture mechanics assumes that materials encountered in practice always contain defects and examines the conditions under which these defects begin to propagate in an unstable or catastrophic manner. The founders of fracture mechanics theory are Neuber, Griffith (linear elastic fracture mechanics, LRTM) and Irwin-Orowan (stress intensity factor, K), fracture mechanics in the small plastic range, Wells (critical crack opening COD or □c theory), followed by analysis of the relationship between □c and KIC, Rice (J integral theory), and the Czoboly-Radon relationship for small radius notches.

The 2-5 most important required readings:
- Gdoutos, E. E.: Fracture Mechanics: An Introduction. 3rd ed., Springer, Cham, 2020. ISBN: 978-3-030-35097-0. DOI: 10.1007/978-3-030-35098-7.
- Abdel Wahab, M. (ed.): Proceedings of the 10th International Conference on Fracture Fatigue and Wear: FFW 2022. Springer, Singapore, 2023. DOI: 10.1007/978-981-19-7808-1.
- Bahram Farahmand, Ph.D: Fracture Mechanics of Metals, Composites, Welds, and Bolted Joints Application of LEFM, EPFM, and FMDM Theory, Kluwer Academic Publishers, 2001.
- Kenneth A. Macdonald: Fracture and fatigue of welded joints and structures, Woodhead Publishing Limited, 2011.

The 2-5 most important recommended references:
- Bahram Farahmand, Ph.D: Fracture Mechanics of Metals, Composites, Welds, and Bolted Joints Application of LEFM, EPFM, and FMDM Theory, Kluwer Academic Publishers, 2001.
- Kenneth A. Macdonald: Fracture and fatigue of welded joints and structures, Woodhead Publishing Limited, 2011.
- Czoboly E., Havas I.: Fracture and fatigue of metals, BME University lecture notes, Budapest 2004.
- Gdoutos, E. E.: Fracture Mechanics: An Introduction. 3rd ed., Springer, Cham, 2020. ISBN: 978-3-030-35097-0. DOI: 10.1007/978-3-030-35098-7.

- Abdel Wahab, M. (ed.): Proceedings of the 10th International Conference on Fracture Fatigue and Wear: FFW 2022. Springer, Singapore, 2023. DOI: 10.1007/978-981-19-7808-1.

Date: December 27, 2025.
Prepared by: Tünde Kovács
Course title:
1.1.7 Analysis of damage processes in structural materials
Credit value: 6
Course coordinator and instructor: Tünde Kovács
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to introduce the forms of damage to structural materials and the kinetics of damage processes (wear, corrosion, aging, etc.). The effects of complex stresses under model and real operating conditions. Possibilities for modeling damage processes. Prediction of damage through material testing and in-situ inspection during operation. Course content: The course provides an overview of the forms of damage, their manifestations, detection possibilities, and the material structural causes of damage initiation. Possibilities for preventing damage, surface treatment and heat treatment technologies for structural materials. Causes of the onset of damage processes, methods for determining the kinetic function of damage, and modeling.

List of the 2-5 most important required readings with bibliographic data:
Ginsztler J.; Dévényi L.: Applied Materials Science.
Corrosion: Fundamentals, Testing, and Protection. ASM Handbook, Vol. 13A. ASM International, Materials Park, OH, 2003.
Bhushan, B.: Introduction to Tribology. 2nd ed., John Wiley & Sons, Chichester, 2013.
Wang, X.; Zhao, W.; Shi, T.; Cheng, L.; Hu, S.; Zhou, C.; Cui, L.; Li, N.; Liaw, P. K.: A Review on Tribological Wear and Corrosion Resistance of Surface Coatings on Steel Substrates. Coatings, 15(11) (2025) 1314. DOI: 10.3390/coatings15111314.
Souza, M. D. P.; et al.: Carbon steel corrosion monitoring: Why opting for an electroanalytical instead of a physicochemical method? Journal of Electroanalytical Chemistry, 991 (2025) 119982.

List of the 2-5 most important recommended references with bibliographic data:
Totten, G. E.; Liang, H.: Surface Modification and Mechanisms: Friction, Stress, and Reaction Engineering. CRC Press, Boca Raton.
Totten, G. E. (ed.): Steel Heat Treatment Handbook. Marcel Dekker, New York, 2004.
Mardanshahi, A.; et al.: Sensing Techniques for Structural Health Monitoring: A Systematic Review. Sensors, 25(5) (2025) 1424.
Non-destructive techniques for corrosion detection: A review. Corrosion Engineering, Science and Technology (2024). DOI: 10.1177/1478422X241229621.
Sun, K.; et al.: Research Progress on the Corrosion Mechanism and Protection Strategies for Fe and Al and Their Alloys in Power Systems. Coatings, 15(2) (2025) 119.
Date: December 18, 2025.
Prepared by: Tünde Kovács

Course title:
1.1.8 Technological Process Design
Credit value: 6
Course coordinator and instructor: Balázs Mikó
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to familiarize students with the tasks, principles, and methods of component manufacturing and assembly process planning. Course content: Technological planning links product design with the physical realization of manufacturing, so planning the manufacturing process is an important activity from both a technical and economic point of view. The aim of the course is to present the tasks to be performed during component manufacturing and assembly planning, and to introduce the principles and methods of planning. It analyzes the possibility of putting individual methods and principles (abstraction, analogies, heuristics, optimization) into practice. It deals with the relationship between production preparation and production management, measurement technology, and quality assurance, as well as the place of technological design in the Industry 4.0 concept. The course also examines IT solutions that can be used in technological design (e.g., CAM systems).

List of 2-5 most important required readings with bibliographic data:
Kalpakjian, S.; Schmid, S. R.: Manufacturing Engineering and Technology. 7th SI ed., Pearson, 2013. ISBN 978-981-06-9406-7.
Nee, A. Y. C. (ed.): Handbook of Manufacturing Engineering and Technology. Springer, London, 2015. DOI: 10.1007/978-1-4471-4670-4.
Marzia, S.; Ahmad, R.; et al.: Integrated Process Planning and Scheduling Framework for Setup Planning in Intelligent Manufacturing. Mathematics, 13(16) (2025) 2605.
Adalat, O.; et al.: Model-based generation of manufacturing process plans from product and resource models for Industry 4.0 systems. Computers in Industry (2025).
Fu, X.; et al.: Digital twin technology in modern machining. Computer Integrated Manufacturing Systems / review article (2025).

List of the 2-5 most important recommended references with bibliographic data:
Zhou, J.; et al.: Computer-aided process planning in immersive virtual reality: a review. Computers in Industry, 2021.
Azab, A.; et al.: CAPP-GPT: A computer-aided process planning framework in smart manufacturing environments. Journal of Manufacturing Systems, 2024.
da Silva, L. R. R.; et al.: Review of Applications of Digital Twins and Industry 4.0 for Machining Processes. Machines, 9(7) (2025) 211.
Liu, Y.; et al.: Digital twin-based assembly process framework utilizing multi-stage manufacturing data. Advanced Engineering Informatics, 2025.
Singh, P.; et al.: A Review of Production Scheduling with Artificial Intelligence and Digital Twins in Smart Manufacturing. Manufacturing, 10(1) (2025) 6.
Date: December 26, 2025.
Prepared by: Balázs Mikó

Course title:

1.1.9 Finite element modeling of material technologies
Credit value: 6
Course coordinator and instructor: Viktor Gonda
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
In the design of mechanical technologies, finite element analysis greatly facilitates the determination of shape changes, stress distribution, temperature distribution, and technological data in the case of complex geometries. Using the MARC finite element system, we solve mechanical-plastic, thermal, and coupled thermal-mechanical problems with practical applications in mind. After completing the course, students should be able to create a simplified mechanical and thermal model of a simple materials technology problem (forming, heat treatment), formulate it in a finite element program, run the task, and evaluate the results. The MARC work environment, solving flexible finite element problems. Plastic parameters: flow conditions, material model settings. Finite element analysis of basic tasks of compression and flow. Solving sheet metal forming tasks. Methods of specifying thermal models. Building and running coupled thermal-mechanical models. Mesh refinement, setting up automatic remeshing. Importing geometric models from design programs, setting up, running, and evaluating finite element mechanical problems. Automating finite element analysis with macros.
The 2-5 most important required readings:
- Pidaparti, R. M.: Engineering Finite Element Analysis. Springer, Cham, 2022. DOI: 10.1007/978-3-031-79570-1.
- Lyu, Y.: Finite Element Method: Element Solutions. Springer, Singapore, 2022. DOI: 10.1007/978-981-19-3363-9.
- Henry S. Valberg: Applied metal forming, Cambridge University Press, 2010.

The 2-5 most important recommended readings:
- Henry S. Valberg: Applied metal forming, Cambridge University Press, 2010.
- Pidaparti, R. M.: Engineering Finite Element Analysis. Springer, Cham, 2022. DOI: 10.1007/978-3-031-79570-1.
- Lyu, Y.: Finite Element Method: Element Solutions. Springer, Singapore, 2022. DOI: 10.1007/978-981-19-3363-9.

Date: February 17, 2026.
Prepared by: Viktor Gonda
Course title:
1.1.10 Basic Knowledge of Technical Ceramics
Credit value: 6
Course coordinator and instructor: Szilvia Klébert
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to introduce the main types of technical ceramics, describe their production and occurrence, and examine the relationship between structure and properties. Course content: Types of ceramics based on their chemical composition: oxide, nitride, carbide, and other base ceramics. Functional and structural ceramics. Bulk ceramics, ceramic coatings, layers, films. Monolithic and composite ceramic materials. Comparison of ceramic materials with other structural materials (metals, plastics). The relationship between chemical composition, microstructure, and properties. Requirements for raw materials. Synthesis of ceramic raw materials using physical and chemical processes. Traditional and modern methods of synthesis. Production of raw materials under special conditions. Important methods for characterizing raw materials (granular materials, powders, colloidal systems). The role of bulk and surface properties. Ceramic raw materials consisting of micro- and nanoscale particles: advantages and disadvantages. Production of compact ceramic bodies. The role and types of forming and heat treatment additives, practical methods of adding additives. Mechanics of dispersion systems, deformation behavior during forming. Forming and heat treatment (shrinking, sintering) processes. Material structure and kinetic aspects of sintering. Sintering under special conditions (thermal plasma, explosion, etc.). Post-processing of dense ceramics. Formation of ceramic layers and coatings (powder spraying, PVD, CVD, PACVD, etc.). The relationship between microscopic and macroscopic structure. Amorphous and crystalline ceramics. Micro- and nanostructured ceramics. Measurement and evaluation of physical, thermal, and mechanical properties. Determination and role of chemical and surface chemical properties. Measurement of electrical characteristics. Examination of optical properties. Determination of biocompatibility. Possibility of manufacturing defects. Reliability analyses.

List of 2-5 most important required readings with bibliographic data:
Chavarria, J.: Ceramics. Novella, Budapest, 1996.
Brook, R. J.: Concise Encyclopedia of Advanced Ceramic Materials. Pergamon Press, Oxford, 1991.
Terpstra, R. A.; Pex, P. P. A. C.; de Vries, A. H.: Ceramic Processing. Chapman & Hall, London, 1995.
Advanced Ceramics. Springer, Cham, 2024. DOI: 10.1007/978-3-031-43918-6.
Li, B. (ed.): Advances in Ceramic Materials and Processing. Springer, Singapore, 2025. DOI: 10.1007/978-3-031-80664-3.

List of the 2-5 most important recommended references with bibliographic data:
Alper, A. M.: Phase Diagrams in Advanced Ceramics. Academic Press, London, 1994.
Segal, D.: Chemical Synthesis of Advanced Ceramic Materials. Cambridge University Press, Cambridge, 1989.
Li, B. (ed.): Advances in Powder and Ceramic Materials Science 2023. Springer, Singapore, 2023. DOI: 10.1007/978-3-031-22622-9.
Medvedovski, E.: Advanced ceramics and coatings for wear and corrosion protection of industrial components: A review. Ceramics International, 50 (2024).
Ren, X.; et al.: Advances in ultra-high-temperature ceramic coatings with boride–silicon systems on carbon-based composites: A review. Extreme Manufacturing, 2025.
Date: February 25, 2026.
Prepared by: Szilvia Klébert

Course title:
1.1.11 Biomaterials for medical applications
Credit value: 6
Course coordinator and instructor: Csaba Balázsi
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30

Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to present the technological production processes of ceramics, glass, and polymers (powder production, pressing, additive technologies, atomization, sintering), and to discuss the physical, chemical, and technological properties of materials with particular regard to medical applications. Course content: composition and structural properties of materials produced by various methods (ceramics, glass, and polymers) and their medical applications; bioactive ceramics, which are currently used as coatings for metal devices, promoting the formation of natural bone tissue and its integration into hard tissues; ceramic particles, microspheres, and nanosystems in cancer treatment; structures for tissue engineering as carriers for dental implants; new bioceramics with improved mechanical and biological functions, zirconium and hydroxyapatite-based composites, and non-oxide ceramics.

List of 2-5 most important required readings with bibliographic data:
Hench, L. L.; Wilson, J. (eds.): An Introduction to Bioceramics. World Scientific, Singapore, 1993.
A Manual for Biomaterials/Scaffold Fabrication Technology. World Scientific, Singapore, 2007.
Sonowal, L.; et al.: Advancements of bioceramics in biomedical applications. Materials Today Bio, 2025.
Furkó, M.; et al.: Bioglasses Versus Bioactive Calcium Phosphate Derivatives for Tissue Engineering and Drug Delivery Applications. Biomimetics, 16(5) (2025) 161.
Farag, M. M. (ed.): Biomaterials for Tissue Regeneration. Springer, Cham, 2025.

List of the 2-5 most important recommended references with bibliographic data:
Hench, L. L.; Wilson, J. (eds.): An Introduction to Bioceramics. World Scientific, Singapore, 1993.
A Manual for Biomaterials/Scaffold Fabrication Technology. World Scientific, Singapore, 2007.
Cinici, B.; et al.: Fabrication Strategies for Bioceramic Scaffolds in Bone Tissue Engineering. Bioengineering, 9(7) (2024) 409.
Kumar, R.; et al.: A comprehensive review of advancements in additive manufacturing for medical applications. 2025.
Rheima, A. M.; et al.: Nano bioceramics: Properties, applications, hydroxyapatite and zirconia-based systems in medicine. 2024.
Date: January 31, 2026.
Prepared by: Csaba Balázsi

Course title:
1.1.12 The impact of Industry 4.0 on manufacturing technology
Credit value: 6
Course coordinator and instructor: Balázs Mikó
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:

The aim of the course is to introduce the technical and economic impact of Industry 4.0 key technologies on manufacturing technology, product design and production preparation processes, and the manufacturing environment. Course content: The Industry 4.0 concept is transforming today's industry, manufacturing processes, and tools. The integration of nine key technologies (simulation, system integration, IoT, cybersecurity, cloud technology, additive manufacturing, augmented reality, big data analysis, autonomous robots) offers new opportunities to increase efficiency throughout the entire product life cycle. The aim of the course is to introduce the development of these technologies, their potential applications, and their technical and economic impact on manufacturing technology, product design and production preparation processes, and the manufacturing environment.

List of 2-5 most important required readings with bibliographic data:
Kusiak, A.: Smart manufacturing. International Journal of Production Research, 56(1–2) (2018) 508–517. DOI: 10.180/00207543.2017.1351644.
Folgado, F. J.; et al.: Review of Industry 4.0 from the Perspective of Automation and Supervision Systems: Architecture and Enabling Technologies. Electronics, 13(4) (2024) 782.
Leng, J.; et al.: Review of manufacturing system design in the interplay of Industry 4.0 and Industry 5.0. Computers in Industry, 169 (2025) 104064.
Gao, T.; et al.: Review of industrial software towards smart manufacturing. Computers in Industry, 169 (2025) 104048.
Ahmmed, M. S.; et al.: A Systematic Review of Industry 4.0 and AI. Machines, 12(10) (2024) 681.

List of the 2-5 most important recommended references with bibliographic data:
da Silva, L. R. R.; et al.: Review of Applications of Digital Twins and Industry 4.0 for Machining Processes. Manufacturing, 9(7) (2025) 211.
Goecks, L. S.; et al.: Industry 4.0 and Smart Systems – Guidelines for Implementation. Smart Cities, 7(2) (2024) 24.
Bongomin, O.; et al.: Digital twin technology advancing Industry 4.0 and Industry 5.0 in manufacturing: a review. Smart Manufacturing, 4 (2025).
Brarda, P. G.; et al.: Roadmap to Digital Factories in Industry 4.0. International Journal of Production Economics, 2025.
Bandhana, A.; et al.: AI-Driven Manufacturing: Surveying for Industry 4.0 and Beyond. Journal of The Institution of Engineers (India): Series B, 2025.
Date: December 15, 2025.
Prepared by: Balázs Mikó

Course title:
1.1.13 Materials for Nuclear Power Plants
Credit value: 6
Course coordinator and instructor: Zoltán Hózer
Classification of the subject: foundation subject
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to familiarize students with the characteristics of materials used in nuclear power plants, the criteria for their selection, the basics of nuclear power plant operation, the thermal processes taking place in nuclear reactors, the typical mechanical loads on reactor materials, and the methods used

to test them. Course content: • Characteristics of nuclear fuel, Fuel assemblies and control rods, Characteristics of coolants, Pressurized water and boiling water reactors, Materials and structure of the reactor vessel • Heat generation in the reactor, heat transfer, heat conduction in the fuel, operational limits during normal operation, operational limits during malfunction (LOCA and RIA) • Mechanical behavior of reactor materials, methods of mechanical testing, creep, fracture mechanics.

List of 2-5 most important required readings with bibliographic data:
- Yu, J.: Fundamental Principles of Nuclear Engineering. Springer, Singapore, 2022. https://doi.org/10.1007/978-981-16-0839-1
- Liu, H.; Lei, G.-H.; Huang, H.-F.: Review on Synergistic Damage Effect of Irradiation and Corrosion on Reactor Structural Alloys. Nuclear Science and Techniques, 35 (2024) Article 57. https://doi.org/10.1007/s41365-024-01415-3
- Rebak, R. B.: Improved and Innovative Accident-Tolerant Nuclear Fuel Materials Considered for Retrofitting Light Water Reactors - A Review. Corrosion and Materials Degradation, 4(3) (2023) 466-487. https://doi.org/10.3390/cmd4030024

List of the 2-5 most important recommended references with bibliographic data:
- Yu, J.: Fundamental Principles of Nuclear Engineering. Springer, Singapore, 2022. https://doi.org/10.1007/978-981-16-0839-1
- Wang, P.; Bachhav, M.: Editorial: Nuclear Material for Current and Future Reactor Design. Frontiers in Nuclear Engineering, 3 (2024) 1392742. https://doi.org/10.3389/fnuen.2024.1392742
- Liu, H.; Lei, G.-H.; Huang, H.-F.: Review on Synergistic Damage Effect of Irradiation and Corrosion on Reactor Structural Alloys. Nuclear Science and Techniques, 35 (2024) Article 57. https://doi.org/10.1007/s41365-024-01415-3
- Rebak, R. B.: Improved and Innovative Accident-Tolerant Nuclear Fuel Materials Considered for Retrofitting Light Water Reactors - A Review. Corrosion and Materials Degradation, 4(3) (2023) 466-487. https://doi.org/10.3390/cmd4030024
Date: February 23, 2026.
Prepared by: Zoltán Hózer

Course title:
1.1.14 Fundamentals of Materials Science
Credit value: 6
Course coordinator and instructor: Mária Marosné Berkes
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of lesson: ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to provide doctoral students with different backgrounds in materials science with a solid and uniform theoretical basis on the relationships between the structure, properties, and performance of metallic and non-metallic materials used in engineering practice, their material-specific mechanical behavior, the most important directions of material development, with particular emphasis on meeting ever-increasing functional and technological requirements. Course content: General characterization of material groups, the effect of the nano-, micro- and macrostructure of materials and state factors. Structural characterization of ideal and real crystalline materials. Theoretical background of elastic and plastic deformation, the role of dislocations in deformation. Transport phenomena, diffusion.

Types of interfaces and their role in phase transformations. Equilibrium and non-equilibrium crystallization of Fe-C alloys, their characteristic microstructures. Mechanical behavior of single- and multi-phase metallic material systems, methods of strength enhancement. Modern high-strength steels and aluminum alloys. Properties of technical ceramics, possibilities for increasing toughness. Viscoelasticity of polymers and its consequences for mechanical behavior. The most important mechanical tests of brittle, ductile, and viscoelastic materials.

List of 2-5 most important required readings with bibliographic data:
- Tisza, M.: Fundamentals of Materials Science, Miskolc University Press, Miskolc, 2008. p.285. ISBN: 978-963-661-844-5.
- Prohászka J.: Mechanical Properties of Metals and Alloys, Műegyetemi Kiadó, 2001. p.409. ISBN 963 420 671.
- Callister, W. D.: Materials Science and Engineering, an introduction, 7th Ed. John Wiley, New York, 1994, p.975. ISBN:13-978-0-471-73696-7.
- Porter, D. A., Easterling, K. E., Sherif, M. Y.: Phase Transformation in Metals and Alloys, 4th edition, CRC Press 2022, ISBN-13 978-0367430344, p.556
- Gál, I.; Kocsisné, B. M.; Lenkeyné, B. Gy.; Lukács, J.; Marosné, B. M.; Nagy, Gy.; Tisza, M.: Materials Testing. Edited by: Tisza, M. Miskolc University Press, 2001. ISBN 963 661 452 0.

List of the 2-5 most important recommended references with bibliographic data:
- Tisza, M.: Fundamentals of Materials Science, Miskolc University Press, Miskolc, 2008. p.285. ISBN: 978-963-661-844-5.
- Prohászka J.: Mechanical Properties of Metals and Alloys, Műegyetemi Kiadó, 2001. p.409. ISBN 963 420 671.
- Callister, W. D.: Materials Science and Engineering, an introduction, 7th Ed. John Wiley, New York, 1994, p.975. ISBN:13-978-0-471-73696-7.
- Porter, D. A., Easterling, K. E., Sherif, M. Y.: Phase Transformation in Metals and Alloys, 4th edition, CRC Press 2022, ISBN-13 978-0367430344, p.556
- Gál, I.; Kocsisné, B. M.; Lenkeyné, B. Gy.; Lukács, J.; Marosné, B. M.; Nagy, Gy.; Tisza, M.: Materials Testing. Edited by: Tisza, M. Miskolc University Press, 2001. ISBN 963 661 452 0.
- Ashby, M.F, Jones, D.R.H.: Engineering Materials 1 – An introduction to Microstructures, Processing and Design 3rd ed., Elsevier Butterwoth-Heinemann, Oxford, 2006. ISBN 0 7506 63804.
- Ashby, M.F, Jones, D.R.H.: Engineering Materials 2 – An introduction to properties, Applications and Design 3rd ed., Elsevier Butterwoth-Heinemann, Oxford, 2006. ISBN-13: 978-0-7506-6381-6.
- Tisza, M.: Development of Lightweight Steels for Automotive Applications, doi: 10.5772/intechopen.91024.

Date: January 31, 2026.
Prepared by: Marosné Berkes Mária

1.2 Material testing methods

Course title:
1.2.1 Selected chapters from materials testing methods I.
Credit value: 6
Course coordinator and instructor: Erzsébet Takács, Judit Telegdi
Course classification: foundation course
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation

Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): none
Course description:
To familiarize students with modern material testing methods. Fourier transform infrared spectroscopy (FTIR) Some of the instrumental tests used to examine the structure of compounds and identify structures are collectively known as spectroscopy. The infrared range is located between the visible and microwave ranges of the electromagnetic spectrum. The wavelength of the mid-infrared range is approximately 4000–400 cm–1 (the wavelength is commonly used in IR spectroscopy for practical reasons), and in practice, we mostly examine this range. The lecture summarizes the theoretical basis of the examination and then describes the device. High-performance liquid chromatography – tandem mass spectrometry detection (HPLC-MS) A liquid chromatograph-tandem mass spectrometer (LC-MS/MS) is used to separate and identify the components of a solution containing several dissolved substances. The pumps attached to the instrument are capable of delivering the sample, together with the eluents (carrier fluids), to the column at a maximum pressure of 400 bar. As the sample passes through the column, it is retained (delayed) relative to the liquid flow due to specific chemical or physical interactions with the stationary phase. The degree of retention depends on the properties of the substance being tested and the stationary phase, as well as the composition of the mobile phase. The time it takes for a given substance to elute (appear at the end of the column) is called the retention time. In a given system, the retention time is a relatively unique characteristic of each compound being tested. The signals obtained are displayed by the device software on a so-called chromatogram (time vs. signal graph), where each molecule produces a chromatographic peak. The chromatographic peaks are accompanied by mass spectra (mass/charge vs. signal graph). The mass spectrum contains the mass/charge values (m/z) and relative intensities of the ions and their fragments (fragments) produced during ionization. Based on the data, after appropriate evaluation, the unknown sample component can be identified with a high degree of certainty.
The 2-5 most important required readings:
- Al-Amin, K.; Alam, M. S.; et al.: Fourier transform infrared spectroscopic technique for analysis of inorganic materials: a review. Nanoscale Advances, 2025. DOI: 10.1039/D5NA00522A.
- Gong, Y.; Chen, X.; Wu, W.: Application of Fourier transform infrared (FTIR) spectroscopy in sample preparation: Material characterization and mechanism investigation. Sample Preparation, 4 (2024) 100122. DOI: 10.1016/j.sampre.2024.100122.
- Kissné Erőss Klára: Analytical applications of infrared spectroscopy. Műegyetemi Kiadó, Budapest, 1993.
- Daniel C. Harris: Quantitative Chemical Analysis. W.H. Freeman and Company, New York, 2007.
The 2-5 most important recommended references:
- Kissné Erőss Klára: Analytical applications of infrared spectroscopy. Műegyetemi Kiadó, Budapest, 1993.
- Daniel C. Harris: Quantitative Chemical Analysis. W.H. Freeman and Company, New York, 2007.
- Bertóti I.; Marosi Gy.; Tóth A.: Selected chapters from technical surface science. Műegyetemi Kiadó, 1998.
- Al-Amin, K.; Alam, M. S.; et al.: Fourier transform infrared spectroscopic technique for analysis of inorganic materials: a review. Nanoscale Advances, 2025. DOI: 10.1039/D5NA00522A.
- Gong, Y.; Chen, X.; Wu, W.: Application of Fourier transform infrared (FTIR) spectroscopy in sample preparation: Material characterization and mechanism investigation. Sample Preparation, 4 (2024) 100122. DOI: 10.1016/j.sampre.2024.100122.

