Master Degree
Mining Engineering

1. Introduction

The Department of Petroleum & Mining Engineering covers in its B.Sc. programme the two specialties, namely: Petroleum Engineering and Mining Engineering. Our partner university (Koya) will prepare the M.Sc. programme in Petroleum Engineering and our department at TIU is providing here the M.Sc. programme in Mining Engineering. We will try to cover various advanced subjects in this field to enable our M.Sc. candidates to raise their level in Mining Engineering to a postgraduate level and to enable them to take a leading role in this natural resources field.

2. Aims and Objectives

The objectives of this M.Sc. Programme in Mining Engineering is to serve the mining industry with highly qualified staff who can take a leading role in the development and progress of the relatively new field of mining industry in the Kurdistan Region of Iraq. This will help in the proper and efficient exploitation of the available mineral wealth in the three main governorates in the region (Duhok, Erbil and Sulaymania). The M.Sc. holders in Mining Engineering will also be beneficial to the fields of cement industry, road pavement, steel industry and construction industry.

3. Instrumental Capabilities

The courses that are covered are all advanced and core subjects and of great importance in the field of Mining Engineering.
Other elements and virtues are availability of experienced staff and Laboratory equipment. The department already has the following labs:

- **Reservoir Engineering lab**
- **Drilling Engineering Lab**
- **Mining and Mineral Processing Lab**
- **Petroleum Fluid Lab**
- **Fluid Mechanics Lab**
- **Thermodynamics lab**
- **Computer lab**

It is believed that an MSc course will benefit the region greatly by providing qualified engineers that could serve in both higher educations (Universities) as well as industry. This will help localization of jobs in higher qualified professions.

4. Eligible Applicants:

Any bachelor's degree holder in the following specializations can apply to our M.Sc. programmes:

1. Petroleum Engineering
2. Mining Engineering
3. Petroleum and Mining Engineering
4. Natural Resources Engineering
5. Mineral Resources Engineering

5. Staff:

In addition to the prominent staff of the partner university (Koya), our Petroleum and Mining Engineering Department is supported by highly qualified staff with degrees from reputable international and local universities, enabling the effective and efficient delivery of our two M.Sc. programmes.

#	Name	Academic Rank	Degree/University/Year	Field	St. Supervision
1	Fadhil Ali	Professor	PhD, Salahaddin University, 2001	Geophysics	3
2	Hamed M. Jassim	Professor	PhD, Leoben School of Mines-Austria, 1990	Mining Engineering (Tunneling Eng.)	4
3	Ayad M. Al-Quraishy	Professor	PhD, China University of Geosciences, 2004	Geodetection and IT	3
4	Ziyad J. Talabany	Assistant Professor	M.Sc., Baghdad University, 1975	Chemical Engineering-Heat Transfer	3
5	Ahmed M. Aqrawi	Assistant Professor	PhD., Baghdad Univ., 2000	Geology-Industrial and Applied Mineralogy	2
6	Tariq Hama Karim Kakahama	Professor	PhD., Baghdad University, 1992	Soil Physics	2

6. Courses

- Year 1: Taught Courses (60 ECTS)
- Year 2: M.Sc. Research and Dissertation (60 ECTS)

Year 1 - Semester 1 (30 ECTS)

	Subject	Lecturer	Weekly hours		Credits
			Theory	Practical	
1	Special Topics in Mining Engineering	Prof. Dr. Hamed M. Jassim	3	0	6
2	Advanced Engineering Mathematics	Prof. Dr Tariq Hama Karim Kakahama	3	0	6
3	Advanced Industrial Rocks	Assist. Prof. Dr. Ahmed M. Aqrawi	3	0	6
4	Advanced Mining Geophysics I	Prof. Dr. Fadhil Ali Ghaib	3	0	6
5	Advanced Geoinformatics for Mineral Exploration	Prof. Dr. Ayad M. Al-Qurayshi	3	0	6
				Total	30

Year 1 - Semester 2 (30 ECTS)

	Subject	Lecturer	Weekly hours		Credits
			Theory	Practical	
1	Underground Mine Openings and Tunneling Engineering	Prof. Dr. Hamed M. Jassim	3	0	6
2	Advanced Industrial Minerals	Assist. Prof. Dr. Ahmed M. Aqrawi	3	0	6
3	Advanced Computer Programing	Dr Ezideen Hasso	2	2	6
4	Advanced Research Methodology and Academic Writing	Prof. Dr. Ayad M. Al-Qurayshi	3	0	6
5	Advanced Mining Geophysics II	Prof. Dr. Fadhil Ali Ghaib	3	0	6
				Total	30

Year 2:

M.Sc. Research and Dissertation (60 ECTS credits)

- All MSc students should attend a 20-hour professional development training program, which is a pre-requirement before submitting the master's dissertation. This training program covers: research methodology in engineering, academic writing, ethics in engineering, presentation skills, and seminar preparation.
- Every three months, each MSc student should present a seminar to show the progress of his/her research to the postgraduate committee in the department.

