MASTER OF SCIENCE (M.SC.) IN RESOURCES AND TECHNOLOGY

MODULE HANDBOOK

Content

Introduction

Objectives

The research-oriented M.Sc. program *Resources and Technology* is a 4 semester, 120 CP second-cycle degree program. It is intended to impart methodological competences for solving engineering and related scientific problems, and an advanced technical and scientific knowledge in

- Mechanical Engineering;
- Raw Materials and Process Engineering;
- Environmental Engineering;
- Industrial Engineering;
- Mechatronics;
- Electrical and Energy Engineering
- and other engineering fields.

The program is open to students who have successfully completed B.Sc. and B.Eng. programs in an engineering discipline, natural sciences, or information technology, other related fields provided that they have accumulated at least 180 CP (as defined by the ECTS) or equivalent. It has a strong focus on team-based project work and practical research which is application-oriented and aligned to strategic interests of industry and/or the socio-economic and ecological development goals of Mongolia. Beyond educating highly qualified experts with wide employability, the program aims to be a model for the integration of research and academic education, which is a declared goal in the Mongolian government's strategy to develop research universities.

Learning Outcomes

Graduates of the program have obtained a broad spectrum of methodological competencies that can be applied in a wide range of working environments, plus a specialization in a selected field of engineering. Through this combination, they gained expertise, which is on the one hand holistic, and on the other hand results in a specific and unique profile of each graduate. This creates future perspectives in various sectors of the Mongolian and global economy, including newly emerging fields. Besides preparing graduates for future employment, they also receive an academic education that qualifies them to pursue higher tertiary education and a career in scientific research.

Graduates of the degree course “Resources and Technology” should be able to

1. Broaden and deepen knowledge in the field of resources and technology.

[Research Methods]

2. Structure complex situations, taking into account technological, economic and ecological paradigms.
3. Plan and conduct applied research that fosters technological and societal progress.

4. Analyze, interpret, and communicate precisely and understandably results of scientific and engineering research, both orally and in writing.

[Transforming Research into Solutions]

5. Optimize existing products and processes, and develop new services, products, processes, and methods.
6. Think entrepreneurially and assess the economic and ecological implications of services, products, processes, and methods.
7. Analyze and consider intercultural aspects of global markets and specific regional settings.

[Teamwork, Leadership, and Responsibility]

8. Cooperate with experts of different disciplines to develop interdisciplinary solutions for complex tasks.
9. Scrutinize different propositions and advocate their own opinions in front of specialists and laypeople.
10. Lead and contribute to intra- and interdisciplinary teams.
11. Set realistic and ambitious goals and realize them within an appropriate time frame.
12. Consider holistically the scientific, socio-economic, environmental and ethical implications of technological developments.

Study Plan

<table>
<tr><th>1st semester</th><th>2nd semester</th><th>3rd semester</th><th>4th semester</th></tr>
<tr><td rowspan="2">Design of Experiments 8 CP
(2 UoIL, 4UoIR)</td><td colspan="2">Research Project
2 UoI plus consultation</td><td rowspan="5">Master Thesis and Colloquium
30 CP</td></tr>
<tr><td rowspan="2">Optimization Techniques 6 CP
(2 UoIL, 2 UoIR)</td><td rowspan="2">12 CP</td><td rowspan="3">18 CP</td></tr>
<tr><td rowspan="2">Engineering Ethics 4 CP
(1 UoIL, 1 UoIR, 2 UoIS)</td><td rowspan="2">Innovation and Entrepreneurship 6 CP
(1 UoIL, 1 UoIR, 3 UoIS)</td></tr>
<tr><td rowspan="3">Electives 12 CP</td><td>Engineering Statistics 6 CP
(2 UoIL, 2 UoIR)</td><td rowspan="3">Electives 12 CP</td></tr>
<tr><td>Electives 6 CP</td><td></td></tr>
</table>

Explanations:

Modules in blue	Compulsory modules
Modules in green	Electives
Modules in red	Research-oriented modules

Three or four of the electives are for specialization in an engineering discipline:

- Mechanical Engineering;
- Raw Materials and Process Engineering;
- Environmental Engineering;
- Industrial Engineering;
- Mechatronics;
- Electrical and Energy Engineering.

Two of the electives are for 'general skills' modules (e.g. language courses, IT, …). One of the 'general skills' modules may be replaced by an engineering module, which may be a module in a different field.

The 'Research Project' is a 30 CP module, with a workload of 12 CP during the 2nd and 18 CP during the 3rd semester. Teaching is predominantly by individual consultation of students. This module allows for long-term experiments.

