ANNEX 7.

PROGRAM-SPECIFIC STUDY AND EXAM REGULATIONS OF MASTER OF SCIENCE “RESOURCES AND TECHNOLOGY”

Incl. STUDY PLAN AND MODULE HANDBOOK

Contents

AIMS AND OBJECTIVES

The graduate degree program "Resources and Technology" offered by the German-Mongolian Institute for Resources and Technology aims to educate engineers who can serve Mongolian society with their knowledge, skills, and competencies in applying engineering methods to develop new products and production processes, as well as optimize existing ones.

The program aims to bring engineers together to apply scientific and engineering methods to transform tasks and problems from industrial practice into structured problem-solving procedures. Training in the design of experiments and optimization, as well as entrepreneurship, will enable graduates to apply their knowledge, skills, and competencies in various branches of the industry and economy.

The research-oriented M.Sc. program *Resources and Technology* is 3 semesters, 90 CP second-cycle degree program. It is intended to impart methodological competencies for solving engineering and related scientific problems, and advanced technical and scientific knowledge in:

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

The program is open to students who have completed B.Sc. and B.Eng. programs in an engineering discipline, natural sciences, or information technology, as well as 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 that is application-oriented and aligned with the strategic interests of industry and/or the socio-economic and ecological development goals of Mongolia. In addition to educating highly qualified experts with broad employability, the program aims to serve as a model for the integration of research and academic education, a declared goal in the Mongolian government's strategy to develop research universities.

Graduates of the program have acquired a wide range of methodological competencies that can be applied in various working environments, along with a specialization in a selected field of engineering. This combination has enabled them to develop expertise that is both comprehensive and unique to each graduate. Such a profile provides promising opportunities in different sectors of the Mongolian and global economy, including emerging fields. In addition to preparing graduates for future employment, the program also provides them with an academic foundation that qualifies them for further 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 results of scientific and engineering research precisely and understandably, 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 from 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.

CURRICULUM STRUCTURE

The program includes compulsory modules focusing on research methodology for engineers, engineering ethics, and innovation, as well as a variety of electives including interdisciplinary options. The Advanced Research Project is a project-based module that is closely coordinated with industry, followed by a Master's Thesis. This allows students to choose a wide range of specializations that cater to the needs and interests of those with backgrounds in engineering and natural sciences.

To write a master's thesis, a student must earn at least 45 credit points before beginning the 3rd semester. The total number of credit points required for graduation must be a minimum of 90.

MODULE DESCRIPTIONS

The description of each module is provided in this document following the Study Plan.

ELECTIVES

To participate in and receive recognition for an elective module, it is assumed that the necessary prerequisites for the chosen elective have already been completed. Additionally, changes to teaching schedules for modules can only be approved by the Academic and Student Affairs in rare circumstances. Students must select their subjects in a way that ensures their participation in program-related modules is not compromised or limited.

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

- Mechanical Engineering
- Raw Materials and Process Engineering
- Environmental Engineering
- Industrial Engineering
- Mechatronic Engineering
- Energy and Electrical Engineering

Two of the electives are 'general skill' modules such as language courses or IT. One of the 'general skill' modules may be replaced by an engineering module from a different field.

RESEARCH-ORIENTED MODULES

The 'Advanced Research Project' is a 12 CP module during the 2nd semester. Teaching is primarily done through individual consultations with students. This module allows for long-term experiments.