Date: March 1, 2026.
Prepared by: Erzsébet Takács, Judit Telegdi

Course title:
1.2.2 Selected chapters from material testing methods II.
Credit value: 6
Course coordinator and instructor: Szilvia Klébert
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium

Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
To learn the basics of X-ray photoelectron spectroscopy, X-ray fluorescence spectroscopy, and the determination of specific surface area and pore size distribution by gas adsorption, as well as the specific applications of these methods. X-ray photoelectron spectroscopy X-ray photoelectron spectroscopy (XPS) is based on the photoelectric effect. When an atom is illuminated with electromagnetic radiation (visible or ultraviolet light, X-rays) and the energy of the photon is high enough, electrons can be emitted from it. In practice, the energy of the X-ray photons used (usually Mg Kα and Al Kα) is sufficient to excite electrons from the inner shells of all elements except hydrogen and helium. By measuring the kinetic energy (Ek, kinetic energy, KE) of the emitted electrons, we determine the ionization energy (Ei, binding energy, BE) taking into account the energy of the irradiating photon (hν). Φsp is a correction factor derived from the exit work of the spectrometer and the charge of the sample, which is determined by calibration. The excess energy of the inner ion produced during photoionization is released either by the emission of another X-ray photon (X-ray fluorescence) or by the emission of an additional electron (Auger process). In order to preserve the energy of the electrons emitted from the sample, an ultra-high vacuum (≈10 10 mbar) must be used in the device. X-rays penetrate deeply into the material under investigation and excite photoelectrons throughout its entire volume. However, the mean free path of electrons within the sample, i.e., the average distance between two inelastic collisions, is very small, 1-3 nm. Thus, due to collisions with the atoms of the sample, electrons can only reach the spectrometer without energy loss from a very thin layer of the sample surface, so the method is surface-sensitive. This is a distinct advantage of the method, as the behavior and reactivity of solids are determined by the composition of their surface. To determine the qualitative composition of an unknown sample, we record an overview spectrum (wide energy range (100–1300 eV), large step size (0.5–1 eV)), which contains at least one line for each element. The elements found on the surface of the sample can be identified using appropriate tables based on the binding energy values read from the spectrum. X-ray fluorescence spectroscopy X-ray fluorescence spectroscopy (XRF) is a widely used analytical method for the qualitative and quantitative chemical analysis of solid (and in some cases liquid) samples. During the measurement, high-energy X-rays (approx. 20 keV) are emitted onto the surface of the sample, causing electrons to be ejected from the innermost electron shells of the atoms present there (i.e., the atom becomes ionized). The place of the ejected electron(s) is filled by an electron from a more external shell , and at the same time, the difference between the two energy levels is emitted in the form of an X-ray photon. This X-ray is characteristic, i.e., its energy and wavelength are typical of the element emitting it, and its intensity is proportional to the number of emitting atoms, i.e., their concentration in the sample. Therefore, if we detect the secondary X-ray photons originating from the unknown sample in accordance with the above, based on their energy (energy-dispersive detectors) or wavelength (wavelength-dispersive detectors), we can determine the chemical composition of the sample under examination. It should be noted that XRF is a surface analysis technique, where the average depth of information from which the response signals originate is 100-200 μm. Determination of specific surface area and pore size distribution by gas adsorption Adsorption, or more precisely physisorption, methods can be used to determine the surface area and pore structure of solid materials. During the measurements, a gas or vapor—most commonly nitrogen vapor—is adsorbed onto the surface of the sample, which has been cleaned with vacuum and heating, at a low temperature (77K), and then the amount of adsorbed gas is measured as a function of relative vapor pressure. The resulting isotherms, which are classified into six groups according to their course, can be evaluated using different models. The evaluation is usually based on the BET model, which, unlike the Langmuir model, takes into account multilayer adsorption. For BET evaluation, the adsorption isotherm must be recorded at several points in the relative pressure range of 0.05-0.35. The resulting isotherm is linearized, after which the specific surface area and an energy-related parameter characteristic of the strength of the bonds between the surface and the vapor molecule can be calculated. By examining the pore distribution of the sample, information can be obtained about its micro- and mesopores. Micropores, which are < 2 nm in size, generally exhibit a type I isotherm, while mesoporous materials, in which the pores are between 2 and 50 nm in size, exhibit a type IV isotherm. Due to the increased interaction between the adsorbate and adsorbent, the narrow micropores are already at very low pressure. The physisorption of mesopores takes place in two stages: first, a monolayer-multilayer

adsorption on the pore walls, followed by capillary condensation. The adsorption and desorption curves are characterized by hysteresis. The resulting isotherms are also evaluated here using various models. The Kelvin equation is usually used as the basis for evaluating the size distribution of mesopores.

The 2-5 most important required readings:
- Ortiz Ortega, E.; Hosseinian, H.; Aguilar Meza, I. B.; Rosales López, M. J.; Rodríguez Vera, A.; Hosseini, S.: Material Characterization Techniques and Applications. Springer, Singapore, 2022. Hardcover ISBN: 978-981-16-9568-1. DOI: 10.1007/978-981-16-9569-8.
- Gong, Y.; Chen, X.; Wu, W.: Application of Fourier transform infrared (FTIR) spectroscopy in sample preparation: Material characterization and mechanism investigation. Sample Preparation, 4 (2024) 100122. DOI: 10.1016/j.sampre.2024.100122.
- Berényi Dénes: Photoelectron spectroscopy, New methods of solid surface analysis I., Recent results in solid state research 5., Akadémiai Kiadó, Budapest, 1979.
- Brümmer, O., Heydenreich, J., Krebs, K. H., Schneider, H. G. (eds.): Investigation of solids with electrons, ions and X-rays, Műszaki Könyvkiadó, Budapest, 1984.

The 2-5 most important recommended references:
- Berényi Dénes: Photoelectron spectroscopy, New methods of solid surface analysis I., Recent results in solid state research 5., Akadémiai Kiadó, Budapest, 1979.
- Brümmer, O., Heydenreich, J., Krebs, K. H., Schneider, H. G. (eds.): Investigation of Solids with Electrons, Ions and X-rays, Technical Book Publishing House, Budapest, 1984.
- Varsányi Gy., Veszprémi T., Bertóti I.: Photoelectron Spectroscopy, BME Institute of Continuing Education, 1985.
- Ortiz Ortega, E.; Hosseinian, H.; Aguilar Meza, I. B.; Rosales López, M. J.; Rodríguez Vera, A.; Hosseini, S.: Material Characterization Techniques and Applications. Springer, Singapore, 2022. Hardcover ISBN: 978-981-16-9568-1. DOI: 10.1007/978-981-16-9569-8.
- Gong, Y.; Chen, X.; Wu, W.: Application of Fourier transform infrared (FTIR) spectroscopy in sample preparation: Material characterization and mechanism investigation. Sample Preparation, 4 (2024) 100122. DOI: 10.1016/j.sampre.2024.100122.

Date: December 24, 2025.
Prepared by: Szilvia Klébert

Course title:
1.2.3 Modern separation methods in materials research
Credit value: 6
Course coordinator and instructor: Zoltán Juvancz
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): basic knowledge of analytical chemistry

Course description:
Acquisition of knowledge of chromatography and other separation techniques: flow, diffusion, dissolution phenomena, phase equilibria. Introduction to chromatography, terminology, and equations. Presentation of different chromatographic modes and related techniques. Membrane phenomena. The role of chromatography in analytical chemistry. Advantages of chromatography in environmental protection. Chromatographic processes, distribution, diffusion equilibria, flow profiles, adsorption, absorption phenomena, exclusion, role of ion exchange. Basic equations and terms: retention time, theoretical plate

number, distribution ratio, selectivity, resolution. Types of chromatography: GC, HPLC, SFC, gel and ion exchange chromatography. Column types: packed, capillary, chip, SMB. Coupled techniques: GC/MS, GC/MS-MS, HPLC/MS-MS, GC/FT-IR. Membrane processes

The 2-5 most important required readings:
- Striegel, A. M.: Macromolecular Separation Science. Springer, Cham, 2025. Hardcover ISBN: 978-3-031-83059-4. DOI: 10.1007/978-3-031-83060-0.
- Tsopelas, F.; Mataki, N.; Vallianatou, T.; Chrysanthakopoulos, M.; Vrakas, D.; Ochsenkühn-Petropoulou, M.; Tsantili-Kakoulidou, A.: Biomimetic separations in chemistry and life sciences. Microchimica Acta, 2025. DOI: 10.1007/s00604-025-06980-x.
- József Balla: Chromatography
- Jenő Fekete. High-performance liquid chromatography

The 2-5 most important recommended references:
- József Balla: Chromatography
- Jenő Fekete. High-performance liquid chromatography
- Attila Gáspár: Capillary Electrophoresis
- Striegel, A. M.: Macromolecular Separation Science. Springer, Cham, 2025. Hardcover ISBN: 978-3-031-83059-4. DOI: 10.1007/978-3-031-83060-0.
- Tsopelas, F.; Mataki, N.; Vallianatou, T.; Chrysanthakopoulos, M.; Vrakas, D.; Ochsenkühn-Petropoulou, M.; Tsantili-Kakoulidou, A.: Biomimetic separations in chemistry and life sciences. Microchimica Acta, 2025. DOI: 10.1007/s00604-025-06980-x.

Date: December 13, 2025.
Prepared by: Zoltán Juvancz

Course title:
1.2.4 Fluorescence spectroscopy and microscopy
Credit value: 6
Course coordinator and instructor: Gusztáv Schay
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
Understanding the theoretical principles and applications of the method. Theoretical principles of fluorescence spectroscopy: electron structure, interaction of light and matter, static and time-dependent phenomena. Evaluation of information derived from spectra and lifetime measurements. Areas of application in biological structure studies. Spectroscopic methods and their combination with microscopy imaging: confocal microscopy, two-photon microscopy and super-resolution techniques (SIM, STED, STORM, PALM), fluorescence correlation spectroscopy.

The 2-5 most important required readings:
- Heit, B. (ed.): Fluorescent Microscopy. Methods in Molecular Biology. Humana, New York, 2022. Hardcover ISBN: 978-1-0716-2050-2. DOI: 10.1007/978-1-0716-2051-9.
- Burgers, T. C. Q.; van Schaik, T.; Manzo, C.; Lansdorp, P. M.; Misteli, T.; Verschure, P. J.; Wouters, M. D.; van Cappellen, W. A. et al.: Fluorescence-based super-resolution-microscopy strategies for chromatin studies. Chromosoma, 132 (2023). DOI: 10.1007/s00412-023-00792-9.
- Lakowitz: Principles of fluorescence spectroscopy, Springer, 2006,

The 2-5 most important recommended references:
- Lakowitz: Principles of fluorescence spectroscopy, Springer, 2006,
- Heit, B. (ed.): Fluorescent Microscopy. Methods in Molecular Biology. Humana, New York, 2022. Hardcover ISBN: 978-1-0716-2050-2. DOI: 10.1007/978-1-0716-2051-9.
- Burgers, T. C. Q.; van Schaik, T.; Manzo, C.; Lansdorp, P. M.; Misteli, T.; Verschure, P. J.; Wouters, M. D.; van Cappellen, W. A. et al.: Fluorescence-based super-resolution-microscopy strategies for chromatin studies. Chromosoma, 132 (2023). DOI: 10.1007/s00412-023-00792-9.

Date: January 14, 2026.
Prepared by: Gusztáv Schay

Course title:
1.2.5 Color theory and color measurement
Credit value: 6
Course coordinator and instructor: Ákos Borbély
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
Introduction to the physical, physiological, and psychophysical fundamentals of color, color communication, the basic principles of color systems, and color measurement methods and tools; comprehensive presentation of the application of basic color theory and colorimetry in the media and printing industries. Physical and psychophysical characterization of colors ( ), CIE colorimeter, CIE colorimetry system, perceptually uniform color spaces, color adaptation and modeling, color rendering models, color management, standard color management, colorimetric characterization of image displays, applied color management in the printing and media industry, applied color management in the printing and media industry

The 2-5 most important required readings:
- Schanda, J.: CIE 1931 and 1964 Standard Colorimetric Observers: History, Data, and Recent Assessments. In: Shamey, R. (ed.) Encyclopedia of Color Science and Technology. Springer, Cham, 2023. DOI: 10.1007/978-3-030-89862-5_323.
- Schanda, J.: CIE Standard Illuminants and Sources. In: Shamey, R. (ed.) Encyclopedia of Color Science and Technology. Springer, Cham, 2023. DOI: 10.1007/978-3-030-89862-5_324.
- János Schanda (ed.): Colorimetry: Understanding the CIE System, Wiley 2007, ISBN: 978-0-470-04904-4,
- Gyula Lukács: Color Measurement. Budapest: Műszaki kvk. 1982.

The 2-5 most important recommended references:
- János Schanda (ed.): Colorimetry: Understanding the CIE System, Wiley 2007, ISBN: 978-0-470-04904-4,
- Gyula Lukács: Color Measurement. Budapest: Technical Publishing House, 1982.
- Schanda, J.: CIE 1931 and 1964 Standard Colorimetric Observers: History, Data, and Recent Assessments. In: Shamey, R. (ed.) Encyclopedia of Color Science and Technology. Springer, Cham, 2023. DOI: 10.1007/978-3-030-89862-5_323.
- Schanda, J.: CIE Standard Illuminants and Sources. In: Shamey, R. (ed.) Encyclopedia of Color Science and Technology. Springer, Cham, 2023. DOI: 10.1007/978-3-030-89862-5_324.

Date: January 10, 2026.
Prepared by: Ákos Borbély

Course title:
1.2.6 Examination of surface microgeometry and microtopography
Credit value: 6
Course coordinator and instructor: Gabriella Farkas
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
Methods, techniques, quantifiable parameters, and measuring instruments used to characterize the microgeometry of structural material surfaces. During the course, students review the types of surface irregularities, their parameters and functional characteristics, and the most important elements of their impact on functional behavior (e.g., print quality, etc.). They learn about traditional and modern evaluation methods, related international standards, instruments used in practice and research, computer programs, filtering techniques (amplitude density spectrum analysis, autocorrelation and fractal analysis, etc.), and the limitations of their usability. They will perform measurement and laboratory exercises and analyses.

The 2-5 most important required readings:
- Ghosh, S.; et al.: Towards AI driven surface roughness evaluation in manufacturing: a prospective study. Journal of Intelligent Manufacturing, 2025. DOI: 10.1007/s10845-024-02493-1.
- Persson, B. N. J.; et al.: On the Use of Surface Roughness Parameters. Tribology Letters, 73 (2024). DOI: 10.1007/s11249-023-01700-z.
- Stout, Sullivan, Dong, Mainsah, Luo, Mathia, Zahouni: The development of methods for characterization of roughness in three dimensions, Printing Section, University of Birmingham Edgbuston, Birmingham (1993)
- D.J Whitehouse: Handbook of surface metrology, Inside of Phisics Publ., Bristol (1994)

The 2-5 most important recommended references:
- Stout, Sullivan, Dong, Mainsah, Luo, Mathia, Zahouni: The development of methods for characterization of roughness in three dimensions, Printing Section, University of Birmingham Edgbuston, Birmingham (1993)
- D.J Whitehouse: Handbook of surface metrology, Inside of Physics Publ., Bristol (1994)
- Tom R. Thomas: Rough Surface, Imperial College Press, London (1998)
- Ghosh, S.; et al.: Towards AI driven surface roughness evaluation in manufacturing: a prospective study. Journal of Intelligent Manufacturing, 2025. DOI: 10.1007/s10845-024-02493-1.
- Persson, B. N. J.; et al.: On the Use of Surface Roughness Parameters. Tribology Letters, 73 (2024). DOI: 10.1007/s11249-023-01700-z.

Date: January 7, 2026.
Prepared by: Gabriella Farkas

Course name:
1.2.7 Fracture Mechanics
Credit value: 6

Course coordinator and instructor: Tünde Kovács
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
To familiarize students with the causes of crack formation, methods of detection, and ways of prevention in terms of both material selection and structural design. Study of the toughness behavior of materials, analysis of the fracture process, stable and unstable crack propagation. Fracture mechanics assumes that materials encountered in practice always contain defects and examines the conditions under which these defects begin to propagate in an unstable or catastrophic manner. The founders of fracture mechanics theory are Neuber, Griffith (linear elastic fracture mechanics, LRTM) and Irwin-Orowan (stress intensity factor, K), fracture mechanics in the small plastic range, Wells (critical crack opening COD or □c theory), followed by analysis of the relationship between □c and KIC, Rice (J integral theory), and the Czoboly-Radon relationship for small radius of curvature notches.

The 2-5 most important required readings:
- Gdoutos, E. E.: Fracture Mechanics: An Introduction. 3rd ed., Springer, Cham, 2020. ISBN: 978-3-030-35097-0. DOI: 10.1007/978-3-030-35098-7.
- Abdel Wahab, M. (ed.): Proceedings of the 10th International Conference on Fracture Fatigue and Wear: FFW 2022. Springer, Singapore, 2023. DOI: 10.1007/978-981-19-7808-1.
- Bahram Farahmand, Ph.D: Fracture Mechanics of Metals, Composites, Welds, and Bolted Joints Application of LEFM, EPFM, and FMDM Theory, Kluwer Academic Publishers, 2001.
- Kenneth A. Macdonald: Fracture and fatigue of welded joints and structures, Woodhead Publishing Limited, 2011.

The 2-5 most important recommended references:
- Bahram Farahmand, Ph.D: Fracture Mechanics of Metals, Composites, Welds, and Bolted Joints Application of LEFM, EPFM, and FMDM Theory, Kluwer Academic Publishers, 2001.
- Kenneth A. Macdonald: Fracture and fatigue of welded joints and structures, Woodhead Publishing Limited, 2011.
- Czoboly E., Havas I.: Fracture and fatigue of metals, BME University lecture notes, Budapest 2004.
- Gdoutos, E. E.: Fracture Mechanics: An Introduction. 3rd ed., Springer, Cham, 2020. ISBN: 978-3-030-35097-0. DOI: 10.1007/978-3-030-35098-7.
- Abdel Wahab, M. (ed.): Proceedings of the 10th International Conference on Fracture Fatigue and Wear: FFW 2022. Springer, Singapore, 2023. DOI: 10.1007/978-981-19-7808-1.

Date: December 27, 2025.
Prepared by: Tünde Kovács

Course title:
1.2.8 Analysis of damage processes in structural materials
Credit value: 6
Course coordinator and instructor: Tünde Kovács
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30

Methods, specific modes, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to introduce the forms of damage to structural materials and the kinetics of damage processes (wear, corrosion, aging, etc.). The effects of complex stresses under model and real operating conditions. Possibilities for modeling damage processes. Prediction of damage through material testing and in-situ inspection during operation. Course content: The course provides an overview of the forms of damage, their manifestations, detection methods, and the material structural causes of damage initiation. Possibilities for preventing damage, surface treatment and heat treatment technologies for structural materials. Causes of the onset of damage processes, methods for determining the kinetic function of damage, and modeling.

List of the 2-5 most important required readings with bibliographic data:
Ginsztler J.; Dévényi L.: Applied Materials Science.
Corrosion: Fundamentals, Testing, and Protection. ASM Handbook, Vol. 13A. ASM International, Materials Park, OH, 2003.
Bhushan, B.: Introduction to Tribology. 2nd ed., John Wiley & Sons, Chichester, 2013.
Wang, X.; Zhao, W.; Shi, T.; Cheng, L.; Hu, S.; Zhou, C.; Cui, L.; Li, N.; Liaw, P. K.: A Review on Tribological Wear and Corrosion Resistance of Surface Coatings on Steel Substrates. Coatings, 15(11) (2025) 1314. DOI: 10.3390/coatings15111314.
Souza, M. D. P.; et al.: Carbon steel corrosion monitoring: Why opting for an electroanalytical instead of a physicochemical method? Journal of Electroanalytical Chemistry, 991 (2025) 119982.

List of the 2-5 most important recommended references with bibliographic data:
Totten, G. E.; Liang, H.: Surface Modification and Mechanisms: Friction, Stress, and Reaction Engineering. CRC Press, Boca Raton.
Totten, G. E. (ed.): Steel Heat Treatment Handbook. Marcel Dekker, New York, 2004.
Mardanshahi, A.; et al.: Sensing Techniques for Structural Health Monitoring: A Systematic Review. Sensors, 25(5) (2025) 1424.
Non-destructive techniques for corrosion detection: A review. Corrosion Engineering, Science and Technology (2024). DOI: 10.1177/1478422X241229621.
Sun, K.; et al.: Research Progress on the Corrosion Mechanism and Protection Strategies for Fe and Al and Their Alloys in Power Systems. Coatings, 15(2) (2025) 119.
Date: December 18, 2025.
Prepared by: Tünde Kovács

Course title:
1.2.9 Finite Element Modeling of Materials Technologies
Credit value: 6
Course coordinator and instructor: Viktor Gonda
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4

Prerequisites (if any): none

Course description:
In the design of mechanical technologies, finite element analysis greatly facilitates the determination of shape changes, stress distribution, temperature distribution, and technological data in the case of complex geometries. Using the MARC finite element system, we solve mechanical-plastic, thermal, and coupled thermal-mechanical problems with practical applications in mind. After completing the course, students should be able to create a simplified mechanical and thermal model of a simple materials technology problem (forming, heat treatment), formulate it in a finite element program, run the task, and evaluate the results. The MARC work environment, solving flexible finite element problems. Plastic parameters: flow conditions, material model settings. Finite element analysis of basic tasks of compression and flow. Solving sheet metal forming tasks. Methods of specifying thermal models. Building and running coupled thermal-mechanical models. Mesh refinement, setting up automatic remeshing. Importing geometric models from design programs, setting up, running, and evaluating finite element mechanical problems. Automating finite element analysis with macros.
The 2-5 most important required readings:
- Pidaparti, R. M.: Engineering Finite Element Analysis. Springer, Cham, 2022. DOI: 10.1007/978-3-031-79570-1.
- Lyu, Y.: Finite Element Method: Element Solutions. Springer, Singapore, 2022. DOI: 10.1007/978-981-19-3363-9.
- Henry S. Valberg: Applied metal forming, Cambridge University Press, 2010.

The 2-5 most important recommended references:
- Henry S. Valberg: Applied metal forming, Cambridge University Press, 2010.
- Pidaparti, R. M.: Engineering Finite Element Analysis. Springer, Cham, 2022. DOI: 10.1007/978-3-031-79570-1.
- Lyu, Y.: Finite Element Method: Element Solutions. Springer, Singapore, 2022. DOI: 10.1007/978-981-19-3363-9.

Date: February 17, 2026.
Prepared by: Viktor Gonda

Course title:
1.2.10 Measurement of Bioelectrical Activities
Credit value: 6
Course coordinator and instructor: Gergely Márton
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of electrochemistry

Course description:
Course objective: To familiarize students with the sources of electrical potential differences generated by living organisms and the essential properties of microelectrodes used to measure them. Course content: Sources of bioelectrical potential differences and their relationship to Maxwell's equations. Volume conduction. The basic principles of extracellular, juxtacellular, and intracellular measurements. The material and structure of microelectrodes used in practice. The significance and impedance of electrode-electrolyte interfaces. Modern methods of impedance reduction. Noise sources, the effect of surfaces on the signal-

to-noise ratio. Corrosion of electrodes in living tissue. The effects of foreign body reactions caused by tissue, experiments with novel electrode materials to mitigate tissue reactions.