Compulsory Modules

DEXP–510 - Design of Experiments

Module Title	Design of Experiments				**Module-Code**	DEXP-510
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1
Credit Points	8 CP	**Workload**	240 h	**Contact hours**		72 h
				Individual study		168 h
Module Coordinator	Prof. N.Battulga			**Language**	English	
Syllabus	Topics include defining research problems; - Regression and Correlation analysis, - Method of Random Balance, - Plackett-Burman designs, - Latin and Youdens squares, - Box-Wilson Design, - Box-Benken Design, - Simplex Lattice design, - Extreme vertices design. - Furthermore, special emphasis is put on a full factorial and a fractional factorial design of experiments.					
Learning Outcomes	On successful completion of this module, students should be able: 1. to decide on the most appropriate experimental design for the physical and engineering-related situations, carry them out, and 2. to judge the resulting data to obtain objective conclusions, 3. to appraise and evaluate factorial and fractional factorial designs 4. to improve the efficiency of experimentation and facilitate the cost reduction, 5. to explain how the analysis of experimental design data is carried out using different software packages.					
	1. G. Pahl, W. Beitz, J. Feldhusen, K. H. Grote. (2007), 3rd edition, Springer 2. Friedrich Pukelsheim (1993) Optimal Design of Experiments, 1st edition, Wiley 3. Z˘ivorad R. Lazic (2004) Design of Experiments in Chemical Engineering, 1st edition, Wiley 4. Angela Dean, Daniel Voss, Danel Draguljić (2017) Design and Analysis of Experiments, 2nd edition, Springer 5. Paulo Davim, J. (2016) Design of Experiments in Production Engineering, 1st edition, Springer 6. Karl Siebertz, David van Bebber, Thomas Hochkirchen (2017) Statistische Versuchsplanung, 2nd edition, Springer					
Form of teaching	Lecture (2 UoI) Recitation (4 UoI)					

Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	Statistics and numeric, Physics (Bachelor)
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

OPTM-510 - Optimization Techniques

Module Title	Optimization Techniques			**Module-Code**	OPTM-510
Duration	1 Semester	**Semester**	Fall/Spring Semester	**Module-Start**	1
Credit Points	6 CP	**Workload**	180	**Contact hours**	48
				Individual study	132
Module Coordinator	Prof. L.Altangerel/ Prof. Sungchil Lee			**Language**	English

Syllabus	This module covers the fundamentals of optimization methods and advanced techniques which can be used for engineering research and design process. Considering the computational application of this module, the course involves many computational assignments and a term project which is related to students' engineering field. The contents of this module include: - Mathematical preliminaries - Basic concepts of convex analysis - Unconstrained and constrained optimization - Modern techniques in optimization - Engineering applications
Learning Outcomes	On successful completion of this module, the students should be able to: 1. Identify optimization problems and classify them concerning possible solution methods 2. Analyze engineering problems to formulate them into an optimization framework 3. Apply efficient computational techniques to solve optimization problems 4. Apply optimization techniques to engineering design and other applications and evaluate solutions from the engineering perspectives
Literature	1. A.R.Parkinson et al., Optimization Methods for Engineering Design, 2013. 2. S.S. Rao, Engineering Optimization: Theory and Practice , 5th edition, 2009. 3. S.Boyd, L.Vandenberghe, Convex Optimization, 7th edition, 2009. 4. A. Ben-Tal, A.Nemirovski, Lectures on Modern Convex Optimization, 2001 5. Mario Koeppen et al., Intelligent Computational Optimization in Engineering, 2011
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*

Prerequisites for participation	Mathematics 2
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

ENET-510 - Engineering Ethics

Module Title	Engineering Ethics				**Module-Code**	ENET-510
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1
Credit Points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module Coordinator	TBD			**Language**	English	

Syllabus	Ethical tenets of Aristotle, Spinoza, Kant, Heidegger, Jonas, and Anders. Engineering codices. Ethics vs. morale. Case studies of ethical dilemmas and ethical behavior.
Learning Outcomes	After having completed this course, students should be able to 1. Know and discuss viewpoints of eminent ethicist. 2. Know and discuss professional ethical codices. 3. Identify ethical problems and dilemmas in engineering practice. 4. Recognize ethical responsibilities in engineering research and the design, development, use, and disposal of products and processes. 5. Analyze the ethical aspects of technical products and processes. 6. Assess ethical problems and dilemmas in engineering practice. 7. Explain how to behave professionally towards subordinates, colleagues, superiors, and customers
Literature	1. BAURA, Gail D., Engineering Ethics. An Industrial Perspective, Elsevier, Burlington, 2006 2. FLEDDERMAN, Charles B., Engineering Ethics, Pearson, 2012 3. JONAS, Hans, The Imperative of Responsibility, The University of Chicago Press, 1984 4. VAN DE POEL, Ibo and Royakkers, Lamber. Ethics, Technology and Engineering, Wiley, 2011
Form of teaching	Lecture (1 UoI) Recitation (1 UoI) Seminar (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

ENST-510 - Engineering Statistics

Module Title	Engineering Statistics				**Module-Code**	ENST-510
Duration	1 Semester	**Semester**	Fall/Spring Semester		**Module-Start**	2
Credit Points	6 CP	**Workload**	180	**Contact hours**		48
				Individual study		132
Module Coordinator	Prof. L.Altangerel			**Language**	English	

Syllabus	The contents of this module include: - Descriptive statistics and basics of probability - Random variables and probability distributions - Parameter estimation and hypothesis testing - Linear regression and correlation - Statistical inference for two samples - Multiple linear regression - Design and analysis of single and several factors - Statistical quality control
Learning Outcomes	On successful completion of this module, the students should be able to: 1. Apply statistical and probability concepts to solve engineering problems 2. Perform hypothesis tests for a range of engineering problems 3. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering and statistical judgment to draw conclusions
Literature	1. D.C. Montgomery, G.C.Runger, Applied Statistics and Probability for Engineers , 7th edition, 2018. 2. Thomas P.Ryan, Modern Engineering Statistics, 2007 3. Sh. Dowdy et al. Statistics for Research, 2004 4. Theodore T.Allen, Introduction to Engineering Statistics and Six Sigma, 2006
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	Mathematics 2
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

