# Fluid production and transport systems

## Content

# Course program

| | |
|---|---|
| Well control | Code: MFKOT810A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Gabriella Federer Kovács, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Students will get familiar with different method for handling influxes. Students will be able to kill a well. | |
| **Course content and structure:**<br>Drilling and workover operation's safety. The hole's and well's pressure balance. Drilling practices for overpressurized formations. The kick's warning signs. Well shut in procedures. The driller's method, wait&weight method and other unusual methods. Killing of producing wells. Well control equipment. Well control simulation and its practical aspects. | |
| **Evaluation method:**<br>Written exam<br>***Course assignments:***<br>Attendance at classes and match the requirements.<br>***Course point distribution, examination format*:**<br>Written exam. Grading scale: 100% - 91% (5); 90% - 81% (4); 80% - 71% (3); 70% - 60% (2); 59% - 0% (1) | |
| **Required and suggested reading:**<br>T. Bell, D. Eby, J. Larrison, B. Ranka: Blowout Prevention, 4th Ed. 2009. ISBN 0-88698-242-1.<br>R. Baker: Practical Well Control, 4th ed. 1998. ISBN 0-88698-183-2.<br>R. Grace: Blowout and Well Control Handbook, Gulf Publishing Company, ISBN: 0750677082.<br>R. D. Grace: Advanced Blowout & Well Control, Gulf Publishing Company, 1994, ISBN 0-88415-260-X. | |

| | |
|---|---|
| Well completion | **Code**: MFKOT809A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Gabriella Federer Kovács, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Students will be able to explain how a well is designed and how it is completed. | |
| **Course content and structure:**<br>Well structure design. Overpressure prediction, casing seat selection. Well completion. HC well's production analysis. $H_2S$ and $CO_2$ corrosion. Workover fluid design. Wellhead equipment. BOP, casing head, Christmas tree and its components. Tubing design. Tubing stress in gas wells. Determination of the critical velocity in wells. Packer stress, tubing movement, selection of tightening elements. Well completion hardware. Selection of well completion elements. Workover rigs. Slickline, wireline, coiled tubing. | |
| **Evaluation method:**<br>Written exam<br>***Course assignments:***<br>Attendance at classes and match the requirements.<br>***Course point distribution, examination format*:**<br>Written exam. Grading scale: 100% - 91% (5); 90% - 81% (4); 80% - 71% (3); 70% - 60% (2); 59% - 0% (1) | |
| **Required and suggested reading:**<br>H. Rabia: Oilwell Drilling Engineering. Principles and Practice. Graham Tratman Ltd. London 1995. 322 p.<br>Howard B. Bradley: Petroleum Engineering Handbook, Third Printing, Society of Petroleum Engineers, Richardson, TX, U.S.A. 1992.<br>Drilling Data Handbook, Edítion Technip, Paris ISBN 2-2108-0756-4, 1999. 542 p.<br>Erik B. Nelson: Well Cementing. Schlumberger Educational Services. Second Edition, Houston Texas, 2006.<br>Arthur Lubinski (Edited by Stefan Miska): Development of Petroleum Engineering I-II. Gulf Publishing Company, Houston, 1987. | |

| | |
|---|---|
| Applied oilfield chemistry | **Code**: MFAKK805A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Prof. Dr. István Lakatos, DSc, member of HAS, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The main aim of the course is to acquaint students with the theoretical background of the physical and chemical properties of hydrocarbons. The theoretical approach to the search for natural laws is discussed in the course. We focus on the most influential direction, the mechanisms of acidification, formation damage and the physical and chemical processes that take place around the well. An important part of the lecture series is the study of the impact of production on the environment, as well as the latest trends in oilfield chemistry.

**Course content and structure:**
Elemental and group composition of crude oils and natural gases. Classification of crude and natural gases. Fundamentals of phase behaviour of single-, two-, and multiphase systems. Phenomena of super critical and retrograde behaviour. Surface and interfacial properties of oil, gas, water, and their composite systems. Factors influencing surface and interfacial tension at ambient and HTHP conditions. Deliberate alteration of ST and IFT, and materials used to thereon. Bulk and interfacial rheological properties single- and multicomponent fluid systems. Solubility equilibria of non- or partially miscible fluids systems. Interaction of fluid (oil, water, and gas) with reservoir rocks. Fundamentals of wettability, clay swelling and disintegration, and ion exchange processes. Consequences of detrimental effects responsible for declined well performance. Methods applied for prevention and cure of sanding and fine migration causing increased skin factor and collapse of bottomhole region in wells. Colloid chemical solutions and technologies used to stimulate wells lost fluid lifting. Types of chemicals used in treating solution, micro- and macroemulsions, foams and gels to overcome detrimental effects. Chemical basis and materials of mud chemistry, fracturing and completion fluids and matrix acidizing. Accumulation of asphaltenes, paraffins, and other high molecular weight components of crude oils in the bottomhole. Technologies to remove the accumulated depositions using aqueous and organic solutions, microemulsions, and foams. Scale formation in the nearby region of bottomhole and surface facilities. Mechanical and chemical methods of scales and materials to inhibit scale formation. New trends in oilfield chemistry. Environmental questions of oilfield chemistry, removal of hydrocarbon contamination from water and solid surfaces.

**Evaluation method:**
***Course assignments:***
Active participation in consultations and the timely completion of individual mid-year tasks.
***Course point distribution, examination format*:**
Oral and/or written examination. Assessment: 0-59% is fail; 60-69% is pass; 70-79% is satisfactory; 80-89% is good; 90-100% is excellent.

**Required and suggested reading:**
Slide Show of subject (I. Lakatos)
W. W. Frenier, M. Ziauddin: Chemistry for Enhancing the Production of Oil and Gas, SPE, Richardson, USA (2014).
Lakatos, I.: Progress in Oilfield Chemistry I-IX, Akadémiai Kiadó, Budapest (1999-2011).

| | |
|---|---|
| Biogas and alternative gases | **Code**: MFKGT818A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. István Szunyog, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
By acquiring the expertise in the subject, engineers will be able to understand the properties of biogases and other alternative gases, manage their limitations of use, analyse risk, review their fire possibilities, identify technical and operational problems with their natural gas network mix-up, formulate and develop development proposals.

**Course content and structure:**
Typical compositions and chemical characteristics of natural gases and biogases. Phase behaviour of hydrocarbons and other gases. Thermal characters. Condensation point. Formation of hydrates. Cleaning of biogas: physical and chemical adsorption, membrane separation, molecular filters, condensing, and other cleaning technologies. Separation of carbon dioxide and hydrogen sulphide. Cleaning to natural gas quality. Odorisation. Utilization of biogases: direct firing, combined heat and power, bio-motor fuels. Biogas utilization systems. Biogas boilers. Biomethane injection into natural gas pipelines. Quality upgrading. Risk factors from the quality of biogases. Quality and quantity boundary conditions of biogas injection into natural gas systems. Alternative combustible gases: LNG, CNG, SNG, hydrogen. Their characteristics, production, cleaning, technical issues of distribution, use, direct use and pipeline transport. Their natural gas network injection possibilities.

**Evaluation method:**
***Course assignments:***
Active participation in consultations and the timely completion of individual mid-year tasks.
***Course point distribution, examination format*:**
Oral and/or written examination. Assessment: 0-59% is fail; 60-69% is pass; 70-79% is satisfactory; 80-89% is good; 90-100% is excellent.

**Required and suggested reading:**
Bailón, L. - Hinge, J.: Biogas and bio-syngas upgrading Report; Danish Technological Institute, Aarhus, December 2012.
Henry W. (HANK) Poellnitz: Interchangeability of natural gas sources; Southern Natural Gas, 2009.
Kilinski, S. Hauptschriftleiter: STUDIE Einspeisung von Biogas in das Erdgasnets; Institut für Energetik und Umwelt gGmbH; Leipzig, 2006. pp.1-196. ISBN 3-00-018346-9.
N.V. Nederlandse Gasunie: Physical properties of natural gases, 1988. pp. 33-212.
Persson, M. – Jönsson, O. – Wellinger, A.: Biogas upgrading to vehicle fuel standards and grid injection; IEA Bioenergy, December 2006.
Polman, E.A.: GT-070127 Quality Aspects of Green Gas; Kiwa N.V., Rijswijk, the Netherlands, 2007.

| | |
|---|---|
| Natural gas systems | **Code**: MFKGT821A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. István Szunyog, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
By acquiring the expertise in the subject, engineers will be able to review the parts and the whole gas systems of natural gas, PB gas and alternative gases outside an inside of land borders, identify technical and operational problems, formulate and develop development proposals.

**Course content and structure:**
Physical-chemical properties of natural gases. Parts of natural gas distribution system. The structure and characters of gas industry, technical-safety-legal systems. Gas pressure regulation; pressure regulation stations. Planning and constructing natural gas distribution pipelines. Simulation and development of pipeline systems. Operating of distribution systems. Domestic gas appliances: types, characterisation, firing- and thermal measurements. Gas burners: construction, classification, working, designing and dimensioning. Flue gas systems: classification, designing and dimensioning. Natural gas utilization systems inside building site: structure, parts, designing. Special side of natural gas industry: production, transmission, storage and utilization of liquefied natural gas; planning, constructing and operating of propane-butane gas systems. Safety engineering of propane-butane supply. Use of alternative gases.

**Evaluation method:**
***Course assignments:***
Active participation in consultations and the timely completion of individual mid-year tasks.
***Course point distribution, examination format*:**
Oral and/or written examination. Assessment: 0-59% is fail; 60-69% is pass; 70-79% is satisfactory; 80-89% is good; 90-100% is excellent.

**Required and suggested reading:**
H.R.N. Jones: Domestic gas burner design; British Gas, Spon, London and New York, 1989. ISBN 0 419 14800 0.
Hazlehurst, John: Tolley's Basic Science and Practice of Gas Service; Vol1, Routledge, 2009, ISBN9781856176712.
Hazlehurst, John: Tolley's Domestic Gas Installation Practice; Vol2, Routledge, 2012, ISBN9781856176835.
Hazlehurst, John: Tolley's Industrial and Commercial Gas Installation Practice; Vol3, Routledge, 2009, ISBN 9781856176729.
J. Warnatz, U. Maas, R.W. Dibble: Combustion; Springer-Verlag, New York, 2006. ISBN 9 783 54025 992 3.
Lackner, Maximilian; Palotás, Árpád; Winter, Franz: Combustion; Wiley-VCH, ISBN9783527333516.
N.V. Nederlandse Gasunie: Physical properties of natural gases, 1988. pp. 33-212.

| | |
|---|---|
| Sucker-rod pumping | **Code**: MFKOT811A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Prof. Dr. Gábor Takács, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The task of the course is to provide the knowledge necessary for the design and operation of sucker-rod pump system. The aim of the course is to present potential scientific research areas in the field of sucker-rod pumping.

**Course content and structure:**
Components of the sucker-rod pumping system, their interaction. Obtaining the optimum pumping mode. Analysis of the energy conditions of the system, establishing the operating conditions with minimum energy usage. Analysis of the torque conditions of gearboxes, ways to attain optimum counterbalancing conditions. Basics of Nodal Analysis applied to the sucker-rod pumping system. Critical analysis of the methods used to investigate operating conditions, features of the calculation models describing operating conditions. Problems of calculating downhole dynamometer cards, solutions of the wave equation applied to the sucker-rod string.

***Course assignments:***
Active participation in consultations and the timely completion of individual mid-year tasks.
***Course point distribution, examination format*:**
Oral and/or written examination. Assessment: 0-59% is fail; 60-69% is pass; 70-79% is satisfactory; 80-89% is good; 90-100% is excellent.

**Required reading:**
Takács G.: HIMBÁS-RUDAZATOS MÉLYSZIVATTYÚZÁS. ISBN 963-05-7649-X. Akadémiai Kiadó. Budapest, 1999, 295 p.
Szilas, A.P.: "PRODUCTION AND TRANSPORT OF OIL AND GAS." 2nd Ed. Part B Elsevier Publishing Co. (1985).
Takács G.: Artificial Lifting II. Miskolc-Egyetemváros: Miskolci Egyetem, 2014. 212 p.
Takács G.: SUCKER-ROD PUMPING HANDBOOK. ISBN 978-0-12-417204-3. Gulf Professional Publishing, an Imprint of Elsevier. 2015, 585 p.
**Suggested reading:**
Takács G.: MODERN SUCKER-ROD PUMPING. ISBN 0-87814-383-1 PennWell Books, Tulsa Oklahoma, 1993, 230 p.
Takács G.: SUCKER-ROD PUMPING MANUAL. ISBN 0-87814-899-2 PennWell Books, Tulsa Oklahoma, 2003, 395 p.
Gibbs, S. G.: ROD PUMPING. ISBN 978-0-9849661-0-3. Midland, Texas, 2011. 660 p.
Bommer, P. M.-Podio,A.L.: THE BEAM LIFT HANDBOOK. PETEX, Austin Texas, 2012.

| | |
|---|---|
| Gas lifted production systems | **Code**: MFKOT812A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Prof. Dr. Gábor Takács, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The task of the course is to provide the knowledge necessary for the design and operation of gas lifted production systems. The aim of the course is to present potential scientific research areas in the field of gas lifted production systems.

**Course content and structure:**
Examination of downhole completion of gas lifted wells, determination of optimal well completion. Description of the multiphase flow in continuous and intermittent gas lifted wells. Calculation methods to determine the injection gas requirements. Economical effect of the most important operational parameters of gas lifting: injection pressure, tubing size, wellhead pressure. Economical effect of elements on the whole gas lifted production system. Design of the surface gas lift supply system, and its effect on the gas requirements. Design of the production system in case of time dependent operational condition.

***Course assignments:***
Active participation in consultations and the timely completion of individual mid-year tasks.
***Course point distribution, examination format*:**
Oral and/or written examination. Assessment: 0-59% is fail; 60-69% is pass; 70-79% is satisfactory; 80-89% is good; 90-100% is excellent.

**Required reading:**
Szilas, A.P.: "PRODUCTION AND TRANSPORT OF OIL AND GAS." 2nd Ed. Part A Elsevier Publishing Co. (1985).
Takács, G.: Fundamentals of Production Engineering. Oktatási segédlet, Miskolci Egyetem, 2005.
Takacs, G.: Artificial Lifting I. Miskolci Egyetem, 2014. 283 p.
**Suggested reading:**
Takács, G.: GAS LIFT MANUAL, PennWell Corporation, Tulsa, USA. 2005.
Brown, K. E.: GAS LIFT THEORY AND PRACTICE. Petroleum Publishing Co., Tulsa, Oklahoma, 1967.
Shaw, S. F.: GAS LIFT PRINCIPLES AND PRACTICES. Gulf Publishing Co., Houston, Texas, 1939.
Brown, K.E.: THE TECHNOLOGY OF ARTIFICIAL LIFT METHODS. Vol.1 Petroleum Publishing Co., 1977.

| Underground gas storage | **Code**: MFKGT813A |
|---|---|
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and title of instructor/course coordinator:** Dr. Marianna Vadászi, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**

Candidates will learn how temperature-based fluctuations (i.e. daily/weekly changes in gas consumption) can be managed, and how the seasonal variability of gas supply/demand can be effectively met by using/relying on the capacity of large-scale underground storage facilities. The subject encompasses all the technologies, both theoretical and practical, that are relevant for the subsequent transport and use of natural gas. It deals with gas drying, treatment and processing equipment. By acquiring the skills related to their topic, students will be able to operate gas preparation technologies and ensure the smooth operation of the system.

**Course content and structure:**

Underground storage facilities are capable of providing flexible and reliable gas supply adjusted to highly volatile and seasonally varying consumption needs. Underground facilities are implemented for reasons of supply safety and/or for commercial/business purposes. During the summer season, considerable volumes of excess gas are injected in high-capacity storage blocks and are mobilized as fuel source during the winter. Storage facilities are characterized by three basic/key parameters: working gas volume, downstream/input capacity and output/upstream capacity. Most EU Member States utilize depleted hydrocarbon fields, aquifers, salt caverns or depleted mines for purposes of cyclic gas injection and withdrawal. In the past few decades, several underground salt caverns have been leached so that gas can be stored within. Such man-made cavities are highly flexible and allow for regular refillment more than once a year. EU Member States share all information about their storage capacities: storage data are disclosed and made available to the public in standardised databases. Gas laws, state equations and their applications. Phase behavior of natural gas mixtures, calculation of vapor-liquid equilibrium. Natural gas hydrates. Principles of separation, types of separators, their sizing. Absorption gas dryer, gas processing technology. Adsorption technology. Cold separation technology. Purificatoin methods and equipment. LNG.

**Evaluation methods:**

***Course assignments:***

Active participation in consultations and the timely completion of individual mid-term tasks.

***Form of examination, scoring*:**

Oral and/or written examination. Assessment: 0 to 59% = fail; 60 to 69% = pass; 70 to 79% = satisfactory; 80 to 89% = good; 90 to 100% = excellent.

**Required and suggested reading:**

Pápay J.: Development of Petroleum Reservoirs. Akadémiai Kiadó, Budapest 2003.

Rasin T.: Natural Gas Underground Storage: Inventory and Deliverability. PennWell Publishing. Co. 1996.

Natural Gas Market Review 2007 – Security in a globalising market to 2015, OECD/IEA, Paris, 2007.

Lanigan O.: Underground Gas Storage Facilities, Gulf Publishing Co., Houston 1995.

Alireza B.: Natural Gas Processing, Elsevier, 2014, ISBN: 9780080999715

Peebles M.: NaturalGas Fundamentals, Shell International Gas Ltd., 1992.

S. Mokhatab, W. Poe, J. Mak: Handbook of Natural Gas Transmission and Processing, Elsevier, 2015, ISBN: 9780128014998.

John M. Campbell: Gas Conditioning and Processing – Volume 1: Basic Principles 2014, ISBN 978-0-9703449-2-2

| Gas pipeline systems | **Code**: MFKGT814A |
|---|---|
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and title of instructor/course coordinator:** Dr. Marianna Vadászi, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introduce students to the special design and operation tasks of hydrocarbon transport systems. The subject encompasses all the technologies, both theoretical and practical, that are relevant for the subsequent transport and use of natural gas. It deals with gas drying, treatment and processing equipment. By acquiring the skills related to their topic, students will be able to operate gas preparation technologies and ensure the smooth operation of the system.

**Course contents and structure:**
The importance/role of natural gas in European energy supply. The evolution of pipeline technology used for the long-distance transportation for hydrocarbon fuels. The nominal sizing of pipelines (based on *General Flow equation*). Calculating gas flow pressure and temperature change. Transient and steady-state gas flow in natural gas pipeline systems. The function/role of the pipeline stock in maintaining smooth operation and optimized delivery throughout the pipeline network/ throughout the supply system. Optimizing compressor station performance (volume capacity, design flow rate) with due respect to polytrophic efficiency. Technical and safety standards for the construction and operation of compressor stations. Pressure regulating and metering stations. Mixing and blending stations. Gas flow measurement and financial accounting (fiscal or custody transfer). Technical and economic questions of long-distance gas transportation. Pipeline infrastructure: design, construction, instalment, and service. Transmission pipeline cleaning methods (chemical cleaning, pigging etc.). Gas laws, state equations and their applications. Phase behavior of natural gas mixtures, calculation of vapor-liquid equilibrium. Natural gas hydrates.

**Evaluation methods:**
***Course assignments:***
Active participation in consultations and the timely completion of individual mid-term tasks.
***Form of examination, scoring*:**
Oral and/or written examination. Assessment: 0 to 59% = fail; 60 to 69% = pass; 70 to 79% = satisfactory; 80 to 89% = good; 90 to 100% = excellent.

**Required and suggested reading:**
Mohitpour M. – Golsham H. – Murray A.: *Pipeline Design and Construction*. ASME Press, pp. 654, 2000, ISBN 0-7918-0156-X.
Mohitpour M.–Szabo J. – Hardeveld T.: *Pipeline Operation and Maintenance*. ASME Press, pp. 653, 2005, ISBN 0-7918-0232-9.
Mohitpour M. – Murray A. – Mcmanus M.–Colquhoun I.: *Pipeline Integrity Assurance*. ASME Press, pp. 582, 2010, ISBN 978-0-7918-5956-8.
Mohitpour M. – Botros K. – Hardeveld T.: *Pipeline Pumping and Compression Systems*. ASME Press, pp. 582, 2008, ISBN 978-0-7918-0278-6.
Gas Processing – Basic Principles: https://www.gie.eu/publications/
Alireza B.: Natural Gas Processing, Elsevier, 2014, ISBN: 9780080999715
Peebles M.: NaturalGas Fundamentals, Shell International Gas Ltd., 1992.
S. Mokhatab, W. Poe, J. Mak: Handbook of Natural Gas Transmission and Processing, Elsevier, 2015, ISBN: 9780128014998.

| | |
|---|---|
| Fluid dynamics | **Code**: MFKGT801A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Anikó Nóra Tóth, PhD, honorary professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
After learning about this subject, engineers will be able to understand and describe the transport processes which determine fluid flow; with the sophisticated theoretical tools thus acquired, they will then have both the theoretical and practical tools needed to solve difficult technical tasks.

**Course content and structure:**
Elements of kinematics, Balance equations: conservation of mass, momentum equation. balance of angular momentum, balance of kinetic energy, conservation of energy, balance of entropy. The perfect fluid: Euler's equation, Bernoulli equation, Kelvin's vortex theorem, elements of gas dynamics. Laminar flow: Navier-Stokes equation, dynamical similarity, Poiseuille flow. Elementary boundary layer theory. Turbulent flow: Reynolds equation, Kármán's similarity criterion, mixing length, turbulent flow in pipes, energy equation, head losses in pipes and fittings.

**Evaluation method:**
***Course assignments:***
Active participation in consultations and the timely completion of individual mid-year tasks.
***Course point distribution, examination format*:**
Oral and/or written examination. Assessment: 0-59% is fail; 60-69% is pass; 70-79% is satisfactory; 80-89% is good; 90-100% is excellent.

**Required reading:**
Bobok E.: Fluid Mechanics for Petroleum Engineers. Elsevier, Amsterdam, New York, Tokyo 1993.
W. R. Schowalter: Mechanics of Non-Newtonian Fluids, Pergamon Press, Oxford, 1978.
**Suggested reading:**
D. J. Acheson: Elementary Fluid Dynamics, Oxford Applied Mathematics and Computing Science Series, ISBN 978-0-19-859679.
R. von Mises: Mathematical Theory of Compressible Fluid Flow, Academic Press INC, New York, 1958.

| | |
|---|---|
| Geothermal and renewable energy | **Code**: MFKGT817A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Anikó Nóra Tóth, PhD, honorary professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>After learning about this subject, engineers will be able to: understand and describe the exploration, exploitation and utilization of geothermal energy sources; determine the exploitable energy content for any potential geothermal opportunity; analyse and evaluate relevant geothermal risk factors; and develop their own geothermal-project proposals. | |
| **Course content and structure:**<br>Behaviour of geothermal energy. Geothermal fields. Significant geothermal reservoirs. Method of the calculation of geothermal potential. Geothermal heat flow. Criterions of the convective heat flow. Simple reservoir models. Flow in porous reservoir. Structures of the geothermal wells. Injection to the reservoir. Heat mining. Flow in the production well. Temperature distribution in the well. Pressure and heat loss in a steam well. Production equipment's: submersible pumps, heat exchangers, heat pumps. Steam and extreme hot water transmission pipelines. Environmental impacts of the geothermal energy production. | |
| **Evaluation method:**<br>***Course assignments:***<br>Active participation in consultations and the timely completion of individual mid-year tasks<br>***Course point distribution, examination format*:**<br>Oral and/or written examination. Assessment: 0-59% is fail; 60-69% is pass; 70-79% is satisfactory; 80-89% is good; 90-100% is excellent. | |
| **Required reading:**<br>Toth A-Bobok E.: Flow and Heat Transfer in Geothermal Systems, Elsevier 2016.<br>Hardcover ISBN: 9780128002773, eBook ISBN: 9780128005255.<br>**Suggested reading:**<br>Lund J.: Direct Heat Utilization of Geothermal Energy Geo Heat Center, Oregon, USA, 2002.<br>Tester, Jefferson, W.:Energy and the Environment in the 21st Century, MIT, USA, ISBN-13: 978-0262200783. | |

| | |
|---|---|
| Underground fluid mechanics | **Code**: MFKOT802A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Zoltán Turzó, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of this subject that the candidate gets acquainted with hydraulic-, material-, and thermal processes of fluids moving or filtrating through the porous and double porous medium. The candidates get knowledge of the hydraulic processes of the fluid production (or exploitation hydrocarbon or water) that are taken place in the layers and reservoirs. They get comprehensive knowledge about the flow patterns of hydraulic processes, the rock, the fluid properties that influence the flow in the reservoir, and general mathematical equations by which these processes can be calculated. This subject give information about how one can influence and control the flow patterns and systems of single or multiphase flow around or between the wells that were drilled in the reservoirs.

**Course content and structure:** Equation of single phase filtration. Solution of the equation of single phase filtration. The radial-diffusivity equation, solutions to the radial-diffusivity. Principle of superposition. The equation of two phase filtration, vertical two-phase filtration of incompressible fluids, the fractional flow equation, frontal displacement determination of the frontal saturation by material balance method. Fundamentals of Transient Well Test Behavior. Interpretation methodology: Data processing, Flow regime identification, Derivative computation**.** Use of type curves**.** Use of numerical simulation**.** Specialized Test Types**.** Pressure Transient and System Analysis.

**Mid-term account method:**
The condition for obtaining the signature is the min. 60% participation and writing 1 test for at least 50%.

**Rating:**
The examination of the subject begins with a written examination and continues with an oral examination if at least 70% of the basic questions are answered correctly. Grading scale: > 90%: excellent; 89 – 80%: good; 79 – 70%: medium; 69 – 60%: satisfactory; < 60%: unsatisfactory.

**Required reading:**
Craft and Hawkins: Applied Petroleum Reservoir Engineering, Prentice Hall, 1991, ISBN 0-13-039884-5.
Towler: Fundamental Principles of Reservoir Engineering, SPE Textbook Series, Vol.8., 2002, ISBN 1-55563-092-8.
T. Ahmed: Advanced Reservoir Engineering, Gulf Publishing Co. 2005, ISBN-13: 978-0-7506-7733-2.

**Suggested reading:**
T. Ahmed: Reservoir Engineering Handbook, Gulf Publishing Co., 2001, ISBN 0-88415-770-9.
L. P. Dake: Fundamentals of Reservoir Engineering, Elsevier, 1978, ISBN 0-444-41830-X.

| | |
|---|---|
| Improved oil and gas recovery methods | **Code**: MFKOT806A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Hazim Dmour, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of this subject to introduce the complex (IOR and IGR) methods that are capable to produce a further major share of the resources that can not be produced by natural energy. The candidates get knowledge about physical-chemistry, filtration, mass- and thermal transport processes and reservoir mechanical theoretical basics of complex methods. The candidates acquire the development design, the controlling, and the practical application of this complex (IOR, or IGR) production methods.

**Course content and structure:** Hydrodynamic principles of oil displacement with miscible fluids. Hydrodynamic principles of oil displacement with immiscible fluids. Areal and edge flooding methods: well systems, displacement. Areal and edge flooding methods: areal and vertical displacement. Areal and edge flooding methods: volumetric efficiencies. Enhanced Oil Recovery methods (EOR). Oil displacement by $CO_2$ injection. Oil displacement by polymer flooding. Oil displacement with tensides and with polymer-tensides. Oil displacement with foam. Thermal methods: in-situ combustion (wet combustion). Thermal methods: hot water injection. Thermal methods: steam injection. Special displacement methods (heavy oil, bitumen production).

**Mid-term account method:**
The condition for obtaining the signature is the min. 60% participation and writing 1 test for at least 50%.

**Rating:**
The examination of the subject begins with a written examination and continues with an oral examination if at least 70% of the basic questions are answered correctly. Grading scale: > 90%: excellent; 89 – 80%: good; 79 – 70%: medium; 69 – 60%: satisfactory; < 60%: unsatisfactory.

**Required reading:**
Ahmed Tarek: Reservoir Engineering Handbook, Gulf Publishing Co., 2001, ISBN 0-88415-770-9.
P. Dake: Fundamentals of Reservoir Engineering, Elsevier, 1978, ISBN 0-444-41830-X.
József Pápay: Development of Petroleum Reservoirs, Akadémiai Kiadó, Budapest 2003. ISBN 963 05 7927 8.

**Suggested reading:**
József Pápay: Explotation of Unconventional Petroleum Accumulation, Akadémiai Kiadó, Budapest 2013. ISBN 978 963 05 9464 6.

| | |
|---|---|
| Petrophysics | **Code**: MFAKK803A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Hazim Dmour, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of this subject to introduce the petrophysical behavior of oil, gas and water bearing layers that influence the storage and production capacity of reservoir rocks. Subject covers the laboratory determination methods of basic (porosity, permeability, saturation) and special (relative permeability, capillary pressure, specific surface area, tourtoozity, i.e.) petrophysical properties that are important from the point of view of hydrocarbon and water production. The subject also covers the correlation methods that are necessary to determine these properties without laboratory measurement. The subject summarizes the parameters that influence the petrophysical properties and the relationships between the petrophysical properties. Knowing the petrophysical properties of reservoir rock the original oil and gas in place can be determined.

**Course content and structure:** Introduction to Mineralogy**.** Introduction to Petroleum. Geology**.** Porosity and Permeability. Formation Resistivity and Water Saturation. Capillary Pressure**.** Wettability. Applications of Darcy's Law. Naturally Fractured Reservoirs. Effect of Stress on Reservoir Rock Properties. Reservoir Characterization. Fluid-Rock Interactions. Basic Well-Log Interpretation.

**Mid-term account method:**
The condition for obtaining the signature is the min. 60% participation and writing 1 test for at least 50%.

**Rating:**
The examination of the subject begins with a written examination and continues with an oral examination if at least 70% of the basic questions are answered correctly. Grading limit: > 90%: excellent; 89 – 80%: good; 79 – 70%: medium; 69 – 60%: satisfactory; < 60%: unsatisfactory.

**Required reading:**
Djebbar Tiab, Erle C. Donaldson: Petrophysics, Gulf Professional Publishing, USA, 2012. ISBN: 978-0-12-383848-3.
József Pápay: Development of Petroleum Reservoirs, Akadémiai Kiadó, Budapest, 2003. ISBN 963 05 7927 8.
HONARPOUR, M., KOEDERITZ, L., HERBERT HARVEY, A.: Relative permeability of petroleum reservoirs. CRC Press, Inc., 0-8493-5739-X, 1986.
T. Ahmed: Reservoir Engineering Handbook, Gulf Publishing Co., 2001, ISBN 0-88415-770-9.

**Suggested reading:**
TÓTH J., BÓDI T., SZŰCS P., CIVAN F.: Direct Determination of Relative Permeability from Nonsteady-State Constant Pressure and Rate Displacements. SPE 67318, SPE. Production and Operations Symposium, Oklahoma City, Oklahoma, 2001. március 24-27.
PINTÉR Á., BÓDI T.: Comparison of capillary pressure and relative permeability curve determination methods (Usporedba metoda za odredivanje krivulja kapilarnog tlaka i relativnih propusnoti). Nafta i Plin, INA, Strucni Casopis, Hrvatske Udruge Naftnih Inzenjera i Geologa, Vol. 33., Nr. 137/2013., ISSN 1330-2434.