List of the 2-5 most important required readings with bibliographic data:
- Ramesh Srinivasan: Anatomical constraints on source models for high-resolution EEG and MEG derived from MRI (Technol Cancer Res Treat. 2006 Aug; 5(4): 389–399.)
- Pouria Fattahi, Guang Yang, Gloria Kim, Mohammad Reza Abidian: A Review of Organic and Inorganic Biomaterials for Neural Interfaces (Adv Mater. 2014 Mar 26; 26(12): 1846–1885.)
- In Vivo Microelectrode Arrays for Neuroscience. Nature Reviews Methods Primers, 2025.
- Kim, D.; et al.: Recent Advances in Microelectrode Array Interfaces for Electrophysiological Study of Neural Tissues. Bioengineering, 11(2) (2026) 142.

List of 2-5 most important recommended references with bibliographic data:
- Pour Aryan, Naser, Kaim, Hans, Rothermel, Albrecht: Stimulation and Recording Electrodes for Neural Prostheses (2015, book).
- Amelia A. Schendel, Kevin W. Eliceiri, Justin C. Williams: Advanced Materials for Neural Surface Electrodes. Curr Opin Solid State Mater Sci. 2014 Dec 1; 18(6): 301–307.
- Gergely Márton: Development and Characterization of novel microelectrode arrays for neurophysiology (Ph.D. dissertation, 2015)
- Siwakoti, U.; et al.: Recent Progress in Flexible Microelectrode Arrays for Bioelectrical Recordings. Biosensors, 15(2) (2025) 100.
- Schröter, M.; et al.: Advances in Large-Scale Electrophysiology with High-Density Microelectrode Arrays. Lab on a Chip, 2025.

Date: January 29, 2026.
Prepared by: Gergely Márton

Course title:
1.2.11 Optical Characterization of Thin Films
Credit value: 6
Course coordinator and instructor: Péter Petrik
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the subject in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of physics

Course description:
Course objective: To learn the mathematical description of polarized light, to become familiar with measurement methods based primarily on the measurement of light polarization and the interpretation of measured quantities, and to learn about light-matter interaction and the investigation of material properties based on this. Course content: Optics of polarized light; propagation, refraction, and reflection of light at interfaces and in layer systems; theory of ellipsometry, measurement principle, operating principle of measuring devices; optical modeling of nanostructures; separation of thin films; measurement setups for the examination of thin films; determination of the refractive index and structure of nanolayers

List of 2-5 most important required readings with bibliographic data:
- Azzam Bashara: Ellipsometry and polarized light
- Ma, L.; et al.: A Review of Measurement and Characterization of Film Layers by Spectroscopic Ellipsometry. Nanomaterials, 15(4) (2025) 282.

- Park, J.; et al.: Spectroscopic Ellipsometry Utilizing Frequency Division Multiplexing for Fast Optical Metrology. Communications Physics, 2024.

List of 2-5 most important recommended references with bibliographic data:
- E. Irene, H. Tompkins: Handbook of Ellipsometry
- M. Losurdo, K. Hingerl: Ellipsometry at the nanoscale
- Losurdo, M.; Hingerl, K. (eds.): Ellipsometry at the Nanoscale. Springer, Berlin, 2013.
- Aulika, I.; et al.: Comprehensive Optical Characterization of Organic Thin Films by Spectroscopic Ellipsometry. Journal of Materials Research and Technology, 2025.

Date: February 14, 2026.
Prepared by: Péter Petrik

Course title:
1.2.12 Structural analysis of different materials using transmission electron microscopy
Credit value: 6
Course coordinator and instructor: Katalin Balázsi
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): basic knowledge of physics

Course description:
Understanding modern electron beam instruments used for the analysis of solid materials, with particular emphasis on transmission electron microscopy (TEM). Use of TEM in the study of various materials, such as thin films, powders, ceramics, or metals; learning about all the possibilities of the method (bright or dark field imaging, TEM scanning mode, electron diffraction); the CM-20 transmission electron microscope with 200 kV accelerating voltage; the high-resolution TEM Jeol 3010 with EELS capability and the innovative Cs-corrected TEM/STEM Themis 4 microscope equipped with an EDS detector. Two different methods of preparing TEM samples and lamellae using SEM/FIB and ion bombardment techniques.

The 2-5 most important required readings:
- Sun, L.; Xu, T.; Zhang, Z. (eds.): In-Situ Transmission Electron Microscopy. Springer, Singapore, 2023. DOI: 10.1007/978-981-19-6845-7.
- Transmission Electron Microscopy (TEM). In: Encyclopedia entry, 2025. Springer reference work entry on TEM applications and principles.

The 2-5 most important recommended literature:
- Sun, L.; Xu, T.; Zhang, Z. (eds.): In-Situ Transmission Electron Microscopy. Springer, Singapore, 2023. DOI: 10.1007/978-981-19-6845-7.
- Transmission Electron Microscopy (TEM). In: Encyclopedia entry, 2025. Springer reference work entry on TEM applications and principles.

Date: February 2, 2026.
Prepared by: Katalin Balázsi

Course title:
1.2.13 Numerical methods for evaluating optical measurements
Credit value: 6

Course coordinator and instructor: Péter Petrik
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the subject in the curriculum (which semester): can be taken in semesters 1-4
Prerequisites (if any): physics

Course description:
To familiarize students with methods of describing light and light-matter interactions. To learn how to use programming and numerical methods related to the topic. Description of light polarization and propagation; Reflection and transmission of light at interfaces and in thin films; Software for evaluating optical measurements; Programming languages that can be used to analyze optical measurements; Modeling of homogeneous materials and interfaces; Optical methods suitable for examining surfaces and thin films; Thin film fabrication processes; Modeling of refractive index dispersion of materials; Fitting and minimizing multi-parameter models; Performance analysis of numerical methods

The 2-5 most important required readings:
- Riedling, K.: Ellipsometry for Industrial Applications. Springer, Vienna, 2024. DOI: 10.1007/978-3-7091-8961-0.
- Maliska, C. R.: Fundamentals of Computational Fluid Dynamics. Springer, Cham, 2023. DOI: 10.1007/978-3-031-18235-8.
- H.G. Tompkins, J.N. Hilfiker, Spectroscopic ellipsometry: practical application to thin film characterization, Momentum Press, New York, NY, 2016.
- P. Petrik, Parameterization of the dielectric function of semiconductor nanocrystals, Physica B: Condensed Matter. 453 (2014) 2–7. https://doi.org/10.1016/j.physb.2014.03.065.

The 2-5 most important recommended references:
- H.G. Tompkins, J.N. Hilfiker, Spectroscopic ellipsometry: practical application to thin film characterization, Momentum Press, New York, NY, 2016.
- P. Petrik, Parameterization of the dielectric function of semiconductor nanocrystals, Physica B: Condensed Matter. 453 (2014) 2–7. https://doi.org/10.1016/j.physb.2014.03.065.
- Poole Jr, C. P., & Owens, F. J. (2003). Introduction to nanotechnology. John Wiley & Sons.
- Riedling, K.: Ellipsometry for Industrial Applications. Springer, Vienna, 2024. DOI: 10.1007/978-3-7091-8961-0.
- Maliska, C. R.: Fundamentals of Computational Fluid Dynamics. Springer, Cham, 2023. DOI: 10.1007/978-3-031-18235-8.

Date: December 14, 2025.
Prepared by: Péter Petrik

Course title:
1.2.14 Modern surface inspections
Credit value: 6
Course coordinator and instructor: Mária Marosné Berkes
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium

Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
The aim of the course is to familiarize students with modern material testing methods that can be used to characterize the physical, mechanical, tribological, material structure and topographical properties of the surfaces and surface layers of engineering structures, with particular emphasis on improving the performance of surfaces exposed to tribological stress. The purpose of surface testing, measurement methods, and areas of application. Theoretical and experimental investigation of damage to gradient and heterogeneous surfaces, complex tribological characterization of surface layers and coatings. Surface physics aspects of tribological damage (atomic approach to surface tension, adhesion, friction, and wear). Methods and tools for surface geometry testing (testing of 2D and 3D roughness parameters). Micro- and nano-level characterization of surface mechanical properties (micro- and nano-scratches, micro- and nano-hardness, micro- and nanotribological testing, Calotest). Examination of the microstructure of surface layers and coatings at different levels of scale (optical microscopy, SEM, TEM, AFM, XRD, EDX, Raman spectroscopy, etc.). Applications in engineering practice (examination of thin films, diffusion and coating layers, micro- and nanocomposites, MEMS/NEMS devices, magnetic storage systems, etc.).

The 2-5 most important required readings:
- Ortiz Ortega, E.; Hosseinian, H.; Aguilar Meza, I. B.; Rosales López, M. J.; Rodríguez Vera, A.; Hosseini, S.: Material Characterization Techniques and Applications. Springer, Singapore, 2022. DOI: 10.1007/978-981-16-9569-8.
- Pakseresht, A.; Sharifahmadian, O. (eds.): Handbook of Research on Tribology in Coatings and Surface Treatment. IGI Global, 2022. ISBN13: 9781799896838. DOI: 10.4018/978-1-7998-9683-8.
- B. BHUSHAN: Modern Tribology Handbook, Volume One, CRC Press, ISBN0-8493-8403-6, 2001. p1760
- O'CONNOR, D. J., SEXTON, B. A.: Surface Analysis Methods in Materials Science, Springer, 2003. pp1-585

The 2-5 most important recommended references:
- B. BHUSHAN: Modern Tribology Handbook, Volume One, CRC Press, ISBN0-8493-8403-6, 2001. p1760
- O'CONNOR, D. J., SEXTON, B. A.: Surface Analysis Methods in Materials Science, Springer, 2003. pp1-585
- VALASEK, I.: Tribology 1 – Fundamentals of Tribology, Tribotechnik Kft. Budapest, ISBN 963 00 8688 3; 2002.
- Ortiz Ortega, E.; Hosseinian, H.; Aguilar Meza, I. B.; Rosales López, M. J.; Rodríguez Vera, A.; Hosseini, S.: Material Characterization Techniques and Applications. Springer, Singapore, 2022. DOI: 10.1007/978-981-16-9569-8.
- Pakseresht, A.; Sharifahmadian, O. (eds.): Handbook of Research on Tribology in Coatings and Surface Treatment. IGI Global, 2022. ISBN13: 9781799896838. DOI: 10.4018/978-1-7998-9683-8.

Date: December 13, 2025.
Prepared by: Marosné Berkes Mária

Course title:
1.2.15 Application of thermal and fluid dynamics modeling and numerical simulation in materials technologies
Credit value: 6
Course coordinator and instructor: András Zachár
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of lesson: ea/consultation, total number of hours: 30
Methods, (specific) modes, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case presentation, case study, literature review, project work, study preparation

Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (semester): can be taken in semesters 1-4
Prerequisites (if any): Thorough knowledge of mathematics, physics, fluid mechanics, and thermodynamics taught in the field of engineering.

Course description:
Presentation of basic knowledge that will enable students to effectively apply numerical fluid mechanics tools in the fields of materials science and materials technology. Lecture (theoretical): Students will learn the basics of the theoretical background of modern numerical fluid mechanics simulation software. Finite volume method (FVM), discretization of various terms in transport equations. Problems of numerical stability, Courant-Forsyth-Laplace condition (CFL cond.), various discretization methods for convection terms, numerical diffusion (UpWind, QUCIK). Linear solvers (Solvers) direct and iterative methods, important iterative methods (Gauss-Seidel, gradient methods, multigrid methods), advantages, disadvantages, connection to the use of practical software (CFX). Practical (computer lab practice) During the practicals, students will become familiar with the Ansys-CFX numerical fluid dynamics software, which can be used to examine complex thermal and fluid dynamics problems. Students learn how to import and process the geometry of the problem to be investigated, generate an efficiently applicable numerical grid, and perform the steps involved in setting various initial and boundary conditions ( ). Students evaluate the results (post-process) for each sample task.

The 2-5 most important required readings:
- Maliska, C. R.: Fundamentals of Computational Fluid Dynamics. Springer, Cham, 2023. DOI: 10.1007/978-3-031-18235-8.
- Pidaparti, R. M.: Engineering Finite Element Analysis. Springer, Cham, 2022. DOI: 10.1007/978-3-031-79570-1.
- Stoyan Gisbert, Numerical Mathematics for Engineers and Programmers, Typotex, Budapest, 2007.
- Stoyan Gisbert, Takó Galina, Numerical Methods 3, Typotex, Budapest, 1997.

The 2-5 most important recommended references:
- H. K. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics, The Finite Volume Method, Pearson Prentice Hall, London, New York, 2007.
- Maliska, C. R.: Fundamentals of Computational Fluid Dynamics. Springer, Cham, 2023. DOI: 10.1007/978-3-031-18235-8.
- Pidaparti, R. M.: Engineering Finite Element Analysis. Springer, Cham, 2022. DOI: 10.1007/978-3-031-79570-1.

Date: December 21, 2025.
Prepared by: András Zachár

Course title:
1.2.16 Physical testing of textile clothing materials
Credit value: 6
Course coordinator and instructor: Mariann Halász
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, (specific) modes and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment (coll. / gyj. / other): colloquium
Additional (specific) methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum (semester): can be taken in semesters 1-4
Prerequisites (if any): none

Course description:
In this course, doctoral students will learn about methods for testing the physical properties of textiles and textile clothing materials. Methods for testing the physical properties of textiles and textile clothing materials using modern electronics, computer technology, and imaging techniques: water content, properties related to water, heat, and air exposure, shape and geometric properties, color and brightness, strength (tensile, compressive, bending, shearing, composite, multidirectional tests), resistance to creasing, friction, adhesion, abrasion resistance and tendency to pill, electrical properties, resistance to aging and aging, resistance to biological pests, familiarization with testing standards.

The 2-5 most important required readings:
- Liu, S.; Zhang, W.; He, J.; Lu, Y.; Wu, Q.; Xing, M.: Fabrication Techniques and Sensing Mechanisms of Textile-Based Strain Sensors: From Spatial 1D and 2D Perspectives. Advanced Fiber Materials, 6 (2024). DOI: 10.1007/s42765-023-00338-9.
- Yun, E.; Yun, C.: Development of a test method for the dynamic drapability of fabrics using reciprocating motion. Fashion and Textiles, 10 (2023) 35. DOI: 10.1186/s40691-023-00355-7.
- Gyimesi János: Physical testing of textile materials. Technical Book Publishing House, 1968
- Saville B.P.: Physical Testing of Textiles. Woodhead Publishing, 1999

The 2-5 most important recommended references:
- János Gyimesi: Physical Testing of Textiles. Technical Book Publishing House, 1968
- Saville B.P.: Physical Testing of Textiles. Woodhead Publishing, 1999
- Liu, S.; Zhang, W.; He, J.; Lu, Y.; Wu, Q.; Xing, M.: Fabrication Techniques and Sensing Mechanisms of Textile-Based Strain Sensors: From Spatial 1D and 2D Perspectives. Advanced Fiber Materials, 6 (2024). DOI: 10.1007/s42765-023-00338-9.
- Yun, E.; Yun, C.: Development of a test method for the dynamic drapability of fabrics using reciprocating motion. Fashion and Textiles, 10 (2023) 35. DOI: 10.1186/s40691-023-00355-7.

Date: January 6, 2026.
Prepared by: Mariann Halász

1.3 Research methodology

Course title:
1.3.1 Experiment design and evaluation
Credit value: 6
Course coordinator and instructor: Ágota Drégelyi-Kiss
Classification of the course: foundation course
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to introduce the mathematical and statistical basis of experimental design and the evaluation of results using multivariate methods. Course content: basic probability theory and statistical concepts; one-sample and two-sample t-tests, Levene's test, ANOVA; full factorial two-level and three-level designs; partial factorial designs and screening designs; response surface method for taking quadratic effects into account; robust design and Taguchi experimental design.

List of 2-5 most important required readings with bibliographic data:

- Kemény S.; Deák A.; Lakné Komka K.; Kunovszki P.: Design and Evaluation of Experiments. Typotex Publishing, Budapest, 2017.
- Montgomery, D. C.: Design and Analysis of Experiments. 9th ed., John Wiley & Sons, Hoboken, 2017.
- Drégelyi-Kiss, Á.: Application of Experimental Design-Based Predictive Models and Optimization in Additive Manufacturing – a Review. Hungarian Journal of Industry and Chemistry, 52(1) (2024). https://doi.org/10.33927/hjic-2024-08
- Hisam, M.W.; Dar, A.A.; Elrasheed, M.O. et al.: The Versatility of the Taguchi Method: Optimizing Experiments Across Diverse Disciplines. Journal of Statistical Theory and Applications, 23 (2024) 365–389. https://doi.org/10.1007/s44199-024-00093-9

List of the 2-5 most important recommended references with bibliographic data:
- Myers, R. H.; Montgomery, D. C.; Anderson-Cook, C. M.: Response Surface Methodology: Process and Product Optimization Using Designed Experiments. 4th ed., John Wiley & Sons, Hoboken, 2016.
- Taguchi, G.; Chowdhury, S.; Wu, Y.: Taguchi's Quality Engineering Handbook. John Wiley & Sons, Hoboken, 2005.
- Chen, H.-Y.: A Study of the Response Surface Methodology Model with Regression Analysis in Three Fields of Engineering. Methods and Protocols, 8(4) (2025) 99.
- Drégelyi-Kiss, Á.: Application of Experimental Design-Based Predictive Models and Optimization in Additive Manufacturing – a Review. Hungarian Journal of Industry and Chemistry, 52(1) (2024). https://doi.org/10.33927/hjic-2024-08

Date: December 18, 2025.
Prepared by: Drégelyi-Kiss Ágota

Course title:
1.3.2 Statistical hypothesis testing
Credit value: 6
Course coordinator and instructor: Márta Takács
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to introduce the basic principles and practical application of statistical hypothesis testing used in engineering applications. Course content: overview of event algebra and the basics of probability theory; basic statistical concepts; correlation and regression analysis; general decision theory theorems; basic principles of statistical decisions; point and interval estimation; hypothesis testing; nonparametric tests; comparison of variances; tests for the mean; software background and use of the MATLAB toolbox; hypothesis testing and decision making in engineering systems.

List of 2-5 most important required readings with bibliographic data:
- Fay, M. P.; Brittain, E. H.: Statistical Hypothesis Testing in Context: Reproducibility, Inference, and Science. Cambridge University Press, Cambridge, 2022. https://doi.org/10.1017/9781108528825
- Rigdon, S. E.; Fricker, R. D.; Montgomery, D. C.: Introduction to Probability and Statistics for Data Science with R. Cambridge University Press, Cambridge, 2025. https://doi.org/10.1017/9781316286166
- Sayed, A. H.: Inference and Learning from Data. Volume 1: Foundations. Cambridge University Press, Cambridge, 2022.

- Shreffler, J.; Huecker, M. R.: Hypothesis Testing, P Values, Confidence Intervals, and Significance. In: StatPearls [Internet]. StatPearls Publishing, Treasure Island (FL), 2023/2025.

List of the 2-5 most important recommended references with bibliographic data:
- Fay, M. P.; Brittain, E. H.: Statistical Hypothesis Testing in Context: Reproducibility, Inference, and Science. Cambridge University Press, Cambridge, 2022. https://doi.org/10.1017/9781108528825
- Rigdon, S. E.; Fricker, R. D.; Montgomery, D. C.: Introduction to Probability and Statistics for Data Science with R. Cambridge University Press, Cambridge, 2025. https://doi.org/10.1017/9781316286166
- Kiers, H. A. L.; Tendeiro, J. N.: Bridging Null Hypothesis Testing and Estimation: A Practical Guide to Statistical Conclusion Drawing From Research in Psychology. Advances in Methods and Practices in Psychological Science, 8(3) (2025). https://doi.org/10.1177/25152459251365960
- Shreffler, J.; Huecker, M. R.: Hypothesis Testing, P Values, Confidence Intervals, and Significance. In: StatPearls [Internet]. StatPearls Publishing, Treasure Island (FL), 2023/2025.

Date: January 7, 2026.
Prepared by: Márta Takács

Course title:
1.3.3 Engineering Education
Credit value: 6
Course coordinator and instructor: Péter Tóth
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to prepare doctoral students for teaching and developing technical subjects, including materials science and technology, as well as interpreting and disseminating their research results. Course content: the transformation of the higher education system and technical training; the pedagogical consequences of rapidly changing curriculum content and student heterogeneity; planning and organizing the educational process; psychological and sociological aspects of education; inductive and deductive methods of teaching material processing; preparation for lectures; presentation and teacher communication; the specifics of practical classes; planning and implementation of laboratory work; modern educational technology tools; pedagogical research in higher education; interpretation of research results.

List of 2-5 most important required readings with bibliographic data:
- Srinivasa, K. G.; Kurni, M.; Saritha, K.: Learning, Teaching, and Assessment Methods for Contemporary Learners: Pedagogy for the Digital Generation. Springer Singapore, 2022. https://doi.org/10.1007/978-981-19-6734-4
- Auer, M. E.; Rüütmann, T. (eds.): Futureproofing Engineering Education for Global Responsibility: Proceedings of the 27th International Conference on Interactive Collaborative Learning (ICL2024), Volume 4. Springer Cham, 2025. https://doi.org/10.1007/978-3-031-83520-9
- Mishra, A.; Singh, S. S.: Smart Pedagogical Learning and Assessment Methodologies—Outcome Based Education: A Novel Quality Assurance Framework with Attainment Computation for Indian Engineering Higher Education Programs. Journal of Computers in Education, 12 (2025) 1231–1282. https://doi.org/10.1007/s40692-024-00344-9

- Mangalore, P.; Gamit, J. S.; Kanchan, M.: Developing a Framework for Sustainable Engineering Education Through Transformative Learning Principles. Discover Sustainability, 6 (2025) 1473. https://doi.org/10.1007/s43621-025-02146-0

List of the 2-5 most important recommended references with bibliographic data:
- Srinivasa, K. G.; Kurni, M.; Saritha, K.: Learning, Teaching, and Assessment Methods for Contemporary Learners: Pedagogy for the Digital Generation. Springer Singapore, 2022. https://doi.org/10.1007/978-981-19-6734-4
- Sanz-Angulo, P.; Galindo-Melero, J.; De-Diego-Poncela, S. et al.: Promoting Soft Skills in Higher Engineering Education: Assessment of the Impact of a Teaching Methodology Based on Flipped Learning, Cooperative Work and Gamification. Education and Information Technologies (2025). https://doi.org/10.1007/s10639-025-13322-0
- Mishra, A.; Singh, S. S.: Smart Pedagogical Learning and Assessment Methodologies—Outcome Based Education: A Novel Quality Assurance Framework with Attainment Computation for Indian Engineering Higher Education Programs. Journal of Computers in Education, 12 (2025) 1231–1282. https://doi.org/10.1007/s40692-024-00344-9
- Auer, M. E.; Rüütmann, T. (eds.): Futureproofing Engineering Education for Global Responsibility: Proceedings of the 27th International Conference on Interactive Collaborative Learning (ICL2024), Volume 4. Springer Cham, 2025. https://doi.org/10.1007/978-3-031-83520-9

Date: January 24, 2026.
Prepared by: Péter Tóth

Course title:
1.3.4 Writing and publishing scientific works
Credit value: 6
Course coordinator and instructor: Tünde Kovács
Classification of the subject: foundation subject
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to assist students in writing and publishing scientific papers. Course content: general advice on writing high-quality scientific articles; timing and language of writing; choosing a good title; content requirements for each section – abstract, introduction, experimental results, summary, conclusions, and additional information; issues of co-authorship and acknowledgements; selecting the appropriate journal; responding to reviewers' comments; types of scientific publications, formal and content requirements; the process of publishing one's own research results or literature reviews.