INNE-510 - Innovation and Entrepreneurship

Module Title	Innovation and Entrepreneurship				**Module-Code**	INNE-510
Duration	1 semester	**Semester**	Fall/Spring semester		**Module-Start**	2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**		60 h
				Individual study		120 h
Module Coordinator	Prof. Ch.Enkhzaya			**Language**	English	

Syllabus	Entrepreneurship is not confined to the context of new ventures or start-ups only, it can occur within large and mature organizations (intrapreneurship) as well as within the non-profit sector. Thus, the module aims to help students develop the awareness and mindset, attitudes, and competencies to create and implement "the new". The role of entrepreneurial learning and social networking is considered along with the planning and implementation of successful innovations. Students will examine alternative approaches, methodologies, and case studies demonstrating an understanding of the risks and challenges associated with them.
Learning Outcomes	After having completed this course, students should be able to: 1. Identify the nature and scope of issues and problems involved concerning managing an innovative project. 2. Understand the various options/perspectives available in terms of developing an entrepreneurial organization in different contexts. 3. Critically reflect on the factors associated with good practices in developing and utilizing appropriate entrepreneurial networks to access resources innovatively. 4. Recognize the imperatives of innovative technologies and demonstrate how they can form the basis of a sustainable business. 5. Apply numeracy skills to calculate the amount of start-up capital and time to break-even. 6. Seriously analyze their skills and knowledge and how these can be utilized to exploit a business opportunity. 7. Engage in various exercises such as brainstorming to develop organizational, communication, and team-working skills. 8. Assess the validity of certain conclusions based on data and statistical analysis. 9. Explore the information requirements to enable creative decisions to be taken and the ways that information is used. 10. Explain how entrepreneurship and innovation contribute to broader outcomes (of organizations and communities).
Literature	*1.* NECK, H., NECK, C., Murray, E., Enterpreneurship: the Practice and Mindset, Second Edition, Thousand Oaks: SAGA Publishing, 2020 *2.* KAHNEMANN, Daniel, Thinking Fast and Slow, *3.* RIES, Eric, The Lean Start-Up,
Form of teaching	Lecture (1 UoI)

	Recitation (1 UoI) Seminar (3 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

Elective Modules

COFD-511 - Computational Fluid Dynamics

Module Title	Computational Fluid Dynamics				**Module-Code**	COFD-511
Duration	1 semester	**Semester**	Fall/Spring		**Module-Start**	1,2,3
Credit Points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module Coordinator	Prof. N.Battulga			**Language**	English	

Syllabus	Topics include; • Continuity, Navier Stokes and Energy Equations • Finite Difference Method, • Finite Element Method, • Finite Volume Method, • Explicit and Implicit methods • Linear multistep methods • Runge-Kutta Methods • Stability analysis of numerical methods
Learning Outcomes	On successful completion of this module, students should be able: 1. to decide on the most appropriate governing differential equations, boundary and initial conditions, and the proper numerical methods for the given fluid dynamics engineering applications, 2. to evaluate concepts of stability, and convergence of the numerical methods, 3. to assess numerical solutions to improve accuracy. 4. to judge the numerical simulation results to obtain objective conclusions for the given fluid dynamics tasks,
Literature	1. D .Jr. Anderson. (1995), 1st edition, Computational Fluid Dynamics, McGraw-Hil 2. S.Patankar, (1980) 1st edition, Numerical Heat Transfer and Fluid Flow, CRC 3. H. Versteeg, W Malalasekera. (2007) 2nd edition, An Introduction to Computational Fluid Dynamics: The Finite Volume Method 4. T.J. Chung, (2010) Computational Fluid Dynamics, Cambridge University Press 5. CFD Module Application Library Manual, 1998-2017 COMSOL
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	Fluid Mechanics course

Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

AMFM-511 - Analytical Methods of Fluid Mechanics

Module Title	Analytical Methods of Fluid Mechanics				**Module-Code**	AMFM-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module Coordinator	Prof. N.Battulga			**Language**	English	
Syllabus	Topics include mass conservation, momentum, and energy equations for continua, similarity and dimensional analysis, fluid statics laws, circulation and vorticity theorems, potential flow, an introduction to turbine and pump applications, lift and drag, dynamic methods of an inviscid fluid. The class assumes students have had one prior undergraduate class in the area of fluid mechanics. Emphasis is placed on being able to formulate and solve typical problems of engineering importance.					
Learning Outcomes	On successful completion of this module, students should be able to: 1. derive and apply general governing equations for various fluid flows and 2. apply different methods and strategies of fluid mechanics on fluid systems with emphasis on pump and turbine applications					
Literature	1. Fluid Mechanics: Analytical Methods by Michel Ledoux, Abdelkhalak El Hami, 2017 2. Viscous Flows by F. Sherman 3. Boundary Layer Theory by H. Schlichting 4. Viscous Fluid Flow by F. M. White					
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)					
Assessment methods	Individual report + oral presentation					
Associated study program	*M.Sc. in Resources and Technology*					
Prerequisites for participation	Fluid Mechanics course					
Requirements for receiving credit points	Passing the module					
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)					