PINTÉR Á., BÓDI T.: Determination of Capillary Pressure and Relative Permeability Curves with a Novel Ultra Rock Centrifuge. Geosciences and Engineering, A Publication of the University of Miskolc, Vol. 1, Nr. 1 (2012), HU ISSN 2063-6997.

| | |
|---|---|
| Reservoir fluids | **Code**: MFKOT804A |
| | **Responsible department/institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Zoltán Turzó, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of this subject is to analyze the properties of the oil, gas and water reservoir fluids that are important from the point of view of oil, gas and water production. The subject covers the theoretical and practical questions of phase behaviors of the fluids. Summarize the correlation procedures that can be used to calculate the temperature and pressure dependent properties of oil, gas, and reservoir water (i.e., formation volume factor, density, viscosity, dissolved gas ratio). The candidates get acquainted with the theoretical basics of PVT measurement and with practical application with equations of state (EOS) in the petroleum industry generally.

**Course content and structure:** Compounds in natural hydrocarbon system. Characterization of hydrocarbon systems. Physico-chemical fundamentals. Fundamental physic-chemical studies. PVT Behavior of ideal systems. Correction of ideal laws for real PVT behavior. Equations of state. PVTC Correlation for natural gases. PVTC correlations with undersaturated black oils. Equilibrium ratio correlation for hydrocarbon vapor-liquid two-phase systems. Total volume of hydrocarbon vapor-liquid two-phase systems from correlations. PVTC Correlations for formation waters. Phase equilibria in hydrocarbon-formation water systems from correlations. Viscosity correlations for petroleum reservoir fluids.

**Mid-term account method:**
The condition for obtaining the signature is the min. 60% participation and writing 1 test for at least 50%.

**Rating:**
The examination of the subject begins with a written examination and continues with an oral examination if at least 70% of the basic questions are answered correctly. Grading limit: > 90%: excellent; 89 – 80%: good; 79 – 70%: medium; 69 – 60%: satisfactory; < 60%: unsatisfactory.

**Required reading:**
József Pápay: Development of Petroleum Reservoirs, Akadémiai Kiadó, Budapest, 2003. ISBN 963 05 7927 8.
János Török, Lipót Fürcht, Tibor Bódi: PVT Properties of Reservoir Fluids. University of Miskolc, Miskolc, Hungary 2012. ISBN 978-963-661-988-5 p. 1-192.

**Suggested reading:**
Curtis H Whitson and Michael R. Brule: Phase Behavior. SPE Monograoh Volume 20. Richardon, Texas, 2000.
Copy of relevant scientific papers.

# Raw material extraction and preparation, environmental process technology

## Content

| Mechanical process engineering: Fabrication, characterization, motion, phase separation and mixing of disperse particulate systems | **Code:** MFEET821B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Prof. Dr. József Faitli, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To prepare the students for being able to characterise and apply the different dispersity behaviours of coarse disperse systems in the scientific field of mechanical processing during their doctoral research work.

**Course content and structure:**
Characterisation of solid – liquid and solid – gas coarse disperse systems. Suspension production. The process engineering aim of mixing, the random uniform state of mixtures. The process engineering design of discontinuous (propeller) mixing. The process engineering design of continuous (flow technique) mixing. Phenomena of particles motion. Settling of single particles in one- and multiphase, Newtonian and non-Newtonian media. Measurement techniques of the terminal settling velocity. Settling of particles bulks, the batch settling test and its evaluation. The effect of vibration on settling. The phase separation of solid – liquid and solid – gas coarse disperse systems. The main principles and equipment of phase separation and their process engineering design methodologies.

**Evaluation method:**
Oral exam.
***Course assignments:***
Literature summary and design assignment.
***Course point distribution, examination format*:**
The oral defence of the presented literature summary and design assignment. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
J. Faitli, I. Gombkötő: Some technical aspects of the rheological properties of high concentration fine suspensions to avoid environmental disasters. Journal of Environmental Engineering and Landscape Management. (2015).
Faitli, J: Continuity theory and settling model for spheres falling in non-Newtonian one- and two-phase media. INTERNATIONAL JOURNAL OF MINERAL PROCESSING 169: 1 pp. 16-26. , 10 p. (2017).
Faitli, J: Theory and Experimental Verification of Continuum- or Discrete Element-like Behaviour of Ground Solid – liquid Mixtures. In: H, Benzer (szerk.) Proceedings of the 15th International Symposium on Comminution and Classification (2017).
Tarján, I ; Faitli, J: Solid-liquid mixing in a vessel by vertical flow. In: Lakatos, I (szerk.) Recent Advances in Enhanced Oil and Gas Recovery Budapest, Magyarország: Elsevier Science Publishers, Akadémiai Kiadó, (2001) pp. 245-254. , 10 p.
Faitli, József ; Tarján, Iván: Scale-up methods of dense slurry production by propeller and flow technique mixers. In: Leon, Lorenzen (szerk.) Proceedings of the XXII International Mineral Processing Congress Marshalltown, Dél-Afrikai Köztársaság: South African Institute of Mining and Metallurgy (SAIMM), (2003) pp. 452-453. , 2 p.

**Suggested reading:**

J. Faitli, I. Gombkötő: Some technical aspects of the rheological properties of high concentration fine suspensions to avoid environmental disasters. Journal of Environmental Engineering and Landscape Management. (2015).

Horsley M.R., Horsley R.R., Wilson K.C., Jones R.L.: Non-Newtonian effects on fall velocities of pairs of vertically aligned spheres. J. Non-Newtonian Fluid Mech. 124 (2004) 147-152.

Matousek, V.,: Effect of solids distribution near a pipe wall on flow friction in a slurry pipeline. The 4th International Conference for Conveying and Handling of Particulate Solids. Budapest, Hungary, Proceeding: pp. 13.19 – 13.24. (2003).

| Sampling, evaluation and control of processing plants, quality assurance | **Code**: MFEET822B<br>**Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
|---|---|
| **Name and position of course coordinator:** Prof. Dr. József Faitli, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** signature/exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To prepare the students for being able to measure and ensure quality of mechanical raw material processing technological circuits.

**Course content and structure:**
Fundamental cases of sampling, the estimation of the population mean, population standard deviation, the composition and the contaminant spreading by sampling. The theoretical features of the population and the empirical characteristics of the sample. The determination of the accuracy of a measurement device or method by sampling and statistical evaluation. Fundamental technological circuits of mechanical primary- and secondary raw material processing and the elements of the technological flow-sheet. Design methodology of technological sampling and measurements. Examples for sampling plans for some mechanical processing technologies. Fundamental quality- and environmental assurance systems and standards.

**Evaluation method:**
Oral exam.
***Course assignments:***
Literature summary and design assignment.
***Course point distribution, examination format*:**
The oral defence of the presented Literature summary and design assignment. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Faitli J: Sampling in Processing Plants. University notes. University of Miskolc. 2016.
Faitli, J. ; Romenda, R.: Detailed Sampling Protocol for the Analysis of Residual Municipal Solid Wastes. In: K., Moustakas; M., Loizidou (szerk.) Proceedings of the 7th International Conference on Sustainable Solid Waste Management Herakleion, Görögország : Hellenic Mediterranean University, (2019) pp. 1-10. Paper: Session XXIII. paper 10. , 10 p.
Faitli, J ; Nagy, S ; Romenda, R ; Gombkötő, I ; Bokányi, L ; Barna, L: Assessment of a residual municipal solid waste landfill for prospective 'landfill mining' WASTE MANAGEMENT & RESEARCH 29 Oct. 2019 p. 0734242X1988119 , 11 p. (2019).
**Suggested reading:**
J, Faitli ; T, Magyar ; A, Erdélyi ; A, Murányi: Characterization of thermal properties of municipal solid waste landfills WASTE MANAGEMENT 36 : 1 pp. 213-221. , 9 p. (2015)
ASTM D5231-92 (2016), Standard Test Method for Determination of the Composition of Unprocessed Municipal Solid Waste, ASTM International, West Conshohocken, PA
EU Project Report: SWA-Tool, Development of a Methodological Tool to Enhance the Precision & Comparability of Solid Waste Analysis Data (SWA-Tool). Available at: https://cordis.europa.eu/project/rcn/54884/reporting/en

French standard: NF X30-413: Constitution of a sample of Derived from the MODECOM™ methodology household waste contained in a waste collection vehicle.
German standard: LAGA PN 98 Guideline for the handling of physical, chemical and biological investigations in connection with the recovery / disposal of waste.
Gy P M (1979) Sampling of Particulate Materials – Theory and Practice. Elsevier Scientific Publishing Company, New York
Hungarian standard: MSZ 21420-28, 2005, Characterization of wastes. Part 28: Investigation of municipal wastes. Sampling.
Hungarian standard: MSZ 21420-29, 2005, Characterization of wastes. Part 29: Investigation of municipal wastes. Preparation of sample, characterization of material composition by the selection of material categories.

| Rheology of suspensions and powders, hydraulic and pneumatic transport of multiphase mixtures | **Code:** MFEET827B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Prof. Dr. József Faitli, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** signature/exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To prepare the students for being able to characterise and apply the different dispersity behaviours of coarse disperse systems in the scientific field of mechanical processing during their doctoral research work.

**Course content and structure:**
Characterisation of solid – liquid and solid – gas coarse disperse systems. Continuity theory for the characterisation of different continuum- or discrete element like mixture behaviours. Rheology of single phase media, time behaviour, elastic and viscous behaviour, Newtonian and non-Newtonian behaviour. Rheological measurements, falling body-, rotational- and tube rheometers and viscometers. Pipe flow of solid – liquid mixtures, process engineering design of hydraulic transport. Pipe flow of solid – gas mixtures, process engineering design of pneumatic transport. Flow properties of bulk materials. Comparison of the flows of liquids and powders. Angle of repose, flow yield locus, inner friction angles, flow function, etc… Forces and stresses in powders. Powder flow testing, the Jenike- and the ring shear cells. Sample preparation and consolidation, flow testing and the evaluation. Equipment of bulk storage, plug-flow and mass-flow bins. Fundaments of process engineering design of bulk storage bins.

**Evaluation method:**
Oral exam.
***Course assignments:***
Literature summary and design assignment.
***Course point distribution, examination format*:**
The oral defence of the presented Literature summary and design assignment. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
D. Schulze: Powders and Bulk Solids (Behaviour, Characterization, Storage and Flow), Elsevier, (2012).
Jenike A. W.: Storage and flow of solids. Bulletin of the University of Utah, (1964).
J. Faitli, I. Gombkötő: Some technical aspects of the rheological properties of high concentration fine suspensions to avoid environmental disasters. Journal of Environmental Engineering and Landscape Management. (2015).
Faitli, J: Continuity theory and settling model for spheres falling in non-Newtonian one- and two-phase media. INTERNATIONAL JOURNAL OF MINERAL PROCESSING 169 : 1 pp. 16-26. , 10 p. (2017).
Faitli, J: Theory and Experimental Verification of Continuum- or Discrete Element-like Behaviour of Ground Solid – liquid Mixtures. In: H, Benzer (szerk.) Proceedings of the 15th International Symposium on Comminution and Classification (2017).
**Suggested reading:**

J. Faitli, I. Gombkötő: Some technical aspects of the rheological properties of high concentration fine suspensions to avoid environmental disasters. Journal of Environmental Engineering and Landscape Management. (2015).
Horsley M.R., Horsley R.R., Wilson K.C., Jones R.L.: Non-Newtonian effects on fall velocities of pairs of vertically aligned spheres. J. Non-Newtonian Fluid Mech. 124 (2004) 147-152.
Matousek, V.,: Effect of solids distribution near a pipe wall on flow friction in a slurry pipeline. The 4th International Conference for Conveying and Handling of Particulate Solids. Budapest, Hungary, Proceeding: pp. 13.19 – 13.24. (2003).

| Chemical- and bio process engineering | **Code:** MFEET804B<br>**Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
|---|---|
| **Name and position of course coordinator:** Dr. Ljudmilla Bokányi, CSc, honorary professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Teaching of Chemical- and Bio Process Engineering with a special regard on technical-scientific tasks and challenges. | |
| **Course content and structure**:<br>Fundamentals of mass transfer. Molecular diffusion. Turbulent diffusion. Convective diffusion. Differential equations. Driving force of mass transfer. Average driving force. Principles and fundamentals of design of chemical techniques and reactors. Absorption, adsorption and desorption. Cristallisation and precipitation. Solid-liquid extraction. Liquid-liquid extraction. Classification of microorganism, their structure, built up and metabolism. Population growth and its laws. Limitation factors and inhibitors. Physiological activity. Mutations, adaptation, gen-engineering. Mechanism and kinetics of enzyme-catalysed reactions. Basic phenomena and processing systems of bioleaching (biosolubilisation). Bioaccumulation and biosorőtion of metal ions: basic phenomena and processing. Application of microorganisms in mining and processing of fossil fuels. Fermentation processes. Biosynthesis. Biodegradation and its application. Combination of chemical and biological techniques for the sake of the achieving of a given processing aim. | |
| **Evaluation method:**<br>Oral exam (defending of the review).<br>***Course assignments:***<br>Submitting literature review on the specific segment of the course related to the PhD research.<br>***Course point distribution, examination format*:**<br>81....100% -excellent, 71...80% -good, 61…70% -satisfactory**,** 51...60% -sufficient, 0…50% -unsufficient. | |
| **Required reading:**<br>Kohei Ogawa: Chemical Engineering: a New Perdpective. ISBN: 978-0-444-53096-7<br>Brauer, H. (ed.): Biotechnology. ISBN: 0-89573-042-1.<br>Bioprocess Engineering Principles, Second Edition by Pauline M. Doran ISBN-13: 978-0122208515 Bioprocessing for Value-Added Products from Renewable Resources, New Technologies and Applications, *Edited by:Shang-Tian Yang* ISBN: 978-0-444-52114-9, 2007 Elsevier B.V.<br>**Suggested reading:**<br>Periodical scientific journals. | |

| Ore and coal processing | **Code:** MFEET809B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Ljudmilla Bokányi, CSc, honorary professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Teaching of ore and coal processing with a special regard on technical-scientific tasks and challenges.

**Course content and structure:**
Organisation of ore processing technologies: selective, collective, rougher, cleaning and scavenger operations. Defining and economy of ore dressing. Processing of iron- and managanese ores. Processing of copper- and complex sulphide ores. Processing of nickel-wolfram-. molybdenum and tin ores. Processing of alkali metals ores. Processing of non-metallic ores; fluorite, barite, feldspars, and phosphates. Processing of gold-containing ores and alluvial gold. Dressing of precious and semi-precious stones. Specific character of processing of rare ores and alluvials. Processing of Ti and Cr ores. Processing of Be and Li ores. Processing of uranium ore. Processing of Ta-Nb ores. Processing of rare Earth elements ores. Processing for the high-tech industry needs, i.e. batteries. Genesis of fossil coal, classification in accordance to coalification rank, petrographic, mineral, immediate and elemental composition, physical and physical-chemical properties of the coal components. Washability of coals, gravitational, flotational, etc. preparation techniques, as well as techniques for dewatering; their equipment. Processing of bituminous, energetical and ultra-clean coals. Meeting of the high-tech requirements.

**Evaluation method:**
Oral exam (defending of the review).
***Course assignments:***
Submitting literature review on the specific segment of the course related to the PhD research.
***Course point distribution, examination format*:**
81....100% -excellent, 71...80% -good, 61…70% -satisfactory**,** 51...60% -sufficient, 0…50% -unsufficient.

**Required reading:**
Barry A. Wills, Tim Napier-Munn: Mineral Processing Technology. 2006 Elsevier Science & Technology Books ISBN: 0750644508
SME Handbook of Mineral Processing . Ed.:Weiss, N. L. USA, 1985 ISBN: 0895204436
Barbara J. Arnold, Mark S. Klima, Peter J. Bethell: Designing the Coal Preparation Plant of the Future SME, 2007. ISBN-13:978-0-87335-257-4
**Suggested reading:**
Proceedings of International Mineral Processing Congresses
Proceedings of International Coal Preparation Congresses

| Waste water and soil treatment | **Code:** MFEET813B<br>**Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
|---|---|
| **Name and position of course coordinator:** Dr. Ljudmilla Bokányi, CSc, honorary professor with involving Dr. Valéria Üveges Mádai, PhD, assistant professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Teaching of waste water and soil treatment with a special regard on technical-scientific tasks and challenges. | |
| **Course content and structure:**<br>Water protection: biological aspects, quality definitions, water cycle, water concumption, water contamination, waste water, self-cleaning of natural reservoirs. Aims and tasks of water management. Legal issues. Aim of waste water treatment. Relationships between water quality protection and water management and the waste water treatment. Theoretical background, conditions, equipment, reactors and realisation of mechanical-, chemical-, physical-chemical-,biological water treatment techniques.Technologies for municipal and industrial waste water treatment, their selection, design and optimisation, dimensioning. Laboratory modelling. Sewage sludge characterisation and handling. Biological aspects of soil protection. Characterization of soils, their properties, and types. Legal issues. Soil contamination and ground water pollution. Mobility of soil contaminants and the interactions with soil components. Theoretical background, conditions, equipment and realisation of physical-chemical-, chemical- and biological processes. Technological layout and technological design. Laboratory modelling of soil cleaning. Innovative technologies for the treatment of municipal and industrial wastewater, as well as municipal sewage sludge. | |
| **Evaluation method:**<br>Oral exam (defending of the review).<br>***Course assignments:***<br>Submitting literature review on the specific segment of the course related to the PhD research.<br>***Course point distribution, examination format*:**<br>81....100% -excellent, 71...80% -good, 61…70% -satisfactory**,** 51...60% -sufficient, 0…50% -unsufficient. | |
| **Required reading:**<br>Dr. Öllős G.: Szennyvíztisztító telepek-üzemeltetése I.II. Akadémiai Kiadó 1995.<br>H. Brauer (Hrsg): Handbuch des Umweltschutzes und Umweltschutztechnik. Band 4. Additiver Umweltschutz: Behandlung von Abwasser; Springer-Verlag Berlin Heidelberg, 1996.<br>Hartinger, L. (1994) Handbook of ***Effluent*** Treatment and Recycling for the ***Metal Finishing Industry***, ***Finishing*** Publications Ltd & ASM International, 2nd ed.<br>Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants Committee on Technologies for Cleanup of Subsurface, Contaminants in the DOE Weapons Complex, National, Research Council. ISBN: 0-309-51961-6, 304 pages, 6 x 9, (1999).<br>Innovations in Ground Water and Soil Cleanup: From Concept to Commercialization Committee on Innovative Remediation Technologies, National Research Council.<br>ISBN: 0-309-52148-3, 310 pages, 6 x 9, (1997).<br>Bajpai, R.K.-Zappi, M.E.: Bioremidiation of Surface and Subsurface Contamination.New York Academy of Sciences, 1997. ISBN:1-57331-065-4. | |

Noyes, R. Unit operations in Environmental Engineering. Noyes Publications, USA, 1994

**Suggested reading:**

Periodical scientific journals.

| | |
|---|---|
| Thermal processing | **Code:** MFEET816B |
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Ljudmilla Bokányi, CSc, honorary professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Teaching of Thermal Processing with a special regard on technical-scientific tasks and challenges | |
| **Course content and structure:**<br>Definition and scope of the thermal processing, its place in the creation of circular economy. Waste-to Energy concept. Pyrolysis, its processes and equipment. Application area. Gasification, its processes and equipment. Application area. Rectification, its processes and equipment. Application area. Plasma processes, application in waste treatment. High temperature reaction processes, their thermodynamic and reaction aspects, types, processes, equipment. | |
| **Evaluation method:**<br>Oral exam (defending of the review).<br>***Course assignments:***<br>Submitting literature review on the specific segment of the course related to the PhD research.<br>***Course point distribution, examination format*:**<br>81....100% -excellent, 71...80% -good, 61…70% -satisfactory**,** 51...60% -sufficient, 0…50% -unsufficient. | |
| **Required reading:**<br>J. Ren (ed): Waste-to-Energy: multi-Criteria Decision Analysis for Sustainability. Elsiever, 2020. ISBN: 978-0-12816394-8.<br>Bruce Miller: Clean Coal Engineering Technology. Elsiever, 2011.ISBN: 978-1-85617-710-8<br>**Suggested reading:**<br>Periodical scientific journals. | |

| Advanced, environmental friendly cements and concretes with special quality and application properties | **Code:** MFEET829B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Viktória Gável, PhD, honorary associate professor | |
| **Weekly lecture+seminar hours:** 0+2 | **Evaluation method:** signature and exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to acquaint students with the natural and secondary raw materials, production technology, quality requirements of advanced cements and concretes met the increasing demands of modern construction industry and environmental protection. They get an overall picture of development of cements met special requirements for special application purposes and of high-performance concretes with particular attention to durability and climate protection.

**Course content and structure:**
Quality and environmental protection-based optimization of composition and manufacturing of cements with reduced clinker content. Development of new type cements and of cementitious materials. Connections between the composition, production parameters, quality and application properties of cement and performance, corrosion resistance of concrete. Importance of developments in the cement and concrete industry in decreasing global warming: direct and indirect effects. Composition and manufacturing of cements and concretes with advantageous properties from ecological point of view. Utilization of secondary raw materials and industrial by-products in the cement and concrete production. Recycling of crushed concrete as concrete aggregates and cement additive.

**Evaluation method:**
Oral exam.
***Course assignments:***
Assignment of report on a pre-agreed subject.
***Course point distribution, examination format*:**
Oral defence of the presented report. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
H.F.W. Taylor: Cement Chemistry, 2nd edition, Thomas Telford Publishing, London, 1997 (ISBN: 0 7277 2592 0).
S. N. Ghosh: Advances in Cement Technology: Chemistry, Manufacturing and Testing, 2nd edition, Tech Books International, New Delhi, 2002 (ISBN: 81-88305-04-9).
Balázs György – Balázs L. György: Különleges betonok és betontechnológiák (in English: Special Concretes and Concrete Technologies) I-V., Akadémiai Kiadó, Budapest, 2007-2014.
Balázs György – Balázs L. György: Betonszerkezetek tartóssága (in English: Durability of Concrete Constructions), Műegyetemi Kiadó, Budapest, 2008 (ISBN: 978 963 420 954 6).
VDZ Tätigkeitsbericht 2015-2018 / VDZ Activity Report 2015-2018, Verein Deutscher Zementwerke e.V., Düsseldorf, 2018.
VDZ Betontechnische Berichte 2016-2018 / VDZ Concrete Technology Reports 2016-2018, Verein Deutscher Zementwerke e.V., Düsseldorf, 2019.
**Suggested reading:**

Articles in the last 5 years of the journal Cement International and of Zement-Kalk-Gips concerning the subject of the report.
Articles in the last 5 years of the journal Global Cement Magazine concerning the subject of the report.
Articles in the last 5 years of the journal Cement & Concrete Research concerning the subject of the report.
Publications of the Magyar Cement-, Beton- és Mészipari Szövetség (in English: Hungarian Cement Concrete and Lime Association) (cembeton.hu) concerning the subject of the report
Publications of the European Cement Association (cembureau.eu) concerning the subject of the report.
Publications of the European Cement Research Academy (ecra-online.org) concerning the subject of the report.
Publications of the Portland Cement Association (cement.org) concerning the subject of the report.
Publications of the Verein Deutscher Zementwerke e.V. (in English: Association for the German Cement Industry) (vdz-online.de) concerning the subject of the report.
Publications of the Vereinigung der Österrechischen Zementindustrie (in English: Association for the Austrian Cement Industry) (zement.at) concerning the subject of the report.
Publications of the Smart Minerals GmbH (smartminerals.at) concerning the subject of the report.

| | |
|---|---|
| Comminution | **Code:** MFEET801B |
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Prof. Dr. Barnabás Csőke, CSc, professor emeritus with involving Dr. Ádám Rácz, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is for students to deepen their knowledge of the basic phenomena that occur during comminution, the operation of comminution devices and their areas of application. Develop their knowledge of the process evaluation and description of the comminution process. With the acquired knowledge, scientists in this field should be able to conduct experimental and theoretical research, to recognize, systematize, publish novel phenomena occurring in the comminution technology process, and to further develop procedures and equipment.

**Course content and structure:**
Material properties, process engineering characterization of the fracture properties. Deformation-fracture. Types of fracture. Criteria, reason of the fracture and explanation by the microstructure: physical fracture theory, crack propagation models. Primary and secondary processes of the energy and material conversion during comminution, physical and mechanochemical phenomenon and properties changes by mechanical effect. Work consumption of the comminution, comminution theories (Rittinger, Kick-Kirpicsev, Bond, Beke theories). Efficiency of the comminution. Comminution circuits. Characterization of the comminution result, description of the comminution process, comminution functions and models: matrix and population balance model. Description of the technology, simulation and optimization. Comminution devices: 1. Equipment for comminution brittle materials; 2. Equipment for comminution non-brittle materials. Determination of the main parameters of crushers, mills. Mechanical stresses acting in comminution devices. Grindability of materials. Relationship between stress and fracture mechanical material properties and fracture particle size distribution.

**Evaluation method:**
Written or oral exam.
***Course assignments:***
Preparation and submission of a summary of the studied comminution literature in the context of his/her research work.
***Course point distribution, examination format*:**
Certified comprehensive knowledge of written and / or oral exam material. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Tarján G. (1981): Mineral Processing I-II., Akadémiai kiadó, Budapest.
Jan Drzymala: Mineral Processing: Foundations of theory and practice of minerallurgy (2007) Wroclaw University of Technology.
B. A. Wills: Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery (2006).

Rácz, Á.; Csőke, B.: Application of the product related stress model for product dispersity control in dry stirred media milling. INTERNATIONAL JOURNAL OF MINERAL PROCESSING 157 pp. 28-35., 8 p. (2016).
Csőke, B.; Hatvani, Z ; Papanastassiou, D ; Solymár, K: Investigation of grindability of diasporic bauxites in dry, aqueous and alkaline media as well as after high pressure crushing. INTERNATIONAL JOURNAL OF MINERAL PROCESSING 74 : Supl.1 pp. S123-S128., 6 p. (2004).

**Suggested reading:**

Advances in Comminution (Edited by S. Komar Kawatra), (ISBN 978-0-87335-246-8).Society of Mining, Metallurgy, and Exploration, Inc. (SME). Littleton, Colorado, USA, 2005.
Juhász A. Z:,- Opoczky L.: Mechanical activation of silicates by fine grinding, Akadémiai Kiadó. Budapest., 1982.
Csőke, B. ; Rácz, Á.; Mucsi, G.: Determination of the Bond work index of binary mixtures by different methods. INTERNATIONAL JOURNAL OF MINERAL PROCESSING 123 pp. 78-86. , 9 p. (2013).
Rácz, Á.; Csőke, B.: Comminution of single real waste particles in a swing-hammer shredder and axial gap rotary shear. POWDER TECHNOLOGY 390 pp. 182-189. , 8 p. (2021).
Mucsi, G.; Csőke, B.; Solymár, K.: Grindability characteristics of lateritic and karst bauxites. INTERNATIONAL JOURNAL OF MINERAL PROCESSING 100 : 3-4 pp. 96-103. , 8 p. (2011).
Minerals Engineering, International Journal of Mineral Processing, Powder Technology – relevant articles of the last five years.

| Agglomeration | **Code:** MFEET802B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Sándor Nagy, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
PhD students should understand and learn the principles of agglomeration methods (binding, strength, quality of agglomerates), advantages and aim of agglomeration, the main methods and the special industrial applications of it. Students should be able with their knowledge to design (process engineering design) agglomeration technologies, to select the proper process and equipment, and to configure new technological processes.

**Course content and structure:**
Properties of agglomerates, process engineering characterisation of agglomerate properties. Binding and strength: binding mechanisms and binding forces, theoretical strength of agglomerates. Measurement of fracture-mechanical parameters. Binders and intermediates.
Pressure agglomeration: compacting, briquetting, tabletting and its equipment. Describing the extrusion procedures (Johansson correlation). Determination of main technical parameters, scale up models. Applications. Tumble or growth agglomeration. Pelletization, microgranulation. Introduction of the process. Main machine types. Agglomeration by Heat. Description of sintering process, applications. Special industrial applications: mining-, chemical- and pharmaceutical industries, food industry and construction material industry.

**Evaluation method:**
Oral exam.
***Course assignments:***
Participation on consultancies.
***Course point distribution, examination format*:**
Oral exam; Minimal requirements: main definitions, processing technologies of waste streams. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Wolfgang Pietsch: Agglomeration in Industry (Occurrence and Applications), 2005., WILEYVCH Verlag GmbH & Co. KGaA, Weinheim, ISBN 3-527-30582-3.
Aitber Bizhanov , By Valentina Chizhikova: Agglomeration in Metallurgy. Springer Nature Switzerland AG, 2019, 3030260240.
Ram Pravesh Bhagat: Agglomeration of Iron Ores. CRC, 2019.
Wolfgang Pietsch: Agglomeration Processes, Phenomena, Technologies, Equipment. Wiley-VCH Verlag, Weinheim, 2002.
G Tarján: Mineral Processing II., Akadémia kiadó Budapest, 1986.
**Suggested reading:**
H. Schubert: Aufbereitung fester mineralischer Rohstoffe, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1984.
G. Alderborn, C. Nyström: Pharmaceutical Powder Compaction Technology. CRC Press, 2019.
Stiess: Mechanische Verfahrenstechnik 2, Springer Lehrbuch 1993

Schubert: Mechanische Verfahrenstechnik I, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig 1977.
SME Mineral Processing Handbook, Society of Mining Engineering of the American Institute of Mining Metallurgical and Engineers.

| Processing of metallic, high-tech production and utilisation wastes | **Code:** MFEET824B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Sándor Nagy, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Understand the importance of metallic waste management for recovery of structural materials. Get acquainted with situation, structure, composition, and the possible recycling technologies of metallic waste material flows. Main groups of introduced wastes: end of life vehicles, waste from electrical and electronic equipment (WEEE) from household and industry, accumulators. Objective is that PhD students get acquainted with more operating waste processing plants in details. Students should be able with their knowledge to design waste processing/preparing systems, to select the proper process and equipment, and to configure new technological processes.

**Course content and structure:**
Technologies of processing and utilization of metal wastes. Mechanical, chemical and thermal processes of preparation. Knowledge of quality related to products. Topic of waste management, waste utilisation and waste processing. Economical and ecological importance of waste generation and recycling. Circular Economy. Urban Mining.Detailed topics: Introduction of waste types. Waste amounts (absolute and specific). Technological backgrounds 1: Comminution. Technological backgrounds 2: Separators. Processing of WEEE: computer, laptop, mobile phone. Processing of WEEE: LCDs, photo voltaic panels. Batteries (also production scrap) of Electric Vehicles. Processing of large household equipment. EoLV recycling.

**Evaluation method:**
Oral exam.
***Course assignments:***
Participation on consultancies.
***Course point distribution, examination format*:**
Oral exam; Minimal requirements: main definitions, processing technologies of waste streams. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
V. Goodship: Waste Electrical and Electronic Equipment (WEEE) Handbook. Woodhead Publishing, 2019.
M. E. Schlesinger: Aluminium Recycling. CRC Press
J. Földessy: Criticel Monography Series 10: Research of Strategic Raw Materials in Hungary. Miskolc, 2014.
Alexandre Chagnes, Gérard Cote, Christian Ekberg, Mikael Nilsson, Teodora Retegan: WEEE Recycling: Research, Development, and Policies. Elsevier, 2016.
**Suggested reading:**
R. E. Hester: Electronic Waste Management, RSC Publishing, 2009.

Schönmayr, David: Automotive Recycling, Plastics, and Sustainability: The Recycling Renaissance Sally Morgan: Waste, Recycling and Reuse. White-Thomson Publishing Ltd. 2006.

| Preparation technologies of municipal wastes, complex systems, waste management | **Code:** MFEET825B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Sándor Nagy, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The main objectives are the introduction of fundamentals of waste management and circular economy, processing methods and possibilities of various types of wastes (industrial and municipal wastes, municipal solid waste, bulky waste, household type industrial waste, packaging material, equipment, processing and utilisation of plastic, rubber, glass). Objective is that PhD students get acquainted with more operating waste processing plants in details. Students should be able with their knowledge to design waste processing/preparing systems, to select the proper process and equipment, and to configure new technological processes.