List of 2-5 most important required readings with bibliographic data:
- Mack, C. A.: How to Write a Good Scientific Paper. SPIE Press, Bellingham, 2018. ISBN 9781510619135.
- Day, R. A.; Gastel, B.: How to Write and Publish a Scientific Paper. 8th ed., Cambridge University Press, Cambridge, 2022.
- Thomas, C. G.: Research Methodology and Scientific Writing. 2nd ed., Springer Cham, 2021. https://doi.org/10.1007/978-3-030-64865-7
- Luby, S.; Southern, D. L.: The Pathway to Publishing: A Guide to Quantitative Writing in the Health Sciences. Springer Cham, 2022. https://doi.org/10.1007/978-3-030-98175-4

- Wirth, F.; Cadogan, C. A.; Fialová, D. et al.: Writing a Manuscript for Publication in a Peer-Reviewed Scientific Journal: Guidance from the European Society of Clinical Pharmacy. International Journal of Clinical Pharmacy, 46 (2024) 548–554. https://doi.org/10.1007/s11096-023-01695-6

List of the 2–5 most important recommended references with bibliographic data:

- Scholz, F.: Writing and Publishing a Scientific Paper. ChemTexts, 8 (2022) 8. https://doi.org/10.1007/s40828-022-00160-7
- Thomas, C. G.: Research Methodology and Scientific Writing. 2nd ed., Springer Cham, 2021. https://doi.org/10.1007/978-3-030-64865-7
- Luby, S.; Southern, D. L.: The Pathway to Publishing: A Guide to Quantitative Writing in the Health Sciences. Springer Cham, 2022. https://doi.org/10.1007/978-3-030-98175-4
- Ebrahim, S. H.: Scientific Writing—an Editor's Memo to Emerging Authors-1. Journal of Epidemiology and Global Health, 15 (2025) 128. https://doi.org/10.1007/s44197-025-00476-w
- Wirth, F.; Cadogan, C. A.; Fialová, D. et al.: Writing a Manuscript for Publication in a Peer-Reviewed Scientific Journal: Guidance from the European Society of Clinical Pharmacy. International Journal of Clinical Pharmacy, 46 (2024) 548–554. https://doi.org/10.1007/s11096-023-01695-6

Date: February 18, 2026.
Prepared by: Tünde Kovács

2. Optional subjects in materials science

2.1 Polymers

Course title:
2.1.1 Chemistry and Physics of Polymers
Credit value: 6
Course coordinator and instructor: Sándor Pekker
Course classification: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Aim of the course: To learn about the formation and structure of polymers and the physical and chemical properties of various macromolecular systems. Course content: Introduction. The formation of polymers. Polymerization. The mechanism of radical and living polymerization, the distribution function of the degree of polymerization. Polycondensation, polyaddition. Methods for determining the degree of polymerization. The structure of polymers. Constitution, homopolymers, copolymers. Linear and branched polymers. Dendrimers. Hyperbranched polymers and the formation of networks, percolation models. Configuration. Cis-trans isomerism, optical isomerism, tacticity. Classification of polymers based on constitution and configuration. Conformation. Methods of conformation analysis. Conformations of simple chains, the three-state approximation. Cooperativity, ordered structures, polymer helices. Glass transition. Statistical description of the ideal polymer coil. Thermodynamic basis of rubber elasticity. Elasticity of the ideal coil. Macromolecular systems. Ideal and real solutions, theta state. Phase diagram of polymer solutions, blob model. Polymer blends, self-organizing structures in copolymers. Polymer gels and networks. Crystalline

polymers. Non-classical polymers: supramolecular systems, coordination polymers, metal-organic networks

List of the 2-5 most important required readings with bibliographic data:
- Sándor Pekker: own notes.
- Gedde, U. W.; Hedenqvist, M. S.; Ifwarson, M.; Gedde, C.: Applied Polymer Science. Springer, Cham, 2021. DOI: 10.1007/978-3-030-68472-3.
- Ricarte, R. G.; Burns, A. B.; McKenna, G. B.; Sumerlin, B. S.: A tutorial review of linear rheology for polymer chemists: basics and best practices for covalent adaptable networks. Polymer Chemistry, 15 (2024). DOI: 10.1039/D3PY01367G.

List of the 2-5 most important recommended references with bibliographic data:
- Pekker Sándor: personal notes.
- Gedde, U. W.; Hedenqvist, M. S.; Ifwarson, M.; Gedde, C.: Applied Polymer Science. Springer, Cham, 2021. DOI: 10.1007/978-3-030-68472-3.
- Ricarte, R. G.; Burns, A. B.; McKenna, G. B.; Sumerlin, B. S.: A tutorial review of linear rheology for polymer chemists: basics and best practices for covalent adaptable networks. Polymer Chemistry, 15 (2024). DOI: 10.1039/D3PY01367G.

Date: December 14, 2025.
Prepared by: Sándor Pekker

Course title:
2.1.2 Physics of macromolecules
Credit value: 6
Course coordinator and instructor: Károly Belina
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: chemistry of macromolecules, physical chemistry

Course description:
Course objective: The course deals with the relationship between the structure and properties of macromolecular materials. Students will learn about the molecular characteristics that determine the special properties of polymer materials and the relationship between macroscopic properties and molecular characteristics. Course content: Characterization of individual macromolecules. Intermolecular interactions in macromolecular systems, CED. Multicomponent polymer systems: solutions, mixtures. Molecular motion in polymers. Physical states and characteristics of polymers. Energy and entropy elastic deformation. Temperature-time equivalence principle. Highly elastic, glassy, and viscous physical states. Characteristics of the crystalline state of macromolecular materials. Morphology of crystalline polymers. Crystallization kinetics. Characteristics of the melting of crystalline polymers. Time-dependent properties of polymers. Optical properties of polymers.

List of 2-5 most important required readings with bibliographic data:
- Billmeyer, F. W. Jr.: Textbook of Polymer Science. 3rd ed., Interscience, New York, 1984.
- Rubinstein, M.; Colby, R. H.: Polymer Physics. Oxford University Press, Oxford, 2003. ISBN: 9780198520597.

- Ricarte, R. G.; Burns, A. B.; McKenna, G. B.; Sumerlin, B. S.: A tutorial review of linear rheology for polymer chemists: basics and best practices for covalent adaptable networks. Polymer Chemistry, 15 (2024). DOI: 10.1039/D3PY01367G.

List of the 2-5 most important recommended references with bibliographic data:
- Manson, J. A.; Sperling, L. H.: Polymer Blends and Composites. Plenum Press, New York, 1976.
- Treloar, L. R. G.: The Physics of Rubber Elasticity. 3rd ed., Clarendon Press, Oxford, 1975.
- Wunderlich, B.: Macromolecular Physics. Vol. I-III. Academic Press, Orlando, 1973.
- Rubinstein, M.; Colby, R. H.: Polymer Physics. Oxford University Press, Oxford, 2003. ISBN: 9780198520597.

Date: December 22, 2025.
Prepared by: Károly Belina

Course title:
2.1.3 Characterization and modification of polymer surfaces
Credit value: 6
Course coordinator and instructor: Éva Kiss
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To describe the surface/interface interactions characteristic of polymer materials and the surface modification processes that influence them Course content: Physical-chemical interactions between the components of a solid surface and a liquid medium. Interface phenomena in polymer-containing material systems. The laws governing wetting and adsorption, models used to describe the kinetics of the phenomenon and process. Surface analysis methods for determining chemical composition: modern, surface-sensitive techniques (ESCA, SIMS, FT-IR), high-performance imaging methods (e.g., AFM). Direct and indirect methods suitable for studying interfacial interactions: wetting, direct force measurement, particle adhesion, colloidal stability, macromolecule adsorption, self-assembling systems, formation of Langmuir-Blodgett films. Surface modification of polymers by chemical "wet" processes and plasma treatment.

List of the 2-5 most important required readings with bibliographic data:
- D.J.Shaw: Introduction to Colloid and Surface Chemistry, Műszaki Könyvkiadó, Budapest, 1986.
- J. Andrade: Surface and Interfacial Aspects of Biomedical Materials, Plenum Press, N.Y. 1985.
- Primc, G.; Mozetič, M.: Surface Modification of Polymers by Plasma Treatment for Appropriate Adhesion of Coatings. Materials, 17(7) (2024) 1494. DOI: 10.3390/ma17071494.
- Xiang, Y.; et al.: Characterization of Surface Modifications in Oxygen Plasma Treated Polymer Films. Langmuir, 40 (2024).

List of the 2-5 most important recommended references with bibliographic data:
- F. McRitchie: ChemistryatInterfaces, Acad. Press, London, 1990.
- Kiss Éva: Cardiovascular Materials, pp.260-277 Technical Surface Science and Its Applications in Medicine and Biology (Sz. Bertóti I., Marosi Gy. Tóth A.) B+V Lap és Könyvkiadó Kft. 2003.
- Nakulan, A.; et al.: Surface Modification and Patterning of Polymer Thin Films by Plasma Glow Discharge. Materials Today Communications, 2024.

- Primc, G.; Mozetič, M.: Surface Modification of Polymers by Plasma Treatment for Appropriate Adhesion of Coatings. Materials, 17(7) (2024) 1494. DOI: 10.3390/ma17071494.

Date: December 19, 2025.
Prepared by: Éva Kiss

Course title:
2.1.4 Cellulose Chemistry
Credit value: 6
Course coordinator and instructor: Judit Borsa
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of course : ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To introduce natural and natural-based artificial fibers as raw materials and basic materials for materials science research. Course content: Chemical and physical structure of cellulose, main characteristics of cellulose-based natural and artificial fibers (cotton, linen, hemp, viscose, Lyocell), cellulose as a raw material, the most important physical and chemical modification options: swelling in various activating agents, production of derivatives in polymer analog reactions, graft copolymerization, modification of surface characteristics with plasma, natural fiber-reinforced composites.

List of 2-5 most important required readings with bibliographic data:
- Lewin, M.; Pearce, E. M. (eds.): Handbook of Fiber Chemistry. 3rd ed., Marcel Dekker, New York, 2007.
- Klemm, D.; Philipp, B.; Heinze, T.; Heinze, U.; Wagenknecht, W.: Comprehensive Cellulose Chemistry. Wiley-VCH, Weinheim, 1998.
- Madhushree, M.; Chinnaswamy, T.; Baheti, V.: A Comprehensive Review of Cellulose and Cellulosic Materials, Their Sources, Preparation, and Applications. Journal of Macromolecular Science, Part A, 62(1) (2024). DOI: 10.1080/15440478.2024.2418357.
- Shen, D.; Yu, X.; et al.: Fibrillation in cellulose-based Lyocell: Chemical insights, challenges and future prospects. Carbohydrate Polymers, 2025. DOI: 10.1016/j.carbpol.2025.123928.

List of 2-5 most important recommended references with bibliographic data:
- Franck, R. R. (ed.): Bast and Other Plant Fibres. Woodhead Publishing, Cambridge, 2005.
- Woodings, C. (ed.): Regenerated Cellulose Fibers. Woodhead Publishing, Cambridge, 2001.
- Madhushree, M.; Chinnaswamy, T.; Baheti, V.: A Comprehensive Review of Cellulose and Cellulosic Materials, Their Sources, Preparation, and Applications. Journal of Macromolecular Science, Part A, 62(1) (2024). DOI: 10.1080/15440478.2024.2418357.

Date: January 11, 2026.
Prepared by: Judit Borsa

Course title:
2.1.5 Paper industry fibers and their surface characteristics
Credit value: 6
Course coordinator and instructor: László Koltai
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice

Type of class: ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course : The aim of the course is to familiarize doctoral students with the physical and colloid-chemical properties of the raw materials used in sheet-like fiber products and their effect on the mechanical properties of the sheets. Course content: Properties of fiber materials used in the paper industry. Structural composition of fibers. Colloid-chemical structure of cellulose fibers. Chemical and surface structure of cellulose fibers. The pore system of cellulose fibers. Binding energy of fibers. Characteristics of cellulose fibers in aqueous media. Interpretation of the surface of cellulose fibers. The concepts of surface area and specific surface area. Traditional methods of surface analysis. Surface analysis by particle adsorption. The significance of the specific surface area of fibers in terms of paper

List of the 2-5 most important required readings with bibliographic data:
- Koltai, L.: Surface characteristics of paper industry fibers. Óbuda University, teaching aid, 2010.
- Kaewprasit, C.; Hequet, E.; Abidi, N.; Gourlot, J. P.: Application of Methylene Blue Adsorption to Cotton Fiber Specific Surface Area Measurement Part I. Methodology. Journal of Cotton Science, 2 (1998) 164-173.
- Semple, K. E.; et al.: Moulded pulp fibers for disposable food packaging: A state-of-the-art review. Journal of Environmental Management, 317 (2022) 115331. DOI: 10.1016/j.jenvman.2022.115331.

List of the 2-5 most important recommended references with bibliographic data:
- Shaw, D. J.: Introduction to Colloid and Surface Chemistry. Műszaki Könyvkiadó, 1986.
- Szántó, F.: Fundamentals of Colloid Chemistry. Gondolat Publishing House, 1987.
- Annus, S.; Erdélyi, J.; Kóbor, L.; Szőke, A.; Térpál, S.: Paper Industry Lexicon. Papír-Press Association, 2003. pp. 69-70.
- Semple, K. E.; et al.: Moulded pulp fibers for disposable food packaging: A state-of-the-art review. Journal of Environmental Management, 317 (2022) 115331. DOI: 10.1016/j.jenvman.2022.115331.

Date: January 18, 2026.
Prepared by: László Koltai

Course title:
2.1.6 Cellulose and paper production
Credit value: 6
Course coordinator and instructor: László Koltai
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: to provide an overview of paper industry and fiber technology processes and materials. Course content: Structure and anatomy of wood/straw. Wood preparation. Wood chipping, storage. Straw

preparation, chopping. The main principles of cellulose production, cellulose production technology, its development and types. Mechanical cellulose production, wood pulp production. TMP/CTMP production. Theory and technology of sulfite cellulose production, preparation of cooking chemicals and use of by-products, chemical regeneration. Theory and technology of alkaline pulp production (sulphite). Alkaline regeneration and the use of by-products. Single- and multi-stage bleaching systems. Bleaching equipment. Environmental protection in the pulp industry. Pulp treatment (classification, compaction, packaging). Use of cellulose, paper-forming properties. Preparation and refining of raw materials. Grinding of fibrous materials, grinding theory, grinding equipment, grinding control. Classification and cleaning of fibrous materials, development of classification systems. Paper sizing, preparation of sizing materials, theory of sizing, sizing techn . Paper filling, theory of filling, conditions for the economical use of filling materials. Paper coloring, coloring techniques, optical brighteners. Waste processing technology, fiber separation, cleaning, deinking. Preparation and grinding of paper industry fiber materials. Sizing of fiber suspensions. Filling and coloring of fiber suspensions. Examination of retention agents.

List of 2-5 most important required readings with bibliographic data:
- Smook, G. A.: Handbook for Pulp and Paper Technologists. 4th ed., TAPPI Press, Peachtree Corners, 2016.
- Semple, K. E.; et al.: Moulded pulp fibers for disposable food packaging: A state-of-the-art review. Journal of Environmental Management, 317 (2022) 115331. DOI: 10.1016/j.jenvman.2022.115331.
- Pătrăucean-Patrașcu, C. I.; Dinu, M. V.; et al.: Chemical Transformations and Papermaking Potential of Recycled Fibres in Closed Water Circuits. Applied Sciences, 15(24) (2025) 13034. DOI: 10.3390/app152413034.

List of 2-5 most important recommended references with bibliographic data:
- Smook, G. A.: Handbook for Pulp and Paper Technologists. 4th ed., TAPPI Press, Peachtree Corners, 2016.
- Law, J. C. H.; Wade, K. G.; Parker, K. G.; Mutukumira, A. N.; Sloane, M.: Sustainable Paper-based Packaging from Hemp Hurd Fiber: A Potential Material for Thermoformed Molded Fiber Packaging. BioResources, 19(1) (2024) 1728-1743.
- Pătrăucean-Patrașcu, C. I.; Dinu, M. V.; et al.: Chemical Transformations and Papermaking Potential of Recycled Fibres in Closed Water Circuits. Applied Sciences, 15(24) (2025) 13034. DOI: 10.3390/app152413034.

Date: January 26, 2026.
Prepared by: László Koltai

Course title:
2.1.7 Mechanical and physical properties of paper and corrugated products
Credit value: 6
Course coordinator and instructor: László Koltai
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: The objective is to familiarize doctoral students with the types of sheet-like fiber products and corrugated products, their general physical and mechanical characteristics, and the methods used to measure them in practice. Course content: The significance and history of paper, cardboard, and corrugated

product manufacturing. Types and characteristics of paper and corrugated products. Classification of material tests in the paper industry. Mechanical tests of paper and factors influencing the tests. Physical tests of paper and factors influencing the tests. Mechanical tests of corrugated paperboard. Mechanical testing of boxes. The effect of the SCT values of base papers on the ECT value of the board. Reasons for the loss of SCT values. The effect of the square meter weight of the corrugated layer on the SCT value. The effect of the volume weight of the base paper on the SCT value. The effect of the porosity of base papers on the ECT value. The resistance of boxes to compressive force as a function of ECT. Designing the ECT value of the board according to the BCT value.

List of the most important required reading for 2-5 with bibliographic data:
- Markström, H.: Testing Methods and Instruments for Corrugated Board. Lorentzen and Wettre, Kista, 2005.
- Twede, D.; Selke, S. E. M.: Cartons, Crates and Corrugated Board: Handbook of Paper and Wood Packaging Technology. DEStech Publications, Lancaster, 2005.
- Fitas, R.; Dinis, M.; et al.: A Review of Optimization for Corrugated Boards. Sustainability, 15(21) (2023) 15588. DOI: 10.3390/su152115588.

List of the 2-5 most important recommended references with bibliographic data:
- Koltai, L.: Corrugated products and their testing. BMF, teaching aid, 2008.
- Kerekes, T.: Introduction to Packaging Technology I. Paper-Press Association, 2000. pp. 123-125.
- Fitas, R.; Dinis, M.; et al.: A Review of Optimization for Corrugated Boards. Sustainability, 15(21) (2023) 15588. DOI: 10.3390/su152115588.

Date: February 2, 2026.
Prepared by: László Koltai

Course title:
2.1.8 Synthetic Fibers and Technical Textiles
Credit value: 6
Course coordinator and instructor: Judit Borsa
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To introduce newly developed, non-traditional fibers and their applications. Course content: Characteristics of polymers suitable for fiber formation, fiber structure models (spherulite-fibril, fringed micelle, fringed fibril, paracrystalline structure), crystallinity and orientation, aggregate, phase, and physical state of polymers, classification of fibers, most important fiber properties, methods of artificial fiber production (modification possibilities of synthetic fibers: at the molecular level, during fiber formation), special fibers (hollow, bicomponent, micro- and nanofibers, carbon fibers)

List of 2-5 most important required readings with bibliographic data:
- McIntyre, J. E. (ed.): Synthetic Fibers: Nylon, Polyester, Acrylic, Polyolefin. Woodhead Publishing, Cambridge, 2005.
- Hearle, J. W. S. (ed.): High-Performance Fibers. Woodhead Publishing, Cambridge, 2005.
- Liu, Z.; Yue, H.; Zhang, Y.; Chen, P.; Xu, J.; Shao, H.; Wang, X.: The past, present and future of high-performance fibers. National Science Review, 11(10) (2024) nwae310. DOI: 10.1093/nsr/nwae310.

List of 2-5 most important recommended references with bibliographic data:
- Horrocks, A. R.; Anand, S. C. (eds.): Handbook of Technical Textiles. Woodhead Publishing, Cambridge, 2000.
- Mallick, P. K.: Fiber-Reinforced Composites. CRC Press, Boca Raton, 2008.
- Liu, Z.; Yue, H.; Zhang, Y.; Chen, P.; Xu, J.; Shao, H.; Wang, X.: The past, present and future of high-performance fibers. National Science Review, 11(10) (2024) nwae310. DOI: 10.1093/nsr/nwae310.

Date: February 8, 20
Prepared by: Judit Borsa

Course title:
2.1.9 Characteristics of antimicrobial raw materials in the light industry
Credit value: 6
Course coordinator and instructor: Bayoumi Hamuda Hosam
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To introduce the relationships between material structure and biological activity. To present the biochemical basis of the processes and their regulation in microorganisms as living organisms.
Course content: Preservatives for fiber, leather, rubber, and other natural polymer materials. Substances used to inhibit microbiological damage and their effects. Requirements for antimicrobial activity, antimicrobial finishing technologies. Types of antimicrobial fibers. The need for antimicrobial surfaces. Evaluation of the effects of fungi using three practical test methods. Mechanism and evaluation of antimicrobial activity. Commercially available antimicrobial agents and fibers.

List of 2-5 most important required readings with bibliographic data:
- Sharma, V. K.; Yngard, R. A.; Lin, Y.: Silver nanoparticles: Green synthesis and their antimicrobial activities. Advances in Colloid and Interface Science, 145 (2009) 83-96.
- Jain, A.; Krihnan, K.; et al.: Development of Wash-Durable Antimicrobial Cotton Fabrics by In Situ Green Synthesis of Silver Nanoparticles and Investigation of Their Antimicrobial Efficacy against Drug-Resistant Bacteria. Antibiotics, 11(8) (2022) 1062. DOI: 10.3390/antibiotics11081062.
- Emon, J. H.; et al.: Advancements in Antibacterial Textile Fabrics with Inorganic Nanoparticles: A Review. Materials Today Sustainability, 2026. DOI: 10.1016/j.mtsust.2026.100206.

List of the 2-5 most important recommended references with bibliographic data:
- Lischer, S.; Körner, E.; Balazs, D. J.; Shen, D.; Wick, P.; Grieder, K.; Haas, D.; Heuberger, M.; Hegemann, D.: Antibacterial burst-release from minimal Ag-containing plasma polymer coatings. Journal of the Royal Society Interface, 8 (2011) 1019-1030.
- Torres, J. A. J.; et al.: Antimicrobial Textile Finishing Based on Silver Nanostructures. Textiles, 5(4) (2025) 61. DOI: 10.3390/textiles5040061.
- Jain, A.; Krihnan, K.; et al.: Development of Wash-Durable Antimicrobial Cotton Fabrics by In Situ Green Synthesis of Silver Nanoparticles and Investigation of Their Antimicrobial Efficacy against Drug-Resistant Bacteria. Antibiotics, 11(8) (2022) 1062. DOI: 10.3390/antibiotics11081062.

Date: February 13, 2026.
Prepared by: Bayoumi Hamuda Hosam

Course title:
2.1.10 Biomaterials for Medical Applications
Credit value: 6
Course coordinator and instructor : Balázsi Csaba
Course classification: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To present the technological production processes of ceramics, glass, and polymers (powder production, pressing, additive technologies, atomization, sintering), and to discuss the physical, chemical, and technological properties of materials with a special focus on medical applications. Course content: Composition and structural properties of materials produced by various methods (ceramics, glass, and polymers) and their medical applications; bioactive ceramics, which are currently used as coatings for metal devices, promoting the formation of natural bone tissue and its integration into hard tissues; ceramic particles, microspheres, and nanosystems in cancer treatment; structures for tissue engineering as carriers for dental implants; new bioceramics with improved mechanical and biological functions, zirconium- and hydroxyapatite-based composites, and non-oxide ceramics.

List of 2-5 most important required readings with bibliographic data:
- Hench, Larry L.; Wilson, June (eds.): An Introduction to Bioceramics. World Scientific, Singapore, 1993.
- A Manual for Biomaterials/Scaffold Fabrication Technology. World Scientific, Singapore, 2007.
- Sonowal, L.; Gautam, S.; Mambiri, L. T.; Depan, D.: Advancements of Bioceramics in Biomedical Applications. Next Materials, 9 (2025) 101010. https://doi.org/10.1016/j.nxmate.2025.101010
- Qi, H.; Zhang, B.; Lian, F.: 3D-Printed Bioceramic Scaffolds for Bone Defect Repair: Bone Aging and Immune Regulation. Frontiers in Bioengineering and Biotechnology, 13 (2025) 1557203. https://doi.org/10.3389/fbioe.2025.1557203

List of the 2-5 most important recommended references with bibliographic data:
- Chen, Q.; Thouas, G. A.: Metallic Implant Biomaterials. Materials Science and Engineering R, 87 (2015) 1-57.
- Baskaran, P.; et al.: A Systematic Review on Biomaterials and Their Recent Progress in Tissue Engineering and Regenerative Medicine. Reviews in Inorganic Chemistry (2025).
- Sonowal, L.; Gautam, S.; Mambiri, L. T.; Depan, D.: Advancements of Bioceramics in Biomedical Applications. Next Materials, 9 (2025) 101010. https://doi.org/10.1016/j.nxmate.2025.101010
- Qi, H.; Zhang, B.; Lian, F.: 3D-Printed Bioceramic Scaffolds for Bone Defect Repair: Bone Aging and Immune Regulation. Frontiers in Bioengineering and Biotechnology, 13 (2025) 1557203. https://doi.org/10.3389/fbioe.2025.1557203

Date: February 26, 2026.
Prepared by: Csaba Balázsi

Course title:
2.1.11 Examination of plastics and plastic-based composites
Credit value: 6
Course coordinator and instructor: Andrea Ádámné Major

Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to teach the subject matter: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: Students will become familiar with methods for testing plastics and plastic-based composites. Course content: Classification of methods for testing plastics. Purpose of testing. Preparatory operations. Manufacture and preparation of test specimens. Conditioning. Sampling. Standards. Mass and density. Mechanical testing methods for plastics. Hardness. Tensile strength. Compressive strength. Shear properties. Charpy impact test. Fracture toughness. Structural testing of plastics. Scanning electron microscopy (SEM). Flow properties of plastic melts. Flow indices, Melt Flow Rate, Melt Flow Index (MFR, MFI, MVR). Thermal properties of plastics. Differential scanning calorimetry (DSC), testing the crystallization and melting of plastics.