STDY-511 - Structural Dynamics

Module Title	Structural Dynamics			**Module-Code**	SRDY-511
Duration	1 semester	**Semester**	Fall/Spring Semester	**Module-Start**	1,2,3
Credit Points	6 CP	**Workload**	180h	**Contact hours**	48 h
				Individual study	132 h
Module Coordinator	Prof. Sungchil Lee			**Language**	English

Syllabus	This module covers the fundamentals of structural dynamics, advanced numerical techniques, and programming for dynamic analysis. In modern engineering computer programming to solve engineering problems is being practiced in every area so it is compulsory. Students should have the capability and knowledge to write codes and evaluate the dynamic response. Thus this module is taught by computer programming using Matlab and assignments and a term project will be assigned to use their computer code to solve them. The contents of this module include: • Undamped & damped SDOF system • Response of SDOF: Analytical solution • Response spectra • Nonlinear structural response • Response of MDOF system-Numerical methods • Application to system identification.
Learning Outcomes	On successful completion of this module, the students should be able to: 1. Formulate engineering problems for structural dynamic analysis. 2. Apply the Structural Dynamics knowledge to design and analyze mechanical systems. 3. Compute the dynamic response of the mechanical system. 4. Evaluate the dynamic response of structures for safety.
Literature	1. Mechanical and Structural Vibrations, Demeter G. Fertis, John Wiley & Sons. 2. Engineering Vibrations, Daniel J. Inman, Prentice Hall 3. Structural Dynamics: Theory and Computation, Mario Paz, Y.H. Kim 2018, Springer
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	Finite Element Method & Engineering Mechanics V: Vibration
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

DSPR-511 - Digital Signal Processing

Module Title	Digital Signal Processing				**Module-Code**	DSPR-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	4	**Workload**	120	**Contact hours**		36
				Individual study		84
Module Coordinator	Prof. N.Odbileg			**Language**	English	

Syllabus	The contents of this module include: Continuous and Discrete Signals, IIR and FIR filters, Data Acquisition, Sampling, Reconstruction, Fast Fourier Transform, Discrete Fourier Transform, 2D Discrete Wavelet Transform, Continuous Wavelet Transform, MATLAB Wavelet Tool Box, Wavelet Filter Design
Learning Outcomes	On successful completion of this module, the students should be able to: 1. Recall properties, theorems, and mathematical representations of continuous-time and discrete-time signals, Fourier Transforms, and Wavelet Transforms 2. Define the behaviors continuous and discrete signals 3. Acquire signals using Data Acquisition Devices 4. Apply knowledge in Wavelet analysis using MATLAB Wavelet Toolbox
Literature	*1.* Michael Weeks (2011) *Digital Signal Processing using MATLAB and Wavelets, 2nd edition,* 2. Mathworks (2020) *Wavelet Toolbox User's Guide*
Form of teaching	Lecture (2 UoI) Laboratory (1 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

HMEX-511 - Hydrometallurgical Metal Extraction

Module Title	Hydrometallurgical Metal Extraction				**Module-Code**	HMEX-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	6 CP	**Workload**	180h	**Contact hours**		48 h
				Individual study		132 h
Module Coordinator	Prof. M.Bayanmunkh			**Language**	English	

Syllabus	The contents of this module include: • Usage of chemical and electrochemical reaction principles • Preparation and Handling of raw materials • Solubility/Equilibrium/Phase stability diagrams • Mass transport and electrochemical kinetics • Metal separation and recovery/Extraction • Production design/Cost estimation • Emissions and Environmental Impacts • Commercial Applications
Learning Outcomes	On successful completion of this module, the students should be able to: 1. interpret and apply the hydrometallurgical process in the production 2. utilize plant principles and design in general 3. understand emissions and environmental impacts of the hydrometallurgical process
Literature	1. Free, M. L. (2013) Hydrometallurgy, Fundamentals and Application, Wiley 2. Jackson E. (1986) Hydrometallurgical Extraction and Reclamation, Ellis Horwood Limited 3. Weiss N. L. (1985) *SME Mineral Processing Handbook*, Vol. 2.
Form of teaching	Lecture (2 UoI) Recitation (1 UoI) Excursion (1 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

RNEX-511 - Resource Nexus

Module Title	Resource Nexus				**Module-Code**	RNEX-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	6 CP	**Workload**	180	**Contact hours**		48
				Individual study		132
Module Coordinator	Prof. Daniel Karthe			**Language**	English	