STUDY PLANS

<table>
<tr><th>Credit points</th><th>1st semester</th><th>2nd semester</th><th>3th semester</th></tr>
<tr><td>1</td><td rowspan="8">Design of Experiments
8 CP (2 UoIL, 4UoIR)</td><td rowspan="4">Innovation and Entrepreneurship
6 CP (1 UoIL, 1 UoIR, 2 UoI)</td><td rowspan="28">Master Thesis and Colloquium
30 CP</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td><td rowspan="6">Engineering Statistics
6 CP (2 UoIL, 2 UoIR)</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td><td rowspan="6">Optimization Techniques
6 CP (2 UoIL, 2 UoIR)</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td><td rowspan="2">Research Seminar
2 CP</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td><td rowspan="4">Engineering Ethics
4 CP (1 UoIL, 1 UoIR, 2 UoIS)</td><td rowspan="12">Advanced Research Project
12 CP</td></tr>
<tr><td>16</td></tr>
<tr><td>17</td></tr>
<tr><td>18</td></tr>
<tr><td>19</td><td rowspan="12">Electives
12 CP</td></tr>
<tr><td>20</td></tr>
<tr><td>21</td></tr>
<tr><td>22</td></tr>
<tr><td>23</td></tr>
<tr><td>24</td></tr>
<tr><td>25</td></tr>
<tr><td>26</td></tr>
<tr><td>27</td><td rowspan="4">Electives
4 CP</td></tr>
<tr><td>28</td></tr>
<tr><td>29</td></tr>
<tr><td>30</td></tr>
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Compulsory modules
Elective modules
Research-Oriented modules

COMPULSORY MODULES

DEXP 501 - DESIGN OF EXPERIMENTS

Module Title	Design of Experiments				**Module-Code**	DEXP 501
Duration	1 semester	**Semester**	Fall 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	
Contents	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.					
Literatue	1. Dean A, Voss D, Draguljić D. Design and Analysis of Experiments, 2nd edition, Springer, 2017. 2. Siebertz K, Bebber D, Hochkirchen, T. Statistische Versuchsplanung, 2nd edition, Springer, 2017. 3. Davim PJ. Design of Experiments in Production Engineering, 1st edition, Springer, 2016. 4. Pahl G, Beitz W, Feldhusen J, Grote KH. 3rd edition, Springer, 2007. 5. Pukelsheim F. Optimal Design of Experiments, 1st edition, Wiley, 1993. 6. Lazic ZR. Design of Experiments in Chemical Engineering, 1st edition, Wiley, 2004.					

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 501 - OPTIMIZATION TECHNIQUES

Module Title	Optimization Techniques			**Module-Code**	OPTM 501
Duration	1 Semester	**Semester**	Fall Semester	**Module-Start**	1
Credit Points	6 CP	**Workload**	180 h	**Contact hours**	48 h
				Individual study	132 h
Module Coordinator	Prof. L.Altangerel			**Language**	English

Contents	This module covers the fundamentals of optimization methods and advanced techniques that can be used for engineering research and design processes. 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. Parkinson AR, Balling RJ, Hedengren JD. Optimization Methods for Engineering Design. Brigham Young University; 2013. 2. Koeppen M, Schaedfer G, Abraham A. Intelligent Computational Optimization in Engineering. Techniques & Applications. Springer; 2011. 3. Rao SS. Engineering Optimization: Theory and Practice, 5th edition; 2009. 4. Boyd S, Vandenberghe L. Convex Optimization, 7th edition. Cambridge University Press; 2009. 5. Ben-Tal A, Nemirovski A. Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications. Society for Industrial and Applied Mathematics Philadelphia, Mathematical Programming Society Philadelphia; 2001.
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)

Assessment methods	Performance assessments, 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 consists of the academic performance during the module accounting for 50% and the individual report + presentation accounting for 50%.

ENET 501 - ENGINEERING ETHICS

Module Title	Engineering Ethics				**Module-Code**	ENET 501
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2
Credit Points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module Coordinator	Prof. B.Battsengel			**Language**	English	

Contents	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. Fleddermann CB. Engineering Ethics. Pearson; 2012. 2. Ibo VDP, Lamber R. Ethics: Technology and Engineering. Wiley; 2011. 3. Baura G. Engineering Ethics: An Industrial Perspective. Elsevier; 2006. 4. Jonas H. The Imperative of Responsibility. The University of Chicago Press; 1984.
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 501 - ENGINEERING STATISTICS