List of 2-5 most important required readings with bibliographic data:
- Brown, R.: Handbook of Polymer Testing. iSmithers Rapra Publishing, Shawbury, 2002.
- Polymer Testing. Carl Hanser Verlag, Munich, 2024. DOI: 10.3139/9781569909201.
- Cuthbertson, A. A.; et al.: Characterization of polymer properties and identification of additives in commercial plastics to inform mechanical recycling. Green Chemistry, 26(12) (2024). DOI: 10.1039/D4GC00659C.
- Dzoh Fonkou, J. P.; et al.: Analytical Methods for In-Depth Assessment of Recycled Plastics. Environments, 12(5) (2025) 154. DOI: 10.3390/environments12050154.

List of the 2-5 most important recommended references with bibliographic data:
- Brown, R.: Handbook of Polymer Testing. iSmithers Rapra Publishing, Shawbury, 2002.
- Grellmann, W.; Seidler, S. (eds.): Deformation and Fracture Behaviour of Polymer Materials. Springer, Berlin, 2017. DOI: 10.1007/978-3-319-41879-7.
- Cuthbertson, A. A.; et al.: Characterization of polymer properties and identification of additives in commercial plastics to inform mechanical recycling. Green Chemistry, 26(12) (2024). DOI: 10.1039/D4GC00659C.

Date: February 21, 2026.
Prepared by: Andrea Ádámné Major

Course name:
2.1.12 Structure of polymers
Credit value: 6
Course coordinator and instructor: Andrea Ádámné Major
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description :
Course objective: To familiarize students with the structure of polymers and the relationship between structure and properties. Course content: Size and spatial structure of macromolecules, polymolecularity. Configuration and conformation. Concept of state of matter, phase state, physical state. Overview of the physical states of polymers using thermomechanical curves. Polymer-based multicomponent systems. Characteristics determining the supermolecular structure and macroscopic behavior of polymers. Molecular weight, molecular weight distribution, chain flexibility, segment motion. Intermolecular interactions of macromolecules, cross-linked polymers, types of cross-links. Characteristics of high elasticity, nature of relaxation. Mechanical relaxation in polymers. Glassy and viscous liquid states of amorphous polymers. Crystalline state and supermolecular structure of polymers. Morphology of crystalline polymers. Mechanism and kinetics of crystallization. Rheology of plastics. Rheological responses: ideal cases and deviations from them, realistic cases. Interpretation of viscosity and its temperature dependence. Viscoelastic behavior of polymers.

List of 2-5 most important required readings with bibliographic data:
- Bower, D. I.: An Introduction to Polymer Physics. Cambridge University Press, Cambridge, 2002.
- Rubinstein, M.; Colby, R. H.: Polymer Physics. Oxford University Press, Oxford, 2003. ISBN: 9780198520597.
- Ricarte, R. G.; Burns, A. B.; McKenna, G. B.; Sumerlin, B. S.: A tutorial review of linear rheology for polymer chemists: basics and best practices for covalent adaptable networks. Polymer Chemistry, 15 (2024). DOI: 10.1039/D3PY01367G.

List of the 2-5 most important recommended references with bibliographic data:
- Doi, M.: Introduction to Polymer Physics. Clarendon Press, Oxford, 1996.
- Gedde, U. W.; Hedenqvist, M. S.; Ifwarson, M.; Gedde, C.: Applied Polymer Science. Springer, Cham, 2021. DOI: 10.1007/978-3-030-68472-3.
- Ricarte, R. G.; Burns, A. B.; McKenna, G. B.; Sumerlin, B. S.: A tutorial review of linear rheology for polymer chemists: basics and best practices for covalent adaptable networks. Polymer Chemistry, 15 (2024). DOI: 10.1039/D3PY01367G.

Date: February 26, 2026.
Prepared by: Andrea Ádámné Major

Course name:
2.1.13 Engineering polymers
Credit value: 6
Course coordinator and lecturer: Mária Marosné Berkes
Classification of the course: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: The objective of the course is to familiarize PhD students with the material-specific characteristics of engineering polymers, the advantages and limitations of their technical applications, the characteristics of their mechanical behavior that differ from those of metals and their measurement parameters, and to enable them to assess specific user requirements that arise under various operating conditions, primarily those that can be met by the use of polymer materials, and to select the appropriate technical polymer. Course content: Micro- and macro-level material structure of polymers. The relationship

between structure, properties, and mechanical behavior in thermoplastics, thermosets, elastomers, and liquid crystal polymers. The concept and types of homogeneous and heterogeneous polymer structures. The material science background and characteristics of the mechanical behavior of polymers. The most important mechanical models of viscoelastic materials. Rheology: viscoelasticity and time-dependent behavior. Materials science background and characteristics of the mechanical behavior of polymers. The most important mechanical models of viscoelastic materials. Rheology: viscoelasticity and time dependence. Short- and long-term mechanical testing of polymers. Deformation, fracture, and characteristic failure modes of polymers. Information content, definition and scope of application of mechanical properties. Polymer production technologies, characteristics and limitations of individual processes, areas of application. Characteristic technical applications of engineering polymers (PA, PE, PP, PC, POM, ABS, polyimide, polysulfone, PVC, epoxies, phenols, amines, silicones, etc.) with special regard to automotive applications. Polymer matrix composites, polymer fibers. Environmental protection, recycling.

List of 2-5 most important required readings with bibliographic data:
Fakirov, S.: Fundamentals of Polymer Science for Engineers. Wiley-VCH, Weinheim, 2017. DOI: 10.1002/9783527802180.
Kalácska, G.: Technical Polymers and Composites in Mechanical Engineering Practice. 3C-Grafika Kft., Gödöllő, 2007.
Harun-Ur-Rashid, M.; et al.: Emerging Trends in Engineering Polymers: A Paradigm Shift in Advanced Material Science. Recent Progress in Materials, 6(3) (2024) 024.
Weyhrich, C. W.; Long, T. E.: Additive manufacturing of high-performance engineering polymers: present and future. Polymer International, 71(5) (2022) 532-536. DOI: 10.1002/pi.6343.
Collar, E. P.; García-Martínez, J.-M.: Mechanical Behavior of Polymeric Materials: Recent Studies. Polymers, 16(19) (2024) 2821. DOI: 10.3390/polym16192821.

List of the 2-5 most important recommended references with bibliographic data:
Kutz, M.: Applied Plastics Engineering Handbook: Processing and Materials. Elsevier, Oxford, 2011. DOI: 10.1016/C2010-0-67336-6.
Mittal, V. (ed.): High Performance Polymers and Engineering Plastics. Wiley, Hoboken, 2011.
Gerdeen, J. C.; Rorrer, R. A. L.: Engineering Design with Polymers and Composites. 2nd ed., CRC Press, Boca Raton, 2012.
Weyhrich, C. W.; Long, T. E.: Additive manufacturing of high-performance engineering polymers: present and future. Polymer International, 71(5) (2022) 532-536. DOI: 10.1002/pi.6343.
Alabi, O. O.; et al.: Advanced technologies for plastic waste recycling. Current Opinion in Green and Sustainable Chemistry, 2025.

Date: March 1, 2026.
Prepared by: Mária Marosné Berkes

2.2 Ceramics

Course title:
2.2.1 Technology of Technical Ceramics
Credit value: 6
Course coordinator and instructor: János Dusza
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation

Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites : none

Course description:
The aim of the course is to introduce the technology of technical ceramics. Course content: Thanks to their excellent mechanical and functional properties, technical ceramics are widely used in many areas of industry, including light industry. The course presents in detail the manufacturing technologies of technical ceramics, including powder preparation, forming, sintering, and machining. It introduces modern processes such as spark plasma sintering (SPS), HIP technology, and other advanced consolidation methods. It discusses the manufacturing technologies of bulk ceramics and thin films, and details the effect of manufacturing parameters on the structure and mechanical properties of materials.

List of 2-5 most important required readings with bibliographic data:
- Dusza János; Steen, M.: Fractography and Fracture Mechanics Property Assessment of Advanced Structural Ceramics. International Materials Reviews, 44(4) (1999) 165–216.
- Richerson, D. W.; Lee, W. E.: Modern Ceramic Engineering: Properties, Processing, and Use in Design. 4th ed., CRC Press, Boca Raton, 2018.
- Riley, F. L.: Structural Ceramics: Fundamentals and Case Studies. Cambridge University Press, Cambridge, 2009.
- Ćurković, L.; Žmak, I.: Mechanical Properties and Applications of Advanced Ceramics. Materials, 17(13) (2024) 3143. https://doi.org/10.3390/ma17133143
- Chen, Y.; Wang, Y.; Liu, Y.; Chen, C.; Chen, W.; Yuan, S.; Li, J.: Advances in Sintering Technologies for SiC Ceramics: Mechanisms, Challenges, and Industrial Applications. High-Temperature Materials, 2(3) (2025) 10013. https://doi.org/10.70322/htm.2025.10013

List of the 2-5 most important recommended references with bibliographic data:
- Richerson, D. W.; Lee, W. E.: Modern Ceramic Engineering: Properties, Processing, and Use in Design. 4th ed., CRC Press, Boca Raton, 2018.
- Riley, F. L.: Structural Ceramics: Fundamentals and Case Studies. Cambridge University Press, Cambridge, 2009.
- Ćurković, L.; Žmak, I.: Mechanical Properties and Applications of Advanced Ceramics. Materials, 17(13) (2024) 3143. https://doi.org/10.3390/ma17133143
- Bireddy, S. R.; Subbarao, M. V.; Lakshmi, K. S.; Yeddula, R. R.; Sushma, V.; Madhavi, J.: The Role of Microstructure in the Fracture Toughness of Advanced Ceramics. Metallurgical and Materials Engineering, 31(4) (2025) 529–536. https://doi.org/10.63278/1481
- Chen, Y.; Wang, Y.; Liu, Y.; Chen, C.; Chen, W.; Yuan, S.; Li, J.: Advances in Sintering Technologies for SiC Ceramics: Mechanisms, Challenges, and Industrial Applications. High-Temperature Materials, 2(3) (2025) 10013. https://doi.org/10.70322/htm.2025.10013

Date: December 14, 2025.
Prepared by: János Dusza

Course title:
2.2.2 Material Structure and Fracture Mechanism of Technical Ceramics
Credit value: 6
Course coordinator and instructor: János Dusza
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of classes in the given semester: 10 classes
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4

Prerequisites : none

Course description:
The aim of the course is to present the material structure and fracture mechanisms of technical ceramics. Course content: Thanks to their excellent mechanical and functional properties, technical ceramics are widely used in many areas of industry, including light industry. The course presents in detail the role of grain size, grain boundaries, cleavage, interfacial fracture, and other material structure characteristics, as well as the related testing methods, such as light microscopy, scanning electron microscopy, atomic force microscopy, and macro- and microfractography. It discusses the statistical evaluation of material structure parameters and fracture mechanisms, as well as the relationships between technology, material structure, fracture mechanisms, and mechanical properties.

List of 2-5 most important required readings with bibliographic data:
- Richerson, D. W.; Lee, W. E.: Modern Ceramic Engineering: Properties, Processing, and Use in Design. 4th ed., CRC Press, Boca Raton, 2018.
- Brook, R. J. (ed.): Concise Encyclopedia of Advanced Ceramic Materials. Pergamon Press, Oxford, 1991.
- Dusza, J.; Steen, M.: Fractography and Fracture Mechanics Property Assessment of Advanced Structural Ceramics. International Materials Reviews, 44(4) (1999) 165–216.
- Bireddy, S. R.; Subbarao, M. V.; Lakshmi, K. S.; Yeddula, R. R.; Sushma, V.; Madhavi, J.: The Role of Microstructure in the Fracture Toughness of Advanced Ceramics. Metallurgical and Materials Engineering, 31(4) (2025) 529–536. https://doi.org/10.63278/1481
- Ćurković, L.; Žmak, I.: Mechanical Properties and Applications of Advanced Ceramics. Materials, 17(13) (2024) 3143. https://doi.org/10.3390/ma17133143

List of the 2–5 most important recommended references with bibliographic data:
- Riley, F. L.: Structural Ceramics: Fundamentals and Case Studies. Cambridge University Press, Cambridge, 2009.
- Dusza, J.; Šajgalík, P.: Silicon Nitride and Alumina-Based Nanocomposites. In: Tseng, T.-Y.; Nalwa, H. S. (eds.): Handbook of Nanoceramics and Their Based Nanodevices. American Scientific Publishers, Stevenson Ranch, 2009, 253–283.
- Dusza, J.; Steen, M.: Fractography and Fracture Mechanics Property Assessment of Advanced Structural Ceramics. International Materials Reviews, 44(4) (1999) 165–216.
- Bireddy, S. R.; Subbarao, M. V.; Lakshmi, K. S.; Yeddula, R. R.; Sushma, V.; Madhavi, J.: The Role of Microstructure in the Fracture Toughness of Advanced Ceramics. Metallurgical and Materials Engineering, 31(4) (2025) 529–536. https://doi.org/10.63278/1481
- Chen, Z.; Huang, Y.; Koutná, N.; Gao, Z.; Sangiovanni, D. G.; Fellner, G.; Jin, S.; Mayrhofer, P. H.; Kothleitner, G.; et al.: Large Mechanical Properties Enhancement in Ceramics through Vacancy-Mediated Unit Cell Disturbance. Nature Communications, 14 (2023) 8387. https://doi.org/10.1038/s41467-023-44060-x

Date: December 22, 2025.
Prepared by: János Dusza

Course title:
2.2.3 Mechanical Properties of Technical Ceramics
Credit value: 6
Course coordinator and instructor: János Dusza
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment : semester assignment, presentation

Place in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to present the mechanical properties of technical ceramics. Course content: The course provides a detailed description of the methods used to examine the mechanical properties of technical ceramics, including nano-, micro- and macro-hardness measurement, flexural strength, fracture toughness, fatigue and creep testing. It discusses the effect of different measurement methods on results and reviews the relationships between technology, material structure, fracture mechanism, and mechanical properties in terms of mechanical behavior.

List of 2-5 most important required readings with bibliographic data:
- Richerson, D. W.; Lee, W. E.: Modern Ceramic Engineering: Properties, Processing, and Use in Design. 4th ed., CRC Press, Boca Raton, 2018.
- Riley, F. L.: Structural Ceramics: Fundamentals and Case Studies. Cambridge University Press, Cambridge, 2009.
- Dusza, J.; Steen, M.: Fractography and Fracture Mechanics Property Assessment of Advanced Structural Ceramics. International Materials Reviews, 44(4) (1999) 165–216.
- Ćurković, L.; Žmak, I.: Mechanical Properties and Applications of Advanced Ceramics. Materials, 17(13) (2024) 3143. https://doi.org/10.3390/ma17133143
- Bireddy, S. R.; Subbarao, M. V.; Lakshmi, K. S.; Yeddula, R. R.; Sushma, V.; Madhavi, J.: The Role of Microstructure in the Fracture Toughness of Advanced Ceramics. Metallurgical and Materials Engineering, 31(4) (2025) 529–536. https://doi.org/10.63278/1481

List of the 2-5 most important recommended references with bibliographic data:
- Brook, R. J. (ed.): Concise Encyclopedia of Advanced Ceramic Materials. Pergamon Press, Oxford, 1991.
- Dusza, J.; Šajgalík, P.: Silicon Nitride and Alumina-Based Nanocomposites. In: Tseng, T.-Y.; Nalwa, H. S. (eds.): Handbook of Nanoceramics and Their Based Nanodevices. American Scientific Publishers, Stevenson Ranch, 2009, 253–283.
- Chen, Z.; Huang, Y.; Koutná, N.; Gao, Z.; Sangiovanni, D. G.; Fellner, G.; Jin, S.; Mayrhofer, P. H.; Kothleitner, G.; et al.: Large Mechanical Properties Enhancement in Ceramics through Vacancy-Mediated Unit Cell Disturbance. Nature Communications, 14 (2023) 8387. https://doi.org/10.1038/s41467-023-44060-x
- Swab, J. J.; Madrigal, J.; Quinn, G. D.: Compression Strength of Advanced Ceramics: An Overview. Journal of the American Ceramic Society (2025). https://doi.org/10.1111/jace.70099
- Ćurković, L.; Žmak, I.: Mechanical Properties and Applications of Advanced Ceramics. Materials, 17(13) (2024) 3143. https://doi.org/10.3390/ma17133143

Date: January 7, 2026.
Prepared by: János Dusza

Course name:
2.2.4 Powder Technology
Credit value: 6
Course coordinator and instructor: Csaba Balázsi
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum vi: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To introduce powder technology processes and discuss the physical, chemical, and technological properties of the materials produced. Course content: Production of metallic and non-metallic powders, pressing, sintering, and discussion of the relationships between the composition, structure, and properties of materials produced by powder-based processes and their applications.

List of 2-5 most important required readings with bibliographic data:
Gopal Shankar Upadhyaya: Powder Metallurgy Technology. Cambridge International Science Publishing, 2002.
Anish Upadhyaya; Gopal Shankar Upadhyaya: Powder Metallurgy: Science, Technology, and Materials. CRC Press, 2011.
Cs. Balázsi: Carbon-Ceramic Alloys. In: Ceramic Matrix Composites, 2006.
Wang, Z.; Tan, Y.; Li, N.: Powder Metallurgy of Titanium Alloys: A Brief Review. Journal of Alloys and Compounds, 965 (2023) 171030. https://doi.org/10.1016/j.jallcom.2023.171030
Cui, J.; Lv, X.; Fu, H.: Numerical Simulation and Hot Isostatic Pressing Technology of Powder Titanium Alloys: A Review. Metals, 15(5) (2025) 542. https://doi.org/10.3390/met15050542

List of the 2-5 most important recommended references with bibliographic data:
Handbook of Mechanical Nanostructuring, Mechanical Alloying. Wiley-VCH, 2015.
Yadav, M. K.; Yarlapati, A.; Aditya, Y. N.; et al.: Processing and Development of Porous Titanium for Biomedical Applications: A Comprehensive Review. Journal of Manufacturing and Materials Processing, 9(12) (2025) 401. https://doi.org/10.3390/jmmp9120401
Hajra, R. N.; et al.: Comparative Review of the Microstructural and Mechanical Evolution of Titanium Alloys Processed through Powder Metallurgy and Thermomechanical Routes. Journal of Powder Materials, 2024. https://doi.org/10.4150/jpm.2024.00213

Date: February 12, 2026.
Prepared by: Csaba Balázsi

Course name:
2.2.5 Biomaterials for Medical Applications
Credit value: 6
Course coordinator and instructor: Csaba Balázsi
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to present the technological production processes of ceramic, glass, and polymer materials, including powder production, pressing, additive technologies, atomization, and sintering, as well as to discuss the physical, chemical, and technological properties of materials, with particular emphasis on medical applications. Course content: The course reviews the composition-structure-property relationships and medical applications of ceramics, glass and polymers produced by various methods; It introduces bioactive ceramics, coatings that promote bone tissue formation, the role of ceramic particles, microspheres, and nanosystems in tumor treatment, as well as tissue engineering carriers and new bioceramics with improved mechanical and biological functions.

List of 2-5 most important required readings with bibliographic data:

- Hench, L. L.; Wilson, J. (eds.): An Introduction to Bioceramics. 2nd ed., World Scientific, Singapore, 2013.
- Ma, P. X.; Elisseeff, J. (eds.): Scaffolding in Tissue Engineering. CRC Press, Boca Raton, 2005.
- Sonowal, L.; Gautam, S.; Mambiri, L. T.; Depan, D.: Advancements of Bioceramics in Biomedical Applications. Next Materials, 6 (2025) 101010. https://doi.org/10.1016/j.nxmate.2025.101010
- Elshazly, N.; Hamdy, A.; et al.: Advances in Clinical Applications of Bioceramics in the New Regenerative Medicine Era. World Journal of Stem Cells, 16(4) (2024) 339–350.
- Jalaludeen, A. M.; Sajesh, K. M.; Nair, P. D.; et al.: Advancements in Hydroxyapatite Synthesis and Surface Modifications for Emerging Biomedical Applications. Materials Today Bio, 29 (2024) 100552. https://doi.org/10.1016/j.mtbio.2024.100552

List of the 2-5 most important recommended references with bibliographic data:
- Hench, L. L.; Wilson, J. (eds.): An Introduction to Bioceramics. 2nd ed., World Scientific, Singapore, 2013.
- Wang, J.; Zhang, L.; Wang, K.: Bioactive Ceramic-Based Materials: Beneficial Properties and Potential Applications in Dental Repair and Regeneration. Biomaterials Investigation in Dentistry, 11(1) (2024) 2373745. https://doi.org/10.1080/26415275.2024.2373745
- Sonowal, L.; Gautam, S.; Mambiri, L. T.; Depan, D.: Advancements of Bioceramics in Biomedical Applications. Next Materials, 6 (2025) 101010. https://doi.org/10.1016/j.nxmate.2025.101010
- Nguyen, N. H.; Kim, B.-S.; Lee, B.-T.: Engineering Antibacterial Bioceramics: Design Principles, Emerging Advances, and Translational Challenges. Materials Today Bio, 27 (2024) 101117. https://doi.org/10.1016/j.mtbio.2024.101117
- Jalaludeen, A. M.; Sajesh, K. M.; Nair, P. D.; et al.: Advancements in Hydroxyapatite Synthesis and Surface Modifications for Emerging Biomedical Applications. Materials Today Bio, 29 (2024) 100552. https://doi.org/10.1016/j.mtbio.2024.100552

Date: February 2, 2026.
Prepared by: Csaba Balázsi

Course title:
2.2.6 Technical ceramics
Credit value: 6
Course coordinator and lecturer: Mária Marosné Berkes
Classification of the course: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to familiarize doctoral students with the material-specific characteristics of technical ceramics, the advantages and limitations of their application, their typical damage processes and testing methods, and to enable them to assess the applicability of different technical ceramics under given operating conditions. Course content: Micro- and macro-level material structure of crystalline and non-crystalline ceramics; phase transformations and crystal defects in ceramics; mechanical behavior of single-crystal, polycrystalline, and amorphous ceramics; deformation and fracture characteristics at different temperatures; main mechanical properties and testing methods of brittle materials; typical technical applications; state-of-the-art production techniques; methods for increasing strength and toughness; ceramic matrix composites and ceramic reinforcing phases.

List of 2-5 most important required readings with bibliographic data:
- Kingery, W. D.; Bowen, H. K.; Uhlmann, D. R.: Introduction to Ceramics. 2nd ed., Wiley, New York, 1975.

- Richerson, D. W.; Lee, W. E.: Modern Ceramic Engineering: Properties, Processing, and Use in Design. 4th ed., CRC Press, Boca Raton, 2018.
- Somiya, S. (ed.): Handbook of Advanced Ceramics: Materials, Applications, Processing, and Properties. 2nd ed., Academic Press, Oxford, 2013.
- Ćurković, L.; Žmak, I.: Mechanical Properties and Applications of Advanced Ceramics. Materials, 17(13) (2024) 3143. https://doi.org/10.3390/ma17133143
- Bireddy, S. R.; Subbarao, M. V.; Lakshmi, K. S.; Yeddula, R. R.; Sushma, V.; Madhavi, J.: The Role of Microstructure in the Fracture Toughness of Advanced Ceramics. Metallurgical and Materials Engineering, 31(4) (2025) 529–536. https://doi.org/10.63278/1481

List of the 2-5 most important recommended references with bibliographic data:
- Riley, F. L.: Structural Ceramics: Fundamentals and Case Studies. Cambridge University Press, Cambridge, 2009.
- Chiang, Y.-M.; Birnie, D. P.; Kingery, W. D.: Physical Ceramics: Principles for Ceramic Science and Engineering. Wiley, New York, 1996.
- Bengisu, M.: Engineering Ceramics. Springer, Berlin, Heidelberg, 2001. https://doi.org/10.1007/978-3-662-04350-9
- Ćurković, L.; Žmak, I.: Mechanical Properties and Applications of Advanced Ceramics. Materials, 17(13) (2024) 3143. https://doi.org/10.3390/ma17133143
- Chen, Y.; Wang, Y.; Liu, Y.; Chen, C.; Chen, W.; Yuan, S.; Li, J.: Advances in Sintering Technologies for SiC Ceramics: Mechanisms, Challenges, and Industrial Applications. High-Temperature Materials, 2(3) (2025) 10013. https://doi.org/10.70322/htm.2025.10013

Date: February 19, 2026.
Prepared by: Mária Marosné Berkes

2.3 Metals

Course title:
2.3.1 Phenomena related to continuous casting of steel
Credit value: 6
Course coordinator and instructor: Mihály Réger
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To provide an overview of continuous casting technology and mechanical equipment, identify the possibilities and areas of mathematical modeling based on this, learn the details of the thermal model describing continuous casting, and learn the basic principles of other related models. Course content: Continuous casting of steel is a mass production technology widely used around the world. Nevertheless, based on our current knowledge, it is difficult to describe and mathematically model the process and predict product quality, even with approximations. The problems are largely due to the fact that the casting process involves the interaction and mutual influence of thermodynamic, fluid dynamic, solidification, transformation, elastic and plastic deformation, creep, and other phenomena. The difficulties are compounded by the fact that the shape and thickness-width-length ratios of continuously cast products are unfavorable for

mathematical modeling. Verifying the results provided by the models is another challenge, as crystallization occurs inside the cast product, in a system that is difficult to examine from the outside. The course takes into account all significant effects that may influence the quality of the cast product under steady-state and non-steady-state casting conditions.