Syllabus	The "Resource Nexus" addresses the interlinkages between different resources such as raw materials, water, soil, food, energy, and waste; it, therefore, links different disciplines such as raw material, environmental and industrial engineering. This module introduces historical development, scope, and limitations of the resource nexus concept, which is currently propagated by the United Nations as the most promising approach to integrate the management of different resources by looking at (a) synergies and (b) tradeoffs between different nexus elements. Drawing on case studies (e.g. from mining or urban areas), this module focuses on two of the most commonly used variants of the nexus: 1. Water – food – energy nexus 2. Water – soil – waste nexus The nexus is addressed from different angles, e,g. using nexus observatories, modeling tools, life cycle assessments, institutional analysis, resource footprints. Particular consideration is given to 'uncertainty' and 'complexity' as challenging aspects for the practical implementation of the nexus concept.
Learning outcomes	On successful completion of this module, the students should be able to: ● explain the relevance, scope, and limitations of different forms of the nexus concept; ● utilize and integrate different methods related to the practical application of the resource nexus concept; ● critically assess previous experiences of implementing the nexus; ● apply the nexus concept for developing integrated management approaches related two or more nexus elements
Literature	1. Abdul Salam, P.; Shrestha, S.; Pandey, V.P. & Anal, A.K. (Eds.) (2017): Water-Energy-Food Nexus: Principles and Practices. Hoboken, NJ, USA: Wiley & Sons and Washington, D.C.: American Geophysical Union. 2. Bleischwitz, R.; Hoff, H.; Spataru, C.; van der Voet, E. & van Deveer, S.D. (2017): Routledge Handbook of the Resource Nexus. Abingdon, UK and New York, USA: Routledge. 3. Hettiarachchi, H. & Ardakanian, R. (Eds.) (2016): Environmental Resource Management and the Nexus Approach: Managing Water, Soil, and Waste in the Context of Global Change. Cham, Switzerland: Springer.

Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

RSGI-511 - Remote Sensing and GIS Research Applications

Module Title	Remote Sensing and GIS for Research Applications				**Module-Code**	RSGI-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	6 CP	**Workload**	180	**Contact hours**		48
				Individual study		132
Module Coordinator	Prof. Daniel Karthe			**Language**	English	

Syllabus	Remote Sensing of the environment: ● Data sources (satellite imagery, aerial photogrammetry) and their characteristics (spatial/spectral/radiometric/temporal resolution) and limitations ● Remote Sensing applications: ○ Lithosphere and pedosphere: exploration of mineral resources; soil degradation ○ Hydrosphere: hydrological monitoring of rivers and lakes; water quality monitoring ○ Atmosphere: air pollution monitoring ○ Biosphere: vegetation mapping, assessment of vitality; spatio-temporal trends ○ Anthroposphere: monitoring of urban development and mining areas Application of Geographical Information Systems: ● Data types (raster vs. vector data) ● Data integration: time series analysis; multi-sensor data; integrating RS and terrestrial data ● Methods of spatio-temporal data analysis ● Visualization of results
Learning outcomes	On successful completion of this module, the students should be able to: ● describe the potentials of Remote Sensing and GIS for research tasks in environmental sciences and engineering ● identify and use RS products which are openly available online (e.g. digital elevation models, soil/vegetation/water quality indices, …) ● integrate data from different sources ● perform spatiotemporal analyses with both vector and raster data
Literature	1. Bajjali, W. (2018): ArcGIS for Environmental and Water Issues. Cham, Switzerland: Springer. 2. Campbell, J. & Shin, M. (2012): Read more about Essentials of Geographic Information Systems. Minneapolis, MN, USA: Open Textbook Library. 3. Khorram, S.; van der Wiele, C.F.; Koch, F.H.; Nelson, S.A.C. & Potts, M.D. (2016): Principles of Applied Remote Sensing. Cham, Switzerland: Springer. 4. Rees, W.G. (2012): Physical Principles of Remote Sensing- 3rd Edition. Cambridge, UK: Cambridge University Press.

Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

NRIM-511 – Natural Resources of Mongolia and Investigation Methods

Module Title	Natural Resources of Mongolia and Investigation Methods				**Module-Code**	NRIM-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	6 CP	**Workload**	180 h	**Contact hours**		60 h
				Individual study		120 h
Module Coordinator	Prof. R. Herd			**Language**	English	
Syllabus	Lecture Part A: “Geology of Mongolia” This part of the lecture provides an overview of the geology of Mongolia. Topics are: - regional geodynamic evolution and tectonics - geological units of Mongolia, their distribution and properties - magmatic and volcanic activities over time Lecture Part B: “Resource potential and typical raw material deposits of Mongolia” This part of the lecture focusses on the resource potential of Mongolia. Derived from the geodynamic evolution and the local geological units, the potential for natural resources will be estimated. The distribution of energy raw materials, metals, industrial minerals, hard and soft rocks as well as groundwater will be evaluated. Part A and B are supplemented by 3 one-day excursions to typical geological sites, raw material occurrences and active mines. Part C: “Investigation methods and techniques” The lecture provides an overview of the state-of-the-art investigation methods and techniques used for prospecting and the detection of raw materials and groundwater. Methods and techniques such as remote sensing, satellite and aerial image interpretation, seismic, electromagnetic, geoelectric, geomagnetic, radiometric investigations, as well as geochemical and geological methods will be considered. Part C is supplemented by a 3 day Field Training. The students will use different investigation methods in the field and will perform a small prospection campaign for a certain raw material.					
Learning Outcomes	On successful completion of the module, the student should be able to: ● describe the geodynamic evolution of the region ● differentiate the geological units and their distribution ● estimate the resource potential of the different units and regions ● describe the distribution of raw material deposits in Mongolia					