Module Title	Engineering Statistics				**Module-Code**	ENST 501
Duration	1 Semester	**Semester**	Spring Semester		**Module-Start**	2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**		48 h
				Individual study		132 h
Module Coordinator	Prof. L.Altangerel			**Language**	English	

Contents	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. Montgomery DC, Runger GC. Applied Statistics and Probability for Engineers. 7th edition. Wiley; 2018. 2. Ryan TP. Modern Engineering Statistics. John Wiley & Sons; 2007. 3. Allen TT. Introduction to Engineering Statistics and Six Sigma. Springer; 2006. 4. Dowdy Sh, Wearden S, Chilko D. Statistics for Research. Third edition. Wiley; 2004.
Form of teaching	Lecture (2 UoI) Recitation (2 UoI)
Assessment methods	Performance assessments, 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 consists of the academic performance during the module accounting for 50% and the individual report + presentation accounting for 50%.

INNE 501 - INNOVATION AND ENTREPRENEURSHIP

Module Title	Innovation and Entrepreneurship			**Module-Code**	INNE 501
Duration	1 semester	**Semester**	Fall/Spring Semester	**Module-Start**	1,2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**	48 h
				Individual study	132 h
Module Coordinator	Prof. Ch.Enkhzaya			**Language**	English
Contents	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. In volatile and unpredictable times, leadership, especially entrepreneurial leadership qualities are vital if innovation should be fostered within organizations. 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. Realize the various options available for developing an entrepreneurial organization in different contexts. 3. Critically reflect on the factors associated with 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 own skills and knowledge and how these can be utilized to exploit a business opportunity. 7. Engage in various exercises such as brainstorming, mapping, role play to develop organizational, leadership, communication, and team-working skills. 8. Assess the validity of certain conclusions based on data and statistical analysis. 9. Explore the information to enable creative decisions to be taken. 10. Explain how entrepreneurship and innovation contribute to broader outcomes (of organizations and communities).				

Literature	1. Heidi NM, Christopher NP, Emma ML. Entrepreneurship. The Practice and Mindset. 2nd edition. Sage Publishing; 2020. 2. Daniel K. Thinking, Fast and Slow. Farrar, Straus and Giroux; 2013. 3. Ries E. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Currency; 2011.
Form of teaching	Lecture (1 UoI) Recitation (1 UoI) Seminar (2 UoI)
Assessment methods	Individual report, simulations, oral presentation (pitching)
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

MREM 502 - RESOURCE ENGINEERING MANAGEMENT

Module Title	Resource Engineering Management			**Module-Code**	MREM 502
Duration	1 Semester	**Semester**	Fall/Spring Semester	**Module-Start**	1,2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**	48 h
				Individual study	132 h
Module Coordinator	Prof. Thomas Hollenberg			**Language**	English
Contents	1. Leadership and Management 2. General Management Principles 3. Overview of Mine and Resource Management 4. Human Resource Management 5. Stakeholder Relationships 6. Production and Operations Management 7. Materials Management 8. Strategic Planning 9. 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 Resource Management, 2. develop and apply Planning, Controlling, Organizing and Leading procedures for resource industry, 3. recognise factors motivating people's behavior in working environment, 4. compare management structures and apply appropriate types to operations; 5. recognise and appraise factors that deal with Strategic Management of Environmental, Safety and Economic Risks				
Literature	1. AuSIMM. Mine Manager's Handbook, AuSIMM. Monograph 26; 2012. 2. The Australasian Institute of Mining and Metallurgy, Second Edition Monograph 27; 2012. 3. Morse PM. Methods of Operations Research. New York: Dover; 2008. 4. Lock D. Project Management (9th Edition), Gower Publishing Limited; 2007. 5. Noakes M, Lanz T. Cost Estimation Handbook. Carlton Victoria, Australia: The Australasian Institute of Mining and Metallurgy. Parkville, Vic; 1993.				