List of the 2-5 most important required readings with bibliographic data:
B.G. Thomas: Continuous Casting: Modeling. The Encyclopedia of Advanced Materials, Pergamon Elsevier Science Ltd., Oxford, 2001.
M. El-Bealy: Fluctuated Cooling Conditions and Solid Shell Resistance in Continuously Cast Steel Slabs. Canadian Metallurgical Quarterly, 36(3) (1997) 203-222.
Wang, Y.; Zhang, L.: A Review of Macrosegregation Simulation for the Continuous Casting Process. Steel Research International (2025). https://doi.org/10.1002/srin.202500586
Louhenkilpi, S.: Continuous Casting of Steel. In: Encyclopedia of Iron, Steel, and Their Alloys. Elsevier, 2024.
List of the 2-5 most important recommended references with bibliographic data:

B.G. Thomas: Continuous Casting: Modeling. The Encyclopedia of Advanced Materials, Pergamon Elsevier Science Ltd., Oxford, 2001.
M. El-Bealy: Fluctuated Cooling Conditions and Solid Shell Resistance in Continuously Cast Steel Slabs. Canadian Metallurgical Quarterly, 36(3) (1997) 203-222.
Wang, Y.; Zhang, L.: A Review of Macrosegregation Simulation for the Continuous Casting Process. Steel Research International (2025). https://doi.org/10.1002/srin.202500586
Liang, B.; Gao, M.; Li, X.; et al.: Research on Constitutive Modeling of DH460 Continuous Casting Steel during the Solidification End Heavy Reduction Process. Materials, 18(2) (2025) 453. https://doi.org/10.3390/ma18020453

Date: January 8, 2026.
Prepared by: Mihály Réger

Course title:
2.3.2 Modeling of thermally activated transformation processes in alloys
Credit value: 6
Course coordinator and instructor: Tamás Réti
Course classification: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: Secondary or higher education in solid state physics, thermodynamics, heat transfer theory, ordinary and partial differential equations, and discrete geometry

Course description:
Course objective: To present the latest research results related to the modeling and prediction of phase transformations and property changes in f e alloys caused by heat treatment, and to demonstrate their possible applications. Course content: Geometric and topological characterization of the microstructure of alloys based on quantitative criteria, with particular emphasis on the application of stereological methods. Description and classification of the microgeometric structure of materials with cellular morphology, geometric modeling of microstructural changes. Basic types of thermally activated processes in alloys: martensitic and diffusion-type solid phase transformations. Description of transformation processes involving nucleation and growth using ordinary and partial differential equations. Analysis of the relationship between isothermal and non-isothermal transformation processes. The JMAK kinetics function and its extension possibilities, estimation of kinetic parameters based on measurement data. Prediction of non-

isothermal transformation processes using the additivity rule and recursive methods. Solving the fully coupled system consisting of the Fourier equation and kinetic differential equations in various transformation models. Application examples, modeling of surface refinement processes, with particular emphasis on thermochemical and laser surface treatment.

List of 2-5 most important required readings with bibliographic data:
J. W. Christian: The Theory of Transformations in Metals and Alloys. Pergamon Press, Oxford, 1975.
J. S. Kirkaldy; D. J. Young: Diffusion in the Condensed State. The Institute of Metals, London, 1987.
D. Raabe: Computational Materials Science. Wiley-VCH, New York, 1998.
Song, Z.; Liu, Y.; Wang, J.; Zhu, G.; Wang, L.; Zeng, X.; Knezevic, M.: Advanced Phenomenological Models Guided Heat Treating Processes for LPBF Ti-6Al-4V Alloy. Materials Today Communications, 42 (2025) 111186. https://doi.org/10.1016/j.mtcomm.2024.111186
Chang, J.; Wang, M.; Yang, X.; Yang, Y.; Wu, Y.; Mi, Z.: The Role and Modeling of Ultrafast Heating in Isothermal Austenite Formation Kinetics in Quenching and Partitioning Steel. Metals, 15(10) (2025) 1111. https://doi.org/10.3390/met15101111

List of the 2-5 most important recommended references with bibliographic data:

W. C. Leslie: The Physical Metallurgy of Steels. McGraw-Hill, New York, 1981.
Journal articles available for download from the ScienceDirect database (Acta Materialia, etc.).
Song, Z.; Liu, Y.; Wang, J.; Zhu, G.; Wang, L.; Zeng, X.; Knezevic, M.: Advanced Phenomenological Models Guided Heat Treating Processes for LPBF Ti-6Al-4V Alloy. Materials Today Communications, 42 (2025) 111186. https://doi.org/10.1016/j.mtcomm.2024.111186
Chang, J.; Wang, M.; Yang, X.; Yang, Y.; Wu, Y.; Mi, Z.: The Role and Modeling of Ultrafast Heating in Isothermal Austenite Formation Kinetics in Quenching and Partitioning Steel. Metals, 15(10) (2025) 1111. https://doi.org/10.3390/met15101111

Date: February 6, 2026.
Prepared by: Tamás Réti

Course title:
2.3.3 Concentrated Energy Input Material Technologies
Credit value: 6
Course coordinator and instructor: Gyula Bagyinszki
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: Materials Science, Fundamentals of Materials Technology

Course description:
The aim of the course : Primarily a systematic overview of cutting, welding and surface treatment technologies used in mechanical engineering, summarizing their applicability. Presentation of the fundamentals of materials science, processes, mechanization options, and technology design principles of cutting, welding, and surface treatment. Familiarization with testing and certification methods for cut pieces, welded joints, and surface treatment layers. Course content: Forming, joining, and structural modification technologies. High-energy-density heat sources. Thermal and erosion cutting. Arc, resistance, and radiation welding; cold and hot stamping welding. Surface treatments with and without material addition. Work hardening, allotropic transformation, rapid solidification. Adhesion, diffusion, cohesion; metallurgical processes. Equipment, mechanization, robotization, automation. Material databases, computer-aided design methods. Related destructive and non-destructive material testing.

List of the 2-5 most important required readings with bibliographic data:

Gyula Bagyinszki - Enikő Bitay: Introduction to Materials Technology Informatics. Transylvanian Museum Association, Cluj-Napoca, 2007.
Gyula Bagyinszki - Enikő Bitay: Surface Treatment. Transylvanian Museum Association, Cluj-Napoca, 2009.
Gyula Bagyinszki - Enikő Bitay: Welding Technology I. - Processes and Mechanization. Transylvanian Museum Association, Cluj-Napoca, 2010.
Klimpel, A.; Janicki, D.; Lisiecki, A.; et al.: Review and Analysis of Modern Laser Beam Welding Processes. Materials, 17(18) (2024) 4657. https://doi.org/10.3390/ma17184657
Jin, J.; Wang, X.; Chen, J.; et al.: High-Strength and Crack-Free Welding of 2024 Aluminium Alloy Using Oscillating Laser-Arc Hybrid Welding. Nature Communications, 15 (2024) 45660. https://doi.org/10.1038/s41467-024-45660-x

List of the 2-5 most important recommended references with bibliographic data:

Bagyinszki Gyula - Bitay Enikő: Welding Technology II. - Equipment and Measurements. Transylvanian Museum Association, Cluj-Napoca, 2010.
Bunaziv, I.; Akselsen, O. M.; Salminen, A.; Unt, A.: Laser Beam and Laser-Arc Hybrid Welding of Aluminium Alloys. Metals, 11(8) (2021) 1150. https://doi.org/10.3390/met11081150
Mir, F. A.; Khan, N. Z.; Siddiquee, A. N.; Parvez, S.: Friction Based Solid-State Welding - A Review. Materials Today: Proceedings, 62 (2022) 5268-5275. https://doi.org/10.1016/j.matpr.2022.01.457

Date: February 20, 2026.
Prepared by: Gyula Bagyinszki

Course title:
2.3.4 Welding Technologies I: Bulk Welding
Credit value: 6
Course coordinator and instructor: Gyula Bagyinszki
Classification of the course: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 16 contact hours + 14 consultation hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: Materials Science, Fundamentals of Materials Technology

Course description:
Course objective: To introduce the basics, systems, and technological characteristics of bulk welding processes. Course content: Physical and material structure basics of bulk welding. The relationship between bulk welding, metal and thermo . Systematization of bulk welding processes. Self-shielded, gas-shielded, gas, electron and laser beam welding. Equipment, tools, mechanization and automation. Technology design background and qualification tests.

List of the 2-5 most important required readings with bibliographic data:
Gyula Bagyinszki - Enikő Bitay: Welding Technology I. - Processes and Mechanization. Transylvanian Museum Association, Cluj-Napoca, 2010.
Gyula Bagyinszki - Enikő Bitay: Welding Technology II. - Equipment and measurements. Transylvanian Museum Association, Cluj-Napoca, 2010.
József Gáti (ed.): Welding Pocketbook. COKOM Engineering Office Ltd., Miskolc, 2003.

Klimpel, A.; Janicki, D.; Lisiecki, A.; et al.: Review and Analysis of Modern Laser Beam Welding Processes. Materials, 17(18) (2024) 4657. https://doi.org/10.3390/ma17184657
Jin, J.; Wang, X.; Chen, J.; et al.: High-Strength and Crack-Free Welding of 2024 Aluminium Alloy Using Oscillating Laser-Arc Hybrid Welding. Nature Communications, 15 (2024) 45660. https://doi.org/10.1038/s41467-024-45660-x

List of the 2-5 most important recommended references with bibliographic data:
Szunyogh László (editor-in-chief): Handbook of Welding and Related Technologies. GTE, Budapest, 2007.
József Gáti - Mihály Kovács: Arc Welding. Műszaki Kiadó, Budapest, 2013.
Bunaziv, I.; Akselsen, O. M.; Salminen, A.; Unt, A.: Laser Beam and Laser-Arc Hybrid Welding of Aluminium Alloys. Metals, 11(8) (2021) 1150. https://doi.org/10.3390/met11081150
Klimpel, A.; Janicki, D.; Lisiecki, A.; et al.: Review and Analysis of Modern Laser Beam Welding Processes. Materials, 17(18) (2024) 4657. https://doi.org/10.3390/ma17184657

Date: December 27, 2025.
Prepared by: Gyula Bagyinszki

Course title:
2.3.5 Welding Technologies II: Pressure Welding
Credit value: 6
Course coordinator and instructor: Gyula Bagyinszki
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 16 contact hours + 14 consultation hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: Materials Science, Fundamentals of Materials Technology

Course description:
Course objective: To introduce the basics, systems, and technological characteristics of press welding processes. Course content: Physical and material structure basics of press welding. Resistance, induction, friction, ultrasonic, diffusion, cold and hot press welding. Explosive and magnetic pulse welding. Equipment, mechanization, automation, technology design and qualification tests.

List of the 2-5 most important required readings with bibliographic data:
Gyula Bagyinszki - Enikő Bitay: Welding Technology I. - Processes and Mechanization. Transylvanian Museum Association, Cluj-Napoca, 2010.
Gyula Bagyinszki - Enikő Bitay: Welding Technology II. - Equipment and Measurements. Transylvanian Museum Association, Cluj-Napoca, 2010.
B. D. Orlov (ed.): Resistance Welding. Technical Book Publishing House, Budapest, 1980.
Tayebi, M.; Eivani, A. R .; Majidifar, A.; Parsa, S. A.; Mehdizade, M.; Lalegani, Z.; Jafarian, H. R.: A Review of Friction Stir Welding: From Fundamentals to Applications with a Focus on Brass Alloys. Materials & Design, 257 (2025) 115358. https://doi.org/10.1016/j.matdes.2025.115358
Choi, J.-W.; Hino, R.; Ushioda, K.; Fujii, H.; Lee, S.-J.: Critical Review of Solid-State Welding for Al Alloys with High Joint Efficiency: Friction Stir Welding (FSW) vs. Linear Friction Welding (LFW). Metals and Materials International, 32(1) (2026) 139-163. https://doi.org/10.1007/s12540-025-02007-5

List of the 2-5 most important recommended references with bibliographic data:
Gáti József (ed.): Welding Pocketbook. COKOM Mérnökiroda Kft., Miskolc, 2003.

Lunetto, V.; De Maddis, M.; Lombardi, F.; Russo Spena, P.: A Review of Friction Stir Welding of Industrial Alloys: Tool Design and Process Parameters. Journal of Manufacturing and Materials Processing, 9(2) (2025) 36. https://doi.org/10.3390/jmmp9020036
Mir, F. A.; Khan, N. Z.; Siddiquee, A. N.; Parvez, S.: Friction Based Solid-State Welding - A Review. Materials Today: Proceedings, 62 (2022) 5268-5275. https://doi.org/10.1016/j.matpr.2022.01.457
Date: January 15, 2026.
Prepared by: Gyula Bagyinszki

Course title:
2.3.6 Powder Technology
Credit value: 6
Course coordinator and instructor: Csaba Balázsi
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
What methods, specific approaches, and characteristics are used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: Introduction to powder technology processes, discussion of the physical, chemical, and technological properties of the materials produced. Course content: Production of metallic and non-metallic powders, pressing, sintering, and discussion of the relationships between the composition, structure, and properties of materials produced by powder-based processes and their applications.

List of 2-5 most important required readings with bibliographic data:
Gopal Shankar Upadhyaya: Powder Metallurgy Technology. Cambridge International Science Publishing, 2002.
Anish Upadhyaya; Gopal Shankar Upadhyaya: Powder Metallurgy: Science, Technology, and Materials. CRC Press, 2011.
Cs. Balázsi: Carbon-Ceramic Alloys. In: Ceramic Matrix Composites, 2006.
Wang, Z.; Tan, Y.; Li, N.: Powder Metallurgy of Titanium Alloys: A Brief Review. Journal of Alloys and Compounds, 965 (2023) 171030. https://doi.org/10.1016/j.jallcom.2023.171030
Cui, J.; Lv, X.; Fu, H.: Numerical Simulation and Hot Isostatic Pressing Technology of Powder Titanium Alloys: A Review. Metals, 15(5) (2025) 542. https://doi.org/10.3390/met15050542

List of the 2-5 most important recommended references with bibliographic data:
Handbook of Mechanical Nanostructuring, Mechanical Alloying. Wiley-VCH, 2015.
Yadav, M. K.; Yarlapati, A.; Aditya, Y. N.; et al.: Processing and Development of Porous Titanium for Biomedical Applications: A Comprehensive Review. Journal of Manufacturing and Materials Processing, 9(12) (2025) 401. https://doi.org/10.3390/jmmp9120401
Hajra, R. N.; et al.: Com parative Review of the Microstructural and Mechanical Evolution of Titanium Alloys Processed through Powder Metallurgy and Thermomechanical Routes. Journal of Powder Materials, 2024. https://doi.org/10.4150/jpm.2024.00213

Date: February 12, 2026.
Prepared by: Csaba Balázsi

Course title:
2.3.7 Fundamentals of plasticity theory
Credit value: 6

Course coordinator and instructor: Endre Ruszinkó
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To introduce the fundamentals of plasticity theory. Course content: Elastic and plastic deformation, stress-strain diagram, elasticity and yield strength, material models, stress and strain states, flow conditions, deformation theories, hardening models, slip and flow theories, Lode-Nádai variable, and experimental verification of models.

List of 2-5 most important required readings with bibliographic data:
Sándor Kaliszky: Plasticity Theory - Theory and Engineering Applications. Akadémiai Kiadó, 1975.
Rusinko, A.; Rusinko, K.: Plasticity and Creep of Metals. Springer, Berlin, 2011.
Chen, W.; Han, D.: Plasticity for Structural Engineers. Springer, Heidelberg, 1988.
Langdon, T. G.: Review: Developments in the Creep of Materials over a Period of More Than a Century. Journal of Materials Science, 60 (2025) 18158-18176. https://doi.org/10.1007/s10853-025-10922-6
Chawla, H.; Kumar, R.; et al.: Determining Large-Strain Metal Plasticity Parameters Using In Situ Loading and Imaging. Proceedings of the Royal Society A, 479(2275) (2023) 20230061. https://doi.org/10.1098/rspa.2023.0061

List of the 2-5 most important recommended references with bibliographic data:
Dr. László Horváth: Theoretical Foundations of Plastic Deformation Technologies. 1996.
Honeycomb, R.: Plastic Deformation of Metals. Edward Arnold, London, 1984.
Konstantinidis, A.; Aifantis, E. C.: Self-Organization in Metal Plasticity: An ILG Update. Metals, 15(9) (2025) 1006. https://doi.org/10.3390/met15091006
Langdon, T. G.: Review: Developments in the Creep of Materials over a Period of More Than a Century. Journal of Materials Science, 60 (2025) 18158-18176. https://doi.org/10.1007/s10853-025-10922-6

Date: January 24, 2026.
Prepared by: Endre Ruszinkó

Course title:
2.3.8 Non-classical problems of plasticity and creep
Credit value: 6
Course coordinator and instructor: Endre Ruszinkó
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Aim of the course: To introduce modern plasticity theory and creep theory. Course content: General principles of plastic and creep behavior, classical and non-classical models, effects, relationship between

plastic and creep deformation, effects of thermal and mechanical pretreatments, ultrasound and creep, phase transformations, pseudoelasticity, effective temperature, and fundamentals of synthesis theory.

List of 2-5 most important required readings with bibliographic data:
Sándor Kaliszky: Plasticity Theory - Theory and Engineering Applications. Akadémiai Kiadó, 1975.
Rusinko, A.; Rusinko, K.: Plasticity and Creep of Metals. Springer, Berlin, 2011.
Rusinko, A.: Ultrasound and Irrecoverable Deformation in Metals. LAP Lambert Academic Publishing, 2012.
Langdon, T. G.: Review: Developments in the Creep of Materials over a Period of More Than a Century. Journal of Materials Science, 60 (2025) 18158-18176. https://doi.org/10.1007/s10853-025-10922-6
Shaikhutdinov, R.; et al.: A Creep Model with a Real Structural Parameter for Description of Creep Stages in Metals. Physics, 6(4) (2025) 91. https://doi.org/10.3390/physics6040091

List of the 2-5 most important recommended references with bibliographic data:
Betten, J.: Creep Mechanics. Springer, Heidelberg, 2005.
Chen, W.; Han, D.: Plasticity for Structural Engineers. Springer, Heidelberg, 1988.
Chawla, H.; Kumar, R.; et al.: Determining Large-Strain Metal Plasticity Parameters Using In Situ Loading and Imaging. Proceedings of the Royal Society A, 479(2275) (2023) 20230061. https://doi.org/10.1098/rspa.2023.0061
Nasir, K. M. Z.; et al.: Constitutive Modeling of Anisotropic Plasticity with ML-Assisted Identification for Metals Used in Nuclear Reactors. Nuclear Technology (2025). https://doi.org/10.1080/00295450.2024.2410620

Date: December 19, 2025.
Prepared by: Endre Ruszinkó

Course name:
2.3.9 Cutting Theory
Credit value: 6
Course coordinator and instructor: Richárd Horváth
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: Comprehensive introduction to the machinability of various materials, the cutting ability of cutting tools, and the main topics of cutting theory. Course content: Systematization of machining processes, regular and irregular chip separation, force measurements and force models, tool materials, wear, tool life, roughness, finding the optimum point, machining different base materials, and the relationship between machining parameters and geometric accuracy.

List of 2-5 most important required readings with bibliographic data:
David A. Stephenson; John S. Agapiou: Metal Cutting Theory and Practice. 2nd ed., 2005.
Viktor P. Astakhov: Geometry of Single-Point Turning Tools and Drills. 2010.
Zoltán Pálmai: Machinability of Metals. 1980.
Machado, A. R.; da Silva, L. R. R.; Pimenov, D. Y.; de Souza, F. C. R.; Kuntoğlu, M.; de Paiva, R. L.: Comprehensive Review of Advanced Methods for Improving Machinability of Steels. Journal of Manufacturing Processes, 111 (2024) 111-142. https://doi.org/10.1016/j.jmapro.2024.07.044

Abellán-Nebot, J. V.; Vila Pastor, C.; Siller, H. R.: A Review of the Factors Influencing Surface Roughness in Machining and Their Impact on Sustainability. Sustainability, 16(5) (2024) 1917. https://doi.org/10.3390/su16051917

List of the 2-5 most important recommended references with bibliographic data:
Kano, S.: A Short Review: Tribology in Machining to Understand Conventional and Latest Modeling Methods with Machine Learning. Machines, 13(2) (2025) 81. https://doi.org/10.3390/machines13020081
Stephenson, D. A.; Agapiou, J. S.: Metal Cutting Theory and Practice. 3rd ed., CRC Press, Boca Raton, 2018. https://doi.org/10.1201/9781315373119

Date: February 27, 2026.
Prepared by: Richárd Horváth

Course title:
2.3.10 Titanium and titanium alloys
Credit value: 6
Course coordinator and instructor: Péter Pinke
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, lecture
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: MSc

Course description:
Course objective: Introduction to titanium and titanium alloys, discussion of the production, properties, and applications of individual titanium variants and titanium alloys. Course content: Production and processing of titanium into semi-finished products, titanium alloys, composition-structure-property relationships, alpha, alpha+beta and beta phase alloys, processing technologies, heat treatment and areas of application from aerospace to medical technology.

List of 2-5 most important required readings with bibliographic data:
Leyens, C.; Peters, M. (eds.): Titanium and Titanium Alloys, Fundamentals and Applications. Wiley-VCH, Weinheim, 2003.
Lütjering, G.; Williams, J. C.: Titanium. Springer, Berlin, 2007.
Joshi, V. A.: Titanium Alloys - An Atlas of Structures and Fracture Features. Taylor & Francis, 2006.
Najafizadeh, M.; Yazdi, S.; Bozorg, M.; Ghasempour-Mouziraji, M.; Hosseinzadeh, M.; Zarrabian, M.; Cavaliere, P.: Classification and Applications of Titanium and Its Alloys: A Review. Journal of Alloys and Compounds Communications, 3 (2024) 100019. https://doi.org/10.1016/j.jacomc.2024.100019
Luo, B.; Miu, L.; Luo, Y.: Titanium Alloys for Biomedical Applications: A Review on Additive Manufacturing Process and Surface Modification Technology. International Journal of Advanced Manufacturing Technology, 137 (2025) 3215-3227. https://doi.org/10.1007/s00170-025-15287-3

List of the 2-5 most important recommended references with bibliographic data:
Cotton, J. D. et al.: State of the Art in Beta Titanium Alloys for Airframe Applications. JOM, 67(6) (2015) 1281-1303.
Wang, L.; Zhang, L. C. (eds.): Development and Application of Biomedical Titanium Alloys. Bentham Science, 2018.
Sabour, M. R.; Taherkhani, E.; Faraji, G.: A Comprehensive Review on Solid-State Recycling of Titanium and Its Alloy Machining Chips. Resources, Conservation and Recycling Advances, 2025.

Kareem, S. A.; Anaele, J. U.; Olanrewaju, O. F.; et al.: Hot Deformation of Biomedical Titanium Alloys: A Review of Deformation Mechanisms, Constitutive Modeling and Processing Maps Analysis. International Journal of Material Forming, 18 (2025) 87. https://doi.org/10.1007/s12289-025-01949-w

Date: January 31, 2026.
Prepared by: Péter Pinke

Course name:
2.3.11 Materials for Nuclear Power Plants
Credit value: 6
Course coordinator and instructor: Zoltán Hózer
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the subject, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours 30
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to familiarize students with the characteristics of materials used in nuclear power plants, the criteria for their selection, the basics of nuclear power plant operation, the thermal processes taking place in nuclear reactors, the typical mechanical loads on reactor materials, and the methods used to test them. Course content: • Characteristics of nuclear fuel, Fuel assemblies and control rods, Characteristics of coolants, Pressurized water and boiling water reactors, Materials and structure of the reactor vessel • Heat generation in the reactor, heat transfer, heat conduction in the fuel, operational limits during normal operation, operational limits during malfunction (LOCA and RIA) • Mechanical behavior of reactor materials, methods of mechanical testing, creep, fracture mechanics.