	● recall the state-of-the-art investigation methods ● explain the principles of the investigation methods and their field of application
Literature	1. Evans, A. M. (1992): Ore Geology and Industrial Minerals. Blackwell. Oxford. 2. Lillesand, T. M.; Kiefer, R. M.; Chipman, J. W. (2008): Remote sensing and image interpretation. Wiley. Hoboken. 3. Reynolds, J. M. (2011): An introduction to applied and environmental geophysics. Wiley-Blackwell. Chichester. 4. Vogelsang, D. (1995): Environmental Geophysics. Springer. Berlin.
Form of teaching	Lectures (1 UoI) Excursion (2 UoI) / 3 days Field Training (2 UoI) / 3 days
Assessment methods	Report for the field training (8-10 pages) + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	Knowledge of Applied Geosciences recommended
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

METE-511 - Materials Handling, Extraction and Transport Equipment

Module Title	Materials Handling, Extraction and Transport Equipment				**Module-Code**	METE-511
Duration	1 Semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	6 CP	**Workload**	180 h	**Contact hours**		48 h
				Individual study		132 h
Module Coordinator	Prof. Thomas Hollenberg			**Language**	English	
Syllabus	1. Bulk solids handling equipment 2. Conveyor systems 3. Aerial transportation 4. Underground scraper winch systems 5. Rail transportation. 6. Loading equipment. 7. Shaft sinking 8. Vertical and inclined hoisting devices. 9. Drilling Rigs, Road headers, Ploughs and Shearer Loader 10. Draglines, Bucket Wheel Excavator's, Chain Ladder Excavators, Dredging, etc. 11. Off highway Dump/Haulage Trucks 12. Pumps and reticulation of liquids 13. Maintenance and Workshops 14. Storage techniques. 15. Solid waste management. 16. Compressed air, water and power supply. 17. Safety					
Learning Outcomes	On successful completion of this module, the students should be able to: 1. select appropriate material handling techniques, the related mining equipment and equipment chains for specific mining projects, 2. select appropriate shaft installation and execute the engineering calculations related to the use of that equipment, 3. apply the fundamental principles and concepts of physics and mathematics to understand and evaluate the interaction between the mining equipment and the efficiency of the chosen equipment to utilize these to find the most economically way of usage, 4. assess the Safety, Health and Environmental impacts of the various equipment chains.					
Literature	1. Nichols, H. & Day, D. (2010). *Moving The Earth: The Workbook of Excavation (Sixth Edition). USA:* McGraw-Hill Professional. *2.* Haddock. K. (2008). *Bucyrus Heavy Equipment: Construction and Mining Machines 1880-2008.* USA: Iconografix. 3. Jack de la Vergne, Edition 5 (2014). *Hard Rock Miner's Handbook.* Edmonton, Alberta, Canada: Stantec Consulting Ltd 4. Tatiya, R. (2012). *Surface and Underground Excavations, 2nd Edition: Methods, Techniques and Equipment*. USA: CRC 5. Ulf Linder, Edition 3 (2008). *Mining Methods in Underground Mining.* Örebro, Sweden: Atlas Copco Drills AB					

	6. The Australasian Institute of Mining and Metallurgy, Second Edition Monograph 27 (2012). *Cost Estimation Handbook.* Carlton Victoria, Australia: The Australasian Institute of Mining and Metallurgy 7. SME Society for Mining, Metallurgy and Exploration, 3rd Edition (2011). *SME Mining Engineering Handbook Volume 1 and 2.* USA: Cushing-Malloy
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Individual report + oral presentation
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

MREM-511 - Mine and Resource Engineering Management

Module Title	Mine and Resource Engineering Management				**Module-Code**	MREM-511
Duration	1 Semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit Points	6 CP	**Workload**	180 h	**Contact hours**		48 h
				Individual study		132 h
Module Coordinator	Prof. Thomas Hollenberg			**Language**	English	
Syllabus	1. General Management Principles 2. Overview of Mine Management 3. Human Resource Management 4. Stakeholder Relationships 5. Production and Operations Management 6. Materials Management 7. Strategic Planning 8. Ethics and Engineering Code of Conduct					
Learning Outcomes	On successful completion of this module, the students should be able to: 1. apply principles of performance measures used in Mine Management, 2. develop and apply Planning, Controlling, Organizing and Leading procedures for mines, 3. recognise factors motivating people's behavior in mine working environment, 4. compare management structures and apply appropriate types to mining operations; 5. recognise and appraise factors that deal with Strategic Management of Environmental, Safety and Economic Risks					
Literature	1. AuSIMM (2012). Mine Manager's Handbook, AuSIMM (Monograph 26). 2. Sloan DA (1983). Mine Management. Chapman and Hall Ltd. London 3. Morse, P.M. (2008). Methods of Operations Research. New York: Dover. 4. Lock, D. (2007). Project Management (9th Edition), Gower Publishing Limited. 5. Shannon, R. E. (1980). Engineering Management (1st Edition). New York: Wiley 6. The Australasian Institute of Mining and Metallurgy, Second Edition Monograph 27 (2012). Cost Estimation Handbook. Carlton Victoria, Australia: The Australasian Institute of Mining and Metallurgy					
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)					
Assessment methods	Individual report + oral presentation					

Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

AWEN–511 - Academic Writing

Module title	Academic Writing				**Module-Code**	AWEN-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module coordinator	Prof. Ch.Gunpilmaa			**Language**	English	
Syllabus	The purpose of this course is to provide participants with the opportunity to improve their skills in writing a research article and other academic texts. This course builds upon the fundamentals that were learned in Introduction to Academic Writing. Students apply what is learned by drafting short academic articles and abstracts related to their area of specialization, all the while critiquing their writing to improve their autonomous learning skills.					
Learning outcomes	On successful completion of this module, the students should be able to: 1. Understand the interaction between writer, text, and reader; 2. Discriminate between academic writing and other forms of writing and English; 3. Identify and select suitable grammatical structures and academic vocabulary for a variety of texts; 4. Formulate and write a research proposal; 5. Effectively record data and experiments so that others can understand them, and so that they can form the basis of a thesis; 6. Communicate science using a thesis, written in the format of a scientific journal article; 7. Practice effective, correct, and appropriate writing in the students' area of specialization; 8. Examine and critique their scientific writing to improve upon their writing; 9. Provide feedback on other people's writing.					
Literature	1. Rowena Murray, Third Edition (2011). How to write a Thesis. Berkshire. England; McGraw Hill Open University Press. 2. Laurie Rozakis. (1999). Schaum's Quick Guide to Writing Great Research Papers. NY, U.S.A.; McGraw Hill. 3. Beverly Ann Chin. (2004). How to Write a Great Research Paper. NJ, U.S.A.; John Wiley & Sons, Inc.					
Form of teaching	Recitation (4 UoI)					
Assessment methods	A collection of writing that is drafted, revised, and edited during the course is required, including a minimum of 4 extended formal research papers. Rubrics to evaluate student writing will be derived from the outcomes listed above.					

Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	C1 level of English
Requirements for receiving credit points	At least 70% of the course grade will be based on evaluation of the formal writing. Formal research writing assignments are required.
Grading system	Preliminary Research Portfolio: 20% Critical Presentation: 30% Final Portfolio: 50%

CCSG–511 – Climate Change: The Science and Global Impact

Module title	Climate Change: The Science and Global Impact				**Module-Code**	CCSG-511
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module coordinator	Prof. G.Gantuya			**Language**	English	
Syllabus	This course is aimed to provide the broad and deep scientific concepts for students to understand the drivers and impacts of anthropogenic climate change, negative impacts, international initiatives on global climate change and address mitigation and adaptation strategies. The content of this module include: ● Principles of atmospheric science ● Climate data collection and interpretation ● Climate modeling ● Climate and CO2 in the atmosphere ● Recent global warming ● Impacts on human systems ● Scientific consensus and uncertainty, the IPCC science assessment ● Future climate change projections					
Learning outcomes	On successful completion of this module, the students should be able to: 1. learn a deep scientific understanding of why and how the climate system has been changing, 2. explain the mechanisms of these changes, 3. develop a systems thinking approach to analyzing the impacts of climate change on both natural and human systems, 4. gain scientific basis on Earth's possible climate future, including the role of human choices.					
Literature	1. Climatology: An Atmospheric Science, 3rd edition. Prentice Hall, 2010. 2. The Hockey Stick and the Climate Wars: Dispatches from the Front Lines, Columbia University Press, 2012. 3. Science of the Earth, Climate and Energy, World Scientific Publishing, 2018. 4. https://www.edx.org/course/climate-change-the-science-and-global-impact					
Form of teaching	Lecture (2UoI) Recitation (2UoI)					
Assessment methods	Individual report + oral presentation					
Associated study program	*M.Sc. in Resources and Technology*					

Prerequisites for participation	None
Requirements for receiving credit points	Passing the module
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

MOOC–520 – Water: Addressing the Global Crises

Module title	Water: Addressing the Global Crises				**Module-Code**	MOOC-520
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit points		**Workload**	9 weeks, 3-5 hours per week	**Contact hours**		
				Individual study		
Module coordinator	SDGAcademyX Dr. Ts.Ariuntuya			**Language**	English	
Syllabus	● The scale, scope, and challenges in achieving the SDG 6 , safe access to water for all. ● The issues of climate change and its influence on water. ● Water and sanitation for health, the food, energy and water nexus. ● The environmental, economic and social dimensions of SDG 6 and the critical role of water governance. ● The transboundary cooperation needed to achieve the goal on water. ● Lessons from concrete practices around the world through a series of case studies.					
Learning outcomes	On successful completion of this module, the students should be able to:					
Literature	https://www.edx.org/course/water-addressing-the-global-crisis-2					
Form of teaching						
Assessment methods						
Associated study program						
Prerequisites for participation						
Requirements for receiving credit points						
Grading system						

MOOC–521 – Energy Within Environmental Constraints

Module title	Energy Within Environmental Constraints				**Module-Code**	MOOC-521
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit points		**Workload**	10 weeks, 3-5 hours per week	**Contact hours**		
				Individual study		
Module coordinator	SDGAcademyX Dr. Ts.Ariuntuya			**Language**	English	
Syllabus	● The basic engineering, environmental science, and economics of our energy system. ● A working understanding of energy technologies. ● Environmental impacts of the energy system, focusing on air pollution, climate change, and land use. ● Techniques for estimating monetary costs and carbon impacts.					
Learning outcomes	On successful completion of this module, the students should be able to:					
Literature	https://www.edx.org/course/energy-within-environmental-constraints					
Form of teaching						
Assessment methods						
Associated study program						
Prerequisites for participation						
Requirements for receiving credit points						
Grading system						