	6. Sloan DA. Mine Management. Chapman and Hall Ltd. London; 1983. 7. Shannon RE. Engineering Management (1st Edition). New York: Wiley; 1980.
Form of teaching	Lecture (4 UoI)
Assessment methods	Examination and academic performance
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 consists of the academic performance during the module accounting for 30% and the module examination accounting for 70%.

COFD 502 - COMPUTATIONAL FLUID DYNAMICS

Module Title	Computational Fluid Dynamics				**Module-Code**	COFD 502
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2
Credit Points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module Coordinator	Prof. N. Battulga			**Language**		English

Contents	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. CFD Module Application Library Manual. COMSOL; 1998-2017. 2. Chung TJ. Computational Fluid Dynamics, Cambridge University Press; 2010. 3. Versteeg H, Malalasekera W. An Introduction to Computational Fluid Dynamics: The Finite Volume Method. 2nd edition; 2007. 4. Anderson DJR. Computational Fluid Dynamics, 1st edition. McGraw-Hill; 1995. 5. Patankar S. Numerical Heat Transfer and Fluid Flow, 1st edition. CRC; 1980.
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 502 - ANALYTICAL METHODS OF FLUID MECHANICS

Module Title	Analytical Methods of Fluid Mechanics				**Module-Code**	AMFM 502
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2
Credit Points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module Coordinator	Prof. N. Battulga			**Language**	English	

Contents	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. Ledoux M, El Hami A. Fluid Mechanics: Analytical Methods. Wiley; 2017. 2. Schlichting H, Gersten K. Boundary Layer Theory. Springer; 2017. 3. White FM. Viscous Fluid Flow. McGraw-Hill; 1991. 4. Sherman FS. Viscous Flows. McGraw-Hill; 1990.
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 502 - STRUCTURAL DYNAMICS

Module Title	Structural Dynamics				**Module-Code**	STDY 502
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**		48 h
				Individual study		132 h
Module Coordinator	Prof. Sungchil Lee			**Language**		English

Contents	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. Paz M, Kim YH. Structural Dynamics: Theory and Computation. Springer; 2018. 2. Fertis DG. Mechanical and Structural Vibrations. Wiley India; 2014. 3. Inman DJ. Engineering Vibrations. Prentice Hall; 1994.
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 %)

SGPR 502 - SIGNAL PROCESSING

Module Title	Signal Processing				**Module-Code**	SGPR 502
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2
Credit Points	4	**Workload**	120	**Contact hours**		36
				Individual study		84
Module Coordinator	Prof. N.Odbileg			**Language**	English	

Contents	The contents of this module include: Continuous and Discrete Signals, Filtering, Sampling, Reconstruction, Signal Convolution and Its Applications, Signal Correlation and Its Applications, Fast Fourier Transform, Wavelet Transform and Its Applications.
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 in Matlab 2. do convolution and correlation of signals by Matlab 3. acquire signals using Data Acquisition Devices 4. apply knowledge of Signal Wavelet Analysis using MATLAB
Literature	1. Wavelet Toolbox for Use with MATLAB. User's Guide. MatWorks Web site; 2020. 2. Weeks M. Digital Signal Processing using MATLAB and Wavelets, 2nd edition; 2011. *3.* Mandal M. Continuous and Discrete Time Signals and Systems, 1st edition; 2007.
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 502 - HYDROMETALLURGICAL METAL EXTRACTION

Module Title	Hydrometallurgical Metal Extraction				**Module-Code**	HMEX 502
Duration	1 semester	**Semester**	Fall/Spring Semester		**Module-Start**	1,2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**		48 h
				Individual study		132 h
Module Coordinator	Prof. M. Bayanmunkh			**Language**	English	

Contents	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 ML. Hydrometallurgy, Fundamentals and Applicationв Wiley; 2013. 2. Jackson E. Hydrometallurgical Extraction and Reclamation. Ellis Horwood Limited; 1986. 3. Weiss NL. SME Mineral Processing Handbook, Vol. 2; 1985.
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 %)