**Course content and structure:**
Waste management, waste utilization and waste preparation, waste handling. Economic and ecological significance of waste generation and waste recycling, legal environment. Conception of circular economy. Main concepts of waste management: industrial and municipal wastes, municipal solid waste, bulky waste, household type industrial waste, packaging material and equipment, process engineering parameters. Process for sampling, analysis and evaluation for the determination of quality composition. Material balance calculation, estimation of generated waste amounts. Complex integrated waste management system; reducing of waste generation, selective collection, processing technologies (selective collected waste stream and residual waste stream), processing of residues, processing of slag, landfilling. Process engineering targets and results of selective collection and processing. Plastic, rubber and glass preparation and utilisation. Technologies of mixes waste (residue). Systems in western European countries. Possible new directions, conceptions, solutions in Hungary. Economical questions of waste collection and processing.

**Evaluation method:**
Oral exam.
***Course assignments:***
Participation on consultancies.
***Course point distribution, examination format*:**
Oral exam; Minimal requirements: main definitions, processing technologies of waste streams. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Worrell, W. A. – Vesilind, P. A.: Solid Waste Engineering. Cengage Learning, Stamford, 2012.
P. Jayarama Reddy: Municipal Solid Waste Management Processing - Energy Recovery - Global Examples, 2011, ISBN 9780415690362, Published November 30, 2011 by CRC Press.
Organic Waste Recycling Technology and Management: Chongrak Polprasert (2007) IWA Publishing.
Ramesha Chandrappa, Diganta Bhusan Das: Solid Waste Management. Springer, 2024.
**Suggested reading:**

Tchobanoglous, G.- Kreith, F.: Handbook of Solid Waste Management. McGRAW-HILL, New York, 2002.
Tchobanoglous, G.-Theisen, H.-Vigil, S.: Integrated Solid Waste Management. McGraw-Hill, Inc., New York, 2002.

| Environmental chemistry | **Code:** MFEET805B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Valéria Üveges Mádai, PhD, assistant professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:** Environmental process engineering is the technological restoration of poor-quality environmental elements, so negative effects on wildlife can be minimized. Accordingly, the aim of the subject is to familiarise students with the pollutants of water, air and soil, the harmful effects of pollution, the cleaning technologies, their physical, chemical and biological fundamentals. Students will be able to decide on the type of intervention to be taken in a given situation.

**Course content and structure:**
Basics of environmental chemistry, its role. Measurement of pollution, limit values; Basic ecological concepts, key ecological factors; basic toxicology. Biological aspects of water, air, soil protection, reactions in the atmosphere, hydrosphere and lithosphere, cycling of elements. The most common and dangerous water, air and soil pollutants and their behaviour, classification of the elements of the environment. Pollutants of natural and anthropogenic origin and their environmental chemistry. Waste as a pollutant, characteristics of pollutants generated during waste disposal, incineration, recycling, their hazardousness. Sampling of liquids, soil, air, waste, sample preparation. Contaminants measurement methods, standards.

**Evaluation method:**
Active participation in lectures/consultations is essential.
***Course assignments:***
Preparation of a literature review on the environmental chemistry aspects of the doctoral research topic, then oral examination.
***Course point distribution, examination format*:**
The oral examination is based on the level of the subject knowledge and the oral defence of the submitted assignment. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good.
Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Des W. Connell: Basic concept of Environmental Chemistry; Taylor and Francis Groip, CRC Press, 2005.
**Suggested reading:**
J.E. Andrews, P. Brimblecombe, T.D. Jickells, P.S. Liss, B.J. Reid: An introduction to environmental chemistry, Blackwell Publishing, 2004 (related sections).
Scientific papers in the field of doctoral research topic.

| Preparation technologies of industrial minerals, product design and product quality control | **Code:** MFEET823B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Prof. Dr. Gábor Mucsi, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to know the technological systems of raw material preparation plants in the construction industry. Get to know the special procedures and machines, equipment and specific solutions of each technology. With the acquired knowledge they should get acquainted with the technological systems of these processing and preparation plants and be able to optimize and develop these plants.

**Course content and structure:**
Mineral based construction materials applied in civil engineering, processing and production technology of construction materials (like concrete and composites) and also raw materials as cement, aggregates or perlite including design of process elements and machinery. The course includes knowledge on physical-chemical properties of the components and also the effect of production to these properties. Complex quality issues and management as well as special issues and trends of the field. Non-ceramic type industrial mineral applications (limestone, lime), processing and production including technology and their components. Complex quality issues and management as well as special issues and trends of the field. Links between the product design (targeted product properties) and applied technology are also part of the course. Preparation of raw materials of fine and coarse ceramics (clays, kaolin, volcanic rocks, feldspar, quartz, metakaolin) and additives (comminution, mixing, classification, pressing, heat treatment). Effect of the process engineering parameters of a given apparatus on the characteristics of the middle and final product (fineness, purity). Metakaolin, as a geopolymer raw material.

**Evaluation method:**
Oral and / or written exam.
***Course assignments:***
During the semester, completion of the mid-term report at a level of at least 60%, as well as participation in at least 70% of the lectures and assignment of a complex task.
***Course point distribution, examination format*:**
The final grade is calculated on the basis of the performance in the oral and / or written examination. Sufficient (2) level 50%. In the exam, students will receive two explanatory questions from the lecture material. The exam is evaluated according to a five-point scale: He does not have basic knowledge - failed. He has basic knowledge - enough. He / she has basic knowledge and can demonstrate its application in practice - intermediate. He knows the sub-areas of his knowledge at the system level, in their context - good. He has outstanding detail and system-wide knowledge - excellent. In the case of a written exam 0-49% is insufficient 50-59% is sufficient, 60-69% is medium, 75-84% is good, 85-100% is excellent.

**Required reading:**
Industrial minerals and their uses: a handbook and formulary / edited by Peter A Ciullo. 1996 by Noyes Publications.
Reuse of Materials and Byproducts in Construction Waste Minimization and Recycling edited by Alan Richardson Springer 2013.
**Suggested reading:**

Sear, Lindon K.: The Properties and Use of Coal Fly Ash. Thomas Telford, London, UK 2001.
Recently published issues of the Journal of Ceramics International, Journal of Cement and Concrete Composites.

| Special applications of fine-, micro-, and nano-grinding | **Code:** MFEET828B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Prof. Dr. Gábor Mucsi, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to know the mechanism of fine grinding as well as mechanical activation. Get to know the special procedures and machines, equipment and specific solutions of micronization and nanonization (nano-grinding). With the acquired knowledge they will be able to develop and optimize new decices and procedures, materials.

**Course content and structure:**
Mechanism of fine grinding. Apparatuses of fine grinding (ball mill, vibrating mill, stirred media mill, ring mill), main dimensional and operating parameters. Phenomena (obstacles) occurring during fine grinding (aggregation, agglomeration). Effect of mechanical and mechanochemical activation on the material properties concerning its dispersion characteristics and mineralogical composition. Fundamentals of mechanical alloying. Design and working principle of the high energy density mills, with special regards to the stirred media mills. Operation of the continuous working special designed nano-mills. Stress models, stress number, stress intensity theories. Process engineering design of fine grinding mills. Characteristics of dry and wet grinding, effect of the main dimensional and operating parameters (velocity, diameter and shape of grinding media, material of liners and media, size of grinding chamber, filling ratios, etc…) on the fineness of the ground product. Investigation of the relationship between particle size and specific grinding energy. Stabilization methods of suspensions of wet ultrafine grinding: steric, electrostatic and electrosteric stabilization, advantages and disadvantages. Types, properties and mechanisms of grinding aids applied in dry grinding.

**Evaluation method:**
Oral and / or written exam.
***Course assignments:***
During the semester, completion of the mid-term report at a level of at least 60%, as well as participation in at least 70% of the lectures and assignment of a complex task.
***Course point distribution, examination format*:**
The final grade is calculated on the basis of the performance in the oral and / or written examination. Sufficient (2) level 50%. In the exam, students will receive two explanatory questions from the lecture material. The exam is evaluated according to a five-point scale: He does not have basic knowledge - failed. He has basic knowledge - enough. He / she has basic knowledge and can demonstrate its application in practice - intermediate. He knows the sub-areas of his knowledge at the system level, in their context - good. He has outstanding detail and system-wide knowledge - excellent. In the case of a written exam 0-49% is insufficient 50-59% is sufficient, 60-69% is medium, 75-84% is good, 85-100% is excellent.

**Required reading:**
Juhász A. Z., Opocky L. (1990) Mechanical activation of minerals by grinding, pulverizing and morphology of particles. Akadémiai kiadó, Budapest and Ellis Horwood Limited.
Kwade, A, 2004. Mill selection and process optimization using a physical grinding model, International Journal of Mineral Processing 74S S93-S101.
Mucsi Gábor: A review on mechanical activation and mechanical alloying in stirred media mill. Chemical Engineering Research and Design 148, 460-474.

**Suggested reading:**

Kwade, A, 1999. Determination of the most important grinding mechanism in stirred media mills by calculation stress intensity and stress number, Powder Technology 105, p. 382-388.

Recently published issues of the following journals: Minerals Engineering, International Journal of Mineral Processing, Powder Technology.

| Preparation and utilization of industrial wastes | **Code:** MFEET808B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Prof. Dr. Gábor Mucsi, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**

The primary goal of the course is for students to get to know the type, generation and characteristics of basic industrial waste, as well as to gain knowledge about their main processing possibilities and application methods. Particular attention is paid to the use of pre-treatment operations, especially to increase reactivity by mechanical activation.

**Course content and structure:**

Types of the silicate- and aluminosilicate bearing waste materials. Their quality and quantity produced yearly worldwide. Generation and types of power station fly ash and slags. Physical and chemical properties of fly ash (FA), their environmental impact. Conventional utilization methods (filler material, cement industrial raw material, mine backfill material). Generation, types and composition of metallurgical slags. Utilization of converter slag as concrete aggregate. Preparation of granulated blast furnace slag (GBFS) in order to use as alternative binder material. Construction industrial waste materials and their generation. Utilization and preparation of excavated soil, road construction and demolition waste, wastes of structural engineering, construction site wastes. Processing apparatuses and technologies. New preparation processes and technologies for the treatment of silicate- and aluminosilicate bearing waste materials: mechanical activation (MA) by grinding, effect of classification on the properties of the final product. Alkali activated materials, geopolymer, micro-binder, cenospheres, and encapsulation of hazardous and nuclear waste. Special apparatuses developed for waste preparation, single and multiple stage technologies. Dry and wet technologies. Development of low-carbon binders and geopolymers from silicate-containing waste. The effect of technologies and production conditions on the characteristics of the final product, in particular the use of mechanical activation to increase reactivity. Optimization of the circumstances of glass foam production from waste streams and its application in the construction industry (heat- and sound insulation material). Utilization of secondary raw materials (waste glass, fly ash, slags, bricks, tiles) in the production and preparation of construction materials and ceramic raw materials. Correlation between process parameters and material characteristics.

**Evaluation method:**

Oral and / or written exam.

***Course assignments:***

During the semester, completion of the mid-term report at a level of at least 60%, as well as participation in at least 70% of the lectures and assignment of a complex task.

***Course point distribution, examination format*:**

The final grade is calculated on the basis of the performance in the oral and / or written examination. Sufficient (2) level 50%. In the exam, students will receive two explanatory questions from the lecture material. The exam is evaluated according to a five-point scale: He does not have basic knowledge - failed. He has basic knowledge - enough. He / she has basic knowledge and can demonstrate its application in practice - intermediate. He knows the sub-areas of his knowledge at the system level, in their context - good. He has outstanding detail and system-wide knowledge - excellent. In the case of a written exam 0-49% is insufficient 50-59% is sufficient, 60-69% is medium, 75-84% is good, 85-100% is excellent.

**Required reading:**

J. Davidovits (2011): Geopolymer chemistry and application. Published by: Institut Geopolimére 16. rue Galilée F-02100 Saint-Quentin France, ISBN: 9782951482050 pp. 283, 286.

Sear, Lindon K.: The Properties and Use of Coal Fly Ash. Thomas Telford, London, UK 2001.

**Suggested reading:**

Recently published issues of the Journal of Ceramics International, Journal of Cement and Concrete Composites, Cement International.

| Optimalization modelling and controlling of grinding-classification systems | **Code:** MFEET819B<br>**Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
|---|---|
| **Name and position of course coordinator:** Dr. Ádám Rácz, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** signature and exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to acquaint students with the theoretical foundations, types, control methods and possibilities of grinding systems. Develop their knowledge in the process evaluation, control, and description of milling cycles.

**Course content and structure:**
Types of grinding-classifying systems, operation of mills and classifiers. Impact of mill and classifier type on system operation. Theoretical bases of control. Control of the continuous operation mills. The task of control, the basic characteristics of the controlling system. Control of dry and wet grinding systems. Controlling of continuous wet and dry stirred media mills, ball mills, vertical roller mills.

**Evaluation method:**
Oral exam.
***Course assignments:***
Literature summary assignment.
***Course point distribution, examination format*:**
Oral defence of the presented Literature summary assignment. Oral exam certifying comprehensive knowledge of the educational material. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
A.J. Lynch: Mineral Crushing and Grinding Circuits: Their Simulation, Optimization, Design and Control, Elsevier, 1977.
Béla Beke: The process of fine grinding, 1981. Akadémiai Kiadó, Budapest.
Tarján G. (1981) Mineral Processing, Akadémiai kiadó, Budapest.
**Suggested reading:**
Barnabás, Csőke ; Ádám, Rácz ; Gábor, Mucsi, Determination of the Bond work index of binary mixtures by different methods, INTERNATIONAL JOURNAL OF MINERAL PROCESSING 123 pp. 78-86. , 9 p. (2013).
Articles in the last 5 years of the journal Minerals Engineering concerning the subject of the examination.
Articles from the last 5 years of Advanced Powder Technology journal on the subject area of the examination.
Articles from the last 5 years of the journal Powder Technology concerning the subject of the examination.

| Particle design | **Code:** MFEET818B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Ádám Rácz, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** signature and exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to acquaint students with the topic, aims and tools of particle design. They get a comprehensive picture of the conscious control and planning of the properties of particulate materials.

**Course content and structure:**
Particle design and product design in process engineering. Characterization and design of the disperse state (particle size, specific surface area, particle shape, surface properties) and structural properties (crystal structure, amorphousness, fabric structure, intragranular inhomogeneity, layering) of the material during grinding and fine grinding. Designing of product properties with functions. Interpretation of material, mill and process functions and their relationship. Particle shaping in stirred media mill. Coating. “Top down” and “bottom up” methods to produce particulate materials. Modern measurement methods for determining dispersity properties.

**Evaluation method:**
Oral exam.
***Course assignments:***
Literature summary assignment.
***Course point distribution, examination format*:**
Oral defence of the presented Literature summary assignment. Oral exam certifying comprehensive knowledge of the educational material. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Peukert, W. (2004). Material properties in fine grinding. International Journal of Mineral Processing, 74, S3–S17. doi:10.1016/j.minpro.2004.08.006
Ko Higashitani, Hisao Makino, Shuji Matsusaka, Powder Technology Handbook, Fourth Edition, Taylor&Francis, 2019
D. Schultze: Powders and Bulk solids, Springer, Berlin, 2007.
Ádám, Rácz, Reduction of Surface Roughness and Rounding of Limestone Particles in Stirred Media Mill, CHEMICAL ENGINEERING & TECHNOLOGY 37 : 5 pp. 865-872. , 8 p. (2014)
Rácz Á. (2014) Research and development of the grinding process for the production of ultrafine materials, Theses of doctoral (PhD) dissertation
**Suggested reading:**
Rácz, Á ; Csőke, B, Application of the product related stress model for product dispersity control in dry stirred media milling, INTERNATIONAL JOURNAL OF MINERAL PROCESSING 157 pp. 28-35. , 8 p. (2016).
Articles in the last 5 years of the journal Minerals Engineering concerning the subject of the examination.

Articles from the last 5 years of Advanced Powder Technology journal on the subject area of the examination.
Articles from the last 5 years of the journal Powder Technology concerning the subject of the examination.

| Separation in complex force fields and sorting by sensor technology | **Code:** MFEET826B |
|---|---|
| | **Responsible Institute:** Institute of Raw Material Preparation and Environmental Technology |
| **Name and position of course coordinator:** Dr. Ádám Rácz, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** signature and exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is introducing the separation process in complex force fields and the sorting by sensor technology.

**Course content and structure:**
The physical and mechanical characteristics of granular materials relevant to separation. Separation in moving dispersed systems and sorting procedures based on material recognition and on physical (optical, magnetic, electrical...) characteristics and their applications. Sensory sorting technologies. Principles of separation processes based on density, magnetic and electrical properties and optical, thermal, surface and mechanical properties. Forces during separation, separation in complex force fields. Conditions for effective separation, the main equipment types and technological systems of the processes, equipment dimensioning, technology planning and equipment selection.

**Evaluation method:**
Oral exam.
***Course assignments:***
Literature summary assignment.
***Course point distribution, examination format*:**
Oral defence of the presented Literature summary assignment. Oral exam certifying comprehensive knowledge of the educational material. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Gusztáv Tarján: Mineral Processing I-II., Akadémia kiadó Budapest, 1986.
R.P.King. Modeling and Simulation of Mineral Processing Systems, Butterworth-Heinemann 2001, ISBN:0750648848.
Sathish Paulraj Gundupalli, Subrata Hait, Atul Thakur 2017 A review on automated sorting of source-separated municipal solid waste for recycling. Waste Management 60 (2017) 56–74.
**Suggested reading:**
Errol G. Kelly, David J. Spottiswood Introduction to mineral processing Wiley, 1982
Ashok Gupta, Denis Yan, Mineral Processing Design and Operation: An Introduction Elsevier Science 2006 ISBN: 0444516360.
Maurice C. Fuerstenau, Kenneth N. Han Principles of Mineral Processing SME, 2003 ISBN: 0873351673.
Barry A. Wills, Tim Napier-Munn: Mineral Processing Technology. 2006 Elsevier Science & Technology Books ISBN: 0750644508.

| Production techniques in mining | **Code:** MFBGT831B |
|---|---|
| | **Responsible Institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. József Molnár, PhD, associate professor | |
| **Weekly lecture+seminar hours:** weekly hours of full time education 2+0, hours per semester for the part time education 8+0 | **Evaluation method:** written and oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introducing the candidate to the up-to-date solutions of the surface mining technology.

**Course content and structure:**
Geological models and measures of the mineral reserve as the basis of mine design. Effect of different characteristics, such as depth, seam thickness, faults, parameters of country rocks, mine hazards, etc. on the operation of the mine. Taking into account main parameters of the deposit in determining optimal mining technology. Role of mining in the industry and its economic consideration. Types of mineral deposits from mining point of view. Types of mines, mine opening and development. Primary cutting methods, blasting and mechanized cutting. Selective cutting. Tasks and methods of haulage in surface mining. Storage of mine products and waste disposal. Mine dewatering. Ventilation underground mines. Environmental friendly solutions of mining. Reclaiming mined out areas.

**Evaluation method:**
Written and oral exam.
***Course assignments:***
Conditions of course assignment: (1) visiting contact hours *and* (2) fulfilling all projects works of the course to a no less than satisfactory (2) degree.
***Course point distribution, examination format*:**
Written and oral exam. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Students of the subject receive their compulsory literature or the list of them from the instructor.
**Suggested reading:**
Cooper, Paul: Explosives Engineering. Blackwell Publishers (Wiley), 1996. ISBN 9780471186366.
Hartman, Howard L. – Mutmansky, Jan M.: Introductory Mining Engineering. 2nd Edition. John Wiley & Sons, 2002. ISBN 9780471348511.
Hartman, Howard L. (Senior Editor): SME Mining Engineering Handbook I.-II.. 2nd Edition. Society for Mining, Metallurgy and Exploration, Inc. Littleton, Colorado, 1992.
Hustrulid, William A.: Blasting Principles for Open Pit Mining, Set of 2 Volumes. Volume 1: General Design Concepts, Volume 2: Theoretical Foundations. Taylor & Francis, 2005. ISBN 9789054104582.
Persson, Per-Anders – Holmberg, Roger – Lee, Jaimin: Rock Blasting and Explosives Engineering. CRC Press, 1993. ISBN 9780849389788.

| | |
|---|---|
| Establishing mining production systems | **Code:** MFBGT836B |
| | **Responsible Institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. József Molnár, PhD, associate professor | |
| **Weekly lecture+seminar hours:** weekly hours of full time education 2+0, hours per semester for the part time education 8+0 | **Evaluation method:** written and oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introducing the candidate to the basic concepts of establishing mining systems.

**Course content and structure:**
Basic parameters of complex systems of raw materials production, preparation and consumption, such as coalmine-preparation plant-power station. General problems of transportation problems. Ton-kilometers of movement of masses of materials in 2D and 3D space and over topographic surfaces or along lines of networks. Determining optimal lines of movement and location of mining facilities minimizing traffic-flow (e.g. payload distance in ton-kilometers, etc.) or costs. Capital investment and operational costs as functions of basic parameters of the mine, and determining its optimal output. Role of time in optimizing output and location of mining facilities. Logistic problems of the systems of mining (extraction, transportation, storage and distribution). Considering further factors (e.g. geography, mine hazards, risk resulted by technological and economic factors, etc.). Feasibility studies and procedure of opening mines.

**Evaluation method:**
Written and oral exam.
***Course assignments:***
Conditions of course assignment: (1) visiting contact hours *and* (2) fulfilling all projects works of the course to a no less than satisfactory (2) degree.
***Course point distribution, examination format*:**
Written and oral exam. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Students of the subject receive their compulsory literature or the list of them from the instructor.
**Recommended reding:**
Birolini, A.: Quality and Reliability of Technical Systems. Theory – Practice – Management. Springer Verlag. Berlin – Heidelberg – New York – London – Paris – Tokyo – Hong Kong – Barcelona – Budapest. 1994. ISBN 3-540-50603-9, ISBN 0-387-50603-9
Gentry, D. W. – O'Neill: Mine Investment Analysis. Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers Inc., New York, New York, 1984.
Hartman, Howard L. (Senior Editor): SME Mining Engineering Handbook I.-II.. 2nd Edition. Society for Mining, Metallurgy and Exploration, Inc. Littleton, Colorado, 1992.
Hillier, Frederick S. – Lieberman, Gerald J.: Introduction to Operations Research. Holden Day Inc., 1986

Hustrulid, W. A. (editor): Underground Mining Methods. Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc. New York, New York, 1982.

| Stability and support of underground excavations | **Code:** MFBGT829B |
|---|---|
| | **Responsible Institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Ákos Debreceni, PhD, associate professor | |
| **Weekly lecture+seminar hours:** weekly hours of full time education 2+0, hours per semester for the part time education 8+0 | **Evaluation method:** written and oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introducing the candidate to the basic concepts of stability and support of underground excavations.

**Course content and structure:**
Prerequisite of the subject is knowledge of Rock Mechanics of M. Sc. level. Underground excavations, mechanical state of rocks around circular shafts in general, elastic and plastic conditions of rocks. Mechanical state of elastic rocks around horizontal drifts of circular, elliptical, rectangular and combined cross sections. Support of drifts, characteristics and the role of support, determination the load bearing capacity of the support. Main properties of different roof supports, masonry supports, steel arches and bolts. In situ tests in rock mechanics, measurements of stress, loads, expansion of rocks and convergence, rock movements. Huge underground excavations made from environmental protection purposes: aspects of selecting location, valuation of discontinuations of the rocks, methods of excavations and their support.

**Evaluation method:**
Written and oral exam.
***Course assignments:***
Conditions of course assignment: (1) visiting contact hours *and* (2) fulfilling all projects works of the course to a no less than satisfactory (2) degree.
***Course point distribution, examination format*:**
Written and oral exam. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Students of the subject receive their compulsory literature or the list of them from the instructor.
**Recommended reading:**
Brady, B. H. G., Rock Mechanics For Underground Mining, Springer Verlag, 2012. ISBN 9789401165037.
Hoek, E.; Kaiser, P.K.; Bawden, W.F.: Support of Underground Excavations in Hard Rock, Taylor & Francis, 2000. ISBN 9789054101864.
Jaeger, C.: Rock Mechanics and Engineering, Cambridge University Press, 2009. ISBN 9780521103381.
Kolymbas, Dimitrios: Tunnelling and Tunnel Mechanics, Springer Verlag, 2010. ISBN 9783642064364.
Tang, Chun'An; Hudson, John A.: Rock Failure Mechanisms, CRC Press, 2010. ISBN 9780415498517.

| Construction large underground excavations for waste disposal | **Code:** MFBGT834B<br>**Responsible Institute:** Institute of Mining and Energy |
|---|---|
| **Name and position of course coordinator:** Dr. Ákos Debreczeni, PhD, associate professor | |
| **Weekly lecture+seminar hours:** weekly hours of full time education 2+0, hours per semester for the part time education 8+0 | **Evaluation method:** written and oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introducing the candidate to the basic concepts of waste disposal in underground excavations.

**Course content and structure:**
Prerequisite of the subject is knowledge of Rock Mechanics of M. Sc. level. Requirements of characteristics of country rocks. Qualification of new or abandoned excavations. Classification and qualification of wastes to be disposed. Radioactive and toxic wastes. Classes of wastes which are allowed to be disposed in determined types of geological formations. Final and temporary disposal of wastes. Natural and artificial seals, closure of storing chambers. Requirements of quality assurance of waste storage. Parameters to be taken into account and their measurement. Loading, hauling and storing wastes. Comparison of different methods of disposal from economical and risk aspect.

**Evaluation method:**
Written and oral exam.
***Course assignments:***
Conditions of course assignment: (1) visiting contact hours *and* (2) fulfilling all projects works of the course to a no less than satisfactory (2) degree.
***Course point distribution, examination format*:**
Written and oral exam. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Students of the subject receive their compulsory literature or the list of them from the instructor.
**Recommended literature:**
Blight, Geoffrey E.: Geotechnical Engineering for Mine Waste Storage Facilities, CRC Press, 2009. ISBN 9780415468282.
Hudson, John; Harrison, John: Engineering Rock Mechanics - an Introduction to the Principles, Elsevier Science & Technology, 2000. ISBN 9780080438641.
Wittke, Walter: Rock Mechanics Based on an Anisotropic Jointed Rock Model (AJRM), Wiley-VCH, 2014. ISBN 9783433030790.
Amadei, B.; Stephansson, O.: Rock Stress and Its Measurement, Springer Verlag, 2012. ISBN 9789401062473.

| Transportation systems and logistics in mining and geotechnical operations | **Code:** MFEGT825B<br>**Responsible Institute:** Institute of Mining and Energy |
|---|---|
| **Name and position of course coordinator:** Dr. Zoltán Virág, PhD, associate professor | |
| **Weekly lecture+seminar hours:** weekly hours of full time education 2+0, hours per semester for the part time education 8+0 | **Evaluation method:** written and oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Students have theoretical knowledge in the area of exact processes in projecting and problem solutions of transport and handling machinery.

**Course content and structure:**
Students have theoretical knowledge in the area of exact processes in projecting and problem solutions of transport and handling machinery based on mathematical and physical principals, with the application of specialised modern information technologies and processes, which means mainly knowledge of transported materials, transport machinery and equipment, and also the creation of complex logistic systems. Obtained knowledge forms the basis for original thinking and enables participation in research. The understanding of principals, theories and methods corresponds to their position in management, leading and research.

**Evaluation method:**
Written and oral exam.
***Course assignments:***
Conditions of course assignment: (1) visiting contact hours *and* (2) fulfilling all projects works of the course to a no less than satisfactory (2) degree.
***Course point distribution, examination format*:**
Written and oral exam. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
William A. Hustrulid, Mark Kuchta, Randall K. Martin: Open Pit Mine Planning and Design, 2006, ISBN 1466575123.
Hartman (Howard L. (Senior Editor): SME Mining Engineering Handbook I.-II.. 2nd. Edition. Society for Mining, Metallurgy and Exploration, Inc. Littleton, Colorado, 1992.
Hartman, Howard L. – Mutmansky, Jan M.: Introductory Mining Engineering. 2nd Edition. John Wiley & Sons, 2002. ISBN 9780471348511.
**Suggested reading:**
Hustrulid, W. A. (editor): Underground Mining Methods. Society of Mining Engineers of the American institute of Mining, Metallurgical and Petroleum Engineers, Inc. New York, New York, 1982.
Dr. Bocsánczy János: Bányászati szállítóberendezések, Tankönyvkiadó, Budapest, 1976
William A. Hustrulid (Editor), Richard L. Bullock (Editor): Underground Mining Methods: Engineering Fundamentals and International Case Studies, 2001, ISBN 0873351932.

| Mine haulage equipment | **Code:** MFEGT836B |
|---|---|
| | **Responsible Institute:** Institute of Mining and Energy |
| **Name and position of course coordinator:** Dr. Zoltán Virág, PhD, associate professor | |
| **Weekly lecture+seminar hours:** weekly hours of full time education 2+0, hours per semester for the part time education 8+0 | **Evaluation method:** written and oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the subject is to learn about the haulage equipment typical of surface and underground mining. The student should be able to choose the appropriate transport machine for the transport task, determine and check the main parameters of the machine.

**Course content and structure:**
It will provide a comprehensive understanding of the the principles and applications of materials handling and transport systems, and support infrastructure. The course will provide a comprehensive overview of the subject of belt and chain conveying and other hoist engines. It will present the fundamental concepts related to the static and dynamic design of belt conveyor systems. It will provide the understanding necessary for designing and selecting suitable equipment for reliable bulk solids handling and transportation, and for the efficient operation of belt and chain conveyors. Transport equipment connected to a track (rail, suspension rail, suspension rope tracks). Transport equipment with rubber wheels. Vertical transport: hoisting equipment.

**Evaluation method:**
Written and oral exam.
***Course assignments:***
Conditions of course assignment: (1) visiting contact hours *and* (2) fulfilling all projects works of the course to a no less than satisfactory (2) degree.
***Course point distribution, examination format*:**
Written and oral exam. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
Hartman, Howard L. – Mutmansky, Jan M.: Introductory Mining Engineering. 2nd Edition. John Wiley & Sons, 2002. ISBN 9780471348511.
William A. Hustrulid, Mark Kuchta, Randall K. Martin: Open Pit Mine Planning and Design, 2006, ISBN 1466575123.
Conveyor Equipment Manufacturers Association. Engineering Co.: Belt Conveyors for Bulk Materials, 2014.
**Suggested reading:**
Hartman (Howard L. (Senior Editor): SME Mining Engineering Handbook I.-II. 2nd. Edition. Society for Mining, Metallurgy and Exploration, Inc. Littleton, Colorado, 1992.
Hustrulid, W. A. (editor): Underground Mining Methods. Society of Mining Engineers of the American institute of Mining, Metallurgical and Petroleum Engineers, Inc. New York, New York, 1982.
M. E. Fayed, Thomas S. Skocir: Mechanical Conveyors: Selection and Operation, 1996, ISBN 1566764165.

| Introduction to GIS | **Code:** MFGGT824B |
|---|---|
| | **Responsible Institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. István Havasi, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0, 8/ term | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To acquaint students with the most important terminology of geodesy and GIS, data collection procedures creating the geometric foundations of GIS, the structure of GIS system, their IT and program system background. Each student should learn the methods of handling, analysing and displaying geo-referenced information, gain insight into the application of the implemented spatial information systems. To prepare students to be able to solve simple GIS tasks.