MOOC–522 – Natural Resources for Sustainable Development

Module title	Natural Resources for Sustainable Development				**Module-Code**	MOOC-522
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit points		**Workload**	12 weeks, 4-6 h per week	**Contact hours**		
				Individual study		
Module coordinator	SDGAcademyX Z.Uuganbaatar			**Language**	English	
Syllabus	● How countries translate natural resource wealth into sustainable development outcomes ● How governance of extractive industries impacts long term economic development ● The policies necessary for the sustainable management of natural resource wealth ● Why communication between government, industry and citizens critical influences sustainable natural resource management					
Learning outcomes	On successful completion of this module, the students should be able to:					
Literature	https://www.edx.org/course/natural-resources-for-sustainable-development					
Form of teaching						
Assessment methods						
Associated study program						
Prerequisites for participation						
Requirements for receiving credit points						
Grading system						

MOOC–523 – Low Emission Technologies and Supply Systems

Module title	Low Emission Technologies and Supply Systems				**Module-Code**	MOOC-523
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2,3
Credit points		**Workload**	14 weeks, 10-12 h per week	**Contact hours**		
				Individual study		
Module coordinator	SDGAcademyX Dr. Ts.Ariuntuya/Z.Uuganbaatar			**Language**	English	
Syllabus	● Current features of coal, gas and nuclear power generation technologies and their future development ● Basic principles and emissions intensity of oil refining and coal to liquids processes for transportation fuels ● New developments in carbon capture, transportation and storage processes ● Case study of an unconventional gas industry ● The implications of improving efficiencies in carbon intensive industrial processes.					
Learning outcomes	On successful completion of this module, the students should be able to:					
Literature	https://www.edx.org/course/low-emission-technologies-and-supply-systems					
Form of teaching						
Assessment methods						
Associated study program						
Prerequisites for participation						
Requirements for receiving credit points						
Grading system						

ADRP–610 - Advanced Research project

Module Title	Advanced Research Project				**Module-Code**	ADRP-610
Duration	2 semesters	**Semester**	Fall/Spring Semester		**Module-Start**	3
Credit Points	30 CP	**Workload**	900 h	**Contact hours (supervised teamwork)**		300 h
				Individual study		600 h
Module Coordinator	The director of the graduate school			**Language**	English	

Syllabus	In cooperation with external partners (industry, governmental or non-governmental organizations, economy) a task is given to a team of students to develop or improve service, product, or process in the field of resources and technology.
Learning Outcomes	After having completed this course, students should be able to *1.* Analyze tasks, identify deficits of tasks and redefine tasks in the field of resources and technology. 2. Develop a structured approach for solving the given task. *3.* Practice a Design-of-Experiments approach to plan, conduct, and evaluate experimental data or data obtained via simulation. *4.* Optimize products, processes, and procedures *5.* Cooperate in teams, distribute sub-tasks, and solve sub-tasks independently. *6.* Reflect on the technological, economic, ecological, and ethical implications of the task and its solutions. *7.* Write a joint report about the task, with individual contributions of the team members. *8.* Present the results of the teamwork to an audience of experts and lay people.
	1. Pahl, G., W. Beitz, J. Feldhusen, K. H. Grote; Engineering Design. Springer, 2007. *2.* VDI Guidline 2221; Systematic Approach to the Design of Technical Systems and Products, 1987 *3.* Thompson, M. K., ed.; Interdisciplinary Design. Proceedings of the 21st CIRP Conference. KAIST, 2011
Form of teaching	Project course. Supervised teamwork.
Assessment methods	Report with individual contributions, oral presentation, contribution to the teamwork
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	
Requirements for receiving credit points	Passing grades for both the individual contribution to the project report and the oral presentations during the project.
Grading system	The final grade is based on the individual report (70 %) and the oral presentation (30 %)

MAST-611 - Master's thesis

Module Title	Master's Thesis				**Module-Code**	MAST-611
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	4
Credit Points	30 CP	**Workload**	900 h	**Contact hours**		
				Individual study		900 h
Module Coordinator	The director of the graduate school			**Language**	English	
Syllabus	Current research topic in the research field of the supervising professor.					
Learning Outcomes	After having completed this Master Thesis, students should be able to *1.* Identify and elaborate research questions in the field of resources and technology. *2.* Broaden and deepen knowledge in the field of resources and technology through independent research. *3.* Present the research questions, the methods applied in the research, and the obtained research results in written and oral form for experts and laypeople.					
Literature	1. ECO, Umberto; How to Write a Thesis. The MIT Press, Cambridge, 2015					
Form of teaching	Supervised independent research					
Assessment methods	Written thesis (14 weeks writing period) and defense (30 min presentation followed by a 30 min discussion)					
Associated study program	*M.Sc. in Resources and Technology*					
Prerequisites for participation	Completion of the third semester and at least 90 CP earned					
Requirements for receiving credit points	Passing the thesis and the presentation					
Grading system	The final grade for the Master thesis consists of the grade of the thesis and the grade performance in the thesis defense with a weighting of 4:1, provided that the thesis was graded as "passed" (1.0).					