Course Description:

Semester 1:

1. Special Topics in Mining Engineering

Description:

A- Mine transport using belt conveyors: It includes: Construction of belt conveyor, Belt conveying over long distances, Material piling on belt conveyor, Belt tensions and non-slip ratio, Factors affecting the use of belt conveyors: (Straight line alignment, angle of belt inclination, Sizes of carried rock lumps), The carrying capacity of belt conveyors, Belt strength, Power requirements, Chain Conveyors, Bucket elevators.

B- Fluid transport of solid materials: It includes: Hydraulic systems (Open flumes, Pipeline transport, Pneumatic transport, Mechanics of fluid transport, Fluid transport of very fine solids.

C- Mine transport using rope haulage: It includes: Types of rope haulage (1- One group of waggons: a- Main rope haulage, b- Tail rope haulage, c- Main and tail rope haulage, d- Reversible endless, 2- Two groups of waggons: a- Balanced main rope, b- Balanced tail rope, c- Balanced reversible endless, 3- Many groups of waggons: Endless rope haulage. Wire ropes, Mass and strength of wire ropes, Rope safety factors, Rope haulage calculations, Types of electric motor rating, Examples.

Objectives:

The objectives of this course are to raise the level of knowledge and understanding of M.Sc. students in the above-mentioned special topics (Mine transport using belt conveyors, Fluid transport of solid materials, Mine transport using rope haulage) and to upgrade their scientific and practical skills to the level which enables them to design and manage a mining project or undergo an M.Sc. research in Mining Engineering.

Learning Outcomes:

A student completing this course will be able to understand and comprehend the details of the above-mentioned topics. He/she can then manage the practical applications and run a practical program or manage an advanced project in Mining Engineering.

He/she will be able to design, run and manage the transport of mining materials, ore deposits and industrial rocks and minerals both underground and on the surface.

References:

1- Mechanics of bulk material handling, By Dr. N. Brook, London Butterworth Publications.
2- Mining Engineering Handbook, Society of Mining Engineers, Volume 1 and 2, SME (Society of Mining Engineers) Publications.
3- Underground Mining Methods Handbook, Society of Mining Engineers, Volume 1 and 2, SME (Society of Mining Engineers) Publications.

2. Advanced Engineering Mathematics

Description:

Review of methods of integration, Classification differential equations based on different criteria, Wronskian test for independence of solutions, Solutions of first, second and high order differential equations. Variation of parameters, the Cauchy-Euler equation. Application of ordinary in different fields of engineering. Solving differential equations with variable coefficients using Laplace transform and series solution. Double and triple integrals, parametrization, line Integral and Green's theorem. Solving systems of linear algebraic equations. Special functions: (Gamma, Beta, Legendre and Bessel functions), Periodic Function, Fourier Series, Dirichlet Conditions, Orthogonal functions, Half range expansion, solution of partial differential equations (steady and unsteady heat equations, vibration equation, etc.), numerical Solutions of partial differential equations, measurement of spread of data, skewness and kurtosis, test of hypothesis, parametric and no-parametric tests, correlation and regression, least squares and maximum likelihood techniques for finding the parameters of the best-fit equations

Objectives:

- To solve differential equations by using different techniques based on the type, order, homogeneity, nature of coefficients and linearity of the differential equation
- To make students analytic regarding building up of mathematic models for solving different problem in the fields of Engineering.
- Use of approximate methods to solve differential equations when the variables can not be defined on the boundaries of the problems
- To build empirical (regression models) after examining the assumptions.
- To perform the tests of normality using different techniques and carrying out testing hypothesis

Learning Outcomes:

- To test the independency of solutions using Wronskian method
- To solve differential equations by selecting the suitable method in different disciplines of engineering.
- To build up mathematical models via using ordinary and partial differential equations.
- To determine the coefficients of different terms of the solutions of partial differential using the orthogonality property of Fourier Series
- To determine sum of series by using Parseval identity
- To solve differential equations with variable equation efficiently Using Laplace transform
- To Use Green's theorem for complicated line integral
- To select the proper test of testing hypothesis
- To Examine, homogeneity and normality of data sets besides identification of outliers.
- To build empirical model based on regression analysis

References:

1. E. Kreyszig, "Advanced Engineering Mathematics", 10th edition, Wiley, 2015.

2. Jain R. K. and S.R.K Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 5th edition, 2016.
3. Thomas and Finney, Calculus and Analytic Geometry, Narosa Publishing House, 2010.