**Course content and structure:**
Terrestrial geodetic reference systems. Map projection systems. Modern geodetic methods in data capturing. Spatial information systems. Types of geo-data. Definition of geo-objects and their features. Various geo-models (vector, raster, and hybrid models). Hardware tools and computer networks. Operation systems. Data base systems. The elements of software development. General features of program systems. Overview and use of wide-spread program systems (ArcGIS, Quantum GIS, GRASS, ITR, FreeTR). Geodetic data capture (terrain point positioning by traditional, satellite, and photogrammetric methods). Practices in program development (C++programming, SQL). Basic practices in with spatial information program systems (ArcGIS, Quantum GIS, GRASS, ITR, FreeTR). Development of spatial information systems.

**Evaluation method:**
Signature.
***Course assignments:***
Active participation in lectures and consultations.
***Course point distribution, examination format*:**
Colloquium, evaluating the performance of the oral exam with results from 1 to 5. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
István Havasi - Gábor Bartha: Introduction to GIS I. Introduction to Geo-informatics (pp. 10.5) (Gábor Bartha).
István Havasi - Gábor Bartha: Introduction to GIS II. Satellite Global Positioning Systems (pp. 67) (István Havasi), digital book, http://digitalisegyetem.uni-miskolc.hu, University of Miskolc. TÁMOP 4.1.2.-08/1/A-2009-0033 project, 2011.
Gábor Bartha: Geo-information Master Course, University of Miskolc, 2014. http://barthagabor.com/eloadasok/GEOINFO/geoinfo-en.pdf
**Suggested reading:**
Wolfgang Torge: Geodesy (2nd Edition) de Gruyter, Berlin – New York 1991.
Petr Vanicek-Edward Krakiwsky: Geodesy: The concepts, 2nd Edition, Amsterdam-New York-Oxford-Tokyo, 1986.

| Modern survey techniques in geodesy and mine surveying | **Code:** MFGGT828B |
|---|---|
| | **Responsible Institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. István Havasi, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0, 8/term | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To teach students the current state-of-the-art surveying instruments and measuring procedures in geodesy and mine surveying. It is required from them to learn their current and future applications.

**Course content and structure:**
Modern total stations and geodetic data capture with them. Digital levels and their application. Satellite global positioning systems. GPS surveying and observation procedures. Laser instruments and their role in geodesy and mining. Ultrasonic survey instruments and their mining use. Laser scanners and terrestrial radars and its application possibilities in mining. Drones in open pit mines, instruments, surveying, and processing. Application of mobile mapping tools in earth sciences.

**Evaluation method:**
Signature.
***Course assignments:***
Active participation in lectures and consultations.
***Course point distribution, examination format*:**
Colloquium, evaluating the performance of the oral exam with results from 1 to 5. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
István Havasi - Gábor Bartha: Introduction to GIS. III. Introduction to Geo-informatics (pp. 10.5) (Gábor Bartha), IV. Satellite Global Positioning Systems (pp. 67) (István Havasi), digital book, http://digitalisegyetem.uni-miskolc.hu, University of Miskolc. TÁMOP 4.1.2.-08/1/A-2009-0033 project, 2011.
**Suggested reading:**
B. Hoffmann-Wellenhof-H. Lichtenegger, and J. Collins: GPS Theory and Practice Springer Wien New York, 1992, ISBN 3-21183534-2.
Wolfgang Torge: Geodesy (2nd Edition) de Gruyter, Berlin – New York 1991.
Petr Vanicek-Edward Krakiwsky: Geodesy: The concepts, 2nd Edition, Amsterdam-New York-Oxford-Tokyo, 1986.
Zoltán Eke – István Havasi: Development of underwater measurement – multibeam sonar. Geosciences and Engineering: a publication of the University of Miskolc, 9: (14), pp. 81-95, http://doi.org/10.33030/geosciences.2021.14.081, 2022.
István Havasi – Marcell Szilvási: Leica GS18I as a new terrestrial photogrammetric instrument – test measurement in mines. New results in technical earth and environmental science 2023 Conference, publication of the Faculty of Earth and Environmental Sciences (pp. 122-131), Editors: Prof. Dr Norbert Szabó - Dr Zoltán Virág, University of Miskolc, Faculty of Earth and Environmental Sciences 2023, (ISBN: 978-963-358-310-4).

| Global positioning systems | **Code:** MFGGT830B |
|---|---|
| | **Responsible Institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. István Havasi, PhD**,** associate professor | |
| **Weekly lecture + seminar hours:** 2+0, 8/term | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Students should learn the geodetic basis of satellite positioning, the structure of the most important fundamental and augmentation systems, the various surveying procedures (the error sources) and their accuracy. They should have an insight into the applications of GPS techniques in geosciences/mining.

**Course content and structure:**
Development of terrestrial geodetic reference systems (ITRF, WGS, EUREF). Reference systems used in Hungary, ground and picture surfaces connecting to them. Physical distance measurement. Development of radio-navigation systems. GNSS, Fundamental and augmentation systems. Structure and actual status of fundamental satellite positioning systems (NAVSTAR-GPS, GLONASS, Galileo, COMPASS /CNSS/. Satellite-Based and Ground-Based Augmentation Systems and their tasks. Subsystems of the NAVSTAR-GPS (GLONASS). Operation principles of satellite receivers and their classification. Error sources of GPS distance measurement and role of satellite geometry (DOP-numbers). Positioning techniques (code and phase measurements). Observation procedures (static, semi-kinematic, kinematic, and RTK surveying methods. Processing survey data. Coordinate-transformation. Evaluation of surveying results, their accuracy. International and national GPS networks. Navigation, GIS, and geodetic applications of GPS. The role of GPS in Earth sciences (in mining).

**Evaluation method:**
Signature.
***Course assignments:***
Active participation in lectures and consultations.
***Course point distribution, examination format*:**
Colloquium, evaluating the performance of the oral exam with results from 1 to 5. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
István Havasi - Gábor Bartha: Introduction to GIS I. Introduction to Geo-informatics (pp. 10.5) (Gábor Bartha),
István Havasi - Gábor Bartha: Introduction to GIS II. Satellite Global Positioning Systems (pp. 67) (István Havasi), digital book, http://digitalisegyetem.uni-miskolc.hu, University of Miskolc. TÁMOP 4.1.2.-08/1/A-2009-0033 project, 2011.
**Suggested reading:**
B. Hoffmann-Wellenhof-H. Lichtenegger, and J. Collins: GPS Theory and Practice Springer Wien New York, 1992, ISBN 3-21183534-2.
István Havasi: Test measurements for the accuracy of absolute and relative GPS positioning, 12th ISM Congress, Conference Proceedings (pp. 142-146), Beijing, China, September 20-27th, 2004.

István Havasi: Fight for the third place of the stand - that is to say Galileo and Compass. Geosciences and Engineering: a Publication of the University of Miskolc, (*ISSN: 2063-6997*) 1: (2) (pp. 69-74) (2012);
István Havasi - Márton Györffy: The accuracy of DGPS surveys on the basis of test measurements with a Leica GS20 receiver. Acta Montanistica Slovaca; ISSN 1335-1788, Volume 12 (2007), Special Issue 3/2007 (pp. 371-379).
Wolfgang Torge: Geodesy (2nd Edition) de Gruyter, Berlin – New York 1991.
Petr Vanicek-Edward Krakiwsky: Geodesy: The concepts, 2nd Edition, Amsterdam-New York-Oxford-Tokyo, 1986.

| Engineering surveys and mine surveying | **Code:** MFGGT834B |
|---|---|
| | **Responsible Institute**: Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. István Havasi, PhD, associate professor | |
| **Weekly lecture + seminar hours:** 2+0, 8/term | **Evaluation method:** |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To teach students the surveying tasks, procedures and modern measuring instruments of engineering geodesy, paying more attention to monitoring of movements. Students should acquire adequate knowledge in mine surveying (especially in opencast mining) and become familiar with the legislation in this special field.

**Course content and structure:**
The purpose and tasks of engineering surveys. Classification, planning, and establishment of survey networks. Traditional and modern survey procedures. Modern survey instruments (total stations; laser instruments; GPS systems; etc.). Setting out, construction guiding, and control surveys. Monitoring of movements. The purpose and tasks of mine surveying. Establishment and measurement of surface and underground control networks. Integration of underground surveys into surface system (connection and orientation measurements, underground height determination). Special instruments in mine surveying (gyroscopic theodolite, laser device, etc. Rock movements, etc. Survey tasks in opencast mines. Underground mine surveying jobs. Special mine survey tasks (breakthrough measurements). Mining maps. Relevant legal regulation. The tasks of a chartered mine surveyor.

**Evaluation method:**
Signature.
***Course assignments:***
Active participation in lectures and consultations.
***Course point distribution, examination format*:**
Colloquium, evaluating the performance of the oral exam with results from 1 to 5. The examination is graded on a five-point scale: No basic knowledge - unsatisfactory. Basic knowledge – pass. Has basic knowledge and can demonstrate its practical application - satisfactory. Has good knowledge and understand the relationships between the different specific fields, apply to apply basic knowledge - good. Has a high level of detailed, systemic knowledge - excellent.

**Required reading:**
István Havasi - Gábor Bartha: Introduction to GIS. Introduction to Geo-informatics (pp. 10.5) (Gábor Bartha). Satellite Global Positioning Systems (pp. 67) (István Havasi). Digital book, http://digitalisegyetem.uni-miskolc.hu, University of Miskolc. TÁMOP 4.1.2.-08/1/A-2009-0033 project, 2011.
István Havasi: Monitoring and evaluation of ground and building movements training-research notebook. MTA Bolyai János Research Scholarship, 1999-2002 (pp. 105).
**Suggested reading:**
B. Hoffmann-Wellenhof-H. Lichtenegger, and J. Collins: GPS Theory and Practice Springer Wien New York, 1992, ISBN 3-21183534-2.
István Havasi – István Zergi – Sándor Bíró – Lajos Nagy: Mine Surveying Jobs of a Greenfield Investment ( Mining Field Eger III – Limestone) Markscheidewesen, 1/2015 (pp. 23-28), (*ISSN: 0174-1357*).
Wolfgang Torge: Geodesy (2nd Edition) de Gruyter, Berlin – New York 1991.
Petr Vanicek-Edward Krakiwsky: Geodesy: The concepts, 2nd Edition, Amsterdam-New York-Oxford-Tokyo, 1986.

Ivan I. Mueller-Karl H. Ramsayer: Introduction to Surveying. Frederick Ungar Publishing, USA, 1979. ISBN 0-8044-4666-0
Zoltán Eke – István Havasi: Development of underwater measurement – multibeam sonar. Geosciences and Engineering: a publication of the University of Miskolc, 9: (14), pp. 81-95, http://doi.org/10.33030/geosciences.2021.14.081, 2022.

# Research in applied geophysics

## Content

# Course program

| | |
|---|---|
| **Title of course:**<br>Geoinformatics | **Neptun code:** MFGFT803C |
| | **Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Endre Nádasi, PhD, assistant professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Getting to know geoinformatics systems and applications.

**Course content and structure:** Summary of the theoretical bases of information theory. The artificial intelligence research in both software and hardware schools, the synthesis of disciplines, development of informatics. The hierarchy of data, news, and information. The general IT and professional informatics. Relation between GIS and geoinformatics, common and different elements. The geoinformatics as an IT-based synthesis of the land and the natural sciences. The task of geoinformatics, static and dynamic structure of the geoinformatics systems. Open GIS based software systems. Overview on part systems of geoinformatics, on essential characteristics and their relationship: the geodetic system, geological sub-systems, geophysical sub-systems, active environmental transformation and environmental management sub-systems, the national economic management and control sub-systems. Data acquisition process and its general characteristics. The process of the data- and information processing and its principal methods. Review of major information sources. The national databases of geoinformatics. Special applications in geoinformatics.

**Evaluation method:**
Written and oral exam.
***Course assignments:***
Participating in consultations and developing a designated topic.
***Course point distribution, examination format*:**
Grading scale: fail (0-45%), pass (46-60%), satisfactory (61-70%), good (71-85%), excellent (86-100%).

**Required reading:**
Turai, E., Herczeg, Á. 2011: Geoinformatics. Digital university notes. Digitális Egyetem, http://digitalisegyetem.hu/elearning/contents.php?subject_ID=MFGFT6008T-EN.
A. Rényi, 1982: Tagebuch über die Informationstheorie, VEB Deutscher Verlag der Wissenschaften, Berlin.
Y. Shirai, J. Tsujii, 1982: Artifical Intelligence, Iwanami Shoten Publishers, Tokyo.
T. Moto-oka, M. Kitsuregawa, 1984: DAI-GO-SEDAI COMPUTER, Iwanami Shoten Publishers, Tokyo.
**Suggested reading:**
Selection from geoinformatics and GIS professional articles and books chapters published in the previous five years.

| | |
|---|---|
| **Title of course:**<br>Engineering Programming | **Neptun code:** MFGFT810C |
| | **Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Endre Nádasi, PhD, assistant professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The main objective of the subject is to familiarize the students with the elements of programming necessary to solve engineering and scientific problems. The course tries to provide fundamental knowledge of programming in Matlab.

**Course content and structure:**
Some basic concepts and definitions. The elements, design, and descriptions of algorithms. Main features of programming languages. Fundamental steps of program development. A brief introduction to Matlab programming language and its development environment. The use of Matlab in interactive and script modes. Matlab variable types and their operators. Numbers and number type conversions in Matlab. Built-in mathematical and other useful functions, constants. Control structures in Matlab. Creating and calling user-defined functions. Managing files and directories. ASCII coded file input / output. Plotting graphs. Technical and scientific computations in Matlab environment. Data processing and inversion related problems. Programming task related to PhD research.

**Evaluation method:**
Exam.
***Course assignments:***
Participation in the consultations.
***Course point distribution, examination format*:**
The examination grade is entirely based on the result of written examination. Grading scale: 0–49 % (fail), 50–64 % (pass), 65–79 % (satisfactory), 80–89 % (good), 90–100 % (excellent).

**Required reading:**
Stoyan Gisbert et al., 2005: Matlab, Typotex, ISBN 963 9548 49 9.
Andrew Knight, 2000: Basics of Matlab and beyond, Chapman & Hall/CRC, ISBN 0-8493-2039-9.
A. Kharab, R. B. Guenther, 2006: An introduction to numerical methods, a Matlab approach, Chapman & Hall/CRC, ISBN 1 58488 557 2.
**Suggested reading:**
Stephen J. Chapman, 2007: Matlab programming for engineers, Bookware Companion Series, ISBN13: 9780495244493.
John W. Eaton, David Bateman, Søren Hauberg, Rik Wehbring: GNU Octave, A high-level interactive language for numerical computations, Edition 5 for Octave version 5.2.0, https://www.gnu.org/software/octave/support.
T H. Cormen et al., 2009: Introduction to Algorithms, The MIT Press Cambridge, Massachusetts London, England, ISBN 978-0-262-03384-8.

| | |
|---|---|
| **Title of course:**<br>Special methods in borehole geophysics II. | **Neptun code:** MFGFT809C |
| | **Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Péter Szabó, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introduction to special evaluation techniques and methods based on well logging, with special attention to modern oil industry procedures. PhD students acquire theoretical and practical knowledge that they can use successfully in their later research.

**Course content and structure:**
Petrophysical properties of geological formations, introduction to petrophysical basis of well logging. Petrophysical modeling of reservoir rocks. Overview of the special borehole geophysical logging methods common in practice. Evaluation methods of shaly sand reservoirs. Evaluation methods of carbonate reservoirs. Evaluation methods for reservoirs with complex lithology. Evaluation of unconventional hydrocarbon reservoirs (e.g., tight gas, shale gas, etc.). Evaluation of freshwater reservoirs and geothermal reservoirs. Well-to-well correlation techniques based on well log analysis. Interpretation of well logs using "quick-look" methods and cross-plot techniques. Visual evaluation techniques based on the graphical representation of well log curves and data. Deterministic interpretation methods. Presentation of the well log interpretation software systems used in industrial practice.

**Evaluation method:**
Exam.
***Course assignments:***
Participation in the lectures.
***Course point distribution, examination format*:**
The examination grade is entirely based on the result of written examination. Grading scale: 0–49 % (fail), 50–64 % (pass), 65–79 % (satisfactory), 80–89 % (good), 90–100 % (excellent).

**Required reading:**
Z. Bassiouni, 1994: Theory, Measurement, and Interpretation of Well Logs, Society of Petroleum Engineers Inc., USA, ISBN: 1-55563-056-1.
O. & L. Serra, 2004: Well Logging Data Acquisition and Applications, Serra Log, ISBN: 978295156125.
Rider, M. H., 1986: The geological interpretation of well logs. 2nd edition. Whittles Publishing, ISBN: 0 9541906 0 2.
**Suggested reading:**
Asquith, G. B, Krygowski, D., Henderson, S., & Hurley, N., 2004: Basic well log analysis, 2nd edition, American Association of Petroleum Geologists, ISBN: 0-89181-667-4.
Ellis D V, Singer J M, 2007: Well logging for earth scientists, Springer, ISBN 978-1-4020-3738-2.
Schlumberger, 1991: Log interpretation principles/applications. Schlumberger Wireline and Testing, TX, USA.

| | |
|---|---|
| **Title of course:**<br>Interpretation of gravity and magnetic datasets | **Neptun code:** MFGFT805C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Péter Szabó, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Introduction to gravitational and magnetic exploration methods and their modern data processing procedures. PhD students acquire theoretical and practical knowledge that they can use fruitfully in their subsequent research. | |
| **Course content and structure:**<br>Theory of gravitational and magnetic exploration methods. Filtering procedures, filter characteristics. Removing the regional trend. Analytical continuations. Reduction to the magnetic pole. Sensitivity tests, depth sensitivity compensation. Possibilities of the estimation of the depth of the causative bodies. Solving the forward problem in the case of an elementary cube. Solution options for an overdetermined inverse problem. 1D, 2D, 2.5D inversion methods. 3D underdetermined gravity and magnetic inverse problems. Regularization conditions, physical constraints. Smoothing operators. Field applications. MATLAB implementation of the above methods. Interactive inversion programs. | |
| **Evaluation method:**<br>Oral/written exam.<br>***Course assignments:***<br>Submission of research report.<br>***Course point distribution, examination format*:**<br>Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%). | |
| **Required reading:**<br>Blakely R. J., 1995. Potential theory in gravity and magnetic applications, Cambridge University Press, Cambridge, UK, pp. 441, ISBN 0-521-41508-X.<br>Steiner F., Zilahi-Sebess L., 1988. Interpretation of Filtered Gravity Maps, Akadémiai Kiadó, Budapest, p. 344.<br>Jacoby W., Smilde P. L., 2009. Gravity Interpretation. Fundamentals and Application of Gravity Inversion and Geological Interpretation. Springer-Verlag Berlin Heidelberg, ISBN 978-3-540-85328-2.<br>**Suggested reading:**<br>UBC Geophysical Inversion Facility homepage: https://www.eoas.ubc.ca/ubcgif. | |

| | |
|---|---|
| **Title of course:**<br>New results of borehole geophysics | **Neptun code:** MFGFT806C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Péter Szabó, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Presentation of state-of-the-art methods of well logging interpretation. PhD students acquire theoretical and practical knowledge that they can use fruitfully in their subsequent research. | |
| **Course content and structure:**<br>Local (depth-to-depth) and interval inversion of well logging data. Parameter sensitivity tests. Simultaneous and automated estimation of layer boundary coordinates, volumetric and zone parameters. Application of global optimization methods (Genetic Algorithm, Simulated Annealing) and other meta-heuristic methods. Possibilities of hyperparameter estimation, application to the joint estimation of volumetric and zone parameters. Rock typing using cluster analysis of wireline logs, identification of hydrocarbon reservoirs. Robust factor analysis of wireline logs. Estimation of shale volume and permeability using factor analysis. Investigation of the regression relationships of reservoir parameters, inclusion of these results in inverse modeling. Replacement of missing data (imputation) using multivariate statistical methods. Multi-borehole applications of well log analysis. Introduction to MATLAB applications and the WellCAD software. | |
| **Evaluation method:**<br>Oral/written exam.<br>***Course assignments:***<br>Submission of research report.<br>***Course point distribution, examination format*:**<br>Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%). | |
| **Required reading:**<br>Serra O., 1984. Fundamentals of well-log interpretation: The acquisition of logging data. Elsevier.<br>Ellis D. V., Singer J. M., 2007. Well logging for earth scientists, Springer, ISBN 978-1-4020-3738-2.<br>Cranganu C. (ed.), 2015. Artificial Intelligent Approaches in Petroleum Geosciences. Springer.<br>Szabó N. P., 2018. Well logging methods. Textbook. https://www.uni-miskolc.hu/~geofiz/Well-logging-methods_new.pdf<br>**Suggested reading:**<br>Dobróka M., Szabó N. P., Tóth J., Vass P., 2016. Interval inversion approach for an improved interpretation of well logs. Geophysics 81, D155-D167.<br>Szabó N. P., Dobróka M., 2018. Exploratory Factor Analysis of Wireline Logs Using a Float-Encoded Genetic Algorithm. Mathematical Geosciences 50, 317-335.<br>Szabó N. P. et al., 2019. Cluster analysis of core measurements using heterogeneous data sources: An application to complex Miocene reservoirs. Journal of Petroleum Science and Engineering 178, 575-585. | |

| | |
|---|---|
| **Title of course:**<br>Modern statistical methods | **Neptun code:** MFGFT804C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Péter Szabó, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Introduction to modern multivariate statistical methods. The subject places great emphasis on the application of robust statistical methods. PhD students acquire theoretical and practical knowledge that they can use fruitfully in their subsequent research. | |
| **Course content and structure:**<br>The most frequent value method (MFV). Covariance and correlation matrices and their generalizations. Nonlinear regression methods. Kriging and interpolation methods. Scaling of multi-dimensional datasets. Principal component analysis (PCA) and factor analysis (FA). Evolutionary factor analysis and its petrophysical applications. Cluster analysis (CA). Robust and resistant statistical procedures. Statistical aspects of inversion methods. Law of error propagation, quality check of inversion estimations. Evolutionary algorithms, neural networks. Meta-heuristic tools for hyperparameter estimation. Applications of modern statistical methods in applied geosciences, geophysics and petrophysics. MATLAB implementation of the above methods. | |
| **Evaluation method:**<br>Oral/written exam.<br>***Course assignments:***<br>Submission of research report.<br>***Course point distribution, examination format*:**<br>Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%). | |
| **Required reading:**<br>Steiner F., 1997. Optimum methods in statistics. Akadémiai Kiadó, Budapest.<br>Isaaks E. H., Srivastava M. R., 1989: An introduction to applied geostatistics. Oxford University Press.<br>Szabó N. P., 2018. Introduction to geostatistics. Textbook. https://exploration.uni-miskolc.hu/files/24167/Geostatistics%20(2).pdf<br>**Suggested reading:**<br>Sarma D. D., 2009. Geostatistics with applications in earth sciences. Springer.<br>Reyment R. A., Jöreskog K. G., 1996. Applied Factor Analysis in the Natural Sciences. Cambridge University Press. | |

| | |
|---|---|
| **Title of course:**<br>Special methods in borehole geophysics I. | **Neptun code:** MFGFT808C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Péter Szabó, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introduction to advanced measurement and data processing methods of well logging. PhD students acquire theoretical and practical knowledge that they can use fruitfully in their subsequent research.

**Course content and structure:**
Nuclear magnetic resonance (NMR) logging and its applications. Determination of effective porosity and pore-size distribution. Determination of permeability based on special measurements (NMR, Stoneley wave propagation time). Determination of anisotropy based on acoustic full-waveform analysis. Borehole radar measurements, cross-borehole radar tomography. Direct push logging methods and evaluations. Analysis of probe response functions. Solution of the forward problem of well logging. Calculation of parameter sensitivity functions for storage parameters and zone parameters. Inversion and statistical methods-based data processing. Application of special methods in environmental, water and hydrocarbon exploration.

**Evaluation method:**
Oral/written exam.
***Course assignments:***
Submission of research report.
***Course point distribution, examination format*:**
Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%).

**Required reading:**
Serra O., 1984. Fundamentals of well-log interpretation: The acquisition of logging data. Elsevier.
Ellis D. V., Singer J. M., 2007. Well logging for earth scientists, Springer, ISBN 978-1-4020-3738-2.
Szabó N. P., 2018. Well logging methods. Textbook. https://www.uni-miskolc.hu/~geofiz/Well-logging-methods_new.pdf
**Suggested reading:**
Asquith G., Krygowski D., 2004. Basic well log analysis. American Association of Petroleum Geologists.
Rider M. H., 2002. The geological interpretation of well logs, 2nd Edition, Rider-French Consulting Ltd.

| | |
|---|---|
| **Title of course:**<br>AVO analysis and inversion | **Neptun code:** MFGFT814C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ernő Takács, PhD, desk officer in charge of earth science affairs (SZTFH), head of SZTFH department (UM) | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Introduction to the Amplitude Versus Offset (AVO) method. PhD students acquire theoretical and practical knowledge that they can use fruitfully in their subsequent research. | |
| **Course content and structure:**<br>Elastic rock-physical parameters (Lambda, Mu, and Poisson's ratio). Elastic impedance. Biot-Gassmann theory for porous fluid-saturated rocks and fluid substitution. Zoeppritz equations and their approximations. Classification of AVO anomalies. Unwanted effects of seismic data processing for the observed AVO responses. True amplitude data processing. Basic AVO attributes (intercept and gradient) and their cross-plots. Derived AVO attributes (product, scaled Poisson's ratio change, shear reflectivity) and their utilization for fluid indication. Lamda-Mu-Rho (LMR) analysis, elastic impedance, and simultaneous P-P and P-S inversion. Anisotropy and uncertainty in AVO. Interpretation in clastic sediments and fractured carbonates. | |
| **Evaluation method:**<br>Oral/written exam.<br>***Course assignments:***<br>Submission of research report.<br>***Course point distribution, examination format*:**<br>Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%). | |
| **Required reading:**<br>Chopra, S. and Castagna J.P., 2014: AVO, Investigations in Geophysics Series No. 16, Society of Exploration Geophysicist, Tulsa, Oklahoma, USA, p. 288.<br>Yilmaz, Ö., 2001: Seismic data analysis: Processing, inversion, and interpretation of seismic data, Investigations in geophysics, No. 10, Society of Exploration Geophysicist.<br>**Suggested reading:**<br>Goodway, B., 2001: AVO and Lame constants for rock parameterization and fluid detection. CSEG Recorder 26, 39-60.<br>Mazzotti, A. and Mirri, S., 1991: An experience in seismic amplitude processing, First Break, 9, 65-73.<br>Mazzotti, A. and Ravagnan, G., 1995: Impact of processing on the amplitude versus offset response of a marine seismic data set, Geophysical Prospecting 43, 263-281. | |

| | |
|---|---|
| **Title of course:**<br>Chapters from continuum physics | **Neptun code:** MFGFT801C |
| | **Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Mihály Dobróka, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Deepening the knowledge in electromagnetics for a better understanding the geoelectric methods of geophysics.

**Course content and structure:**
The main chapters of the subject: basic equations of the electromagnetic field, material equations, the special phenomena of the electromagnetic field. The electrodynamics as continuum theory, definition of the charge density. Introduction of the electromagnetic parameters based on continuum physics. Maxwell's equations in integral and differential forms. Special electromagnetic phenomena and their conditions. Completeness of the Maxwell's equations. Introduction of the electromagnetic potentials, potential equations. Scale transformation. Lorentz condition. Solutions of potential equations, retarded potential. The homogeneous wave equation and its major solutions. Electromagnetic potentials in conductors. Electromagnetic wave propagation in homogeneous, isotropic, infinite insulators and conductors. Telegraphs equations. Electromagnetic wave propagation on the boundary of an infinite conductor half-space. Properties of electromagnetic wave fields in infinite insulator in case of electrical dipole. Properties of electromagnetic wave fields in infinite insulator in case of magnetic dipole. Wave propagation in weakly inhomogeneous space, the Eikonal equation. Wave propagation in weakly inhomogeneous space, WKB method.

**Evaluation method:**
Oral exam.
***Course assignments:***
Visiting the lectures and consultations.
***Course point distribution, examination format*:**
Oral examination. Evaluation limits: >80 %: excellent, 70–80 %: good, 60–70 %: satisfactory, 50–60 %: pass, < 50 %: fail.

**Required reading:**
L. D. Landau and E. M. Lifshitz, 1980. Course of Theoretical Physics, vol. 2. The Classical Theory of Fields.
Dobróka M., Somogyi M. J., 2014. An introduction to continuum mechanics and elastic wave propagation. Lecture notes. University of Miskolc.
**Suggested reading:**
M. Dobróka, 1975. Small amplitude hydromagnetic waves in wave-guides, treated by generalized polytropic equations of state. Plasma Physics 17., 1171-1172.

| | |
|---|---|
| **Title of course:**<br>Geophysical inversion | **Neptun code:** MFGFT802C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Mihály Dobróka, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**

Deepening the knowledge in geophysical inversion. In the frame of the course the PhD students study how can be the geological and geophysical information from the measured data obtained by recent inversion methods.

**Course content and structure:**

Introduction to the vector analysis. Multidimensional Euclidean spaces: N-dimensional dataspace, M-dimensional model parameter space. Classification of geophysical tasks: direct task, inverse task. Explicit and implicit forms of direct tasks. The linearization of the nonlinear direct task, introduction of the Jacobi-matrix. The linear inverse task. Solution of the overdetermined linear inverse task: Gaussian Least Squares method (LSQ). Normal equation, stability, condition number. Definition of the generalized inverse. Solution of the underdetermined linear inverse problem by Lagrange multiplicators, generalized inverse. The principle of the simple solution. Solution of the mixed determined inverse problem: solution of the weighted Least Squares method, Marquardt-algorithm. Relationship between the optimization of the damping factor and the condition number. Solution based on the weighted least squares method in data space. Solution based on the weighted Least Squares method in case of mixed determined inverse problem. Solution based on the weighted Least Squares method in the parameter space. Solution of the inverse task by the minimizing of $L_p$-norm, the method of iterative re-weighting. The qualification of accuracy and reliability of parameter-estimation: covariance and correlation matrices in the parameter space: resolution matrix, in data and parameter space, generalized inverse, sub-division by singular values. Solutions of the nonlinear inverse task by global optimization methods. The Simulated Annealing and the Genetic Algorithm method. Joint inversion. The series expansion-based inversion method. Applying the inversions methods in case of different geophysical datasets.

**Evaluation method:**

Oral exam.

***Course assignments:***

Visiting the lectures and consultations.

***Course point distribution, examination format*:**

Oral examination. Evaluation limits: > 80 %: excellent, 70–80 %: good, 60–70 %: satisfactory, 50–60 %: pass, <50 %: fail.

**Required reading:**

W. Menke, 1984: Geophysical Data Analysis: Discrete Inverse Theory. Academic Press Inc.
Dobróka, M., Völgyesi, L., 2008. Inversion Reconstruction of Gravity Potential based on Gravity Gradients. Mathematical Geoscience 40, pp. 299-311.