List of 2-5 most important required readings with bibliographic data:
- Yu, J.: Fundamental Principles of Nuclear Engineering. Springer, Singapore, 2022. https://doi.org/10.1007/978-981-16-0839-1
- Liu, H.; Lei, G.-H.; Huang, H.-F.: Review on Synergistic Damage Effect of Irradiation and Corrosion on Reactor Structural Alloys. Nuclear Science and Techniques, 35 (2024) Article 57. https://doi.org/10.1007/s41365-024-01415-3
- Rebak, R. B.: Improved and Innovative Accident-Tolerant Nuclear Fuel Materials Considered for Retrofitting Light Water Reactors - A Review. Corrosion and Materials Degradation, 4(3) (2023) 466-487. https://doi.org/10.3390/cmd4030024

List of the 2-5 most important recommended references with bibliographic data:
- Yu, J.: Fundamental Principles of Nuclear Engineering. Springer, Singapore, 2022. https://doi.org/10.1007/978-981-16-0839-1
- Wang, P.; Bachhav, M.: Editorial: Nuclear Material for Current and Future Reactor Design. Frontiers in Nuclear Engineering, 3 (2024) 1392742. https://doi.org/10.3389/fnuen.2024.1392742
- Liu, H.; Lei, G.-H.; Huang, H.-F.: Review on Synergistic Damage Effect of Irradiation and Corrosion on Reactor Structural Alloys. Nuclear Science and Techniques, 35 (2024) Article 57. https://doi.org/10.1007/s41365-024-01415-3
- Rebak, R. B.: Improved and Innovative Accident-Tolerant Nuclear Fuel Materials Considered for Retrofitting Light Water Reactors - A Review. Corrosion and Materials Degradation, 4(3) (2023) 466-487. https://doi.org/10.3390/cmd4030024
Date: February 23, 2026.

Prepared by: Zoltán Hózer

Course title:
2.3.12 Electrochemical Metal Separation
Credit value: 6
Course coordinator and instructor: László Péter
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of physics and materials science

Course description:
Course objective: To introduce the concepts of electrochemical metal separation and electroplating based on the fundamentals of electrochemistry and metallurgy. Course content: Basic concepts of electrochemistry, classification of electrodes, static and dynamic electrochemical methods, electrode reactions, stability diagrams, metal dissolution and separation, transport processes, examination of separated metals, nucleation phenomena, pulse separation, different behavior of crystal planes, dendrite growth, texture, alloy separation, production of nanostructures, and fundamentals of electroplating.

List of 2-5 most important required readings with bibliographic data:
A. Brenner: Electrodeposition of Alloys. Academic Press, New York, 1963.
E. Budevski; G. Staikov; W. L. Lorenz: Electrochemical Phase Formation and Growth. VCH, Weinheim, 1996.
N. Kanani: Electroplating - Basic Principles, Processes and Practice. Elsevier, 2004.
Péter, L.: Electrochemical Methods of Nanostructure Preparation. Springer, Cham, 2021. https://doi.org/10.1007/978-3-030-63798-9
Bograchev, D. A.; Kabanova, T. B.; et al.: Electrodeposition of Metals into Nano/Micropores of Templates: A Type of Electrochemistry under Confinement. Journal of Solid State Electrochemistry, 29 (2025) 1085-1132. https://doi.org/10.1007/s10008-024-06118-8

List of 2-5 most important recommended references with bibliographic data:
Y. D. Gamburg; G. Zangari: Theory and Practice of Metal Electrodeposition. Springer, 2011.

Lotfi, N.; Barati Darband, G.: A Review on Electrodeposited Metallic Ni-Based Alloy Nanostructure for Electrochemical Hydrogen Evolution Reaction. International Journal of Hydrogen Energy, 92 (2024) 256-290. https://doi.org/10.1016/j.ijhydene.2024.09.341
Pappaianni, G.; et al.: Electrodeposition of Nanostructured Metals on n-Silicon for Advanced Applications. Nanomaterials, 14(24) (2024) 2042. https://doi.org/10.3390/nano14242042

Date: February 2, 2026.
Prepared by: Péter László

2.4 Composites

Course title:

2.4.1 Composites
Credit value: 6
Course coordinator and instructor: Szilvia Klébert
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, lecture
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Aim of the course: To provide a comprehensive insight into the world of heterogeneous systems. Course content: The history of composites, their production, application and properties. Classification of composites according to various criteria (e.g., structure and morphology of the matrix and reinforcing material), interfacial interactions, mechanical properties; possibilities for improving or specifically adjusting properties, areas of research. Special production and testing methods.

List of 2-5 most important required readings with bibliographic data:
- Chung, Deborah D. L.: Carbon Fiber Composites. Butterworth-Heinemann, Oxford, 1994.
- Chawla, Krishan K.: Ceramic Matrix Composites. Springer, Boston, 1993.
- Mazumdar, Sanjay K.: Composites Manufacturing: Materials, Product, and Process Engineering. CRC Press, Boca Raton, 2001.
- Bukvić, M.; Milojević, S.; Gajević, S.; Đorđević, M.; Stojanović, B.: Production Technologies and Application of Polymer Composites in Engineering: A Review. Polymers, 17(16) (2025) 2187. https://doi.org/10.3390/polym17162187
- Tserpes, K.; Sioutis, I.: Advances in Composite Materials for Space Applications: A Comprehensive Literature Review. Aerospace, 12(3) (2025) 215. https://doi.org/10.3390/aerospace12030215

List of the 2-5 most important recommended references with bibliographic data:
- Yu, Long: Biodegradable Polymer Blends and Composites from Renewable Resources. Wiley, Hoboken, 2008.
- Wool, Richard P.; Sun, X. Susan: Bio-Based Polymers and Composites. Elsevier, Amsterdam, 2005.
- Huang, X.; Xu, Y.: Recent Developments of Advanced Composite Materials for Structural Strength and Resilience Improvements. Buildings, 15(22) (2025) 4097. https://doi.org/10.3390/buildings15224097
- Lopes, T. J.; et al.: Electrical Properties of Composite Materials. Journal of Composites Science, 9(8) (2025) 438.

Date: February 3, 2026.
Prepared by: Szilvia Klébert

Course name:
2.4.2 Polymer-based nanocomposites
Credit value: 6
Course coordinator and instructor: Andrea Ádámné Major
Course classification: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation

Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: The course deals with nanocomposites produced using polymer matrices and nanoparticles. It presents the possibilities for producing nanocomposites, the effect of nanoparticles on properties, and possible applications. Course content: Overview of possible matrix materials and nanomaterials, with particular emphasis on carbon nanotubes and nano clay minerals. Overview of the preparation and production possibilities of nanocomposites. Changes in the properties of nanocomposites as a function of nanoparticle quantity: structure, electrical conductivity, mechanical properties, thermal properties, crystallization properties, combustibility properties, optical properties. Possible applications of nanocomposites, nanotechnology.

List of 2-5 most important required readings with bibliographic data:
- Bhattacharya, Sati N.; Gupta, Rahul K.; Kamal, Musa R.: Polymeric Nanocomposites: Theory and Practice. Carl Hanser Publishers, Munich, 2008.
- Koo, Joseph H.: Polymer Nanocomposites: Processing, Characterization, and Applications. McGraw-Hill, New York, 2006.
- Musa, A. A.; Obianyo, I.; Sani, A. M.; et al.: Nano-Enhanced Polymer Composite Materials: A Review of Current Advancements and Challenges. Polymers, 17(7) (2025) 893.
- Rout, Lipeeka: Carbon Nanotube-Polymer Nanocomposites: Synthesis, Properties, and Applications. Springer, Singapore, 2024.

List of the 2-5 most important recommended references with bibliographic data:
- Ray, S. S.: Processing of Polymer-Based Nanocomposites. Springer, Cham, 2018.
- Sadiku, E. R.; et al.: Polymers and Two-Dimensional Nanocomposites. Elsevier, Amsterdam, 2024.
- Moharana, S.; Sahu, B. B.; Nayak, A. K. (eds.): Polymer Composites: Fundamentals and Applications. Springer, Singapore, 2024.
- Musa, A. A.; Obianyo, I.; Sani, A. M.; et al.: Nano-Enhanced Polymer Composite Materials: A Review of Current Advancements and Challenges. Polymers, 17(7) (2025) 893.

Date: December 20, 2025.
Prepared by: Andrea Ádámné Major

Course title:
2.4.3 Biomaterials for Medical Applications
Credit value: 6
Course coordinator and instructor: Csaba Balázsi
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the subject in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To present the technological production processes of ceramics, glass, and polymers (powder production, pressing, additive technologies, atomization, sintering), and to discuss the physical, chemical, and technological properties of materials with particular regard to medical applications. Course content: Composition and structural properties of materials produced by various methods (ceramics, glass, and polymers) and their medical applications; bioactive ceramics, which are currently used as coatings for

metal devices, promoting the formation of natural bone tissue and its integration into hard tissues; ceramic particles, microspheres, and nanosystems in cancer treatment; structures for tissue engineering as carriers for dental implants; new bioceramics with improved mechanical and biological functions, zirconium- and hydroxyapatite-based composites, and non-oxide ceramics.

List of 2-5 most important required readings with bibliographic data:
- Hench, Larry L.; Wilson, June (eds.): An Introduction to Bioceramics. World Scientific, Singapore, 1993.
- A Manual for Biomaterials/Scaffold Fabrication Technology. World Scientific, Singapore, 2007.
- Sonowal, L.; Gautam, S.; Mambiri, L. T.; Depan, D.: Advancements of Bioceramics in Biomedical Applications. Next Materials, 9 (2025) 101010. https://doi.org/10.1016/j.nxmate.2025.101010
- Qi, H.; Zhang, B.; Lian, F.: 3D-Printed Bioceramic Scaffolds for Bone Defect Repair: Bone Aging and Immune Regulation. Frontiers in Bioengineering and Biotechnology, 13 (2025) 1557203. https://doi.org/10.3389/fbioe.2025.1557203

List of the 2-5 most important recommended references with bibliographic data:
- Chen, Q.; Thouas, G. A.: Metallic Implant Biomaterials. Materials Science and Engineering R, 87 (2015) 1-57.
- Baskaran, P.; et al.: A Systematic Review on Biomaterials and Their Recent Progress in Tissue Engineering and Regenerative Medicine. Reviews in Inorganic Chemistry (2025).
- Sonowal, L.; Gautam, S.; Mambiri, L. T.; Depan, D.: Advancements of Bioceramics in Biomedical Applications. Next Materials, 9 (2025) 101010. https://doi.org/10.1016/j.nxmate.2025.101010
- Qi, H.; Zhang, B.; Lian, F.: 3D-Printed Bioceramic Scaffolds for Bone Defect Repair: Bone Aging and Immune Regulation. Frontiers in Bioengineering and Biotechnology, 13 (2025) 1557203. https://doi.org/10.3389/fbioe.2025.1557203

Date: February 26, 2026.
Prepared by: Csaba Balázsi

Course title:
2.4.4 Finite element analysis of structures built from composite materials
Credit value: 6
Course coordinator and instructor: András Zachár
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the subject in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of physics and chemistry

Course description:
Course objective: To present basic knowledge that will enable students to effectively apply numerical simulation tools in the fields of materials science and materials technology. Course content: Lecture (theoretical): Students will learn the theoretical background of modern numerical simulation software. Introduction to the fundamentals of the finite element method (FEM), use of the weighted residual method to solve boundary value problems of differential equations and its application in the finite element method. Interpolation and its application in the finite element method, Lagrange, Hermite, and spline interpolation. Problems of numerical stability, Courant condition (CFL). Linear solvers, direct and iterative methods, important iterative methods (Gauss–Seidel, gradient methods, multigrid methods), their advantages, disadvantages, and connection to the use of practical software (Ansys). Practical: students become familiar with the structural analysis modules of the Ansys software, geometry handling, meshing, specifying initial and boundary conditions, and evaluating results.

List of 2-5 most important required readings with bibliographic data:
- Gisbert, Stoyan: Numerical Mathematics for Engineers and Programmers. Typotex, Budapest, 2007.
- Gisbert, Stoyan; Takó, Galina: Numerical Methods 3. Typotex, Budapest, 1997.
- Palaniappan, Sathish Kumar; Lakshminarasimhan, Rajeshkumar; Rangappa, Sanjay M.; Siengchin, Suchart (eds.): Finite Element Analysis of Polymers and Composites. Woodhead Publishing, Duxford, 2024.
- Guan, Z.; et al.: Review of Finite Element Modelling of Composite Structures Subjected to Extreme Loading Conditions. Oxford Open Materials Modelling, 1(1) (2025) wqaf005.

List of the 2-5 most important recommended references with bibliographic data:
- Zienkiewicz, O. C.; Taylor, R. L.; Zhu, J. Z.: The Finite Element Method: Its Basis and Fundamentals. 7th ed., Elsevier, Oxford, 2013.
- Tserpes, K.; Sioutis, I.: Advances in Composite Materials for Space Applications: A Comprehensive Literature Review. Aerospace, 12(3) (2025) 215. https://doi.org/10.3390/aerospace12030215
- Adibi, H.; et al.: Unified Experimental and Finite Element Analysis of the Mechanical Performance of 3D-Printed Sandwich Composite Cores. Results in Engineering (2025).
- Palaniappan, Sathish Kumar; Lakshminarasimhan, Rajeshkumar; Rangappa, Sanjay M.; Siengchin, Suchart (eds.): Finite Element Analysis of Polymers and Composites. Woodhead Publishing, Duxford, 2024.

Date: February 18, 2026.
Prepared by: András Zachár

2.5 Micro- and nanostructured systems

Course title:
2.5.1 Semiconductor Technologies
Credit value: 6
Course coordinator and instructor: Zsolt József Horváth
Course classification: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of physics and chemistry.

Course description:
Course objective: To familiarize doctoral students with the technological steps and sequences involved in the production of important semiconductor materials, devices, and MEMS structures. Course content: Elemental and compound semiconductors. Crystal structure. Crystal growth, Czochralski and Bridgman methods, zone refining. Liquid phase, vapor phase, and molecular beam epitaxy. Physical and chemical methods of separating metals and insulators. Thermal oxidation of Si. Diffusion. Ion implantation. Photolithography, electron, X-ray, and ion beam lithography. Chemical, plasma, and ion etching. Basic steps in bipolar and MOS technology. Silicon on insulator (SOI) technology. MESFET manufacturing process. MEMS technology: surface and bulk micromachining. LIGA technology. Hot embossing. Fabrication of microfluidic structures.

List of 2-5 most important required readings with bibliographic data:
- D. V. Morgan and K. Board: An introduction to semiconductor microtechnology, John Wiley and Sons, New York, 1983.

- Kitai, A.: Fundamentals of Semiconductor Materials and Devices. Wiley, Hoboken, 2023. ISBN 9781119891406.
- Kumar, A.; Ghosh, S. N.; Talukder, S.; Chopra, D.: Lithography and 3D Fabrication Processes: A Review. ES Materials & Manufacturing, 23 (2024) 974.

List of the 2-5 most important recommended references with bibliographic data:
- S. M. Sze: Semiconductor Devices: Physics and Technology, John Wiley and Sons, New York, 1985.
- Karimi, K.; et al.: A Thorough Review of Emerging Technologies in Micro- and Nanochannel Fabrication: Limitations, Applications and Comparison. Micromachines, 15(10) (2024) 1274.
- Omiyale, B. O.; et al.: Towards Robust Flexible Electronics: Fabrication Techniques and Materials Integration. Progress in Organic Coatings, 2025.

Date: January 19, 2026.
Prepared by: Zsolt József Horváth

Course title:
2.5.2 Semiconductor Devices
Credit value: 6
Course coordinator and instructor: Zsolt József Horváth
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of physics and electrical engineering.

Course description:
Course objective: To familiarize doctoral students with the physical principles of modern electronic, optoelectronic, and MEMS semiconductor devices, their structure, and operating principles. Course content: An overview of the structure and operating principles of semiconductor devices, namely bipolar and Schottky diodes, bipolar transistors, MESFETs and MOSFETs, memory devices, solar cells, photodetectors, LEDs and laser diodes, as well as MEMS sensors and actuators. Familiarization with the relevant physical principles and processes and the mathematical models describing them.

List of 2-5 most important required readings with bibliographic data:
- Árpád Csurgay and Károly Simonyi: Physical Fundamentals of Information Technology, Electron Physics, BME Institute of Continuing Education, Budapest, 1997.
- Székely Vladimir: Electronics I. Semiconductor Devices, Műegyetemi Kiadó, 2001.
- Sze, S. M.; Ng, K. K.: Physics of Semiconductor Devices. 4th ed., Wiley, Hoboken, 2021. ISBN 9781119429111.
- Sugiura, T.; et al.: Materials in Electrical and Electronic Devices: A Review for Future Device Design. IET Electrical Materials and Applications, 2025.

List of the 2-5 most important recommended references with bibliographic data:
- Nemcsics Ákos: Solar Cells and Their Development Prospects, Akadémiai Kiadó, Budapest, 2001.
- S. M. Sze, K. K. Ng: Physics of Semiconductor Devices, 3rd Edition, Wiley, New York, 2006.
- D. L. Pulfrey: Understanding Modern Transistors and Diodes, Cambridge University Press, Cambridge, 2010.
- Kitai, A.: Fundamentals of Semiconductor Materials and Devices. Wiley, Hoboken, 2023. ISBN 9781119891406.

- Recent Advances in Semiconductor Devices and Applications. In: Encyclopedia of Materials: Electronics, Springer, 2026.

Date: January 2, 2026.
Prepared by: Zsolt József Horváth

Course title:
2.5.3 Solid-state light sources and their applications
Credit value: 6
Course coordinator and instructor: Zsolt József Horváth
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of physics and electrical engineering.

Course description:
Course objective: To familiarize students with the types, operating principles, and applications of solid-state light sources. Course content: Solid-state light sources are now an integral part of everyday life and are present in virtually all modern electronic devices. In this course, students will learn about the physical fundamentals (properties of electromagnetic radiation and light emission mechanisms – thermal radiation, spontaneous and stimulated emission), the types, structure, materials, properties, and areas of application (medical and industrial applications, optical telecommunications, data transmission, optical data and information storage – CDs, DVDs, holography – display, imaging, and lighting) of solid-state light sources (lasers and light-emitting diodes).

List of the 2-5 most important required readings with bibliographic data:
- Mojzes Imre, Kökényesi Sándor: Photonic Materials and Devices, University Textbook, Műegyetemi Kiadó, 1997.
- Bahaa E.A. Saleh, Malvin Carl Teich: Fundamentals of Photonics, Second Edition, John Wiley & Sons Inc., Hoboken, N.J., 2007.
- Bhattarai, T.; et al.: A Review of Light-Emitting Diodes and Ultraviolet Light-Emitting Diodes and Their Applications. Photonics, 11(6) (2024) 491.
- Peng, J.; et al.: Blue Perovskite LEDs: A Comprehensive Review of Materials, Device Physics and Stability. Progress in Quantum Electronics, 2025.

List of the 2-5 most important recommended references with bibliographic data:
- Optoelectronics and Photonics, Pearson Education, 2013.
- Safa Kasap, Harry Ruda, Yann Boucher: Handbook of Optoelectronics and Photonics, Cambridge Univ. Press, 2009.
- S. M. Sze, K. K. Ng: Physics of Semiconductor Devices, 3rd Edition, Wiley, New York, 2006.
- Zheng, C. L.; et al.: On-Chip Light Control of Semiconductor Optoelectronic Devices Using Integrated Metasurfaces. Opto-Electronic Advances, 2025.
- Li, H.; et al.: Highly Efficient Light-Emitting Diodes via Self-Assembled InP Quantum Dot Films. Nature Communications, 16 (2025).

Date: January 5, 2026.
Prepared by: Zsolt József Horváth

Course title:
2.5.4 Band gap engineering
Credit value: 6
Course coordinator and instructor: Ákos Nemcsics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To provide an introduction to quantum mechanical band engineering using the example of solar cells Course content: Not so long ago, the quantum mechanical study of electrons confined in an idealized potential well was a textbook example. With the advancement of technology, it has become possible to build such systems. We will show how devices utilizing quantum mechanical effects (e.g., resonant tunneling) can be designed using so-called "band gap engineering." Most of the examples will be presented using solar cell designs. (e.g., how to improve efficiency by orders of magnitude.) In addition to design, we will also provide insight into the technology behind these systems.

List of the 2-5 most important required readings with bibliographic data:
- own notes
- Advances in Wide-Bandgap III-V Solar Cells. Applied Physics Reviews, 12(3) (2025) 031309.
- Ali, A. O.; et al.: Advancements in Photovoltaic Technology: Materials, Devices and Future Trends. Materials Today Sustainability, 2025.

List of 2-5 most important recommended literature with bibliographic data:
- Meddeb, H.; et al.: Optical Design and Bandgap Engineering in Ultrathin Si/Ge Multiple Quantum Well Solar Cells. Progress in Photovoltaics, 2025.
- Farias-Basulto, G.; et al.: Improving Perovskite/CIGS Tandem Solar Cells for Higher Efficiency by Optical and Band-Gap Engineering. ACS Applied Materials & Interfaces, 2025.

Date: February 26, 2026.
Prepared by: Ákos Nemcsics

Course title:
2.5.5 Self-organizing low-dimensional systems
Credit value: 6
Course coordinator and instructor: Ákos Nemcsics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:

Course objective: To provide an introduction to the rapidly developing field of materials science indicated in the title, which is revolutionizing computer technology and data storage Course content: Developments in materials science (the science of nanosystems) have revolutionized electronics and computer technology. The miniaturization of computers, increasing their speed, and improving their reliability are limited with today's technology. Beyond a certain limit, achieving one of the listed goals comes at the expense of the others. Nanoscience has already brought about fundamental changes in the field of digital circuits. For example, a traditional 35-element CMOS logic circuit can be implemented with as few as 10 elements using spin-sensitive devices (spintronics). Of course, new design methodologies are needed to design these circuits. Zero-dimensional structures enable quantum computers, which open up new dimensions of miniaturization, speed, and reliability. These 0D quantum dots cannot be produced using traditional microelectronic methods; self-assembly must be used instead. Different architectures require different operating logics. The rapid change in storage capacities (e.g., spin valves) also has a major impact on computer science. The course does not require any special prior knowledge of materials science. After covering the necessary physical knowledge, we focus on the self-organizing formation and operation of structures and their modeling.

List of the 2-5 most important required readings with bibliographic data:
- own notes
- Tasiu, I. A.; et al.: Spintronics Technology: A Comprehensive Review of Materials, Devices and Applications. Results in Engineering, 2025.
- Pan, Y. Y.; et al.: III-V Quantum Dots: A Multidimensional Exploration from Synthesis to Optoelectronic Applications. Materials Today, 2025.

List of 2-5 most important recommended literature with bibliographic data:
- Banerjee, N.; et al.: Materials for Quantum Technologies: A Roadmap for Spin and Topological Platforms. Applied Physics Reviews, 2025.
- Akrema; et al.: Light-Controlled Electrostatic Self-Assembly of Quantum Dots. Journal of Physical Chemistry C, 2025.

Date: February 10, 2026.
Prepared by: Ákos Nemcsics

Course name:
2.5.6 Nanotechnology - Chemical Materials Science
Credit value: 6
Course coordinator and instructor: Éva Kiss
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation, total number of hours: 30
What methods, specific approaches, and characteristics are used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
The aim of the course is to present the relationship between the chemical composition, structure and function of materials, and to introduce the role of nanotechnology in 1D, 2D and 3D systems and practical applications. Course content: Fundamentals of chemical materials science, the relationship between structure and macroscopic properties; the concept of nanotechnology, nanomaterials; production and functionalization of nanoparticles; characteristic properties and applications of quantum dots; colloidal drug delivery systems, their function, materials, main polymer-based types; formation and structure of self-

assembled monolayers, functional monolayers, patterning with SPM; production of nanolayers and surface films and pattern formation using lithographic methods; production of Langmuir-Blodgett films, their structural characteristics and applications; production of nanostructured materials - bottom-up construction - use of association and phase separation; production of nanostructured materials – bottom-up construction – colloidal crystals, colloidal ink, electrostatic spinning; optical properties, structure of optical fibers and a method of their production; photonic materials, structure, production; magnetic properties, classification of materials based on their magnetic properties, ferromagnetism; types of ferromagnetic materials, their characteristics; ferrimagnetic materials, superparamagnetism, giant magnetoresistance; electrical conductivity, types of materials, changes in conductivity with temperature; semiconductors and conductive devices; molecular electronics; special electrical properties of ceramics.