4. Magrab, E.B. Engineering Statistics. Springer, 2022

5. Devore, J.L. Probability and Statistics for Engineering and Sciences, 8th edition. Prentice-Hall Mathematical Series. 2010.

3. Advanced Industrial Rocks

Description:

1- Introduction; definition, importance of nonmetallic, features of the industrial rocks and minerals
2- Classification; conventional treatment, genetic classification, Bates classification
3- Industrial sedimentary rocks; sand and gravel, sandstone, limestone and dolomite,
4- Industrial metamorphic rocks; slate, marble, quartzite, serpentinite.

5- Industrial igneous rocks; granite, basalt and diabase, pumice and pumicite, perlite.
6- Cement industry; types of cement, raw materials, and manufacturing procedure
7- Manufacture of lime, raw materials, physical operation, and chemical conversions
8- Brick industry, raw material, types of bricks, manufacturing

Objectives:

- To provide an in-depth understanding of industrial rocks' classifications, occurrences, and economic significance.
- To discuss the environmental and economic aspects related to industrial rocks.
- Case studies on cement and brick industries

Learning Outcomes:

By the end of this course, students will be able to:

1. Identify and classify various industrial rocks based on their properties and occurrences.
2. Analyze the processing and beneficiation methods for various industrial rocks
3. Evaluate the industrial applications of specific rock in key industries.
4. Assess the environmental and economic implications of industrial mineral exploitation.

5. Apply knowledge from case studies in cement and ceramic as an important industry in our region

References:

1. Kogel, J.E., Trivedi, N.C., Barker, J.M., and Krukowski, S.T.(2009).Industrial minerals and rocks commodities, Market, and Uses, &Edition, Society for Mining, Metallurgy and Exploration, Inc.USA
2. Harben, P.W., & Kuzvart, M. (1996). *Industrial Minerals: A Global Geology.* Industrial Minerals Information Ltd.
3. Evans, A.M. (1993). *Ore Geology and Industrial Minerals: An Introduction.* Blackwell Science.
4. Kogel, J.E., Trivedi, N.C., Barker, J.M., & Krukowski, S.T. (2006). *Industrial Minerals & Rocks: Commodities, Markets, and Uses.* Society for Mining, Metallurgy, and Exploration.
5. Carr, D.D. (1994). *Industrial Minerals and Rocks.* SME.
6. Wills, B.A., & Finch, J. (2015). *Wills' Mineral Processing Technology.* Butterworth-Heinemann.

4. Advanced Mining Geophysics I

Description:

Introduction to Geophysics:

Definitions: Geophysics, Geophysics and Geology

Applied Geophysics, Pure Geophysics, Environmental Geophysics, Passive Geophysical Methods, Active Geophysical Methods, Exploration Geophysics methods

Gravity Method:

Definition, Applications, Principles, Newton’s law, Acceleration of gravity, Magnitude of Gravity Anomaly, Stages of a gravity survey, Types of gravity measurements; Absolute and Relative, Units, Gravity Corrections (Reductions), Instrument drift, Free Air Correction, Bouguer Correction, Latitude, Correction and Terrain (Topographic) Correction, Gravimeters: stable and unstable, Field Activities:

Interpretation of Gravity Data

Separation of Anomalies

Graphical Residualizing, Mean Value Method

Qualitative and Quantitative interpretations

Magnetic Method:

Introduction, Applications, Comparison with Gravity, Basic concepts, Magnetic poles, Magnetic elements, Magnetic force, Flux and induction, Intensity of Magnetization I (Polarization)

Magnetic susceptibilities of some rocks and minerals, Remanent Magnetism (Remanance) and Curie Temperature, The earth's magnetic field, source, Surveying, equipment and Magnetic Anomalies, Variations of magnetic field and corrections, Interpretation.