METE 502 - MATERIALS HANDLING, EXTRACTION AND TRANSPORT EQUIPMENT

Module Title	Materials Handling, Extraction and Transport Equipment			**Module-Code**	METE 502
Duration	1 Semester	**Semester**	Fall/Spring semester	**Module-Start**	1,2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**	48 h
				Individual study	132 h
Module Coordinator	Prof. Thomas Hollenberg			**Language**	English
Contents	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. Vergne JDL. Hard Rock Miner's Handbook. Edmonton, Alberta, Canada: Stantec Consulting Ltd; 2014. 2. Tatiya R. Surface and Underground Excavations, 2nd Edition: Methods, Techniques and Equipment. USA: CRC; 2012. 3. The Australasian Institute of Mining and Metallurgy, Second Edition Monograph 27. Cost Estimation Handbook. Carlton Victoria, Australia: The Australasian Institute of Mining and Metallurgy; 2012. 4. SME Society for Mining, Metallurgy and Exploration. SME Mining Engineering Handbook Volume 1 and 2. USA: Cushing-Malloy; 2011. 5. Nichols H, Day D. Moving the Earth: The Workbook of Excavation (Sixth Edition). USA: McGraw-Hill; 2010. 6. Haddock K. Bucyrus Heavy Equipment: Construction and Mining Machines 1880-2008. USA: Iconografix; 2008. 7. Linder U. Mining Methods in Underground Mining. Örebro, Sweden: Atlas Copco Drills AB; 2008 .
Form of teaching	Lecture (4 UoI)
Assessment methods	Examination and academic performance.
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 consists of the academic performance during the module accounting for 30% and the module examination accounting for 70%.

CCSG 502 - CLIMATE CHANGE: THE SCIENCE AND GLOBAL IMPACT

Module title	Climate Change: The Science and Global Impact			**Module-Code**	CCSG 502
Duration	1 semester	**Semester**	Fall/Spring Semester	**Module-Start**	1,2
Credit points	4 CP	**Workload**	120 h	**Contact hours**	48 h
				Individual study	72 h
Module coordinator	Prof. G.Gantuya			**Language**	English

Contents	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. Hidore JJ, Oliver JE, Snow M, Snow R. Climatology: An Atmospheric Science, 3rd edition. Pearson; 2020. 2. Cole MW, Lueking AD, Goodstein DL. Science of the Earth, Climate and Energy. World Scientific Publishing; 2018. 3. Mann ME. The Hockey Stick and the Climate Wars: Dispatches from the Front Lines. Columbia University Press; 2013. 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 %)

PDRW 502 - PROCESS DESIGN IN RAW MATERIAL AND E-WASTE TREATMENT (LIB)

Module Title	Process design in raw material and e-waste treatment (LiB)			**Module-Code**	PDRW 502
Duration	1 Semester	**Semester**	Fall/Spring semester	**Module-Start**	1,2
Credit Points	6 CP	**Workload**	180 h	**Contact hours**	48 h
				Individual study	132 h
Module Coordinator	Prof. T. Purev-Ochir			**Language**	English
Contents	The contents of this module include: 1. Introduction into raw / secondary material processing 2. Literature review 3. Selection and calculation of processing flow diagrams 4. Processing plant layout 5. Case studies 6. Documentation / write up of a small project				
Learning Outcomes	On successful completion of this module, the students should be able to: 1. demonstrate an understanding of recent processing methods, 2. apply knowledge in engineering drafting, planning, and calculation, 3. utilize essential software such as AutoCAD, Citavi, and Origin Pro, 4. effectively write up a small project.				
Literature	1. Deschênes G. Advances in the Cyanidation of Gold. In: Gold Ore Processing. Elsevier; 2016. 2. Schlesinger ME, Sole KC, Davenport WG. Extractive Metallurgy of Copper. Elsevier; 2011. 3. Crundwell F, Moats M, Ramachandran V, Robinson T, Davenport WG. Extractive Metallurgy of Nickel, Cobalt and Platinum Group Metals. Elsevier; 2011. 4. Marsden J, Iain H. Chemistry of Gold Extraction. 2nd ed. Society for Mining Metallurgy, and Exploration, Inc; 2006. 5. Other relevant books and literatures				
Form of teaching	Lecture (2 UoI) Seminar (2 UoI)				
Assessment methods	Individual report + oral presentation				
Associated study program	*M.Sc. in Resources and Technology*				