List of 2-5 most important required readings with bibliographic data:
- Cahn, R. W.: The Coming of Materials Science. Pergamon, Amsterdam, 2001.
- Callister, W. D.; Rethwisch, D. G.: Materials Science and Engineering: An Introduction. Wiley, Hoboken, 2020.
- Smith, W. F.; Hashemi, J.; Prakash, R.: Foundations of Materials Science and Engineering. McGraw-Hill, New York, 2021.
- Mimona, M. A.; Rimon, M. I. H.; Zohura, F. T.; Sony, J. M.; Rim, S. I.; Arup, M. M. R.; Mobarak, M. H.: Quantum Dot Nanomaterials: Empowering Advances in Optoelectronic Devices. Chemical Engineering Journal Advances, 21 (2025) 100704. https://doi.org/10.1016/j.ceja.2025.100704
- Jana, A.; Meena, A.; Patil, S. A.; Jo, Y.; Cho, S.; Park, Y.; Sree, V. G.; Kim, H.; Im, H.; Taylor, R. A.: Self-Assembly of Perovskite Nanocrystals. Progress in Materials Science, 129 (2022) 100975. https://doi.org/10.1016/j.pmatsci.2022.100975

List of 2-5 most important recommended references with bibliographic data:
- Cahn, R. W.: The Coming of Materials Science. Pergamon, Amsterdam, 2001.
- Callister, W. D.; Rethwisch, D. G.: Materials Science and Engineering: An Introduction. Wiley, Hoboken, 2020.
- Smith, W. F.; Hashemi, J.; Prakash, R.: Foundations of Materials Science and Engineering. McGraw-Hill, New York, 2021.
- Ahire, S. A.; Bachhav, A. A.; Pawar, T. B.; Jagdale, B. S.; Patil, A. V.; Koli, P. B.: The Augmentation of Nanotechnology Era: A Concise Review on Fundamental Concepts of Nanotechnology and Applications in Material Science and Technology. Results in Chemistry, 4 (2022) 100633. https://doi.org/10.1016/j.rechem.2022.100633
- Jawad, M. S.; Rahman, W. U.; Khan, M.; Faysal, A. M.: Nanomaterial Assembly Pathways: Comparative Insights into Self-Assembly and Directed Assembly Techniques. Next Materials, 10 (2026) 101422. https://doi.org/10.1016/j.nxmate.2025.101422
Date: February 23, 2026.
Prepared by: Éva Kiss

Course title:
2.5.7 Medical Applications of Colloidal Systems
Credit value: 6
Course coordinator and instructor: Gergő Gyulai
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To present the areas of application and possibilities of colloidal particles and thin films used in modern medical biology. Course content: General presentation of colloidal dispersion systems. Areas of application for drug delivery particles. Possibilities for the production and use of lipid, surfactant, polymer gel, and solid polymer-based particles. Development of colloidal diagnostic and therapeutic (theranostic) systems. Characterization of colloidal dispersion systems: active ingredient content, encapsulation efficiency, size (static and dynamic light scattering, atomic force microscopy, electron microscopy), determination of surface composition. Possibilities for active ingredient transport (active and passive transport). Presentation of thin-layer-based diagnostic techniques.

List of 2-5 most important required readings with bibliographic data:
- Ghoshisht, M. K.; et al.: Recent Advances in Biomedical Applications of Smart Nanomaterials. Polymer Materials, 2025.
- Theranostic Applications of Tailored Lipid-Based Nanoparticles. ACS Applied Nano Materials, 2025.

List of 2-5 most important recommended literature with bibliographic data:
- Khalid-Salako, F.; et al.: The Nanocarrier Landscape: Evaluating Key Drug Delivery Platforms. Pharmaceutics, 2025.
- Azimizonuzi, H.; et al.: A State-of-the-Art Review of the Recent Advances of Theranostic Nanoparticles. Pharmaceutics, 2025.

Date: February 4, 2026.
Prepared by: Gergő Gyulai

Course title:
2.5.8 Characterization and Modification of Polymer Surfaces
Credit value: 6
Course coordinator and instructor: Éva Kiss
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To describe surface/interface interactions characteristic of polymer materials and the surface modification processes that influence them. Course content: Physical-chemical interactions between solid surfaces and liquid media. Interface phenomena in polymer-containing material systems. The laws governing wetting and adsorption, models used to describe the kinetics of the phenomenon and process. Surface analysis methods for determining chemical composition: modern, surface-sensitive techniques (ESCA, SIMS, FT-IR), high-performance imaging methods (e.g., AFM). Direct and indirect methods suitable for studying interfacial interactions: wetting, direct force measurement, particle adhesion, colloidal stability, macromolecule adsorption, self-assembling systems, formation of Langmuir-Blodgett films. Surface modification of polymers by chemical "wet" processes and plasma treatment.

List of the 2-5 most important required readings with bibliographic data:
- D.J.Shaw: Introduction to Colloid and Surface Chemistry, Műszaki Könyvkiadó, Budapest, 1986.
- J. Andrade: Surface and Interfacial Aspects of Biomedical Materials, Plenum Press, N.Y. 1985.

- Primc, G.; Mozetič, M.: Surface Modification of Polymers by Plasma Treatment for Appropriate Adhesion of Coatings. Materials, 17(7) (2024) 1494. DOI: 10.3390/ma17071494.
- Xiang, Y.; et al.: Characterization of Surface Modifications in Oxygen Plasma Treated Polymer Films. Langmuir, 40 (2024).

List of the 2-5 most important recommended references with bibliographic data:
- F. McRitchie: ChemistryatInterfaces, Acad. Press, London, 1990.
- Kiss Éva: Cardiovascular Materials, pp.260-277 Technical Surface Science and Its Applications in Medicine and Biology (Sz. Bertóti I., Marosi Gy. Tóth A.) B+V Lap és Könyvkiadó Kft. 2003.
- Nakulan, A.; et al.: Surface Modification and Patterning of Polymer Thin Films by Plasma Glow Discharge. Materials Today Communications, 2024.
- Primc, G.; Mozetič, M.: Surface Modification of Polymers by Plasma Treatment for Appropriate Adhesion of Coatings. Materials, 17(7) (2024) 1494. DOI: 10.3390/ma17071494.

Date: December 19, 2025.
Prepared by: Éva Kiss

Course title:
2.5.9 Molecular Beam Epitaxy of III-V Semiconductor Materials
Credit value: 6
Course coordinator and instructor: Ákos Nemcsics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, lecture
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To provide an introduction to epitaxial growth using III-V materials as examples Course content: Molecular beam epitaxy (MBE) is currently the only technology that allows layers and nanostructures to be created on the surface of crystalline semiconductor wafers with atomic-level control. Our investigations will mainly focus on III-V materials, but we will also examine other materials from time to time. Course content: Properties of III-V materials, kinetics of epitaxial growth, growth modes (SK, VW, FM), in-situ growth analysis (RHEED), growth simulation (KMC), production of low-dimensional (0D, 1D, and 2D) structures, technical conditions, and application examples.

List of 2-5 most important required readings with bibliographic data:
- Pan, S.; et al.: Recent Progress in Epitaxial Growth of III-V Quantum-Dot Lasers on Silicon. Journal of Semiconductors, 40(10) (2019) 101302.
- InP Quantum Dot Lasers: From Growth to Devices. Optical Materials Express, 16(1) (2026) 32-64.

List of 2-5 most important recommended references with bibliographic data:
- Pan, Y. Y.; et al.: III-V Quantum Dots: A Multidimensional Exploration from Synthesis to Optoelectronic Applications. Materials Today, 2025.
- Park, H.; et al.: High Performance 1.3 μm III-V Quantum Dot Lasers Grown by Molecular Beam Epitaxy for Optical Communications. Laser & Photonics Reviews, 2025.

Date: January 22, 2026.
Prepared by: Ákos Nemcsics

Course title:
2.5.10 Optical Characterization of Thin Films
Credit value: 6
Course coordinator and instructor: Péter Petrik
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the subject in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of physics

Course description:
Course objective: To learn the mathematical description of polarized light, to become familiar with measurement methods based primarily on the measurement of light polarization and the interpretation of measured quantities, and to learn about light-matter interaction and the investigation of material properties based on this. Course content: Optics of polarized light; propagation, refraction, and reflection of light at interfaces and in layer systems; theory of ellipsometry, measurement principle, operating principle of measuring devices; optical modeling of nanostructures; separation of thin films; measurement setups for the examination of thin films; determination of the refractive index and structure of nanolayers

List of 2-5 most important required readings with bibliographic data:
- Azzam Bashara: Ellipsometry and polarized light
- Ma, L.; et al.: A Review of Measurement and Characterization of Film Layers by Spectroscopic Ellipsometry. Nanomaterials, 15(4) (2025) 282.
- Park, J.; et al.: Spectroscopic Ellipsometry Utilizing Frequency Division Multiplexing for Fast Optical Metrology. Communications Physics, 2024.

List of the 2-5 most important recommended references with bibliographic data:
- E. Irene, H. Tompkins: Handbook of Ellipsometry
- M. Losurdo, K. Hingerl: Ellipsometry at the nanoscale
- Losurdo, M.; Hingerl, K. (eds.): Ellipsometry at the Nanoscale. Springer, Berlin, 2013.
- Aulika, I.; et al.: Comprehensive Optical Characterization of Organic Thin Films by Spectroscopic Ellipsometry. Journal of Materials Research and Technology, 2025.

Date: February 14, 2026.
Prepared by: Péter Petrik

Course title:
2.5.11 Measurement of Bioelectrical Activities
Credit value: 6
Course coordinator and instructor: Gergely Márton
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation

Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: basic knowledge of electrochemistry

Course description:
Course objective: To familiarize students with the sources of electrical potential differences generated by living organisms and the essential properties of microelectrodes used to measure them. Course content: Sources of bioelectrical potential differences and their relationship to Maxwell's equations. Volume conduction. The basic principles of extracellular, juxtacellular, and intracellular measurements. The material and structure of microelectrodes used in practice. The significance and impedance of electrode-electrolyte interfaces. Modern methods of impedance reduction. Noise sources, the effect of surfaces on the signal-to-noise ratio. Corrosion of electrodes in living tissue. The effects of foreign body reactions caused by tissue, experiments with novel electrode materials to mitigate tissue reactions.

List of the 2-5 most important required readings with bibliographic data:
- Ramesh Srinivasan: Anatomical constraints on source models for high-resolution EEG and MEG derived from MRI (Technol Cancer Res Treat. 2006 Aug; 5(4): 389–399.)
- Pouria Fattahi, Guang Yang, Gloria Kim, Mohammad Reza Abidian: A Review of Organic and Inorganic Biomaterials for Neural Interfaces (Adv Mater. 2014 Mar 26; 26(12): 1846–1885.)
- In Vivo Microelectrode Arrays for Neuroscience. Nature Reviews Methods Primers, 2025.
- Kim, D.; et al.: Recent Advances in Microelectrode Array Interfaces for Electrophysiological Study of Neural Tissues. Bioengineering, 11(2) (2026) 142.

List of 2-5 most important recommended references with bibliographic data:
- Pour Aryan, Naser, Kaim, Hans, Rothermel, Albrecht: Stimulation and Recording Electrodes for Neural Prostheses (2015, book).
- Amelia A. Schendel, Kevin W. Eliceiri, Justin C. Williams: Advanced Materials for Neural Surface Electrodes. Curr Opin Solid State Mater Sci. 2014 Dec 1; 18(6): 301–307.
- Gergely Márton: Development and Characterization of novel microelectrode arrays for neurophysiology (Ph.D. dissertation, 2015)
- Siwakoti, U.; et al.: Recent Progress in Flexible Microelectrode Arrays for Bioelectrical Recordings. Biosensors, 15(2) (2025) 100.
- Schröter, M.; et al.: Advances in Large-Scale Electrophysiology with High-Density Microelectrode Arrays. Lab on a Chip, 2025.

Date: January 29, 2026.
Prepared by: Gergely Márton

2.6 Environmental aspects of certain materials science technologies

Course title:
2.6.1 Environmental Chemistry
Credit value: 6
Course coordinator and lecturer: Shaban Abdul
Classification of the course: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to impart the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation

Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: Application of chemical principles to the study of the environment. It includes natural processes and pollution problems related to air, water, and soil. Course content: Part I. Introduction to environmental chemistry: Introduction; Environmental Chemistry: Water; Pollutants of Waters; Unit Operations Water Treatments; Advanced treatments of Waste Water. Part II. Water Analysis: Water Analysis: ions; Water Analysis: low concentrations of common ions; Water Analysis: trace pollutants part 1,2. Part III. Atmosphere: The Atmospheric chemistry; Air Pollutants- General; Air Pollutants: Organic Type. Part IV. Atmospheric Analysis: Atmospheric analysis: Gases 1; Atmospheric analysis: Gases 2; Atmospheric analysis: Particulates. Part V. Soil: Soil formation; Soil properties. Part VI. Soil Analysis: Analysis of soils, sediments and biological specimens. Part VII. Toxicology: Toxicological Chemistry; Toxicology: Organic Compounds; Hazardous wastes: Reactions; Waste reduction and minimization-physical methods of treatment of hazardous-wastes; Chemical treatment of hazardous wastes. Learning outcomes: Upon successful completion of the course, students will be able to demonstrate knowledge of the chemical principles of environmental phenomena and processes in air, water, and soil; apply thermodynamics, kinetics, and photochemistry to environmental problems; and describe industrial processes, water purification, waste treatment, energy production, and pollution mitigation strategies.

List of 2-5 most important required readings with bibliographic data:
- Manahan, S. E.: Environmental Chemistry. 10th ed., CRC Press, Boca Raton, 2017. ISBN 9781498776936.
- Schwarzenbach, R. P.; Gschwend, P. M.; Imboden, D. M.: Environmental Organic Chemistry. 3rd ed., Wiley, Hoboken, 2016. ISBN 9781118767238.
- Worku, A. K.; et al.: Recent Advances in Wastewater Treatment Technologies. Cleaner Water, 1 (2025) 100035.
- Baysal, A.; et al.: Green Analytical Chemistry Approaches on Environmental Analysis. Trends in Environmental Analytical Chemistry, 31 (2022) e00147.

List of the 2-5 most important recommended references with bibliographic data:
- Krause, S.; Clark, H. M.; Ferris, J. P.; Strong, R. L.: Chemistry of the Environment. Elsevier Science & Technology Books, 2002.
- Lecture handouts in digital format.
- Menger, F.; Andersson, P. L.; Weiss, J. M.: A Comprehensive Review of Emerging Environmental Contaminants. Environmental Analysis, Health and Toxicology (2025).
- Tyagi, S.; et al.: Advanced Chemometric Techniques for Environmental Pollution Assessment. Chemosensors, 13(7) (2025) 268.

Date: February 12, 2026.
Prepared by: Shaban Abdul

Course title:
2.6.2 Recycling plastic waste through pyrolysis
Credit value: 6
Course coordinator and instructor: Zsuzsanna Czégény
Course classification: elective course in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium

Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To learn about the basic thermal decomposition processes of plastics. To learn about the possibilities of pyrolytic recycling of plastic waste. Course content: Thermal decomposition of plastics and plastic mixtures. The effect of additives on the thermal decomposition process. Modification and use of the resulting products.

List of 2-5 most important required readings with bibliographic data:
- Kaminsky, W. (ed.): Feedstock Recycling and Pyrolysis of Waste Plastics. John Wiley & Sons, Chichester, 2006.
- Saxena, S.; et al.: Pyrolysis and Beyond: Sustainable Valorization of Plastic Wastes. Cleaner Engineering and Technology, 21 (2025) 100776.
- Roychand, R.; et al.: A Comprehensive Review on the Thermochemical Treatment of Plastic Waste. Carbon Neutrality, 4 (2025) 17.

List of the 2-5 most important recommended references with bibliographic data:
- Yaqoob, H.; et al.: Pyrolysis of Waste Plastics for Alternative Fuel. Sustainable Energy & Fuels, 9 (2025) 1462-1487.
- Aznárez, A.; et al.: Literature Review on the Recycling of Postconsumer Plastic Waste by Chemical Routes. Industrial & Engineering Chemistry Research, 64 (2025) 12234-12266.

Date: February 11, 2026.
Prepared by: Zsuzsanna Czégény

Course title:
2.6.3 Wastewater Treatment Technologies
Credit value: 6
Course coordinator and instructor: Rita Bodáné Kendrovics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To present the technological processes of drinking water production and wastewater treatment. Possible preparatory operations required for drinking water production. Removal of suspended solids, Fe, Mn, As, degassing. Water softening, desalination, nitrate removal. An important part of the course is the presentation of different disinfection technologies. Course content: Within the topic of wastewater treatment technologies, the course analyzes the individual technological stages – Stage I wastewater treatment (mechanical pre-treatment and mechanical treatment), Stage II wastewater treatment (biological treatment), third-stage wastewater treatment (nutrient removal) and the possible treatment steps within each stage. It places great emphasis on the treatment and utilization of sewage sludge, including energy and agricultural utilization options, nature-based wastewater treatment processes, and decentralized technologies.

List of the 2-5 most important required readings with bibliographic data:

- István Barótfy: Environmental Technology. Mezőgazdasági Kiadó, Budapest, 2000.
- Environmental Technology I-II. Ministry of Environment and Water Management.
- Worku, A. K.; et al.: Recent Advances in Wastewater Treatment Technologies. Cleaner Water, 1 (2025) 100035.
- Shamshad, J.; et al.: Innovative Approaches to Sustainable Wastewater Treatment. Environmental Science: Water Research & Technology, 11 (2025) 1120-1148.

List of the 2-5 most important recommended references with bibliographic data:
- Environmental Technology Case Studies. Ministry of Environment and Water Management.
- Current literature.
- Al-Rajhi, A. M. H.; et al.: Innovative Strategies for Wastewater Treatment. Frontiers in Environmental Science, 13 (2025) 1696485.

Date: December 21, 2025.
Prepared by: Rita Bodáné Kendrovics

Course title:
2.6.4 Fundamentals of Hydrology
Credit value: 6
Course coordinator and instructor: Emőke Bardóczyné Székely
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course content: Basic concepts of hydrology. The country's hydrographic characteristics, natural water supply, and spatial and temporal variability of water resources. Domestic water management practices, environmental impacts on natural waters. Hydrological basis of water resource management. Hydrology of diffuse and concentrated pollution affecting natural waters, transport processes and modeling of surface watercourses, processes affecting oxygen balance, and the wastewater load capacity of receiving waters.

List of 2-5 most important required readings with bibliographic data:
- Vermes L.: Water Management. Szaktudás Publishing House, Budapest, 1997.
- Szűcs P.; Sallai F.; Zákányi B.; Madarász T.: Water Resource Protection. Bíbor Publishing House, Miskolc, 2009.
- Wu, W.; et al.: Scenario Thinking to Address Deep Uncertainty in Water Resources Management. Journal of Hydrology, 656 (2025) 132994.

List of the 2-5 most important recommended references with bibliographic data:
- Pásztó P.: Water Quality Protection, Water Quality Regulation. Veszprém University Press, Veszprém, 1998.
- Íjjas I.; Szlávik L.: Water Management I. PHARE-EJF, Baja, 1998.
- Current announcements from the journals Hydrology and Journal of Hydrology.

Date: February 1, 2026.
Prepared by: Emőke Bardóczyné Székely

Course name:
2.6.5 Hydrobiology
Credit value: 6
Course coordinator and instructor: Rita Bodáné Kendrovics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course content: Classification of waters, their physical and chemical characteristics, the cycle of important elements. Trophicity, halobity, saprobity, and toxicity. The role of phytoplankton and macrophytes, oxygen balance in water, biological production, allochthonous and autochthonous pollution, anthropogenic pollution. Biotic communities in standing waters and rivers, plankton, nekton, neuston, benthos, periphyton, as well as the basics of biological production and water quality assessment.

List of 2-5 most important required readings with bibliographic data:
- Szilágyi F.; Orbán V.: Applied Hydrobiology. MaVíz, Budapest, 2007.
- Padisák J.: General Limnology. ELTE Eötvös Publishing House, Budapest, 2005.
- Freshwater Ecology: Limnology. 2nd ed., Academic Press, 2025.

List of 2-5 most important recommended literature with bibliographic data:
- Felföldy L.: Environmental Science of Water. Mezőgazdasági Publishing House, Budapest, 1983.
- Woynárovich E.: Protection of our aquatic environment. Agroinform Publishing House, Budapest, 2007.
- Hydrobiologia - current overview publications on freshwater ecology and water quality assessment.

Date: December 27, 2025.
Prepared by: Rita Bodáné Kendrovics

Course title:
2.6.6 Life cycle analysis
Credit value: 6
Course coordinator and instructor: Ákos Nemcsics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course content: The development of industrial environmental thinking, the integrated environmental approach, life cycle thinking, and the emergence of a multifaceted environmental approach. Life cycle assessment (LCA) as a tool for the uniform, quantitative assessment of environmental impact. Phases of analysis: defining objectives and scope, inventory analysis, impact analysis, interpretation, and critical

review. Processing of relevant standards, software, data quality, databases, and case studies. Additional assessment and design systems based on LCA: EPD, PEF/OEF, and eco-design.

List of 2-5 most important required readings with bibliographic data:
- Sánchez-Burgos, M. A.; et al.: Life Cycle Assessment (LCA) Methodology. In: Life Cycle Analysis Based on Nanoparticles Applied to the Construction Industry. Springer, Cham, 2025, pp. 43-58.
- Mordaschew, V.; et al.: The Product Environmental Footprint – A Critical Review. Procedia CIRP, 122 (2024) 680-685.
- Wang, H.; et al.: Integrating Machine Learning into Life Cycle Assessment. PLOS Climate, 4(1) (2025) e0000732.

List of the 2-5 most important recommended references with bibliographic data:
- Pscherer, T.; et al.: LCA Standards for Environmental Product Assessments in the Bioeconomy Transition. International Journal of Life Cycle Assessment, 30 (2025) 1-18.
- Current LCA case studies and OpenLCA database-based tasks.

Date: December 14, 2025.
Prepared by: Ákos Nemcsics

Course name:
2.6.7 Environmental Product Declaration
Credit value: 6
Course coordinator and instructor: Ákos Nemcsics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
What methods, specific approaches, and characteristics are used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: mid-term assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course content: The basics and significance of environmental product declarations (EPDs) from an economic, environmental, and marketing perspective. Differences and similarities compared to LCA. General requirements for EPD preparation: comparability, prescribed impact categories, format, and verification. Special rules, product category rules (PCR), and case study analysis. Shortcomings and limitations of EPD systems.

List of 2-5 most important required readings with bibliographic data:
- EN 15804+A2: Sustainability of Construction Works - Environmental Product Declarations - Core Rules for the Product Category of Construction Products. CEN, Brussels, latest applicable edition.
- Moshood, T. D.; et al.: A Critical Analysis of Environmental Product Declarations. Sustainability, 16(22) (2024) 9671.
- Olanrewaju, O. I.; et al.: Assessment of Environmental Product Declaration and Database Developments. Environmental Impact Assessment Review, 109 (2025) 107670.

List of the 2-5 most important recommended references with bibliographic data:
- Capolini, F.; Cova, M.; Acampora, A.: Environmental Product Declarations: A Comprehensive Review of Current Research and Practices. Conference Proceedings, 2025.
- Construction Products Association: Environmental Product Declarations (EPD): Comparability – A Technical Review. London, 2024.

- Current PCR documents and certified EPD case studies.

Date: December 18, 2025.
Prepared by: Ákos Nemcsics

Course name:
2.6.8 Environmental impacts of the electronics industry
Credit value: 6
Course coordinator and instructor: Ákos Nemcsics
Classification of the subject: elective subject in materials science
Theoretical and practical nature of the course, "training character": 70% theory, 30% practice
Type of class: ea/consultation and total number of hours in the given semester: 30 hours
Methods, specific approaches, and characteristics used to convey the given knowledge: theoretical summary, practical knowledge, case studies, case studies, literature review, project work, study preparation
Method of assessment: colloquium
Additional specific methods used in knowledge assessment: semester assignment, presentation
Place of the course in the curriculum: can be taken in semesters 1-4
Prerequisites: none

Course description:
Course objective: To present the environmental characteristics of the electronics industry, the challenges arising from the use of special materials and technologies, the regulations applicable to the industry, the basics of preventive thinking and environmentally friendly design, as well as the characteristics and management of electronic waste. Course content: Areas of the electronics industry and their environmental characteristics, environmental benefits of modern electronics, impacts during the product life cycle, effects of global manufacturing chains, European and domestic regulations (RoHS, WEEE, EuP), the role of environmentally friendly design, and the generation, collection, and recycling of e-waste.

List of 2-5 most important required readings with bibliographic data:
- National Academies of Sciences, Engineering, and Medicine: Industrial Environmental Performance Metrics: Challenges and Opportunities. National Academies Press, Washington, DC, 1999.
- Vithanage, M.; et al. (eds.): Handbook of Electronic Waste Management: International Best Practices and Case Studies. Elsevier, 2019.
- Jain, M.; et al.: Review on E-Waste Management and Its Impact on the Environment. Cleaner Materials, 8 (2023) 100180.
- Baldé, C. P.; et al.: Global E-waste Monitor 2024. UNITAR/ITU, Geneva/Bonn, 2024.

List of 2-5 most important recommended references with bibliographic data:
- European Union: Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE), consolidated version.
- Ganesh, S. V.; et al.: Sustainable Electronic Waste Management Framework for Academic Institutions. Scientific Reports, 15 (2025) 24278.
- Current EPD, RoHS, and WEEE case studies and e-waste management technology reviews.

Date: December 31, 2025.
Prepared by: Ákos Nemcsics