Objectives:

This course offers a structured exploration of the application of physical principles to subsurface investigations at both local and regional scales. A foundational knowledge of geology, physics, and mathematics is essential for students to effectively engage with geophysical concepts. The course focuses on two primary geophysical methods, each based on distinct rock properties which are density and magnetic susceptibility. Students will develop the skills necessary to acquire, process, and interpret geophysical data within a geological context. By the end of the course, they will be equipped to select and apply appropriate geophysical methods to solve various geological challenges.

Learning outcomes:

Students will explore the significance of two key potential methods in geophysics: gravity and magnetic methods. They will develop the ability to identify and apply the most appropriate geophysical technique for addressing specific geological challenges, such as resource exploration and structural mapping. Additionally, they will gain a deeper understanding of the crucial role these methods play in mining engineering and mineral exploration, emphasizing their importance in optimizing resource extraction and effective resource management.

References:

- Reynolds, J.M. (1997), An Introduction to Applied and Environmental Geophysics: John Wiley and Sons. 796p.
- Dorbin, M.B. (1976-1983), Introduction to Geophysical Prospecting: McGraw Hill book comparison. 630p.

5. Advanced Geoinformatics for Mineral Exploration

Description:

This course covers advanced geoinformatics methodologies and their applications in mineral exploration. Topics include geological remote sensing, GIS-based mineral potential mapping, hyperspectral remote sensing, geostatistical modeling, and AI-driven spatial data analysis. The course also focuses on the integration of multisource geospatial data, including remote sensing, geophysics, and geochemistry, for mineral resource assessment. Case studies and recent advancements in geoinformatics tools for mineral exploration will be discussed.

Objectives:

- Provide an in-depth understanding of advanced geoinformatics concepts and their applications in mineral exploration.

- Equip students with knowledge of remote sensing and GIS techniques for geological mapping and mineral potential assessment.
- Explore the integration of multispectral, hyperspectral, and geophysical data for enhanced mineral prospecting.
- Discuss modern machine learning and artificial intelligence approaches in geospatial analysis for mineral exploration.
- Develop critical thinking and problem-solving skills through case studies of real-world mineral exploration projects.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

- Explain the advanced principles of remote sensing and GIS applications in mineral exploration.
- Analyze and interpret satellite imagery and geospatial datasets to identify prospective mineral zones.
- Utilize geostatistical and machine learning techniques for mineral prospectivity mapping.
- Evaluate case studies on mineral exploration using geoinformatics methodologies.
- Assess the integration of geophysical, geochemical, and remote sensing data in mineral resource assessments.

References:

Primary Textbooks:

1. **Sabins, F. F., & James, M. (2020).** Remote Sensing: Principles and Interpretation (4th ed.). Waveland Press.
2. **Van Der Meer, F. D., & De Jong, S. M. (2021).** Remote Sensing and Digital Image Processing for Mineral Exploration. Springer.
3. **Carranza, E. J. M. (2018).** Geochemical Anomaly and Mineral Prospectivity Mapping in GIS. Elsevier.
4. **Bonham-Carter, G. (2014).** Geographic Information Systems for Geoscientists: Modelling with GIS. Elsevier.

Supplementary References:

5. **Tucker, C. J. (2022).** Hyperspectral Remote Sensing for Mineral Exploration. CRC Press.
6. **Richards, J. A. (2013).** Remote Sensing Digital Image Analysis: An Introduction (5th ed.). Springer.
7. **Schowengerdt, R. A. (2019).** Remote Sensing: Models and Methods for Image Processing (4th ed.). Academic Press.
8. **Bishop, T. F. A., & Minasny, B. (2018).** Geostatistics for Natural Resources Evaluation. Oxford University Press.

9. **Li, Z., & Yang, X. (2023).** Machine Learning and Geoinformatics for Mineral Resource Exploration. Wiley.

Semester 2:

1. Underground Mine Openings and Tunnelling Engineering

Description:

This course covers the following topics:

Underground openings and tunnel types and their types and historical developments, Geological and geotechnical investigations of tunnel sites, Selection of tunnel axis, Nature of stresses around tunnels, Primary and secondary stresses, Types of tunnel support, Interaction between ground and tunnel support, Tunnel design methods: (Empirical design methods, Observational design methods, Analytical design methods), Rock classification systems: (Terzaghi's classification, Lauffer's classification, Deer's Rock Quality Designation (RQD), Rock Structure Rating (RSR) concept), Bieniawski's classification (or Rock Mass Rating (RMR), Barton's classification (Q system or NGI system), Geotechnical measurements.