Prerequisites for participation	
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 502 - ACADEMIC WRITING

Module title	Academic Writing				**Module-Code**	AWEN 502
Duration	1 semester	**Semester**	Fall/Spring semester		**Module-Start**	1,2
Credit points	4 CP	**Workload**	120 h	**Contact hours**		48 h
				Individual study		72 h
Module coordinator	Prof. Ch.Gunpilmaa			**Language**	English	
Contents	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. Murray R. How to write a Thesis. Berkshire. England. McGraw Hill Open University Press; 2011. 2. Chin BA. How to Write a Great Research Paper. NJ, U.S.A.; John Wiley & Sons, Inc; 2004. 3. Rozakis L. Schaum's Quick Guide to Writing Great Research Papers. NY, U.S.A.; McGraw Hill; 1999.					
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%

IANN 502 - INDUSTRIAL ARTIFICIAL NEURAL NETWORK

<table>
<tr><td>Module Title</td><td colspan="3">Industrial Artificial Neural Network</td><td colspan="2">Module-Code</td><td>IANN 502</td></tr>
<tr><td>Duration</td><td>1 Semester</td><td>Semester</td><td>Fall/Spring Semester</td><td colspan="2">Module-Start</td><td>1</td></tr>
<tr><td rowspan="2">Credit Points</td><td rowspan="2">6 CP</td><td rowspan="2">Workload</td><td rowspan="2">180 h</td><td colspan="2">Contact hours</td><td>48 h</td></tr>
<tr><td colspan="2">Individual study</td><td>132 h</td></tr>
<tr><td>Module Coordinator</td><td colspan="3">Prof. P.Ariunbolor</td><td>Language</td><td colspan="2">English</td></tr>
<tr><td colspan="2">Contents</td><td colspan="5">• Introduction to neural networks and architecture
• Basic structure, introduction to Perceptron, Hamming network and Hopfield network.
• MATLAB Training
• Perceptron Learning Rule
• Developing a learning rule for a perceptron (single neuron case and multiple neuron case)
• Review of Vectors: Vector space, spanning a space, orthogonality, inner product, etc
• Supervised Hebbian Learning
• Review Fundamentals of Optimization
• Taylor series, first order and second order optimality, quadratic functions, optimization methods
• Widrow-Hoff Learning
• ADALINE network, mean square errors, LMS algorithm, analysis of convergence, adaptive filter
• Backpropagation
• Multilayer perceptron, function approximation, backpropogation algorithm, architecture, convergence and generalization
• Variations of Backpropagation
• Drawbacks of backpropogation, heuristic modification, numerical optimization
• Associative Learning
• Simple associative network, unsupervised Hebb rule, decay, simple recognition network (instar), simple recall network (outstar)</td></tr>
<tr><td colspan="2">Learning Outcomes</td><td colspan="5">On successful completion of this module, the students should be able to:
1. exhibit a profound grasp of artificial neural network principles, articulating their relevance to earth sciences issues,
2. develop practical programming skills to implement neural networks, applying them effectively in earth sciences problem-solving,
3. evaluate the strengths and limitations of neural networks in addressing earth sciences challenges.
4. apply critical thinking to assess model suitability for diverse scenarios,</td></tr>
</table>