**Suggested reading:**

Articles presented in periodicals like: Geophysics, Geophysical Prospecting.

| | |
|---|---|
| **Title of course:**<br>Engineering physics | **Neptun code:** MFGFT815C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Mihály Dobróka, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Deepening the knowledge in continuum mechanics for a better understanding the seismic studies. | |
| **Course content and structure:**<br>The principles of continuum physics. The relationship between the micro- and macroscopic descriptions, averaging in time and space. The kinematical principles of deformable continuum, deformation tensor. Volume and surface forces, stress tensor. Basic equations of continuum mechanics, conservation laws. The equation of motion of elastic continuum, integral and differential forms. Law of conservation of mass, continuity equation. Extensive and intensive quantities, the $0^{th}$ law of thermodynamics. General forms of conservation laws. Material equations, the Curie's law. Perfectly elastic body, linearly elastic body. Equation of motion of the Hooke body. Fluid models, ideal fluids, viscous fluids. The Newton body, the Navier-Stokes body. Rheological models, the Kelvin-Voight model, the Maxwell model, the Poynting-Thomson's law for material and motion equation of standard body. Wave propagation in linearly elastic medium. Solutions of wave equation. Wave propagation in different rocks, dispersion, absorption. Disperse waves. | |
| **Evaluation method:**<br>Exam.<br>***Course assignments:***<br>Visiting the lectures and consultations.<br>***Course point distribution, examination format*:**<br>Oral exam. Evaluation limits: > 80 %: excellent, 70–80 %: good, 60–70 %: satisfactory, 50–60 %: pass, < 50 %: fail. | |
| **Required reading:**<br>L. D. Landau and E. M. Lifshitz, 1976. Course of Theoretical Physics, vol. 1., Mechanics.<br>L. D. Landau and E. M. Lifshitz, 1980. Course of Theoretical Physics, vol. 6., Fluid Mechanics.<br>**Suggested reading:**<br>M. Dobróka, 1984. On the determination of rock stresses in a single borehole. Geophysical Transactions, Vol. 30., No. 3., 265-278.<br>M. Dobróka, 1983. On a generalized Poynting-Thomson model. Acta Geodaetica, Geophysica et. Montanistica Hungarica, Vol. 18., No. 3., 281-290. | |

| | |
|---|---|
| **Title of course:**<br>Special direct current geoelectric methods | **Neptun code:** MFGFT807C |
| | **Responsible institute:**<br>Research Institute of Applied Earth Sciences |
| **Name and position of course coordinator:** Dr. Mátyás Krisztián Baracza, PhD, senior research fellow | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Students who participate in the course can deepen their knowledge in solving the geoelectric forward problem in full and half space. Geoelectric methods in engineering geophysics, and environmental applications. Field theory examinations, parameter sensitivity, optimal measurement methods. Inversion of surface measurement data inversion, parameter evaluation. Joint inversion methods in surface research.

**Course content and structure:**
Basic concept of DC geoeletric measurements. DC geoelectric arrays, normal and special types. Topics of geoelectric forward and inverse problem. Geoelectric data processing possibilities. Basic theory of geoelectric inversion, types, application of evaluation parameters. Geoelectric 1.5D, 2D inversion, dataset weighting methods, first assignment. Possibilities of combined inversion technics. Geoelectric 2.5D inversion, dataset weighting methods. 3D forward and inverse problem questions, modeling. Parameter sensitivity, optimalization possibilities. Geoelectric measurements in environmental applications. Joint application of specific resistivity and induced polarization measurements. Software of industrial use, advantages, and disadvantages. Presentation of case studies, handing in assignment.

**Evaluation method:**
Assignment on a chosen topic.
***Signature requirements:***
Attending lectures.
***Requirements for final exam*:**
Fulfillment of one assignment in time. (Defined by lecturer)
***Course point distribution, examination format*:**
Demonstration of proficiency in oral examinations in the field of geoelectric methods. Grading system: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%).

**Required reading:**
Koefed O, 1979. Geosounding Principles, Resistivity Sounding Measurements, Amsterdam.
Gyulai Á, 1997. Engineering and Environmental Applications of Geophysical Methods I. Geoelectric Methods, Educational Guide for PhD Education, University of Miskolc.
Gyulai Á, 2003. Engineering and environmental applications of geophysical methods II. Geoelectric Methods for Research on 2-D Geological Structures, Educational Guide for PhD Education, University of Miskolc.
Publications on the topic of geoelectric series expansion and joint inversion – 1.5D, 2D, 2.5D and the special weighting possibilities of these inversions.
**Suggested reading:**
Philip Kearey et. al., 2013. An introduction to geophysical exploration, Bringwell Science Publishing.
M. E. Everett, 2013. Near-Surface Applied Geophysics, Cambridge University Press.
Johnmary Kiberu, 2002. Induced polarization and Resistivity measurements on a suite of near surface soil samples and their empirical relationship to selected measured engineering

parameters, International Institute for Geo-Information Science and Earth Observation Enschede, The Netherlands.

| | |
|---|---|
| **Title of course:**<br>Special methods in seismics I. | **Neptun code:** MFGFT811C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Tamás Fancsik, CSc, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Discussion of seismic wave propagation in geological formations. PhD students acquire theoretical and practical knowledge that they can use fruitfully in their subsequent research. | |
| **Course content and structure:**<br>Investigation of wave propagation problems in near surface and deep seismic wave conducting structures. Dispersion equations and displacement functions in homogeneous and laterally inhomogeneous wave conductors (ideal and dissipative media). Dispersion equations in case of varying layer thicknesses. Investigation on detection of geological model characteristics based on parameter sensitivity – detection of inhomogeneities. Role of guided waves in the exploration of geological structures. Methods and problems of generating and receiving guided waves. Methods and applications of dispersion analysis. Inversion of dispersion characteristics (single and joint inversion, tomographic relations). | |
| **Evaluation method:**<br>Oral/written exam.<br>***Course assignments:***<br>Submission of research report.<br>***Course point distribution, examination format*:**<br>Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%). | |
| **Required reading:**<br>Aki K., Richards P. G., 2002. Quantitative Seismology, University Science Books, Sausalito, Canada.<br>Yilmaz Ö., 2001. Seismic data analysis: Processing, inversion, and interpretation of seismic data, Investigations in geophysics, No. 10, Society of Exploration Geophysicist.<br>**Suggested reading:**<br>Dobróka M., 1993. Fejezetek az elméleti fizikából (in Hungarian), Nemzeti Tankönyvkiadó, 1993. | |

| | |
|---|---|
| **Title of course:**<br>Special methods in seismics II. | **Neptun code:** MFGFT812C<br>**Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ernő Takács, PhD, desk officer in charge of earth science affairs (SZTFH), head of SZTFH department (UM) | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Introduction to modern reflection data processing methods. PhD students acquire theoretical and practical knowledge that they can use fruitfully in their subsequent research work. | |
| **Course content and structure:**<br>Reflection data processing for structural and/or quantitative imaging. Seismic energy attenuation and the difference between amplitude balanced and true amplitude processing. Vertical and horizontal resolutions. Multiple fold reflection data gathering. Definitions of Common Midpoint, Common Depth Point, and Common Reference Point. Coherent and random noises and signal-to-noise ratio. Reflection data processing sequences and parameter tests. Calculation of the static corrections. Frequency domain band-pass filtering. Automatic Gain Control (AGC) and True Amplitude Recovery (TAR). Spiking and predictive deconvolutions. Multistep velocity analyses and Normal Move-out (NMO) corrections. The difference between CDP stacking and vertical stacking. Post-stack data enhancement procedures, seismic migration tools, and depth conversion. Advanced stacking techniques, Common Reflection Surface (CRS) stacking for imaging dipping and folded geological structures. | |
| **Evaluation method:**<br>Oral/written exam.<br>***Course assignments:***<br>Submission of research report.<br>***Course point distribution, examination format*:**<br>Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%). | |
| **Required reading:**<br>Yilmaz, Ö., 2001: Seismic data analysis: Processing, inversion, and interpretation of seismic data, Investigations in geophysics, No. 10, Society of Exploration Geophysicist.<br>Yilmaz, Ö., 1999: When reflections are not hyperbolas and reflectors are not points, Journal of Applied Geophysics 42, 139-141.<br>**Suggested reading:**<br>Mazzotti, A. and Mirri, S., 1991: An experience in seismic amplitude processing, First Break, 9, 65-73.<br>Jäger, R., Mann, J., Höcht, G., Hubral, P., 2001: Common-reflection-surface stack: image and attributes, Geophysics 66, 97–109. | |

| **Title of course:** New results on the development of electromagnetic methods | **Neptun code:** MFGFT813C<br>**Responsible institute:** Institute of Exploration Geosciences |
|---|---|
| **Name and position of course coordinator:** Dr. Endre Nádasi, PhD, assistant professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Getting to know the latest electromagnetic geophysical method development results. | |
| **Course content and structure:**<br>The new results of rock conductivity. The frequency dependence of the complex conductivity relationship with the rock-forming minerals, with the natural and polluted pores content, and with rock texture. The role of local inhomogeneities and anisotropy in the electromagnetic exploration. 2D and 3D modeling for electromagnetic fields of different sources. The role and impact of spatial distortions on the interpretation. Differences in the sensitivity and the information content of each field strength components. The newer modifications of frequency and time domain soundings. Spectral Induced Polarization (IP) method. High frequency methods (radar, various radio frequency techniques). The EM methods used for marine exploration. Air electromagnetic methods. New trends in electromagnetic interpretation. The approximate inversion modifications. The electromagnetic imaging. The position of the electromagnetic methods in modern research strategy. Integrated application of practical geophysics. Special applications. | |
| **Evaluation method:**<br>Exam.<br>***Course assignments:***<br>Participating in consultations and lectures and developing a designated topic.<br>***Course point distribution, examination format*:** written and oral exam.<br>Evaluation: fail (0-45%), pass (46-60%), satisfactory (61-70%), good (71-85%), excellent (86-100%). | |
| **Required reading:**<br>Kearey P. H., Brooks M., Hill I., 2004: An introduction to geophysical exploration, Blackwell Publishing Co., Oxford.<br>Keller G. W., 1968: Electrical prospecting for oil. Quarterly of the Colorado School of Mines, Colorado.<br>Keller G. W., Frischknecht F. C., 1966: Electrical methods in geophysical prospecting. Pergamon Press, Oxford.<br>Meskó A.: Digital filtering. Akadémiai Kiadó, Budapest, 1984.<br>Sumner J. S., 1976: Principles of induced polarization for geophysical exploration. Elsevier Publishong Co., Amsterdam.<br>Wait J R., 1959: Overvoltage Research and Geophysical Applications. London: Pergamon Press.<br>**Suggested reading:**<br>P. F. Panter, 1965: Modulation, Noise, and Spectral Analysis, McGraw-Hill Book Co.<br>M. Bath, 1974: Spectral Analysis in Geophysics, Elsevier Scientific Publishing Co.<br>J. V. Candy, 1986: Signal Processing, McGraw-Hill Book Company.<br>Selection from electromagnetic professional articles and books chapters published in previous five years. | |

| **Title of course:** | **Neptun code:** MFGFT811TU |
|---|---|

| | |
|---|---|
| Scientometrics, publishing | **Responsible institute:**<br>Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Péter Szabó, DSc, full professor | |
| **Course type:** PhD, autumn semester | |
| **Weekly lecture+seminar hours:** 0+2 | **Evaluation method:** term mark |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>To get to know the indicators of scientific performance and present the rules and methods of publication. Deepening the professional terminology of earth sciences by analyzing quality publications. PhD students should acquire practical knowledge that they can use successfully in their publishing activities. | |
| **Course content and structure:**<br>Publication requirements of the Mikoviny Sámuel Doctoral School of Earth Sciences. Ranking of journals, the quartile system (presentation of the Scimago database), and scientific metrics. Increasing scientific visibility (Researchgate, Google Scholar, presentation, and management of MTMT database). Aspects of the preparation of the scientific publication, special requirements of the journals. Submission of manuscript, review procedure, conditions for publication. Analysis of the form and content of selected scientific articles with the active participation of PhD students. Aspects of preparing a conference presentation. Practicing lecturing and developing the ability to debate in a simulated conference. | |
| **Evaluation method:**<br>Term mark.<br>***Course assignments:***<br>Submission of an individual task: (I) preparation of a conference presentation, (II) preparation of a manuscript on a freely chosen topic.<br>***Course point distribution, examination format*:**<br>Grading scale: fail (0-49%), pass (50-64%), satisfactory (65-79%), good (80-89%), excellent (90-100%). | |
| **Required reading:**<br>Szabó N. P., 2022: Scientometrics, publishing. Powerpoint presentation. https://exploration.uni-miskolc.hu/files/24166/Course-final%20(2).pdf<br>**Suggested reading:**<br>Methodological studies (scientific writing).<br>Scimago ranked scientific publications.<br>Guides for Authors.<br>https://www.scimagojr.com/ | |

# Research on applied geology and hydrogeology

## Content

| Investigation methods of clay minerals | **Code:** MFFAT825D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ferenc Kristály, PhD, senior research fellow | |
| **Weekly lecture+seminar hours:** 0+2 | **Evaluation method:** written/oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**

The course is based on the proper acquirement of the classification and systematic mineralogical grouping of clay minerals, as well as their systematization on a crystal chemical basis. In the light of this knowledge, the next step is to review the applications of different analytical techniques to study clay minerals, through their possibilities and limitations. We get familiarized with the application of diffraction, spectroscopic techniques, and thermal analytical methods for clay mineral identification. For the detailed investigations, the clay fraction separation and X-ray powder diffraction investigations on oriented clay specimens is introduced. Through practical examples, the usefulness of cation exchange processes is introduced for clay mineral species identification, and its practical applications. Finally, we take a survey on the applications of the acquired knowledge for tracking evolution of geological processes, by the knowledge of clay minerals and their transformations. A glimpse into quantitative mineralogical investigation of clay bearing rocks is also offered.

**Course content and structure:**

Review of systematic mineralogy, clay mineral types and structures. Review of analytical technique types and fields. Sample and specimen preparation of clay mineral bearing materials. Sample preparation of clay mineral bearing materials for thermal analysis. Obtaining clay fraction, special specimen preparation methods, diagnostic treatments. Diagnostic clay mineral analysis by X-ray powder diffraction. Crystal structure and crystal chemistry of clay minerals, its importance. Identification of clay minerals by thermal analysis. Special properties of clay minerals observed by thermal analysis. Quantitative determination of clay minerals. Crystal-chemical features evidenced by diffraction analysis. Geological application of clay mineral analysis. Industrial importance and applications of clay mineral analysis. Complementary required analytical methods for complex characterization of clay minerals.

**Evaluation method:**

Oral/written exam; individual task – scientific presentation of measurement results and evaluations on personal samples.

***Course assignments:***

Performing measurements and evaluations on personal samples.

***Course point distribution, examination format*:**

Oral survey of knowledge on measurement and data evaluation related theory. Preconditions of the acceptance to the course are the advanced user's knowledge of X-ray powder diffraction techniques and the related crystal physical and crystal chemical theory background. Grading scale: 100–85% excellent; 84–70% good; 69–60% satisfactory; 59–50% pass; 49–0%: fail.

**Required reading:**

Bish D.L. & Post J.E. (eds.) (1981) Modern Powder Diffraction./Reviews in Mineralogy, 20. Mineralogical Society of America, Washington, D.C.

Pecharsky, V.K. & Zavalij, P.Y. (2003) Fundamentals of Powder Diffraction and Structural Characterization of Materials. Kluwer, Dordrecht.

Földvári M. (2011): Handbook of thermogravimetric system of minerals and its use in geological practice. Budapest: Occasional Papers of the Geological Institute of Hungary; 2011; vol. 213.
Bergaya F., Theng B.K.G. and Lagaly G. eds. (2006) Handbook of Clay Science. Developments in Clay Science, Vol. 1, Elsevier.
**Suggested reading:**
Dinnebier, R.E. & Billinge, S.J.L. (eds.) (2008) Powder Diffraction: Theory and Practice. Royal Society of Chemistry, Cambridge.
Klug H. P. & Alexander L. E. (1974) X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials. John Wiley & Sons, Inc., New York.

| | |
|---|---|
| Physical and structural geology | **Code**: MFFTT814D |
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Norbert Németh, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>Introduction of the basics of geological processes, their physical basis and models. | |
| **Course content and structure:**<br>The Earth as a closed system. Earth's cycles. The inner structure of Earth. Magmatic, sedimentary and metamorphic rock-forming processes in the lithosphere. Primary and secondary structural elements of rocks. Rock deformation, brittle and ductile deformation elements. The evolution and main statements of the plate tectonic theory. Types of plate margins. Global geological processes in plate interiors and along plate margins. Causes of plate movements. Plate tectonic evolution of the Earth's large mountain systems. | |
| **Evaluation method:**<br>Oral exam.<br>***Course assignments:***<br>-<br>***Course point distribution, examination format*:**<br>Oral exam. Grading scale: 85 –100% 5 (excellent), 75 – 84% 4 (good), 63 – 74% 3 (satisfactory), 50 – 62% 2 (pass), 0 – 49% 1 (fail). | |
| **Required reading:**<br>Charles (Carlos) Plummer, Diane Carlson & Lisa Hammersley 2012: Pysical Geology. Science Engineering & Maths. ISBN-13: 978-0078096105, ISBN-10: 0078096103.<br>Twiss, R. J. & Moores, E. M 1992: Structural Geology. Freeman & Co., New York, 532 p.<br>**Suggested reading:**<br>Haakon Fossen 2012: Structural Geology. Cambridge University Press. ISBN-13: 978-0521516648, ISBN-10: 0521516641. | |

| Archeogeology | **Code:** BTKPHDLMFE003 |
|---|---|
| | **Responsible department/institute:** Department of Prehistory and Archaeology |
| **Name and position of course coordinator:** Dr. habil György Lengyel, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To properly evaluate archaeological finds, it is necessary to know the archaeological environment in which the finds are preserved. Since the finds come to light from strata that may be of geological, anthropogenic, and a mixture of these two, the geological examination of the sediments can reveal the formation of strata and the burial conditions of the finds. Archeogeology (application of geological analytical methods on the sediments of archaeological sites) reveals the formation processes of the sites and the effects on the formed strata. The course teaches the methods of geoarchaeology and the applicability of each survey method.

**Course content and structure:**
Introduction. Stratigraphy. Soils. Mass movement. Lake and river water sediments. Aeolian sediments. Cave sediments. Periglacial surface development. Archaeological sediments I. Archaeological sediments II. Taphonomy. Field methods. Laboratory methods. Summary.

**Evaluation method:**
***Course assignments:***
Attending the classes + assignment.
***Course point distribution, examination format*:**
Written exam. Grading scale: 0-50% E, 51-70% D, 71-80% C, 81-90% B, 91-100% A.

**Required reading:**
Borsy Z.: Általános természetföldrajz. Nemzedékek Tudása Tankönyvkiadó, Budapest, 1998.
Butzer, K.W.: Environment and Archaeology: an Ecological Approach to Prehistory. Aldine Press, Chicago, 1964.
Cohen, K.M.–Gibbard, P.L. 2011: Global chronostratigraphical correlation table for the last 2.7 million years. Sub-commission on Quaternary Stratigraphy (International Commission on Stratigraphy), Cambridge, England. http://quaternary.stratigraphy.org/charts/
Garrison, E.:Techniques in Archaeological Geology. Springer, 2016.
Goldberg, P., Mecphail, I.R.: Practical and theoretical geoarchaeology. Wiley, 2006.
Krajcarz M.T., Cyrek K., Krajcarz M., Mroczek P., Sudoł M., Szymanek M., Tomek T., Madeyska T. 2016. Loess in a cave – Lithostratigraphic and correlative value of loess and loess-like layers in caves from the Kraków-Częstochowa Upland (Poland). Quaternary International 399: 13-30.
Kovács G.: Régészeti talaj-mikromorfológia.: Antropogén rétegek talaj-mikromorfológiai vizsgálata.Százhalombatta:Matrica Múzeum. 2011.
Magyari, E.K.–Pál, I.–Vincze, I.–Veres, D.–Jakab, G.–Braun, M.–Szalai, Z.–Szabó, Z.–Korponai, J.: Warm Younger Dryas summers and early late glacial spread oftemperate deciduous trees in Pannonian Basin during the last glacial termination (20–9kyr cal BP). Quaternary Science Reviews 225: 1–22, 2019.
Müller R. (Főszerk.): Régészeti kézikönyv. Budapest, 2011.
Pécsi M. 1993: Negyedkor és löszkutatás. Akadémiai Kiadó, Budapest.
Sümegi P. A régészeti geológia és a történeti ökológia alapjai Szeged : JATEPress, 2013.

Svendsen, J.H.–Astakhov, V.I.–Demidov, I.–Dowdeswelf, J.A.–Funder, S. és szerzőtársaik 2004: Late Quarternary ice sheet history of northern Eurasia. Quarternary Science Reviews 23: 1229–1271.
Wei, Ch.; Lengyel Gy.; Zeeden, Ch.; Péntek A.; Kaminská, Ľ.; Mester Zs.: Early Upper Paleolithic surface collections from loess-like sediments in the northern Carpathian Basin. Quaternary International 485:167–182, 2018.
Wilczyński J., Krajcarz M.T., Moskal-del Hoyo M., Alexandrowicz W.P., Miękina B., Pereswiet-Soltan A., Wertz K., Lipecki G., Marciszak A., Lõugas L., Gradziński M., Szczepanek A., Zastawny A., Wojenka M. 2020. Late Glacial and Holocene paleoecology and paleoenvironmental changes in the northern Carpathians foreland: the Żarska Cave (southern Poland) case study. The Holocene 30 (6): 905-922, 2020.

**Suggested reading:**

Geo-Pedológiai Protokoll (http://www.mnm-nok.gov.hu/szakmai-protokollok.html)
Kovács G. 2012. A talaj-mikromorfológiai vékonycsiszolatok régészeti alkalmazásának lehetőségei Százhalombatta-Földvár bronzkori településen. In: Kreiter A., Pető Á., Tugya B. (szerk.) Környezet –ember –kultúra: Az alkalmazott természettudományok és a régészet párbeszéde Magyar Nemzeti Múzeum Nemzeti Örökségvédelmi Központ pp. 99-106.
Veski, S.–Amon, L.–Heinsalu, A.–Reitalu, T.–Saarse, L.–Stivrins, N.–Vassiljev, J.: Lateglacial vegetation dynamics in the eastern Baltic region between 14,500 and 11,400 calyrBP: A complete record since the Bølling (GI-1e) to the Holocene. Quaternary Science Reviews 40: 39–53, 2012.

| Mineralogy | **Code:** MFFAT801D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ferenc Móricz, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Recognition of the most important minerals (rock-forming), industrial, and environmental aspects.

**Course content and structure:**
Rock-forming silicates. Nesosilicates. Cyclosilicates. Sorosilicates. Inosilicates. Phyllosilicates. Tectosilicates. Rock-forming non-silicates. Oxides and hydroxides. Halogenides. Carbonates. Borates. Sulphates. Phosphates and arsenates. Quartz and felspars – magmatic and metamorphic rocks. Phyllosilicates – chemical weathering, metamorphic, sedimentary processes. Zeolites and ion-exchange capacity. Sulphides, metalls, industrial minerals. Sulphates, weathering of sulphides, acid-rock draining. Oxides-hydroxides, the chemical weathering. Haloids and evaporites. Carbonates, sedimentary rocks. Borates, and sedimentary rocks. Phosphates and biomineralization. Arsenates and environmental hazards.

**Evaluation method:**
***Course assignments:*** Criterion for signature:
Completion of midterm test with at least satisfactory result (>50%). It can be repeated once.
***Course point distribution, examination format*:**
Oral exam. Grading limits: >80%: excellent; 70–80%: good; 60–70 %: satisfactory; 50–60%: passed; <50%: fail.

**Required reading:**
BGS Rock Classification Schemes vol. 1-4. https://www.bgs.ac.uk/.
Wenk, H.R. & Bulakh, A. 2004: Minerals. Their constitution and origin. Cambridge Univ. Press
Szakáll S. 2005: Ásványrendszertan. Egyetemi kiadó, Miskolc.
Pápay L.: Kristályok, ásványok, kőzetek. egyetemi jegyzet. Szegedi Egyetem.
Koch S., Sztrókay K.: Ásványtan I-II. Tankönyvkiadó, Budapest.
Putnis, A. 1992: Introduction to mineral sciences. Cambridge Univ. Press.
Kaldar S.K. & Tisljar J. (2014): Introduction to Mineralogy and Petrology. Elsevier, 2014.

| | |
|---|---|
| Ore geology | **Code:** MFFAT815D |
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Zajzon, PhD, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The objective of the course is to introduce the geology of raw material deposits, their spatial distribution, their quantity, and quality for the different commodities.

**Course content and structure:**
Description of the formation of different ore deposits and industrial mineral resources, and their mineability and industrial use with special focus on the deposit types and explorations available in Hungary based on the most up to date data and knowledge. Historical background. Classification of ore deposits. Geological and geotectonical aspects of ore formation. Regeneration theory of ore forming processes. Shape and structure specifications of ore deposits, ore deposit shapes. Geological, geochemical, and physicochemical aspects of ore formation in magmatic environment. Ore formation in hypergene sedimentary environment. Ore formation during metamorphic processes.

**Evaluation method:**
Oral exam.
***Course assignments:***
To get a signature, the student must be present at least 80% of the classes.
***Course point distribution, examination format*:**
1/3rd of the grade is recognition of different hand specimens with descriptions.
2/3rd of the grade is oral exam about ore deposit classification and genetics. Grading scale: 100–85% excellent; 84–70% good; 69–60% satisfactory; 59–50% pass; 49–0%: fail.

**Required reading:**
Robb, L. 2010: Ore-forming Processes. Blackwell Publishing, Oxford, 373 p. ISBN: 978-0-632-06378-9.
Evans, A.M. 1993: Ore geology and industrial minerals, an introduction. Blackwell Publishing, Malden, Oxford, Carlton. 406 p. ISBN: 978-0-632-02953-2.
**Suggested reading:**
Laznicka, P. 2010: Giant metallic deposits. Springer Heidelberg Dordrecht London New York. 960 p. ISBN 978-3-642-12404-4.
Dill, H.G. 2010: The CHESSBOARD classification scheme of mineral deposits: Mineralogy and geology from aluminium to zirconium. Earth-Science Reviews 100(1-4), Elsevier, Amsterdam, 420 p. ISSN: 0012-8252.
Craig JR, Vaughan DJ (1994): Ore Microscopy & Ore Petrography. *John Wiley and Sons Inc*. ISBN 10158-0012.

| Geochemistry | **Code:** MFFAT802D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ferenc Móricz, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To make the students be familiar with the followings: formation of the elements on the Earth and in the Universe; the rules of the distribution of elements; the chemical composition of the Earth, which is determined by complex physico-chemical processes; the isotope geochemistry, which reveals the chemical evolution of the Earth; the geochemistry of water, soil, organic matter, magmatic, sedimentary, and metamorphic rocks, by which we can describe the processes of mineral and rock formation in the Earth's crust. Geochemistry applications for research of raw materials. Geochemistry also helps to understand the environmental processes.

**Course content and structure:**
Abundance of chemical elements in different spheres. Meteorites. Geochemical classification of elements. Chemical composition of Earth. Stable and radioactive isotopes and geochemistry. Radiometric geochronology. Short thermodynamics. Water chemistry. Characteristics of natural water. Geochemistry of soils. Organic geochemistry. Organic geochemistry of freshwater and seawater. Geochemistry of sedimentary rocks. Chemical weathering. Geochemistry of igneous and metamorphic rocks.

**Evaluation method:**
***Course assignments:*** Criterion for signature:
Completion of a midterm test with at least satisfactory (>50%) result. It can be repeated once.
***Course point distribution, examination format*:**
Oral exam. Grading limits: >80%: excellent; 70–80%: good; 60–70 %: satisfactory; 50–60%: pass; <50%: fail.

**Required reading:**
Dill H.G. (2010): The „chessboard" classification schene of mineral deposits. Elsevier, 2010.
Albared, F. (2005): Geochemistry. An introduction. Cambridge Univ. Press. D.
Sarkar, R. Datta, R. Hanningan: Concepts, and applications in environmental geochemistry, Elsevier 2007.
John W. Anthony, Richard A. Bideaux, Kenneth W. Bladh, and Monte C. Nichols, Eds. (2003): Handbook of Mineralogy. Mineralogical Society of America.
Brownlow, A. H. (1996): Geochemistry. Prentice Hall, New Jersey.
Petruk W.: Applied mineralogy int he mining industry, Elsevier, 2000.
Rankama, K., Sahama, Th.G.: Geochemistry. Univ. Chicago Press.
White, William M. (2013) Geochemistry. Wiley-Blackwell, 668 p.
Raju, R. Dhana (2009) Handbook of Geochemistry: Techniques and Applications in Mineral Exploration. Geological Society of India, 520 p.

| Hydrogeology | **Code**: MFKHT803D |
|---|---|
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Prof. Dr. Péter Szűcs, DSc, member of HAS, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The course deals with the new results of groundwater resource based on geological knowledge. Within the framework of the subject, they learn about the origin of groundwater, its classification according to various aspects, its basic physical properties, the types of aquifer rocks, and its water management and water storage characteristics. They deal in detail with the pressure conditions of the rock and pore content, the temperature of underground water, geothermal energy, and the quality of underground water. They get to know the methods of testing the origin and absolute age of water. After the general knowledge of hydrogeology, the doctoral students deal with the location, types, water flow, pressure conditions, temperature conditions and water quality of shallow and deep groundwater resources, and fissured reservoir rock. They learn about the relations of groundwater flow systems. Finally, they learn about the relationship between underground water and surface water, as well as how underground water comes to the surface - the springs.

**Course content and structure:**
Main definitions in hydrogeology. Investigations of groundwater flow systems. Relations in well hydraulics. Field investigation methods in Hydrogeology. Quantitative and qualitative monitoring in hydrogeology. Drinking water, mineral and medicinal water, and thermal water production. Sustainable utilization.

**Evaluation method:**
Oral examination.
***Course assignments:***
Participation at the consultations.
***Course point distribution, examination format*:**
Oral examination. Evaluation limits: > 80 %: excellent, 70 – 80 %: good, 60 – 70 %: satisfactory, 50 – 60 %: pass, < 50 %: fail.

**Required reading:**
Charles R. Fitts 2002: Groundwater Science. Academic Press, ISBN 978-0-12-257855-7, 450 p.
Neven Kresic, Alex Mikszewski 2013: Hydrogeological Conceptual Site Models. CRC Press, ISBN 978-1-4398-5222-4, 584 p.
**Suggested reading:**
Eileen Poetere t al. 2020: Groundwater in our water cycle. The Groundwater project. ISBN: 978-1-7770541-1-3.

| | |
|---|---|
| Groundwater flow and contaminant transport modelling | **Code:** MFKHT813D |
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Dr. habil. Balázs Kovács, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 0+2 | **Evaluation method:** practical mark |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Understanding numerical modelling as scientific tool to describe, investigate and evaluate groundwater related problems.

**Course content and structure:**
Theoretical background for GW flow modeling. The GW flow equation in saturated and unsaturated media. Solution schemes of the flow equation (analytical solutions: Dupuit, Theis-Jacob, Chow, Tóth, etc.; numerical solutions: finite differences, finite elements, analytic elements, finite volume). Methodology of GW flow modeling: parameters, decisions, errors (conceptual, data or parameter, numerical), modelling techniques. Inverse solution of GW flow equations. Introduction to common GW flow models (MODFLOW (PMWin, Visual Modflow, GMS, GW Vistas) and inverse models (UCODE, PEST). Theory of contaminant transport, the transport equation. Solution of transport equation (analytical solutions, numerical and semi-numerical solutions: finite difference, finite elements, method of characteristics, random-walk). Modeling methodology, problems of contaminant transport models. Common contaminant transport models (MT3D, MT3DMS, RT3D, MOC, Random-Walk). Avoiding characteristic numerical errors during solving the transport equation. Use of models in Hydrogeology and Environmental management, and during remediation contaminated sites (problems and solutions in the practice). Heta transport modelling. Simultaneous use of GW flow and transport models with GIS systems. Datasets of GW flow and contaminant transport models. Accuracy and relevancy of data, aspects of data set evaluation. Errors and data checking. Model calibration. Groundwater flow and contaminant transport modeling using the Processing MODFLOW for Windows (PMWIN) environment. Case studies and stand-alone modeling task solutions.