	5. apply mathematical analysis to resolve earth sciences issues through neural network approaches, honing practical problem-solving skills, 6. apply knowledge to address practical earth sciences problems, showcasing competence in selecting appropriate neural network architectures.
Literature	1. Géron A. Hands-On Machine Learning with Scikit-Learn Keras, and TensorFlow; 2019. 2. Aggarwal CC. Neural Networks and Deep Learning: A Textbook; 2018. 3. Raschka S, Mirjalili V. Python Machine Learning; 2017. 4. Bishop CM. Pattern Recognition and Machine Learning; 2016. 5. Rashid T. Make Your Own Neural Network; 2016. 6. Goodfellow I, Bengio Y, Courville A. Deep Learning, 2015.
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 %)

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
Credit points	4 CP	**Workload**	120 h	**Contact hours**	
				Individual study	120 h
Module coordinator	SDGAcademyX Dr. Ts.Ariuntuya			**Language**	English
Contents	• 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	1. 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
Credit points	6 CP	**Workload**	180 h	**Contact hours**		
				Individual study		180 h
Module coordinator	SDGAcademyX Dr. Ts.Ariuntuya			**Language**	English	
Contents	• 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	1. 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
Credit points	6 CP	**Workload**	180 h	**Contact hours**		
				Individual study		180 h
Module coordinator	SDGAcademyX S.Enkhjargal			**Language**		English
Contents	• 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	1. 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						

RESEARCH-ORIENTED MODULES

RSSR 601 - RESEARCH SEMINAR

Module Title	Research Seminar			**Module-Code**	RSSR 601
Duration	1 semester	**Semester**	Fall/Spring Semester	**Module-Start**	1,2,3
Credit Points	2 CP	**Workload**	60 h	**Contact hours**	24 h
				Individual study	36 h
Module Coordinator	Program coordinator			**Language**	English
Contents	A student research seminar is designed to develop various skills and competencies among students such as critical thinking, research proficiency, effective communication, and collaboration.				
Learning Outcomes	After having completed this course, students should be able to 1. enhance critical thinking abilities, 2. evaluate and analyze information, identify biases, and form logical arguments based on available electronic sources, 3. promote the development of advanced research skills for further study and professional careers, 4. prepare a scientific presentation and present to audience.				
	1. Thompson MK. Interdisciplinary Design. Proceedings of the 21st CIRP Conference. KAIST; 2011. 2. Pahl G, Beitz W, Feldhusen J, Grote KH. Engineering Design. Springer; 2007. 3. VDI Guidline 2221. Systematic Approach to the Design of Technical Systems and Products; 1987.				
Form of teaching	Seminar (2 UoIS)				
Assessment methods	Oral presentation				
Associated study program	*M.Sc. in Resources and Technology*				
Prerequisites for participation					
Requirements for receiving credit points	Regular attendance and the oral presentations during the module.				
Grading system	The final grade consists of the attendance during the module accounting for 50% and the presentation accounting for 50%.				

ADRP 601 - ADVANCED RESEARCH PROJECT

Module Title	Advanced Research Project			**Module-Code**	ADRP 601
Duration	1 semester	**Semester**	Spring Semester	**Module-Start**	2
Credit Points	12 CP	**Workload**	360 h	**Contact hours (supervised teamwork)**	24 h
				Individual study	336 h
Module Coordinator	The director of the graduate school			**Language**	English
Contents	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. Thompson MK. Interdisciplinary Design. Proceedings of the 21st CIRP Conference. KAIST; 2011. 2. Pahl G, Beitz W, Feldhusen J, Grote KH. Engineering Design. Springer; 2007. 3. VDI Guidline 2221. Systematic Approach to the Design of Technical Systems and Products; 1987.				
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 601 - MASTER THESIS

Module Title	Master Thesis				**Module-Code**	MAST 601
Duration	1 semester	**Semester**	Fall/Spring semester		**Module-Start**	2,3
Credit Points	30 CP	**Workload**	900 h	**Contact hours**		
				Individual study		900 h
Module Coordinator	Supervisors			**Language**	English	

Contents	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 (20 min presentation followed by a 20 min discussion)
Associated study program	*M.Sc. in Resources and Technology*
Prerequisites for participation	Completion of the 1st and 2nd semester and at least 45 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).