**Evaluation method:**
Exam on modelling theory or defence of a stand-alone modelling project results.
***Course assignments:***
Understanding of suggested reading and successful submission of prescribed modelling tasks or presenting a description of an individually developed groundwater related (groundwater flow, contaminant or heat transport) numerical model.
***Course point distribution, examination format*:**
Theoretical skills 40%; Practical skills 60%. Grading scale: 0-50% fail; 60-65% pass; 65-80% satisfactory; 80-90% good; 90-100% excellent.

**Required reading:**
Kresic: Quantitative Solutions in Hydrogeology and Groundwater Modeling, CRC Lewis, 1997.
Chiang, W-H. – Kinzelbach, W.(2001): 3D-Groundwater Modeling with PMWIN, A Simulation System for Modeling Groundwater Flow and Pollution, Springer-Verlag Berlin, Heidelberg, New York, ISBN 3-540-67744-5, SPIN 10774334.
R. B. Winston: Getting Started with MODFLOW, The Groundwater Project book, 2023, https://gw-project.org/books/getting-started-with-modflow/.
**Suggested reading:**

Karamouz – Ahmadi – Akhbari: Groundwater Hydrology: Engineering Planning and Management, CRC Press, 2011.
Kinzelbach, W. (1986): Groundwater Modelling (An Introduction with Sample Programs in BASIC), Elsevier, p.331.
J.P Brandenburg: Geologic Frameworks for Groundwater Flow Models, The Groundwater Project book, 2020, https://gw-project.org/books/geologic-frameworks-for-groundwater-flow-models/.

| Karst hydrogeology | **Code**: MFKHT811D |
|---|---|
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Dr. Enikő Tóth-Darabos, PhD, assistant professor | |
| **Weekly lecture+seminar hours:** 1+1 | **Evaluation method:** practical mark |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The course aims to present students with the concept of karstification, with rocks that can karstify and their characteristic morphological elements, and the concept and flow characteristics of karst water. A key goal is to review the basic applicable methods in karst areas and their advantages and disadvantages.

**Course content and structure:**
Karst and related concepts, karst nomenclature. The karst rocks, the process, conditions, and consequences of karstification. Overview of the morphological and hydrogeological peculiarities of flow systems operating in limestone. General methods of analysis of karst flow systems (spring hydrograph analysis, determination of storage characteristics, tracer techniques). Methods for karst water resources calculation. Karst water resource management. Vulnerability of karst reservoirs, and protection areas. Karst water quality (water production, problems). Karst water monitoring systems. The impact of climate change on karst reserves, for example, the Bükk Mountains.

**Evaluation method:**
***Course assignments:***
Continuous contact with the supervisor, continuous solution of subtasks, systematic consultation about the results.
***Course point distribution, examination format*:**
Preparing a professional publication on a relevant topic for the student. A grade may be awarded if the supervisor considers the prepared manuscript suitable for publication. In case of acceptance of the publication or positive review by a reviewer, the grade is excellent.

**Required reading:**
Ford, D. - Williams, P. (2007): Karst Hydrogeology and Geomorphology, Wiley.
Goldscheider, N. - Drew, D. (2007): Methods in Karst Hydrogeology, IAH: International Contributions to Hydrogeology, 26, CRC Press, London.
Gunn, J. [Editor] (2004): Encyclopedia of Caves and Karst Science. Fitzroy Dearborn New York London.
**Suggested reading:**
Bonacci, O. (1987): Karst Hydrology. Springer-Verlag, Berlin / Heidelberg / New York / London / Paris / Tokyo.
Breznik, M. (1998): Storage Reservoirs and Deep Wells in Karst Regions. A. A. Balkema /Rotterdam / Brookfield.
Drew, D. – Hötzl, H. (1999): Karst Hydrogeology and Human Activities. A. A. Balkema /Rotterdam /Brookfield.
Lénárt L. (2005): Some aspects of the „3E's" (Economics-Environment-Ethics) model for sustainable water usage in the transboundary Slovakian and Aggtelek karst region based on some examples from the Bükk Mountains. PhD thesis work, Kassa/Kosice.
Miklós, R. – Lénárt, L. – Darabos, E. – Kovács, A. – Pelczéder, Á. – Szabó, P. N. – Szűcs, P. (2020): Karst water resources and their complex utilization in the Bükk Mountains, northeast

Hungary: an assessment from a regional hydrogeological perspective = *Hydrogeology Journal*. https://doi.org/10.1007/s10040-020-02168-0.
Milanović, P. T. (2004): Water Resources Engineering in Karst. CRC Press, Boca Raton / London / New York / Washington, D.C.

| Petroleum geology | **Code**: MFFTT806D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. habil. Felicitász Velledits, DSc, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>The course deals with the origin of oil and gas, their accumulation, exploration and exploitation. | |
| **Course content and structure:**<br>Petroleum geology is a branch of applied geology that deals with the geological aspects of the formation, accumulation, exploration and production of oil and natural gas. Hydrocarbons play a key role in the world's energy supply, both now and in the near future, and are therefore an indispensable and important industrial raw material. Topics covered: surface and subsurface hydrocarbon occurrences. Origin of oil and natural gas. History of subsidence. Migration of hydrocarbons. Accumulation of hydrocarbons, types of deposits. Fluid content of the reservoir. Geological setting of hydrocarbon deposits. Stratigraphic properties of the reservoir. Mechanism of operation of the reservoir. Methods of hydrocarbon exploration. Reservoir geology. Application of seismics in hydrocarbon exploration. Rock physics: routine (porosity, permeability, water saturation) and special tests (capillary pressure, relative permeability, pore size distribution measurements), static and dynamic model characteristics. Geology of oil and gas fields. Foreign and domestic hydrocarbon occurrences. | |
| **Evaluation method:**<br>The final mark consists partly of the activity on the lessons (20%), partly the homework exercises (20%), partly the oral exam (60%).<br>***Course assignments:***<br>The final mark consists partly of the activity on the lessons (20%), partly the homework exercises (20%), partly the oral exam (60%).<br>***Course point distribution, examination format*:**<br>Grading scale: 100-80%:5; 80-70%: 4; 70-60%: 3; 60-51%:2; 50>1. | |
| **Required reading:**<br>Bjorlykke K. (2010): Petroleum Geoscience: From Sedimentary Environments to Rock Physics. Springer.<br>Hyne N. J. (2001): Nontechnical Guide to Petroleum Geology, Exploration, drilling, and Production. 1-598. PennWell Corporation.<br>Slatt R.M. (2009): Stratigraphic Reservopir Characterization for petroleum Geologists, Geophysicists and Engineers. 1-478. Elsevier.<br>**Suggested reading:**<br>Wayne M. Ahr (2008) Geology of Carbonate Reservoirs. 277. Wiley Publication<br>Lucia (1999, 2007): Carbonte Reservoir Characterization. 226. Springer. | |

| Environmental geology | **Code**: MFFAT816D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ferenc Móricz, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:** By investigation of the shallow earth crust mainly, study the response of the geologic environment, caused by the mankind's activity. Monitoring and mitigating the caused damage. Studying the geological part of reasonable and value saving natural resource management. Investigation of the pollution mechanism of geologic media, understanding of the spreading and working mechanisms of polluting factors. Evaluating the practice of damage mitigation by case studies. | |
| **Course content and structure:**<br>Introduction, place of the subject in the scientific field. Ecology and Geology. Soil usage. Natural hazards. Floods. Earthquakes. Volcanic activity. Mass movements. Shoreline processes. Impact processes. Resources and pollution. Global challenges: climate change. | |
| **Evaluation method:**<br>Signature + exam.<br>***Course assignments:***<br>Project work during the semester.<br>***Course point distribution, examination format*:**<br>Oral exam. Grading scale: 0-50%: 1, 50-60%: 2, 60-70%: 3, 70-90%: 4, 90-100%: 5. | |
| **Required reading:**<br>Edgar, Spencer;Reichard, J S;Reichard, J: Environmental Geology, McGraw-Hill, 2009,<br>Keller, E A: Environmental Geology, Prentice Hall, 2011.<br>Wallacher, L : Környezetföldtan, kézirat, 1996.<br>**Suggested reading:**<br>Erickson, J.: Environmental Geology: Facing the Challenges of Our Changing Earth (Living Earth) Amazon com, 2002.<br>Foley,Duncan: Investigations in environmental geology, Prentice Hall, Upper Saddle River N.J, 2009.<br>Holland, H D.: Treatise on geochemistry, Elsevier, New York NY, 2003.<br>Keith,S..: Environmental hazards, Routledge,, Abingdon, Oxon; New York, 2008.<br>Knödel, K.: Environmental geology : handbook of field methods and case studies, Springer, Berlin; New York, 2007.<br>Montgomery, C W: Environmental Geology, McGraw-Hill, 2010.<br>Patnaik, P.: Handbook of environmental analysis: chemical pollutants in air, water, soil, and solid wastes, Taylor and Francis, 2009. | |

| Environmental risk assessment | **Code**: MFKHT823D |
|---|---|
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Dr. Tamás Madarász, PhD associate professor | |
| **Weekly lecture+seminar hours:** 1+1 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The goal of the course is to provide thorough insight into the theory and engineering practice of contaminated site investigation and remediation.

**Course content and structure:**
Definition of terms (hazard, risk, exposure, risk assessment, conceptual site model, contaminated land, etc.). Risk assessment in various contexts, e. g., geohazards; human health, ecological risk assessment. The detailed study of risk assessment framework related to human health. Elements of the risk assessment protocol Problem formulation (Hazard identification) (elements, steps, conceptual site model, relationship to site investigation). Exposure Assessment (elements and steps of Exposure Assessment, the role of measurements and modeling, calculation of dose). Hydrodynamic and contaminant transport modeling and its role in the RA procedure. Toxicity Assessment (elements, and steps, doze-response relationships, threshold and non-threshold chemicals, toxicological data, RfD, TDI, SF, etc, default assumptions in toxicity assessment). Risk Characterization (Risk estimation and interpretation of risk values, description of uncertainties, HQ, ER, NCR, etc.). Case studies and simple risk calculations. Risk based performance assessment (applications and case studies). Risk assessment in contaminated site remediation, (roles and limitations, risk assessment and contaminant specific target values).

**Evaluation method:**
***Course assignments:***
Course development is adjusted to the background knowledge and research priorities of the PhD candidate student. participation on classes and individual reporting projects.
***Course point distribution, examination format*:**
Oral exam or submission of assignment. Grading scale: > 80 %: excellent, 70 – 80 %: good, 60 – 70 %: average, 50 – 60 %: pass, < 50 %: fail.

**Required reading:**
Kofi Asante-Duah: Public Health Risk Assessment for Human Exposure to Chemicals, DOI https://doi.org/10.1007/978-94-010-0481-7; Kluwer Academic Publishers 2002.
USEPA, (2001): Risk Assessment Guidance for Superfund: Volume III. Part A, Process for conducting probabilistic risk assessment, Office of Emergency and Remedial Response, Washington DC.
Calow P. (1998) Handbook of Environmental Risk Assessment and Management; SBN: 978-0-865-42732-7, Wiley- Balckwell.
ByLouis T., Dupont R. (2012): Environmental Health and Hazard Risk Assessment-Principles and Calculations; ISBN9781315217017; CRC press.
US EPA – Integrated risk information system; https://www.epa.gov/iris.
TERA International Toxicological Estimates for Risk https://www.tera.org/iter/.
**Suggested reading:**
CLARINET and ISBN9781315217017 (2001): The Sustainable Management and Remediation of Contaminated Land, Special Edition of Land Contamination and Reclamation, Editors: Bardos, P. and Lewis, A., Richmond, UK.
Specific papers adjusted to the research topic of the PhD student.

| Petrology | **Code:** MFFAT804D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ferenc Mádai, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Aim of the course in case of magmatic and metamorphic rocks is to introduce the theoretical fundamentals and the modern analytical methods applied for investigation of these rock types. In case of sedimentary rocks, the focus is on the theoretical background and practice of rock characterization based on texture-element analysis. General topics will be extended in the field closely related to the PhD research topic of the student.

**Course content and structure:**
Magmatic rock bodies, rock structures, textures and texture components. Classification fundamentals, methods and normative composition of igneous rocks. Distribution of trace elements and isotopes, their role in petrological interpretation. The relationship between magmatism and plate tectonics. Types of metamorphosis, metamorphic rock textures and texture elements. Formation of metamorphic minerals, mineral reactions. Ductile deformation of rocks. Dynamo-thermal metamorphosis and the relationship of plate tectonics. Weathering of rock-forming minerals, weathering resistivity. Sedimentary structures, sedimentary rocks fabric elements. Characterization of clastic sedimentary rocks based on their textural elements, facies of clastic sediments. Characterization of carbonate rocks based on their texture elements, characteristics of carbonate facies. Clay rocks and their methods of analysis. Software applications to petrographic and petrological questions (application of digital image analysis, geochemical data processing and modelling software).

**Evaluation method:**
***Course assignments:***
Solution of an exercise on CIPW norm calculation and two exercises of quantitative and qualitative texture analysis.
***Course point distribution, examination format*:**
Oral exam on agreed thematic (60%), result of semester exercises (40%). Grading scale: 100–85% excellent; 84–70% good; 69–60% satisfactory; 59–50% pass; 49–0%: fail.

**Required reading:**
Kaldar S.K. & Tisljar J. (2014): Introduction to Mineralogy and Petrology. Elsevier, 2014.
Gill R. (2010): Igneous rocks and processes, a practical guide. Wiley-Blackwell, 2010.
Ahrens T.J. (ed.) (1995): Rock physics and phase relations. American Geophysical Union, 1995.
BGS rock classification schemes Vol. 1-3. – igneous, metamorphic, sedimentary rocks. British Geological Survey, 1999.
**Suggested reading:**
Scholle, P.A. & Ulmer-Scholle D.S. (2003): A color guide to petrography of carbonate rocks: grains, textures, porosity, diagenesis. AAPG, 2003.
Scholle P.A. (1979): A color illustrated guide to constituents, textures, cements and porosities of sandstones and associated rocks. AAPG, 1979.
Németh K. & Martin U. (2001): Practical volcanology. MÁFI, 2001.
Folk R.L. (1974): Petrology of sedimentary rocks. Hemphill Publ. Co. Austin, 1974.
Gonzalez R.C. & Woods R.E. (2001): Digital Image Processing. Prentice Hall, 2001.

| Geology of Hungary | **Code**: MFFTT807D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. György Less, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:** The aim of the subject is to give knowledge on the geology and the structural development of Hungary in the frame of the Alp-Carpathian region. This includes also the overview of the main stratigraphical units and their rock types by subregions with special emphasis on the occurrences of different raw materials.

**Course content and structure:**
Thematics of lectures: The main structural units of the Alps, Carpathians and Dinarides, their stratigraphy and metamorphism. The structure and the development of the Pannonian Basin. The recent structure of Hungary and its vicinity, the relationship of recent geographical units with the characteristics of the Earth's crust. Geology of the continuation of Alps in Hungary (the Kőszeg and Sopron Mts., the basement of the Little Plain). Geology of the Hungarian parts of the Western Carpathians (the Aggtelek-Rudabánya Mts., the crystalline basement of the Northern Börzsöny and of the Tokaj Mts.). Geology of the Pelso Block (the Transdanubian Mid-Mountains). Geology of the Hungarian continuation of the Southern Alps and Dinarides (the Mid-Transdanubian zone, the Szendrő, Uppony- and Bükk Mts.). Geology of the Tisia (the Tisza Unit): the Mecsek Zone including the Szolnok-Maramures flysch Zone, the Villány-Bihor Zone, the Békés-Codru Zone. The Hungarian Paleogene Basin. The Hungarian Neogene and Quaternary. Thematics of practices: Two field surveys (one day each) in the Bükk Mts.

**Evaluation method:**
***Course assignments:*** Criterion for signature:
Completion of inter-semester test with at least satisfactory result (see below). It can be repeated once. Practical requirements: obligatory participation in the field-trips, ppt-presentation for one of them.
***Course point distribution, examination format*:**
Oral exam. Grading limits: >80%: excellent; 70–80%: good; 60–70 %: average; 50–60%: satisfactory; <50%: unsatisfactory.

**Required reading:**
Haas J. (ed.) (2012): Geology of Hungary. Springer, Berlin-Heidelberg.
Trunkó L. (1996): Geology of Hungary. Gebrüder Bornträger, Berlin.
**Suggested reading:**
Bérczi I. & Jámbor Á. (ed., 1998): Magyarország geológiai képződményeinek rétegtana. MOL Rt. és Magyar Állami Földtani Intézet.
Császár G. (2005): Magyarország és környezetének regionális földtana. I. Paleozoikum–paleogén. Egyetemi tankönyv, 328 p. ELTE Eötvös Kiadó, Budapest.
Less Gy.: Geology of Hungary. Elektronikus tananyag, http://digitalisegyetem.hu.

| Engineering geology | **Code:** MFKHT817D |
|---|---|
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Dr. Tamás Kántor, PhD, associate professor | |
| **Number of lessons:** 2+0 | **Evaluation method:** examination |
| **Creditpoints:** 5 | **Study format:** full time and part time |

**Course task and purpose:**
During the course, students get acquainted with the main physical characteristics of soils and rocks, the basic rules of their classification. During these, special emphasis is placed on the laboratory implementation of each test method. Students will gain insight into the main problems of engineering geology: the effects of water on soil and rock, slope stability problems and their solutions, applications and applicability of in-situ field methods, foundation technologies, statics of earth support structures. The main goal of the course is to help PhD students to prepare their dissertation, so to try to answer the engineering geological questions that arise during the writing of the dissertation. After learning the theoretical background, lead PhD students to independent engineering geological solutions, whether in software design, laboratory, or field terms.

**Thematic description of the course:**
Soil and rock identifications. contact of soil and rocks with water. Shear strength issues of soils. In-situ test methods. Supporting structures. Foundation issues. Software design.

**Method of examination:**
Examination.
**Obtaining the signature:**
active participation in consultations and the timely submission and defence of the issued individual tasks in the capacity of an engineer.
**Conditions for admission to the exam:**
Completing the semester tasks.
***Course point distribution, examination format*:**
Examination. Grading scale: 85 -100%: 5 (excellent); 75 – 84%: 4 (good); 65 - 74%: 3 (satisfactory); 50 - 64%: 2 (pass); 0 - 49%: 1 (fail).

**Required literature:**
F.G Bell: Engineering Geology, Elsevier Books, 2006. ISBN 0750680776.
Steven Hencher: Practical Engineering Geology, Taylor and Francis Ltd., 2012. ISBN 04427806.
Juhász József: Mérnökgeológia I., Miskolci Egyetemi Kiadó, Miskolc 1999.
Juhász József: Mérnökgeológia II., Akadémiai Kiadó, Budapest 2002.
Juhász József: Mérnökgeológia III., Miskolci Egyetemi Kiadó, Miskolc 2003.
Gálos Miklós, Kertész Pál: Mérnökgeológi, Műegyetemi Kiadó, 1998. ISBN 0489003269148.
**Recommended literature:**
Fell Robin: Geotechnical Engineering of Dams, Taylor and Francis, 2014. ISBN 1138000086
Peter Fookes, Geoff Pettifer, Tony Waltham: Geomodels in Engineering Geology, Whittles Publishing, 2015. ISBN 9781849951395.

| Advanced analytical methods in materials investigation | **Code:** MFFAT810D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Zajzon, PhD, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The core objective of the course is to introduce the different analytical methods used in mineralogy and geology for the students. There are laboratory classes with individual work about the learned methods nearby the theoretical classes. Through these exercises the students learn what is the best available method to answer certain geological questions.

**Course content and structure:**
It gives a detailed introduction about geometrical (shape, texture) information in the micro- and nano size-range, including the comparison of different electromagnetic wave microscopies (optical, SEM, TEM). Physical properties of minerals, hardness, cleavage, density measurement. Phase analysis, principle of the x-ray powder diffraction with individual practice. Theory of the differential thermal analysis, the thermogravimetry and the differential thermogravimetry with individual practice. Principles of the scanning electron microscopy, energy- and wavelength-dispersive x-ray microanalysis with individual practice. Point analysis, line-profile measurements, and qualitative and quantitative element mapping. Data analysis, chemical formula calculations.

**Evaluation method:**
Lab report about own work and oral exam.
***Course assignments:***
To get a signature, the student must be present at least 80% of the classes. And submit the two lab reports.
***Course point distribution, examination format*:**
Two laboratory report must be written about the individual work (50% of the final grade). The other 50% of the grade is the oral exam at the end of the semester. Grading scale: 100–85% excellent; 84–70% good; 69–60% satisfactory; 59–50% pass; 49–0%: fail.

**Required reading:**
Reed, S.J.B. 2005: Electron Microprobe Analysis and Scanning Electron Microscopy. Cambridge University Press, Cambridge, 232 p. ISBN: 978-0-521-84875-6.
Bish, D.L., Post, J.E. (eds.) 1989: Modern Powder Diffraction. Reviews in Mineralogy and Geochemistry 20, Min. Soc. Am. USA, 369 p. ISBN: 978-0-939950-24-9.
Henderson, G.S., Neuville, D.R., Downs, R.T. (eds.) 2014: Spectroscopic Methods in Mineralogy and Materials Sciences. Reviews in Mineralogy and Geochemistry 78, Min. Soc. Am. USA, 800 p. ISBN: 978-0-939950-93-5.
**Suggested reading:**
Young, R.A. 2002: The Rietveld Method. Int. Union Crystallogr. Newsl., Oxford University Press, Oxford, New York. 298 p.
Whan, R.E. (vol. coordinator) 1998: ASM Metals Handbook Volume 10 (Materials Characterization). ASM International, printed in the United States of America. 1310 p. ISBN 0-87170-007-7(v.1).
O'Donoghue M (2006): Gems: Their sources, descriptions and identification. Elsevier.
Pracejus B (2008): The ore minerals under the microscope: an optical guide. Elsevier.
Goldstein J et al. (2003): Scanning Electron Microscopy and X-ray Microanalysis. Kluwer Academic/Plenum Publishers.
King M. et al. (1993): Mineral Powder Diffraction File Search- and Databook. ICDD, USA.

| Dating methods of the Quaternary | **Code**: BTKPHDLMFE002 |
|---|---|
| | **Responsible department/institute:** Department of Prehistory and Archaeology |
| **Name and position of course coordinator:** Dr. habil. György Lengyel, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
This course discusses the existing dating methods used to estimate the age of a geological formation and archaeological sites. It gives knowledge on how to choose the appropriate dating method and the advantages and limitations of usage of the different methods.

**Course content and structure:**
Dating in natural and archaeological sciences. Stratigraphy: the fundamentals of relative dating. Cultural remains in dating. Yearly grown layered samples. Radiocarbon dating I. Radiocarbon dating II. Optically Stimulated Luminescence (OSL) dating. Thermoluminescence (TL) dating. Electron Spin Resonance (ESR) dating. Uranium–Thorium (U/Th) radiometric dating. Surface (radiation) exposure dating. Calibration of radiocarbon dates. Building chronology.

**Evaluation method:**
***Course assignments:***
Attending the classes + assignment.
***Course point distribution, examination format*:**
Written exam. Grading scale: 0-50% E, 51-70% D, 71-80% C, 81-90% B, 91-100% A.

**Required reading:**
Walker, M.: Quaternary Dating Methods, John Wiley and Sons LTD, 2005.
Coulthard, B.L., Smith, D.J. Dendrochronology. In: Elias, S. A., Mock, C. J. (Eds.) Encyclopedia of Quaternary Science (Second Edition), Elsevier. 2013, 453-458.
Lamoureux, S. (2001). Varve chronology techniques. In Tracking Environmental Change Using Lake Sediments: Physical and Geochemical Techniques (W. M. Last and J. P. Smol, Eds.), Developments in Paleoenvironmental Research 1, pp. 247–260. Kluwer, Dordrecht.
Blockley, S. (2020). Radiocarbon Dating. In M. Richards & K. Britton (Eds.), Archaeological Science: An Introduction (pp. 407-423). Cambridge: Cambridge University Press.
Molnár, M., Janovics, R., Major, I., Orsovszki, J., Gönczi, R., Veres, M., Leonard, A.G., Castle, S.M., Lange, T.E., Wacker, L., Hajdas, I., Jull, A.J.T., 2013a. Status report of the new AMS C-14 preparation lab of the Hertelendi Laboratory of Environmental Studies, Debrecen. Hungary. Radiocarbon 55, 665–676.
Major, I., Futó, I., Dani, J., Cserpák-Laczi, O., Gasparik, M., Jull, A., & Molnár, M. (2019). Assessment and Development of Bone Preparation for Radiocarbon Dating at HEKAL. Radiocarbon, 61(5), 1551-1561.
Thamó-Bozsó, Edit & Nagy, Attila. (2011). OSL dating on the quartz of late Quaternary sediments. Földtani Közlöny 141. 41-56.
Bluszcz A. (2004) OSL Dating in Archaeology. In: Marian Scott E., Alekseev A.Y., Zaitseva G. (eds) Impact of the Environment on Human Migration in Eurasia. NATO Science Series: IV: Earth and Environmental Sciences, vol 42. Springer, Dordrecht. https://doi.org/10.1007/1-4020-2656-0_12.
Richter, D. And Krbetschek, M. (2006), A New Thermoluminescence Dating Technique For Heated Flint. Archaeometry, 48: 695-705.
Rainer Grün, Electron spin resonance (ESR) dating, Quaternary International 1,1989, 65-109.

**Suggested reading:**

Rink, J.W et al ed.. Encyclopedia of scientific dating methods. Springer, 2015.
Reimer, P.J. et al., 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. Radiocarbon 55 (4), 1869–1887.

| Non-metallic industrial minerals | **Code:** MFFAT826D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Ferenc Kristály, PhD, senior research fellow | |
| **Weekly lecture+seminar hours:** 0+2 | **Evaluation method:** oral/written exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:** The subject offers insight into the type, genesis and deposits, extraction methods, industrial applications and economical importance of various industrial minerals – other than ores. The large variety of non-metallic resources are grouped in two main categories: minerals-mineral groups and rocks, according to the method of application. Previous knowledge on systematic mineralogy and petrology (igneous, metamorphic, and sedimentary) are required for the interpretation of industrial mineral deposits generation. The useful analytical methods, exploration strategies and related geochemical properties needed to identify mineral deposits are based on such previously acquired knowledge. Related physical and chemical properties are discussed together with the exploitation, beneficiation and application methods, material properties allowing the targeted applications. The natural, synthetic and secondary raw materials are all discussed in the context of industrial applications. | |
| **Course content and structure:**<br>Review of basic notions in systematic mineralogy, geochemistry and petrology, introductory notes on industrial applications. Native elements and sulphides. Halogenides, oxides and hydroxides. Carbonates, nitrates, borates. Sulphates and phosphates. Silicates, general. Clay minerals, phyllosilicates. Feldspars, zeolites. Perlite, pumicite, diatomite. Basalt, ultrabasites. Building and ornamental stones. Gravel and sand for construction and building industry. Secondary raw materials, recycling. Economical viewpoints in the change of industrial minerals. | |
| **Evaluation method:** written/oral exam; individual task – scientific presentation of own research results related to industrial minerals.<br>***Course assignments:*** performing measurements and evaluations on personal samples or interpretation of available and related results of the PhD research.<br>***Course point distribution, examination format***: oral survey of knowledge on the course core data. Grading scale: 100–85% excellent; 84–70% good; 69–60% satisfactory; 59–50% pass; 49–0%: fail. | |
| **Required reading:**<br>EVANS A.M. (1993) Ore Geology and Industrial Minerals: an Introduction. Blackwell Publishing, 379 p ISBN 978-0-632-02953-2.<br>Ciulo P. A. (1996) Industrial minerals and their uses. Noyes Publication, New Jersey, 607 p.<br>https://minerals.usgs.gov/minerals/pubs/myb.html.<br>https://www.ima-europe.eu/. | |

| Pleistocene and Early Holocene human ecology | **Code**: BTKPHDLMFE001 |
|---|---|
| | **Responsible department/institute:** Dpt. of Prehistory and Archaeology |
| **Name and position of course coordinator:** Dr. habil. György Lengyel, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The course deals with the subsistence strategies of hunter-gatherer human communities. It examines how the fluctuating environmental changes alter the elements of subsistence. The method of human utilization of the environment for food purposes can be described by two strategies. The one adapts to the environmental change. The other does not tolerate environmental changes and creates a mobile life to subsist in a consistent environment. There are several ways to operate both strategies, which are influenced by cultural background, a problem-solving technique that is inherited through generations, which ultimately leave diverse archaeological record.

**Course content and structure:**
Pleistocene environment. Holocene environment. Subsistence strategies of hunter-gatherers. The theory of subsistence strategies of Pleistocene hunter-gatherers. The role the ethno-archaeology in the models of hunter-gatherers subsistence strategies. Subsistence strategies in the Palaeolithic Europe. Subsistence strategies in Early Holocene Europe. Effects of environmental changes on archaeological sites and assemblages. Processual archaeology. Post-processual archaeology. Subsistence strategies from the viewpoint of lithics. The role of stable isotopes in paleoecology.

**Evaluation method:**
***Course assignments:***
Attending the classes + assignment.
***Course point distribution, examination format*:**
Written exam. Grading scale: 0-50% E, 51-70% D, 71-80% C, 81-90% B, 91-100% A.

**Required reading:**
Binford, L.R (1978). Nunamiut ethnoarchaeology. New York: Academic Press.
Borzenkova I. et al. (2015) Climate Change During the Holocene (Past 12,000 Years). In: The BACC II Author Team (eds) Second Assessment of Climate Change for the Baltic Sea Basin. Regional Climate Studies. Springer, Cham. https://doi.org/10.1007/978-3-319-16006-1_2
Britton, K., Grimes, V., Dau, J., Richards, M.P. (2009). Reconstructing faunal migrations using intra-tooth sampling and strontium and oxygen isotope analyses: a case study of modern caribou (Rangifer tarandus granti). Journal of Archaeological Science 36/5, 1163–1172.
Butzer, K. W. (1982). Archaeology as human ecology: Method and theory for a contextual approach. New York and Cambridge: Cambridge University Press.
Mock, C., Elias, S. (ed.) (2013). *Encyclopedia of Quaternary Science*, 2nd Edition, Amsterdam, Elsevier, vol. 1.
Kelly, L. R. (2013). The Lifeways of Hunter–Gatherers. The Foraging Spectrum. Cambridge University Press, Cambridge.
Gornitz V. (eds) (2009). Encyclopedia of Paleoclimatology and Ancient Environments. Encyclopedia of Earth Sciences Series. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-4411-3_198
Henry Patton, Alun Hubbard, Karin Andreassen, Amandine Auriac, Pippa L. Whitehouse, Arjen P. Stroeven, Calvin Shackleton, Monica Winsborrow, Jakob Heyman, Adrian M. Hall,

Deglaciation of the Eurasian ice sheet complex, Quaternary Science Reviews, Volume 169, 2017, Pages 148-172,
Richards, M., Britton, K. (Eds.), Archaeological Science: An Introduction. Cambridge University Press, Cambridge.

**Suggested reading:**

Boivin, N. L., Zeder, M. A., Fuller, D. Q., Crowther, A., Larson, G., Erlandson, J. M., Denham, T., & Petraglia, M. D. (2016). Ecological consequences of human niche construction: Examining long-term anthropogenic shaping of global species distributions. Proceedings of the National Academy of Sciences of the United States of America, 113(23), 6388–6396.
Barton, C.M., Riel-Salvatore, J., Anderies, J.M. et al. Modeling Human Ecodynamics and Biocultural Interactions in the Late Pleistocene of Western Eurasia. Hum Ecol 39, 705–725 (2011).
Vicki Cummings, Peter Jordan, Marek Zvelebil. 2014. The Oxford Handbook of the Archaeology and Anthropology of Hunter-Gatherers

| Sedimentology | **Code**: MFFTT808D |
|---|---|
| | **Responsible department/institute:** Institute of Mineralogy and Geology |
| **Name and position of course coordinator:** Dr. habil. Felicitász Velledits, DSc, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>The course deals with sediments, sedimentary rocks and their genetic origin and forming processes. | |
| **Course content and structure:**<br>Sedimentology is concerned with natural sediments and the sedimentary rocks that are formed from them, their genetic conditions and their processes. Its importance is determined by the global distribution and mass of sedimentary rocks, the energy carriers (coal, oil, natural gas) and many industrial raw materials (evaporites, sedimentary and stratiform iron and manganese ores, bauxites, phosphorites, uranium and rare metal deposits, construction materials) found in sedimentary strata, and the presence of water. The differences in the conditions under which siliciclastic and carbonate sediments are formed are specifically addressed. Sedimentation in continental, coastal, self and oceanic environments is discussed. The course examines in detail sedimentation, diagenesis, the different diagenetic environments and cement types for carbonates, and the applicability of sequence stratigraphy to siliciclastic and carbonate rocks. | |
| **Evaluation method:**<br>Exam.<br>***Obtaining a signature:***<br>To obtain a signature, attendance of 80% of the classes is required.<br>**Prerequisite for passing the examination:**<br>Attendance at 80% of the classes.<br>**Method and assessment criteria for obtaining the practical mark/colloquium:**<br>Completion of the tasks assigned during the course, active participation in the lessons. Grading scale: 100-80%: 5; 80-70%: 4; 70-60%: 3; 60-51%: 2; 50>1. | |
| **Required reading**:<br>Nichols G. 2009: Sedimentology and Stratigraphy. 1-432. Wiley-Blackwell.<br>Tucker M., Wright P. 1991: Carbonate Sedimentology. Blackwell Science.<br>Wilson J.L. 1978: Carbonate Facies in geologic History. Springer.<br>Reading 1996: Sedimentary Environments: Processes, Facies and Stratigraphy, Wiley, London, p.704.<br>Asquith, Gibson 1982: Basic well log analysis for geologists, AAPG, Methods in exploration series.<br>Serra, 1985: Sedimentary environments from wireline logs. Schlumberger p. 211.<br>Einsele, 2000: Sedimentary Basins: Evolution, Facies, and Sediment Budget, p. 792.<br>**Suggested reading:**<br>Leeder, 2011: Sedimentology and Sedimentary Basins: From Turbulence to Tectonics. John Wiley & Sons, p. 784. | |

| Contaminated site remediation | **Code**: MFKHT819D |
|---|---|
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Dr. Tamás Madarász, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 1+1 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The goal of the course is to provide thorough insight into the theory and engineering practice of contaminated site investigation and remediation.

**Course content and structure:**
General questions of contaminated site remediation. Methods and tools of contaminated site investigation, sampling strategies and tools, analytical lab background for site investigation. Latest achievements in stie investigation. Interpretation and visualisation tools of site investigation data, identification of contaminants, pathways and receptors of concern. Conceptual site model formulation. Behaviour of contaminants in soil ang groundwater, soil-contaminant interaction. Methods of contaminant removal, classification and introduction of clean up technologies (remediation without soil excavation, remediation based on soil excavation, hydraulic barriers, isolation from environment). Selection of appropriate remediation techniques, risk assessment.

**Evaluation method:**
***Course assignments:***
Individual research agenda based face-to-face training, assignments, and research exercise.
***Course point distribution, examination format*:**
Oral exam or submission of assignment. Grading scale: > 80 %: excellent, 70 – 80 %: good, 60 – 70 %: average, 50 – 60 %: pass, < 50 %: fail.

**Required reading:**
Meuser H. (2013): Soil Remediation and Rehabilitation: Treatment of Contaminated and Disturbed Land (Environmental Pollution (23)) 2013th Edition.
Chunlong Zhang (2019): Soil and Groundwater Remediation: Fundamentals, Practices, and Sustainability; Whiley ISBN: 978-1-119-39315-3.
Soil and Water Contamination, 2nd Edition, Marcel van der Perk, November 15, 2013 by CRC Press, ISBN 9780415893435.
Remediation Technologies - Tools and resources to assist in contaminated site remediation U.S. EPA Office of Superfund Remediation and Technology Innovation; Online information hub, last updated 2015, http://www.epa.gov/superfund/remedytech/remed.htm#tech.
RemSoc: Practitioners Framework for Remediation; https://www.remsoc.org/framework-for-remediation/, 2019.
http://Geoengineer.org/education – remediation technologies overview.
Selected papers harmonized with individual reasearch topics.

**Suggested reading:**
USEPA, (2001): Risk Assessment Guidance for Superfund: Volume III. Part A, Process for conducting probabilistic risk assessment, Office of Emergency and Remedial Response, Washington DC.
CLARINET and NICOLE (2001): The Sustainable Management and Remediation of Contaminated Land, Special Edition of Land Contamination and Reclamation, Editors: Bardos, P. and Lewis, A., Richmond, UK.

| Soil mechanics | **Code**: MFKHT820D |
|---|---|
| | **Responsible department/institute:** Institute of Water resources and Environmental Management |
| **Name and position of course coordinator:** Dr. Viktória Mikita, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 1+1 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The students will be familiar with the basic concepts of soil mechanics. After a short review the students will study the main topics of applied soil mechanics, in the interest of being able to manage interactions between buildings/objects and subsoil, to solve, handle or expertise occurring problems (construction, building, damages).

**Course content and structure:**
Bearing capacity of soils, foundations. Settlement and consolidation of foundations, solution to problems of stability and settlement. Foundations and embankments over soft soil and peat. Determination of earth pressure, active and passive earth pressure. Stability analysis of natural and artificial slopes, factors in slope design, reconstruction of landslides. Retaining walls, gravity walls, reinforced earth walls, embedded walls. Shallow and deep foundations, the geotechnical aspects of excavations and hydraulic engineering. Geotechnical problems of open pit mining. Geosynthetics. Geotechnical objects of environmental protection. Practical work: self-made solutions of simple case-study problems.

**Evaluation method:**
***Course assignments:***
The student must prepare a report on the processing of a particular problem.
***Course point distribution, examination format*:**
50% the grade of the report and 50% the grade of the exam. The exam is both written and oral. Grading scale: 100–85% excellent; 84–70% good; 69–60% satisfactory; 59–50% pass; 49–0%: fail.

**Required reading:**
Atkinson, J.: The Mechanics of Soils and Foundations. Taylor and Francis, London, 2007.
Jonathan Knappett, R.F. Craig: Craig's Soil Mechanics, Eighth Edition, 2012.
**Suggested reading:**
Braja M. D.: Advanced soil mechanics, Spon Press, 2008.
Smith G. N., Smith I. Smith G. N.: Elements of soil mechanics, Wiley-Blackwell, 1998.
Smoltczyk, U. ed.: Geotechnical Enineering Handbook., Ernst & Sohn, Berlin, 2003.
Mitchell, J. K., Soga, K.: Fundamentals of Soil Behaviour, John Wiley, 2005.

| Remote sensing | **Code**: MFFTT821D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Dr. Norbert Németh, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Introduction of the basics, physical basis, applications and uses of the remote sensing. Students gain insight to the interpretation of certain data recordings.

**Course content and structure:**
General concepts of the remote sensing. Electromagnetic waves and realms of perception, data collecting systems. Instruments of aerial and space remote sensing (photography, CCD, satellites, radar). Remote sensing methods by photography, spectrometry, radiometry and acoustics. Remote sensing observation of global changes of the Earth in the atmosphere, biosphere, hydrosphere and on the continents. Geological and other interpretation of aerial geophysical recordings, aerial photos, radar and acoustic images, use of multispectral and hyperspectral images. Spectral characteristics of the rocks, valley net analysis and recognizable characteristics of classical geological features (volcanic cones, intrusive bodies, bedded strata and tectonic forms). Spectral characteristics of soil types and vegetation. Recognition of soil and plant damages. Spectral characteristics of hydrological systems (rivers, lakes, seas). Application of the remote sensing in environment protection, recognition and monitoring of pollutions. Prediction of geological hazards and catastrophes (volcanic eruption, earthquake).

**Evaluation method:**
Oral exam.
***Course assignments:***
-
***Course point distribution, examination format*:**
Oral exam. Grading scale: 85 –100% 5 (excellent), 75 – 84% 4 (good), 63 – 74% 3 (satisfactory), 50 – 62% 2 (pass), 0 – 49% 1 (fail).

**Required reading:**
Remote sensing tutorials URL: www.nrcan.gc.ca/maps-tools-publications/satellite-imagery-air-photos/tutorial-fundamentals-remote-sensing/9309
Adams, John: Remote sensing of landscapes with spectral images: a physical modeling approach. Cambridge University Press, Cambridge, 2006.
Lillesand T. M. – Kiefer R. W: Remote Sensing and Image Interpretation. Wiley, 1987, 721 p.
McCoy, Roger: Field methods in remote sensing. Guilford Press, New York, 2005.
Schott, John: Remote sensing: the image chain approach. Oxford University Press, New York, 2007.

| Historical geology | **Code**: MFFTT805D |
|---|---|
| | **Responsible department/institute:** Institute of Exploration Geosciences |
| **Name and position of course coordinator:** Prof. Dr. Norbert Zajzon, PhD, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:** The aim of the subject is to give knowledge (1) on the role of time in the geological processes, (2) on the different methods of age-determination, (3) on the structural evolution of the Earth and (4) on the history of life in the Earth with special emphasis on the utility of all these in prospecting raw materials) and how to reconstruct paleoenvironments in geology as basic information for raw material exploration. | |
| **Course content and structure:** Thematics of lectures: Principles of stratigraphy. Basic principles of stratigraphy, litho-, bio- and chronostratigraphy. Different methods of stratigraphical correlation and their significance in raw material prospecting. Age-determining methods: biostratigraphy, radiometry, magnetostratigraphy, chemostratigraphy, event stratigraphy, sequence stratigraphy. Reconstruction of different palaeoenvironments and their application in raw material prospecting. Different magmatic, metamorphic and sedimentary facies types. The geological time scale, the structural, climatological and biological evolution of the Earth during the Precambrian, the Palaeozoic, the Mesozoic and the Cenozoic. The evolution of Homoidea. Thematics of practices: Two field surveys (one day each) in the Aggtelek-Rudabánya Mts. | |
| **Evaluation method:**<br>***Course assignments:***<br>Criterion for signature: completion of inter-semester test with at least satisfactory result (see below). It can be repeated once. Practical requirements: obligatory participation in the field-trips, ppt-presentation for one of them.<br>***Course point distribution, examination format*:**<br>Oral exam. Grading limits: >80%: excellent; 70–80%: good; 60–70 %: average; 50–60%: satisfactory; <50%: unsatisfactory. | |
| **Required reading:**<br>Levin, H.L. (2006) – The Earth Through Time, 8th Ed., 616 p., Wiley.<br>Barnes, C.W. (1988): Earth, Time and Life. John Wiley and Sons, New York.<br>Brookfield, M. (2006): Principles of Stratigraphy. Blackwell Publishing, New York.<br>**Suggested reading:**<br>Boggs S. Jr. (2006): Principles of sedimentology and stratigraphy. 4th Edition. 662 p., Pearson Prentice Hall, ISBN: 0131547283.<br>Haas J. (ed., 2013): Geology of Hungary. 244 p., Springer, ISBN: 978-3-642-21909-2. | |

| Groundwater exploration, groundwater resources management | **Code**: MFKHT824D |
|---|---|
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Dr. Andrea Tóth, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 1+1 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The overall knowledge about the different type of groundwater resources, its properties, recharge, and discharge conditions are essential for the sustainable management. In addition, the theoretical and practical studies of groundwater exploration in terms of quantity, quality and resources management is also necessary.

**Course content and structure:**
Water budget, hydrologic cycle, exchange time. Types of groundwater resources. Basics of sustainable GW management. Groundwater replenishment, recharge and discharge area. Theoretical and practical basics of groundwater protection. Legal and administrative aspects of GW protection, and exploration. Methodology and principles of groundwater exploration. Geological, geotechnical, geophysical, remote sensing and direct (drilling, well installation) methods of GW exploration. Interpretation of the exploration results.

**Evaluation method:**
***Course assignments:***
Attendance in the classes, acceptable computation, and documentation of the exercises is required.
***Course point distribution, examination format*:**
Written and oral exam is needed. The written exam contains overall questions of the subject. The required level is 60 % to continue with the oral part of the examination. The oral exam assesses the professional knowledge and engineering thinking grouped around a topic. The evaluation is based on the results of both part of the exam. Grading scale: 0-50 % fail; 50-60% pass; 60-75% satisfactory; 75-90% good; 90-100% excellent.

**Required reading:**
Fetter C.W. (2014): Applied Hydrogeology, Pearson Education Limited, ISBN-13: 978-0130882394.
Moore, J.E. (2017): Field hydrogeology, CRC Press.
S. Mandel (1981): Groundwater Resources, Investigation and Development, Academic press.
**Suggested reading:**
Nonner (2010): Introduction to Hydrogeology, CRC Press.
Boiten (2008): Hydrometry, CRC Press.
Keys W. S. (1996): A practical guide to borehole geophysics in environmental investigations, CRC Press.
Nielsen D.M. (2005): Practical handbook of environmental site characterization and groundwater monitoring, CRC Press.

| Water quality protection | **Code**: MFKHT809D |
|---|---|
| | **Responsible department/institute:** Institute of Water Resources and Environmental Management |
| **Name and position of course coordinator:** Prof. Dr. Péter Szűcs, DSc, member of HAS, full professor | |
| **Weekly lecture+seminar hours:** 2 l + 0 s | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The role of water quality protection is getting more and more important due to the dramatic increase in the world population and the more powerful pollution of water resources. Water quality modeling will be in the future one of the most important tool to carry out effective water quality protection plans. Quality issues of groundwater resources should be handled with quality aspects. The growing water needs and the worsening water conditions require remediation plans to improve the quality of groundwater resources. Transport modeling can be the useful tool to describe the spatial and temporal evolution of the groundwater quality. The main subject topics include: The tasks of water quality protection. The effect of the impurities in the water biosphere. Surface water and groundwater status of the water cycle system. The mechanisms of different contaminants in surface and subsurface waters. The spread of pollutants in the subsurface medium. Water quality modeling. Determination of waste water loadability.

**Course content and structure:**
Global challenges connected to groundwater resources. Transport processes in groundwater. The actual tasks of water quality protection. Water quality monitoring. Drinking water, mineral and medicinal water, and thermal water production. Sustainable utilization.

**Evaluation method:**
Oral examination.
***Course assignments:***
Participation at the consultations.
***Course point distribution, examination format*:**
Oral examination. Evaluation limits: > 80 %: excellent, 70 – 80 %: good, 60 – 70 %: satisfactory, 50 – 60 %: pass, < 50 %: fail.

**Required reading:**
Szűcs P; Sallai F; Zákányi B; Madarász T (szerkesztők) Szerzők: Jolánkai G; Kovács G; Madarász T; Mádlné Szőnyi J; Mándoki Mónia; Muránszkiné Mojoróczki Mária; Sallai F; Szűcs P; Takács J; Virág M; Zákányi B: Vízkészletvédelem. A vízminőség-védelem aktuális kérdései. Bíbor Kiadó, 2009., ISBN 978-963-9988-00-2, pp. 1-418.
Eileen Poetere et al. 2020: Groundwater in our water cycle. The Groundwater project. ISBN: 978-1-7770541-1-3.
Liu David, Lipták Béla: Groudnwater and Surface Water Pollution. Lewis Publishers, 2000, ISBN 1-56670-511-8, pp. 1-150.
**Suggested reading:**
Merkel Broder, Planer-Friedrich Britta: Groundwater Geochemistry. Springer, 2005, ISBN 3-540-24195-7, pp. 1-200.

# Physical and human geography

## Content

# Course program

| | |
|---|---|
| Subdivision and classification of the landscapes and geomorphologic regions of Carpathians and Carpathian Basin | **Code**: MFKFT801E |
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Attila Hevesi, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to acquaint and critically evaluate the different subdivision and classification of the landscapes of the Carpathians and the Carpathian Basin.

**Course content and structure:**
Within the framework of the course, we review the history of landscape subdivision and classification of the Carpathians and the Carpathian Basin, analyze the changes in the demarcation and naming of landscapes, and explain their reasons. We examine in detail the landscape subdivisions still in use today and evaluate them based on our knowledge of physical and social geography.

**Evaluation method:**
Exam.
***Course assignments:***
Attending on lectures and consultations.
***Course point distribution, examination format*:**
Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% failed.

**Required reading:**
Kocsis K, Schweitzer F (eds.) (2009) Hungary in maps. Geographical Research Institute, Hungarian Academy of Sciences, Budapest, 211 p.
Lóczy D. (2015): Geomorphological Regions. In: Lóczy D. (ed.) Landscapes and Landforms of Hungary. Springer, pp. 39–43.
**Suggested reading:**
Pécsi M (1970) Geomorphological regions of Hungary. Akadémiai Kiadó, Budapest, 45 p.
New, enlarged edition: (1996) Geographical Research Institute, Hungarian Academy of Sciences, Budapest, 121 p.
Pécsi M (1977) Geomorphological map of the Carpathian-Balkan Mountain system, 1:1,000,000. Studia Geomorphologica Carpatho-Balcanica 11:3–11 + colour map.
Pécsi M, Somogyi S (1969) Subdivision and classification of the physiographic landscapes and geomorphological regions of Hungary. In: Sárfalvi B (ed.) Research problems in Hungarian applied geography. Akadémiai Kiadó, Budapest, pp. 7–27.

| Forms of social mobility and migration and their relationship with tourism geography | **Code**: MFKST811E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Beáta Siska-Szilasi, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
New forms of mobility can be found at many scales from the local and national to the global. The aim of the course is to interpret the theories and types of mobility and apply them to the spatial analysis of social forms of movement. The consequences of the new forms of mobility, directly or indirectly, touch most people in the communities, on the one hand, the consequences include gains and losses in labour supply/demand, innovation and contact networks whilst, on the other hand they include changes in house prices, services, and the recourse use of the geographical areas.

**Course content and structure:**
Theories of the formation and survival of migration processes. Major social and economic geographical approaches. Types of migration, changing reasons behind social mobility. Impact of social structure on mobility (socio-economic geographical features). Mobility / emigration as a life strategy. Selective mobility with sociodemographic and economic explanation. Living environment factors and mobility for work. Tourism, migration, circulation and mobility. Tourism and mobility in the changing global world. Changing income streams, increasingly mobile societies. Migration and tourism-led changes. Production-led Mobility: Tourism and Labour Migration. Consumption-led Mobility. Resource management and innovation: mobility and employment of youth people. Presentation of a project task.

**Evaluation method:**
Project task and written exam.
***Course assignments:***
Contact with the subject lecturer.
***Course point distribution, examination format*:**
Assessable completion of the project task and successful writing of the exam test. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% failed.

**Required reading:**
Williams, M.A.—Hall, M.C. 2002: Tourism, migration, circulation and mobility. in: Williams, M.A.—Hall, M.C. (eds.) Tourism and Migration. Netherlands, pp. 1-52.
Scuttari, A. - Della Lucia, M. – Martini, U. 2012: Integrated Planning of Sustainable Tourism and Mobility: An Exploratory Study. in: Tiller, T.R. (ed.): Mobilities and Sustainable Tourism. Conference Proceedings of BEST Education Network, Breoux les Bains, pp. 161-181.
Beáta, Szilasi Siska; Levente, Halász (2018): Reasons and Characteristics of the Dynamizing Emigration Intention of the Hungarian Youth. EASTERN EUROPEAN BUSINESS AND ECONOMICS JOURNAL 4: 1 pp. 79-96, 96 p.
**Suggested reading:**
Zai Liang 2006: The sociology of migration. In: –LOCALITY AND SOCIAL LIFE, pp. 487-495,
http://studysites.sagepub.com/leonguerrero4e/study/materials/reference/05434_socmig.pdf.
Department for International Development: Moving out of poverty –making migration work better for poor people. DFID UK, 2007. 53 p.,
http://www.migrationdrc.org/publications/other_publications/Moving_Out_of_Poverty.pdf.

| Digital soil mapping | **Code**: MFKFT813E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Endre Dobos, PhD, full professor | |
| **Weekly lecture+seminar hours:** 0+2? | **Evaluation method:** practical mark |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To summarize the digital soil mapping tools and make the student capable of using DSM tools and create soil property maps.

**Course content and structure:**
The traditional soil mapping procedure is based on the analysis of the relationship between the soil properties and the soil forming factors. The mapping procedure consists of the model development describing these relationships, and the spatial delineation of the homogeneous soil units. The fast technological development of the past few decades have made available the use of soil related digital data sources, like digital terrain models and satellite data. The relationships between the soil properties and these digital data sources can be described with mathematical, statistical-geostatistical tools, therefore automated soil mapping procedures have become available. The course describes the traditional soil mapping approaches and procedures and their digital soil mapping analogies. It summarizes the potential digital datasets and data sources and the mapping tools and algorithms most commonly used in digital soil mapping and the potential fields of applications.

**Evaluation method:**
***Course assignments:***
Submitted paper on a digital soil mapping project.
***Course point distribution, examination format*:**
The use of adequate variables and tools for mapping and the correct –physical geographical - interpretation of the results. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Dobos, E., Carre F., Hengl T, Reuter H and Tóth G. 2006. Digital soil mapping – as a support for production of functional maps. EUR 22123 ENOffice for the Official Publications of the European Commission. Luxemburg.
Hengl T, Reuter H. (eds) 2009. Geomorphometry. Concepts, Software, Applications. Developments in Soil Science. Vol. 33. Elsevier. Amsterdam
Lagacherie P., McBratney A., Voltz M. 2007. Digital soil mapping. An introductory perspective. Developments in Soil Science. Vol. 31. Elsevier. Amsterdam.
USDA-NRCS.1998: Keys to Soils Taxonomy. Eighth edition. Washington, USA.
IUSS Working group WRB., 2014. World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps. World soil resource report 106. FAO. Rome.
**Suggested reading:**
Driessen P.M. and R. Dudal, 1991. The major soils of the World. Lecture notes on their geography, formation, properties and use. Agricultural University of Wageningen. The Netherlands.

| Ethnic geography | **Code**: MFKST802E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Károly Kocsis, DSc, member of HAS, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Building on to the lower level regional and theoretical ethnic geography courses, this course is an advanced coverage of the history and present of the ethnic and linguistic mapping, its methodology and the applied GIS toolset. By using a problem-oriented approach the course will give a deep insight of the most actual and significant ethnic questions of Europe and the Carpathian Basin, like regional autonomy, international migration, territorial integrity and its changing ethnic structure, national and ethnic minorities (like Gypsies).

**Course content and structure:**
Ethnic and linguistic mapping, ethnic GIS, its past and present. The ethnic geographical background of the territorial autonomies (theory, past and present). The ethnic geographical background of the territorial autonomies (Europe and the Carpathian Basin). The changing ethnic structure of Europe and the international migration. The ethnic geography of Bosnia and Herzegovina. The ethnic geographical background of the Albanian question, especially the Kosovo situation. The ethnic geography of Ukraine, especially the Russian ethnic group. The ethnic geography of Transylvania. The ethnic geography of Slovakia. The ethnic geography of Vojvodina. The ethnic geography of the Hungarian minorities in the Carpathian Basin. The ethnic geography of the Gypsies (Romany population) in the Carpathian Basin. The ethnic geography of North Hungary (with high emphasis on Borsod-Abaúj-Zemplén county.

**Evaluation method:**
***Course assignments:***
Attending on more than 60% of the lectures.
***Course point distribution, examination format*:**
Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% failed.

**Required reading:**
Kocsis K. 2001 Ethnicity, In: Eastern Europe and the Former Soviet Union, Environment and Society, ed. by D. TURNOCK, Arnold, London - Oxford University Press, New York, 2001, pp. 88-103.
Kocsis K. – Tátrai P. 2015 Changing Ethnic Patterns of the Carpatho-Pannonian Area, MTA CSFK FTI, Budapest, http://www.mtafki.hu/konyvtar/karpat-pannon2015/.
Price, P.L. et al. 2005: The Human Mosaic: A Thematic Introduction to Cultural Geography, Freeman and Company, W.H. 496p.
Kocsis K. (ed.) 2021. National Atlas of Hungary. RCEAS Geographical Institute. Budapest. www.nationalatlas.hu.
Kocsis K. – Kocsisné Hodosi E. 1998 Ethnic Geography of the Hungarian Minorities in the Carpathian Basin, Geographical Research Institute, Hungarian Academy of Sciences, Budapest, 241p. http://www.mtafki.hu/konyvtar/kiadv/Ethnic_geography.pdf.
Kocsis K. 2013 Historical predecessors and current geographical possibilities of ethnic based territorial autonomies in the Carpathian Basin. Hungarian Geographical Bulletin 62: (1), 3-46. http://www.mtafki.hu/konyvtar/kiadv/HunGeoBull2013/HunGeoBull_2013_1_3-46.pdf.
**Suggested reading:**

Kocsis K. 1997 – 2009. Series of ethnic maps of the Carpatho-Pannonian Area (Transylvania, Slovakia, Transcarpathia, Vojvodina, Croatia, Prekmurje, Burgenland, Hungary), MTA Geographical Research Institute, Budapest.
http://www.mtafki.hu/konyvtar/kiadv/etnika/indexMAPe.html.
Fernandez – Armesto, F. 1994 „Times" Guide to the Peoples of Europe, Times Books, 400p.

| Geomorphology | **Code**: MFKFT821E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Attila Hevesi, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |
| **Course objectives:**<br>The course is concerned with the classification, description, origin and evolution of landforms. | |
| **Course content and structure:**<br>The course discusses in detail the processes that shape the earth's surface and the topographic features created by them: igneous, tectonic, weathering, hillslope, aeolian, fluvial, marine and lacustrine, glacial, periglacial, biological and anthropogenic processes and landforms. It also reviews the fundamentals of climatic geomorphology. | |
| **Evaluation method:**<br>Exam.<br>***Course assignments:***<br>Attending on lectures and consultations.<br>***Course point distribution, examination format*:**<br>Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail. | |
| **Required reading:**<br>Goudie, A.S. (ed.) 2004: Encyclopaedia of Geomorphology Volume 1 and Volume 2. Routledge. 1156 p.<br>Huggett, R.J. 2011: Fundamentals of Geomorphology (third edition). Routledge. 516 p.<br>**Suggested reading:**<br>Bierman, P.R., Montgomery, D.R. 2014: Key concepts in geomorphology. New York, W.H. Freeman. 494; 21 p.<br>List of Landforms on Earth. Types of Landforms and Definitions. http://worldlandforms.com /landforms/list-of-all-landforms/.<br>Migon, P. (ed.) 2010: Geomorphological Landscapes of the World. Springer. 375 p. https://www.academia.edu/38481707/Geomorphological_Landscapes_of_the_World.<br>Strahler, A.H. 2011: Introducing Physical Geography (5th ed.). John Wiley & Sons. 632 p. | |

| History of geography | **Code**: MFKFT805E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Attila Hevesi, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to acquaint the history of geography and its significant scientists and thinkers and to evaluate the defining geographical science ideas and results in the aspect of the scientific and general knowledge of the age and today.

**Course content and structure:**
The course reviews the history of international and Hungarian geographical science, the development of geographical thinking from antiquity to the present day, the birth and spread of dominant geographical-geological approaches in the scientific world and everyday life. We also focus on less known „geographers" from Carpathian region, whose work is worthy of recognition.

**Evaluation method:**
Oral exam.
***Course assignments:***
Attending on lectures and consultations.
***Course point distribution, examination format*:**
Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Driver, F. (1992) Geography's empire: histories of geographical knowledge, Environment and Planning D: Society and Space, Vol. 10, pp. 23–40. http://www.envplan.com/fulltext_temp/0/d100023.pdf.
Holt-Jensen, A. (1999) Geography. History and Concepts – SAGE Publications, London – Thousand Oaks – New Delhi. 248 p.
Stoddart, D. R. (1986) On Geography and its History. Oxford: Blackwell. 335 p.
**Suggested reading:**
Harley, J. B. and Woodward, D. (eds.) (1987) The History of Cartography, Volume 1, Cartography in Prehistoric, Ancient, and Medieval Europe and the Mediterranean. Chicago, University of Chicago Press. 622 p. http://www.press.uchicago.edu/books/HOC/HOC_V1/Volume1.html.
Harley, J. B. and Woodward, D. (eds.) (1992) The History of Cartography, Volume 2, Book 1. Cartography in the Traditional Islamic and South Asian Societies. Chicago, University of Chicago Press. 604 p. http://www.press.uchicago.edu/books/HOC/HOC_V2_B1/Volume2_Book1.html.
Harley, J. B. and Woodward, D. (eds.) (1994) The History of Cartography, Volume 2, Book 2. Cartography in the Traditional East and Southeast Asian Societies. Chicago, University of Chicago Press. 998 p. http://www.press.uchicago.edu/books/HOC/HOC_V2_B2/Volume2_Book2.html.
Martin, G. J. (2005) All Possible Worlds: A History of Geographical Ideas. Fourth Edition. Oxford University Press. 624 p.
Woodward, D. and Lewis, G.M. (eds.) (1992) The History of Cartography, Volume 2, Book 3. Cartography in the Traditional African, American, Artic, Australian, and Pacific Societies. Chicago, University of Chicago Press. 500 p. http://www.press.uchicago.edu/books/HOC/HOC_V2_B3/Volume2_Book3.html.

Woodward, D. (ed.) (2007): The History of Cartography, Volume 3. Cartography in the European Renaissance, Part 1. Chicago, University of Chicago Press. 2272 p. http://www.press.uchicago.edu/books/HOC/HOC_V3_Pt1/Volume3_Part1.html, http://www.press.uchicago.edu/books/HOC/HOC_V3_Pt2/Volume3_Part2.html.

| GIS applications in natural and social geographic researches and visualization of results | **Code**: MFKFT806E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. János Vágó, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
In physical- and social geographic research, the GIS (Geographic Information System) based methods are useful tools for the visualization of the results. The application of these methods basically means the creation and interpretation of thematic maps. The main advantage of the GIS-based method is that visualizing the geographic data, those conclusions can be also drawn, which could not been available by the „conventional" analyzing methods.

**Course content and structure:**
The course covers the modern, state of the art GIS-based analyzing methods: the possibilities and tools of ESRI ArcMAP and GS MapWiever for spatial data analysis, visualization and interpretation: Quantitative and qualitative thematic mapping methods of spatial data representing surface units (polygon). Quantitative and qualitative thematic mapping methods of spatial data representing discrete objects (point, polyline). Interpolation of discrete spatial data, properties of interpolation methods. Analysis, visualization and interpretation of 3D raster surfaces made by interpolation.

**Evaluation method:**
Exam.
***Course assignments:***
Elaboration of the basic, relevant literature of the topic.
***Course point distribution, examination format*:**
Thematic mapping tasks related to the research topic, applying GIS techniques. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% failed.

**Required reading:**
A.M. MacEachren, D.R.F. Taylor (2013): Visualization in Modern Cartography. Elsevier.
Slocum, Terry A. (2009): Thematic Cartography and Geovisualization. Pearson Prentice Hall.
Michael J. Wilson (2014): Learning ArcGIS 10. 2 Basics. CreateSpace Independent Publishing Platform.
David W. Allen (2011): GIS Tutorial 2: Spatial Analysis Workbook. ESRI Press.
**Suggested reading:**
Jakobi Á. Nemes-Nagy J. (2006): Digital surfaces in social geography. Studia cartologica 13, 185-192.

| Snow and avalanche science and modelling | **Code**: MFKFT814E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Anna Seres, PhD, research fellow | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is to give the students an insight into the world of snow science and basic modelling of natural processes. Beside learning about the snow processes, like formation and metamorphism, they also learn about the formation and characteristics of avalanches and their mitigation. Synthesizing the acquired knowledge, the basics of snowpack and avalanche modelling are also taught.

**Course content and structure:**
Description of snow forming in the atmosphere and its modification on the ground: The connection between different types of snow crystals and different atmospheric conditions. Properties of the snow cover: temperature gradient, wetness, layering. Metamorphism f snow crystals in the snowpack: initial changes, equitemperature metamorphism, temperature gradient metamorphism, melt-freeze metamorphism, formation of bonds between grains, formation of weak layers, metamorphism along hard layers. Avalanche characteristics, formation of avalanches: Classification of avalanches. Formation of different types of avalanches with respect to terrain, snowpack and weather. Forces in the snowpack. Modification of some important meteorological parameters (temperature, wind, precipitation, radiation, etc.) in alpine area. Avalanche modelling: Basics of model building. Spatial modelling of the changes of meteorological parameters and the processes in the snowpack with GIS. Modelling of avalanche risk based on terrain, weather, and snowpack. Active and passive protection against avalanches: snow profiles, stability tests, route selection, necessary equipment, rescue, land use plans, use of explosives, defensive structures.

**Evaluation method:**
Examination and assignment.
***Course assignments:***
Writing a short essay in an arbitrary topic, related to snow and avalanches.
***Course point distribution, examination format*:**
- oral exam (30%)
- creating a theoretical snowpack or avalanche model (30%)
- writing a short essay in an arbitrary topic, related to snow and avalanches (40%)

Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
McClung, D., Schaerer, P. 1999. The Avalanche Handbook, Seattle, Washington, The Mountaineers.
https://www.whiterisk.ch/en/.
http://www.meted.ucar.edu/afwa/avalanche/.
**Suggested reading:**
Goodison, B.E., Ferguson, H.L., McKay, G.A. 1981. Measurement and data analysis in Handbook of Snow: Principles, Processes, Management and Use, (Grey, D.M., Male, D.H. eds.), The Blackburn Press, Cadwell, New Jersey, USA, ISBN: 1-932846-06-9.

| Karst geomorphology | **Code**: MFKFT816E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Attila Hevesi, DSc, professor emeritus | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** examination |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The course provides students with a broader and deeper understanding of karst processes and landforms in order to better understand development of karst landscapes and their special interrelationships between natural and social factors.

**Course content and structure:**
The main topics of the course: the global distribution of karst; karst terminology; relationship between karst and hydrology and hydrogeology; dissolution of carbonate rocks; dissolution of anhydrite, gypsum and salt; biokarst processes; basics of karst hydrology; development of karst drainage systems; small surface karst features, large and polygenetic surface karst features, development of cave systems; cave interior deposits; karst landform development in different climatic regions; human impacts on karst; geomorphological hazards on karst; sustainable management of karst.

**Evaluation method:**
Oral exam.
***Course assignments:***
Attending on lectures and consultations.
***Course point distribution, examination format*:**
Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Ford, D. and P. Williams (2007) Karst Hydrogeology and Geomorphology. John Wiley and Sons Ltd., the West Sussex, England, 562 p.
Hevesi A. (1989) Development and evolution of karst regions in Hungary. Karszt és Barlang Különszáma pp. 3-16. + 2 tables.
Jakucs L. (1977) Morphogenetics of Karst Regions: Variants of Karst Evolution. Akadémiai Kiadó, Budapest, 284 p.
**Suggested reading:**
Encyclopedia Speleologica Practicorum. http://www.speleoencyclopedia.com/encyklopedia_start_eng.php.
Gunn, J. (ed.) (2004) Encyclopedia of cave and karst science. Routledge, 960 p.
Jakucs L., Keveiné Bárány I. and Mezősi G. (1983) A modern interpretation of karst corrosion = A karsztkorrózó korszerű értelmezése. Földrajzi Közlemények Vol. 107. (31.) No. 4., pp. 207–212, 213–217.
Veress M. (2010) Factors influencing solution in karren and on covered karst. Földrajzi Értesítő Vol. 59. No. 3. pp. 289–306.

| | |
|---|---|
| Environmental archaeology | **Code**: MFKFT824 |
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. habil Klára Pusztai-Fischl, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** colloquium |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Environmental Archaeology is an interdisciplinary science. It describes and reconstructs the relationship, interrelationship and interaction between man and his environment by combining archaeological remains and environmental history data. During the course, we will learn about and incorporate the results of environmental archaeological methods (geoarchaeology, archaeobotany, archaeozoology, landscape archaeology) relevant to the research topic and their results into the thesis.

**Course content and structure:**
The concept, fields and dating methods of environmental ecology. Applied environmental archaeological methods 1: Sampling methods for archaeological and environmental sites. Applied methods in environmental ecology 2: Archaeobotany, pollen analysis, anthracology, pedology, palaeovegetation. Applied environmental ecology methods 3: Archaeozoology, malacology, genetics. Applied environmental ecology methods 4: Landscape archaeology. GIS as a technical basis for environmental ecological analysis 1. GIS as a technical basis for environmental ecological analysis 2. Case study 1: Environmental history site: Kelemér-Mohosok. Case study 2: Environmental history site: Lake Balaton. Case study 3: Archaeological site - selected for the specific research period. Case study 4: Archaeological site - selected for the period of research. Overview of the environmental and archaeological aspects of own research 1. Overview of the environmental and archaeological aspects of own research 2. Summary, Conclusions.

**Evaluation method:**
Colloquium.
***Course assignments:***
Class attendance.
***Course point distribution, examination format*:**
The student prepares an individual research paper on a predefined topic on an environmental problem related to his/her doctoral thesis. Grading scale: graded from 1 to 5.

**Required reading:**
Sümegi, P. 2003. Régészeti geológia és a történeti ökológia alapjai. JATEPress, Szeged.
Chris Turney, Matthew Canti, Nick Branch, Peter Clark: Environmental Archaeology: Theoretical and Practical Approaches (Key Issues in Environmental Change) Routledge; 2005.
Bruno David, Julian Thomas (eds.) Handbook of Landscape Archaeology. Routledge 2010.
Benkő Elek - Zatykó Csilla (szerk.): A Kárpát-medence környezettörténete a középkorban és a kora újkorban. Budapest: Archaeolingua, 2021.
Jerem Erzsébet-Laszlovszky József-Pinke Zsolt-Drosztmér Ágnes-Renner Zsuzsa: Történeti tájak – vizes élőhelyek. Archaeolingua 2017.
**Suggested reading:**
Sümegi Pál, Gulyás Sándor (szerk.): The Geohistory of Bátorliget Marshland. An Example for the Reconstruction of Late Quaternary Environmental Changes and Past Human Impact from the Northeastern Part of the Carpathian Basin. Archaeolingua, Budapest, 2004.

Bóka, G. 2008. A Körös-vidéken zajló településtörténeti változások paleoökológiai háttere a késő bronzkor végén és a kora vaskorban. Egy hipotézis. Gyulai Katalógusok, 13, 149–171.
Sümegi, P. 1998. Az utolsó 15000 év környezeti változásai és hatásuk az emberi kultúrákra Magyarországon. In: Ilon, G. (Szerk.) A régésztechnikusok kézikönyve I.Panniculus Ser. B. No.3. Panniculus Régiségtani Egylet, Szombathely, 367 – 397.

| Administrative geography (The relation between geographical factors and administration) | **Code**: MFKST807E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Tibor Elekes, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**

The role of the geographical features in the formation of the administrative units, the significance of the historical, social. economic and political factors in the change of spatial organization structure in the Carpathian-Basin. The modification and revaluation of these factors related to historical periods, can be traced in the social, economic processes. Summing up the administrative changes of a historic area we need to investigate source-books and prepare several time- cross-section cartographic synthesis of administrative units in the Carpathian-Basin.

**Course content and structure:**

The role of the relief and hydrography in the establishment of traditional administrative units in the Carpathian-Basin. The role of social and political features in Administrative Geography in the Carpathian-Basin. The relation between the settlement system and administrative units in the Carpathian-Basin. The summary of the Administrative Geography is a cartographical synthesis. Administrative, spatial and demographic changes in Székelyland in the last hundred years.

**Evaluation method:**

***Course assignments:***

Writing a short essay in an arbitrary subject, related to administrative geography.

***Course point distribution, examination format*:**

Written exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**

Hajdú Z. 2009. Characteristics of historical evolution. In: Kocsis K, Schweitzer F (edit.): Hungary in maps. Geographical Research Institute Hungarian Academy of Sciences, Budapest, pp. 21-28.

Elekes T. 2011. Relation between settlement system and natural environment in Ciuc-basin in the last seven centuries. In: Ecoterra. Year VIII, nr. 26, University Babeş-Bolyai from Cluj-Napoca – S.C.I.C.P.E. Bistrita, pp. 55-60.

Hajdú Z. 2013. Transformation of the Hungarian views concerning the Danube region in the period around the end of World War II and the start of the rearrangement, 1944-1948. In: PROBLEMINA GEOGRAFIJATA (1-2) pp. 74-88.

Elekes T.–Szilágyi F. (2020): Administrative, spatial and demographic changes in Székelyland since the Treaty of Trianon to the present day. Regional Statistics 10 (1): 120-132.

Szilágyi F.–Elekes T. (2020): Changes in administration, spatial structure, and demography in the Partium region since the Treaty of Trianon. Regional Statistics 10 (1): 101-119.

**Suggested reading:**

Elekes T. 2007. Aspects of settlement system and environment relation in Gheorgheni region, Romania, in the last seven centuries. In: STUDIA Universitatis Babeş-Bolyai – AMBIENTUM, I/1, Cluj-Napoca, pp. 87-94.

Elekes T.-Gyenizse P. 2007. Landscape and settlement system relation in the region of Odorhei from 14th Century till nowdays. In: Environment&Progress 9/2007, Mediul-Cercetare, Protecţieşi Gestiune 2006, Cluj-Napoca, pp. 181-186.

| GIS-based analysis of renewable energy sources | **Code**: MFKFT815E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Lajos Szalontai, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 0+2 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The main objective of the subject is to present the possibilities of GIS-based (potential)measurements of renewable energy sources, to describe and develop GIS methodologies in accordance with the PhD student research area (methods, tools, databases). In addition, the basics of GIS-based energy planning (production-storage-consumption) is also part of the subject program.

**Course content and structure:**
The main topics of the course are the followings: Overview of types of renewable energy sources. Overview of energy storage options. Assessing the energy density of renewable energy sources. Creation of statistical databases related to renewable energy sources/energy storage. Defining different (national-regional-district-municipal) analysis options. GIS-based analysis of the renewable energy sources potential. Overview of energy planning methodologies. GIS-based renewable energy potential analysis / developing a GIS-based methodology in to the PhD student's research area.

**Evaluation method:**
Oral exam.
***Course assignments:***
Active, regular (1-2 weekly) contact. Continuous elaboration of specified/personalized tasks.
***Course point distribution, examination format*:**
Processing of relevant literature to the topic - elaboration tasks related to the research topic area during the semester. Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
B. Sorensen, 2017: Renewable Energy. Physics, Engineering, Environmental Impacts, Economics and Planning, Academic Press, 2017, ISBN 9780128045671.
L. Matejicek, 2017: Assessment of Energy Sources Using GIS, Springer ISBN 978-3-319-52693-5, 327 p.
Munkácsy B. 2018: Energiaföldrajz és Enegiatervezés – ELTE, Budapest, 135 p.
T. Rashed – C. Jürgens 2010: Remote Sensing of urban and suburban areas, Springer, 338 p.
A. Gemelli, A. Mancini, C. Diamantini, S. Longhi 2013: GIS to Support Cost-effective Decisions on Renewable Sources: Applications for low temperature geothermal energy, Springer, ISBN 978-1-4471-5054-1, 978-1-4471-5055-8, 84 p.
**Suggested reading:**
Büki G. 2007: Kapcsolt energiatermelés, Műegyetemi Kiadó, 436 p.
Büki G. 2004: Erőművek, Műegyetemi Kiadó, 608 p.
Hunyár M. 2001.: A megújuló és környezetbarát energetika villamos gépei és szabályozásuk, Műegyetemi Kiadó, 330 p.
Varjú V. 2014: Napelemes enegia és környezet, MTA KRTK, 137 p.

| Political geography | **Code**: MFKST803E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Károly Kocsis, DSc, member of HAS, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Building on to the lower level regional and theoretical political geography courses, this course is an advanced coverage of the history and present of the political geographical mapping, its methodology and the applied GIS toolset. By using a problem-oriented approach the course will give a deep insight of the most actual and significant political geography questions of Europe and the Carpathian Basin, like territorial autonomies, irredentism, territorial separatism, international migration, territorial integrity and the changing ethnical geographical face of Europe, national minorities: Hungarians, Albanians, Turks, Russians, etc., pending European territorial conflicts: Bosnia, Kosovo, Transnystria, Crimea, Donets Basin, Caucasian conflicts, ethnical identity and electoral habits.

**Course content and structure:**
Territorial autonomies of Europe and the Carpathian Basin, their past and present
pending European territorial conflicts: Cyprus, Bosnia, Kosovo, Transnystria, Crimea, Donets Basin, Caucasian conflicts. The territory and borders of the Hungary (past and present). The administrative geography of Carpathian Basin and Hungary. The geography of elections of Hungary (past and present). Political geography of Slovakia (state, borders, administration, election). Political geography of Ukraine (state, borders, administration, election). Political geography of Romania (state, borders, administration, election). Political geography of Serbia (state, borders, administration, election). Political geography of Croatia (state, borders, administration, election). Political geography of Austria (state, borders, administration, election).

**Evaluation method:**
***Course assignments:***
Attending on more than 60% of the lectures.
***Course point distribution, examination format*:**
Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Flint, C. 2007: Political geography. World-Economy, Nation-State and Locality (7th ed.), Routledge, 376 p.
Agnew, J. 1996: Political geography: A reader. (1st ed.) Routledge, 384 p.
**Suggested reading:**
Agnew, J. A. – Mitchell, K. – Toal, E. (eds.) 2007: A companion to political geography, Wiley - Blackwell, 512 p.

| Landscape evaluation (Geographical landscape evaluation) | **Code**: MFKST818E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Tibor Elekes, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**

Within the framework of the former subjects (water geography, meteorology, geomorphology, biogeography, etc.) the system-based investigations of the already known landscape elements. Understanding the interrelationships between the components of the landscape elements, their spatial arrangement, their chronological change, and analysis of their quantitative and qualitative characteristics. Exploration and delineation of specific ecotypes, their complex geographic characterization, assessment, and typifying. Possibilities and applications of the geographical evaluations from natural and social aspects in the Carpathian-Basin.

**Course content and structure:**

Basic landscape assessments. Theoretical system of landscape assessment. Morphotype. Climatetype. Hydrotype. Biotype. Ecotype. Socio-economic importance of the ecotypes. Landscape potential. Types of landscape potential.

**Evaluation method:**

***Course assignments:***

Preparation of a paper to be submitted.

***Course point distribution, examination format*:**

During the test-exam it is important that the student can recognize the basic connections of landscape assessment, he/ she must prove his /her ability to recognize and formulate landscape assessment problems in the case of the Carpathian Basin landscapes. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**


Lóczy D, Dingsdale A. 2001. The environmental challenge of societal transition in East Central Europe In: Turnock D (edit.) East Central Europe and the former Soviet Union: environment and society, London: Edward Arnold, 2001. pp. 187-199.

Lóczy D, Sipőcz M. 2008. Evaluating the physico-geographical background to game management: example of red deer in Southern Transdanubia. In: Hanusz Á. (edit.) Tiszteletkötet Dr. Göőz Lajos professzor 80. születésnapjára. Nyíregyháza: Nyíregyházi Főiskola Turizmus és Földrajztudományi Intézet, pp. 147-154.

Elekes T.- Gyenizse P.- Nagyváradi L. 2008. Relation between forests and settlements in the catchment area of the river Feernic. In: STUDIA Universitatis Babeş-Bolyai – AMBIENTUM, 1-2, Cluj-Napoca. pp. 81-87.

Gyenizse P.- Nagyváradi L.- Elekes T. 2009. Settlement expanding and environment survey by geoinformatical methods. In: Ecoterra, an VI, nr.20, Universitatea Babeş-Bolyai – I.C.P.E. Bistrita. pp. 20-21.

Elekes T.- Gyenizse P. 2010. Landscape and settlement system relation in the region of the Aries river from the 12th century till nowdays. In: Ecoterra, an VII, nr. 24, Universitatea Babeş-Bolyai – I.C.P.E. Bistrita. pp. 6-7.


**Suggested reading:**


Elekes T.- Lénárt L. 2007. Some aspects of the relation between settlement system and natural environment in Covasna county. In: Environment&Progress 11/2007, Mediul-Cercetare, Protecţie şi Gestiune 2006, Cluj-Napoca (Romania), pp. 154-159.

| Soil description and analysis procedures | **Code**: MFKFT822E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Erika Micheli Csáki, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** submitted sampling strategy and processing, analysis plan |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
To give an insight into the field sampling procedures and sample processing and analytical tools.

**Course content and structure:**
The course summarizes the field soil profile description and analysis procedures, their field and lab tools and equipments. It covers the topics of site description, soil sampling, processing and storage requirements, its national and international standards and routines, and the state of the art, detailed soil description methodologies, like proximal sensing and data interpretation.

**Evaluation method:**
Submitted sampling strategy and processing, analysis plan.
***Course assignments:***
Development of a sampling strategy and processing, analysis plan for a predefined pilot area.
***Course point distribution, examination format*:**
Adequate strategy and plan, use of potential methods and their interpretation. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
USDA-NRCS. 2014. Soil Survey Investigations Report No. 42, Version 5.0. USDA. Washington. USA.
USDA-NRCS,1998: Keys to Soils Taxonomy. Eight edition. Washington, USA.
IUSS Working group WRB., 2014. World reference base for soil resources 2014.
International soil classification system for naming soils and creating legends for soil maps. World soil resource report 106. FAO. Rome.
**Suggested reading:**
FAO, 2006. Guidelines for soil description. Rome.
Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, Nebraska, USA.

| Soil genetics and classification | **Code**: MFKFT823E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Erika Micheli Csáki, DSc, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The course builds on basic soil science knowledge and provides information on soil genesis and classification. It describes the soil forming processes and factors and the diagnostic properties, horizons that can develop in the soil, and their physical, chemical, and morphological properties.

**Course content and structure:**
The course summarizes the major characteristics and approaches of the traditional and the modern soil classification systems. Having described the internationally used classification systems a thorough comparative description of the Hungarian soil classification system and the correlation of its classes and units will be made. The soil classes will be attributed with their ecological functions and geographic distribution as well.

**Evaluation method:**
Project-based written exam.

***Course assignments:***
A paper focusing on a pilot area, description the soil resources using diagnostic features, horizons, and materials.

***Course point distribution, examination format*:**
Accurate interpretation of the soil resources and adequate usage of diagnostics, classification nomenclature. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
USDA-NRCS, 1998: Keys to Soils Taxonomy. Eight edition.
IUSS Working group WRB., 2014. World reference base for soil resources 2014.
International soil classification system for naming soils and creating legends for soilmaps. World soil resources report 106. FAO. Rome.

**Suggested reading:**
Driessen és Dudal, 1991. The major soils of the World. Lecture notes on their geography, formation, properties and use. Agricultural University of Wageningen. The Netherlands.

| Soil chemistry | **Code**: MFKFT817E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Endre Dobos, PhD, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** oral exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The course focuses on the description of the soil as an environmental factor and its chemical, colloidal properties that responsible for the major processes within the soil environment.

**Course content and structure:**
It summarizes the major anthropogenic organic and inorganic compounds that can occur in the soil and their potential transportation and transformation, degradation processes. The physical, chemical and biological characteristics of the soils have significant impacts on the way how the anthropogenic compounds react. Therefore, the understanding on the soil environment and the joint interpretation of the pollutants and the soil environments is crucial for any soil cleaning activity and the assessment of their environmental an anthropogenic risks. The course describes the most common pollutant and soil interactions and the most typical soil systems, where the pollutants arrive and go through several specific transformation processes. The course also covers the topics of soil sampling and sample processing and some basic analytical and pre-processing procedures.

**Evaluation method:**
***Course assignments:***
-
***Course point distribution, examination format*:**
The adequate use of the field and lab protocols and the interpretation of the results in the soil property context. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Driessen and Dudal, 1991. The major soils of the World. Lecture notes on their geography, formation, properties and use. Agricultural University of Wageningen. The Netherlands.
Bohn, H., McNeal B.L., O'Connor G.A. 2001. Soil chemistry. 3rd Edition. John Wiley & Sons., Inc. New York.
**Suggested reading:**
USDA-NRCS.1998. Keys to Soils Taxonomy. Eighth edition.
IUSS Working group WRB., 2014. World reference base for soil resources 2014. International soil classification system for naming soils and creating legends for soil maps. World soil resources report 106. FAO. Rome.
Stefanovits P. Fip Gy., Füleky Gy. 1999. Talajtan. Mezőgazda Kiadó. Budapest.
Filep Gy. 1988. Talajkémia. Akadémiai Kiadó. Budapest.

| Empirical research methodology of social geography | **Code**: MFKST819E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Beáta Siska-Szilasi, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Within the framework of the subject will be study the necessary knowledge of research preparation and the different empirical methods and basic criteria of data processing. We will examine how to make special research topics, questions, how can be displayed a research proposal, what types of research strategies exist. The quantitative research strategies and their characteristics will have a key role. During the processing the students have to learn how to use the SPSS statistical software.

**Course content and structure:**
During the semester we will study the stages of the intervention areas: Finding Problem: clarify the characteristics of the problem and / or consider why a problem is a problem. Diagnosis (problem determination/definition); Implementation compare interventions, which may solve the problem; Monitoring (testing) to describe the changes; Evaluation: establish the impact of the implementation.
We also deal with the following topics: Validity in the research strategy. Sampling, Interview types and Data Analysis. Comparison of qualitative and quantitative research. Presentation of the results of the research in reports.

**Evaluation method:**
***Course assignments:***
Contact with the subject lecturer.
***Course point distribution, examination format*:**
Assessable completion of the project task and successful writing of the exam test. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
S. Landau-B. S. Everitt 2004: A Handbook of Statistical Analyses using SPSS. CHAPMAN & HALL/CRC, 339 p.
Earl Babbie 2011: The practice of social research. Wadsworth, Cengage Learning Belmont USA. 33 p.
**Suggested reading:**
Thomas D. Fields, Thomas Z. Lys, Linda Vincent 2001: Empirical research on accounting choice. Journal of Accounting and Economics 31 (2001) pp. 255–307.
Empirical Research: Definition, Methods, Types and Examples; 2022 https://www.questionpro.com/blog/empirical-research/.

| Religious geography | **Code**: MFKST804E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Károly Kocsis, DSc, member of HAS, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Building on to the lower level regional and theoretical courses on geography of religions, this course is an advanced coverage of the history and present of the religious geographical mapping, its methodology and the applied GIS toolset. By using a problem-oriented approach the course will give a deep insight of the most actual and significant religious questions of Europe and the Carpathian Basin, like, international migration, and the changing spatial structure of religious geography, territorial integrity and the changing religious structure, secularisation.

**Course content and structure:**
Religious mapping, religious GIS (past and present). Changing structure of the religious geography of Europe and the international migration. Europe and the secularization. Religious geography of the Balkans. The relationship between the state and the Church in the Carpathian Basin (past and present). The spatial structure of the religious administration of the Churches in the Carpathian Basin (past and present). The religious geography of the Carpathian Basin. Religious tourism in the Carpathian Basin. Religious geography of Hungary. Religious geography of North Hungary with high emphases on Borsod-Abaúj-Zemplén county.

**Evaluation method:**
***Course assignments:***
Attending on more than 60% of the lectures.
***Course point distribution, examination format*:**
Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Jordan, T. G. et al. 2006: The Human Mosaic. A Thematic Introduction to Cultural Geography (10th ed.), W. H. Freeman and Co., New York, 464 p.
Kocsis K. (ed.) 2021. National Atlas of Hungary. RCEAS Geographical Institute. Budapest. www.nationalatlas.hu.
**Suggested reading:**
Sopher, D. E. 1967: Geography of religions, Prentice – Hall, 118 p.

| Soil geography of the World | **Code**: MFKFT810E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Prof. Dr. Endre Dobos, PhD, full professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The major objective of the course is to summarize the major soil types and their properties under different climatic zones and under the primary impact of different parent materials and terrain positions. Besides of the major soils of the World, the course will focus on the soil associations of the pilot area of the student1s research.

**Course content and structure:**
The course starts with the definition of the soil functions in the different regions of the World and the related soil and climate conditions. The course uses the commonly accepted WRB classification system to describe and classify the soils. All significant physical and chemical soil properties will be described under the soil units. All regions are characterized with their dominant and associated soil types. Having known the soil conditions the significant land uses will be listed and the major restrictions and risks due to the land management are described as well.
The major soil associations will be described in the following system: Organic soils. Mineral soils conditioned by their parent material. Mineral soils conditioned by their young age. Mineral soils conditioned by their topographic position. Mineral soils of the humid tropical, subtropical areas. Mineral soils of the continental, semi-arid regions. Mineral soils of the steppe zones. Mineral soils of the (sub) humid temperate zones. Mineral soils of the permafrost regions.

**Evaluation method:**
***Course assignments:***
Submitted paper or presentation on the soil resources of the pilot area.
***Course point distribution, examination format*:**
Oral exam. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Driessen és Dudal, 1991. The major soils of the World. Lecture notes on their geography, formation, properties and use. Agricultural University of Wageningen. The Netherlands.
USDA-NRCS,1998: Keys to Soils Taxonomy. Eighth edition.
IUSS Working group WRB., 2014. World reference base for soil resources 2014.
International soil classification system for naming soils and creating legends for soil maps.
World soil resources report 106. FAO. Rome.

| Regional human geography | **Code**: MFKST808E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. Beáta Siska-Szilasi, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
Regional geography has been a major sub-area of geography since the institutionalization of this field as an academic subject in the late-19th century. A subfield of human geography focusing on the sociocultural construction of regions, their meanings for individual and social identities, and on the power relations embedded in region-building processes. For new regional geographers, the region is an entity based on social practice and discourse. The examinations of trends happen in the Earth through the large regions which are changing the current global economic and social features.

**Course content and structure:**
In this course the following main topics' global characteristics and problems will be analysed. New regional geography, Regional geography and the concept of the region. The World's Regions. Globalization and Inequality. Settlement and Development Challenges. Economics and Transport Development. Urban Development and Income Inequality. Natural Hazards and The Changing Landscape. The global economic crisis and small and medium enterprises (SMEs). Interaction between competition and trade policy. Relations between tourism and economy. Future Challenges and Opportunities.

**Evaluation method:**
***Course assignments:***
Contact with the subject lecturer.
***Course point distribution, examination format*:**
Assessable completion of the project task and successful writing of the exam test. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Anssi Paasi: REGIONAL GEOGRAPHY. In Kobayashi, A. (Ed.), International Encyclopaedia of Human Geography, 2nd edition. vol. 11, Elsevier, pp. 309–320. https://dx.doi.org/10.1016/B978-0-08-102295-5.10694- 8; ISBN: 9780081022955.
World Regional Geography; Saylor URL: http://www.saylor.org/books 1073 p.
World Trade Organization, 2010: GLOBAL PROBLEMS, GLOBAL SOLUTIONS: Towards Better Global Governance. 228 p. https://www.wto.org/english/res_e/booksp_e/public_forum09_e.pdf.
**Suggested reading:**
Glenn Kreag, 2001: The Impacts of Tourism. Minnesota Sea Grant. Publication Number: T 13. 20 p. http://www.seagrant.umn.edu/tourism/pdfs/ImpactsTourism.pdf.

| Regional physical geography | **Code**: MFKFT809E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. János Vágó, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is the overall analysis of those geologic, geomorphologic, climatic, hydrogeographic and biogeographic factors which have impact on the physical geography of the continents. The course also covers the examination of the spatial relationship between these factors. The learning material also focuses on the introduction of physical geography of the continents, and on the interaction between the natural environment and the human society.

**Course content and structure:**
The detailed physical geographic introduction of the continents covers the of Europe, Asia, Australia and Oceania, Africa, North- and South America: The location of the continents and its natural borders. The evolution of the continents: Precambian, Paleozoic, Mesozoic, and Cenozoic landscape development, particularly the effects of glacations, periglacial processes. Analysis of the evolution and occurrence of typical landforms. Evaluation of the climatic attributes of the continents and the climate determinant factors (relief, ocean currents, etc.) Hydrographic-hydrogeographic characterization of the continents. The characteristics of rivers and lakes (area and shape of the catchments, discharge, types of lakes). Introduction of the biogeographic characteristics and soils of the continents, geographical zonation. Global natural hazards (including the anthropogenic factors) and the examination of their spatial occurrence.

**Evaluation method:**
Exam.
***Course assignments:***
Elaboration of the basic, relevant literature of the topic.
***Course point distribution, examination format*:**
Physical geographic characterization of the research topic area. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Marsh, W. M., Kaufman M. M. (2012): Physical Geography. Great Systems and Global Environments. Cambridge University Press.
Muller, P.O., Williams, R.S., De Blij, H.J. (2003): Physical Geography: The Global Environment. Oxford University Press.
**Suggested reading:**
Anderson, R. S., Anderson, S. P. (2010): Geomorphology. The Mechanics and Chemistry of Landscapes. Cambridge University Press.

| Drainage basin- and drainage network morphometry | **Code**: MFKFT820E |
|---|---|
| | **Responsible department/institute:** Institute of Geography and Geoinformatics |
| **Name and position of course coordinator:** Dr. János Vágó, PhD, associate professor | |
| **Weekly lecture+seminar hours:** 2+0 | **Evaluation method:** exam |
| **Credits:** 5 | **Study format:** full time and part time |

**Course objectives:**
The aim of the course is the introduction to the analysis of drainage basin morphometry, to the major morphometric parameters and to the methods and possibilities of GIS based- and statistical analysis. The course also covers the valley- and stream network analysis, the calculation of those parameters which have an impact on the development of drainage network, the possible fields of application of drainage morphometry.

**Course content and structure:**
The main topics of the course are the following: Environmental/natural factors of the drainage network- and watershed evolution. Analysis of the morphometric characteristics of watersheds (location, shape, etc.). Drainage hierarchy, stream order and magnitude. Analysis of drainage pattern. Analysis and interpretation of stream profile graphs, application of numerical methods for the calculation of stream gradient. Interpolating and interpretation of stream gradient maps. Classification of valleys according to their aspect. Calculation of valley- stream- and outfall density. Analysis of stream directions.

**Evaluation method:**
Exam.
***Course assignments:***
Elaboration of the basic, relevant literature of the topic.
***Course point distribution, examination format*:**
Morphometric analysis in the student's research area (approximately 20 pages) or solving a practical exam task applying GIS. Grading scale: 100–85% excellent, 84–75% good, 74–63% satisfactory, 62–50% pass, 49–0% fail.

**Required reading:**
Hack, J.T. (1973): Stream-profile analysis and stream gradient index. Jour. Res. U.S. Geol. Survey, Vol.1. No 4. July-Aug. pp. 421-429.
Horton, R. E. (1945): Erosional development of streams and their drainage basins. Hydrophysical approach to quantitative morphology. Bulletin of Geological Society of America 56. pp. 275-370.
Leopold, L.B., M. Gordon Wolman, and John P. Miller (1995): Fluvial Processes in Geomorphology. Reprinted. Dover Publ.
Robert, A. (2003): River Processes: An Introduction to Fluvial Dynamics. Hodder Arnold, London.
Swades, P. (2014): Drainage Basin Morphometric Methods and Analysis. Lambert Academic Publishing.
**Suggested reading:**
Zavoianu, I. (1985): Morphometry of Drainage Basins (Developments in Water Science), Elsevier Science Ltd; 2nd revised edition.