Objectives:

- It provides the M.Sc. students with some understanding of the underground mine openings and their different classifications and applications.
- It is intended to provide the students with the sizes of mine openings and the factors which affect the sizes.
- It is intended to provide the students with the types of tunnels and their historical background and development.
- It is intended to provide the students with Geological and Geotechnical Investigations of Tunnel Sites.
- It is intended to provide the students with the Exploration Borings; Selection of Tunnel Path (Tunnel Axis).
- It is intended to provide the students with the different tunnel design methods
- It is intended to provide the students with the different Rock Mass Classification Systems.

Learning Outcomes:

Upon the successful completion of the course, the students will be able to:

- Understand and distinguish between the different types of underground openings and tunnels.
- Design and manage the excavation of underground mine openings and underground caverns.
- Understand the different types of tunnels and be able to design them.
- Be able to comprehend, calculate and analyse the stresses around underground openings and tunnels.
- Be able to run and analyse geomechanic measuring programme for the excavated underground openings and tunnels
- Understand the different types of rock classification systems and comprehend the necessary factors and parameters which are needed to build and characterize each classification system.
- Be able to act as project managers of underground mine openings and tunnel projects.

References:

1-Underground excavations in rock, by Hoek and Brown

Institution of Mining and Metallurgy, London, 1980

2-Rock mechanics design in mining and tunneling, by Z. T. Bieniawski

Publisher. A.A. Balkema ; Publication date. January 1, 1984 ; ISBN-10. 9061915074 ; ISBN-13. 978-9061915072.

3-Engineering Classification of Rock Masses for the Design of Tunnel Support,

By Barton, N., Lien, R. and Lunde, J.

Rock Mechanics, 6, 189-236. (1974)

2. Advanced Industrial Minerals

Description:

This course provides an in-depth study of industrial minerals, focusing on their geological occurrences, mineralogical characteristics, processing methods, applications, and economic importance. Students will gain a comprehensive understanding of the role of industrial minerals in various industries. The topics of this course include the following:

1- Introduction to Industrial Minerals

- Definition and classification
- Exploration stages of Economic mineral deposits (nonmetallic ores)
- Mining operations

2: Mineral Processing Technology (Treatment and Beneficiation)

- Optical and radioactive separation
- Crushing and grains (particles) size separation
- Specific gravity separation
- Flotation separation
- Electrical conductivity separation
- Thermal treatment separation
- Magnetic separation

3: Sedimentary Industrial Minerals and Their Properties

- Clays Mineral
- Carbonates (Calcite, Aragonite, Diatomite)
- Phosphates and sulfates (gypsum, anhydrite)

4: Igneous Industrial Minerals and Their Properties

- Feldspar Minerals
- Nepheline syenite
- Perlite
- Quality control and product specifications

5: Metamorphic Industrial Minerals and Their Properties

- Mica minerals
- Talc, asbestos,
- Alumina- Silicate mineral (Andalusite, Sillimanite)
- Garnet

6: Ceramic industry; basic raw materials, chemical conversions, classification.

Objectives:

- Understand the geological formation, classification, and distribution of industrial minerals.
- Understanding the mineralogical chemical and physical properties of industrial minerals.
- Industrial applications of various minerals,
- Explore sustainable mining practices and environmental considerations related to industrial mineral extraction and processing.

Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Classify industrial minerals based on their physical and chemical properties.
- Interpret the geological settings and depositional environments that lead to the formation of industrial minerals.
- Apply appropriate analytical techniques to identify and characterize industrial minerals.
- Design beneficiation and processing strategies for different industrial minerals to optimize their industrial use.
- Critically assess the environmental impact of industrial mineral extraction and propose sustainable solutions.

References:

Recommended Textbooks:

1. Harben, P.W., & Kuzvart, M. (1996). *Industrial Minerals: A Global Geology*. Industrial Minerals Information Ltd.
2. Christidis G.E.(2011) Industrial minerals: Significance and important characteristic. European Mineralogical Union Notes in Minerals.
3. . (1993). *Ore Geology and Industrial Minerals: An Introduction*. Blackwell Science.
4. Virginia T. McLemore and George S. Austin(2017). Industrial Minerals and Rocks. New Mexico Geological Society
5. Carr, D.D. (1994). *Industrial Minerals and Rocks: Commodities, Markets, and Uses*. Society for Mining, Metallurgy, and Exploration.
6. Kogel, J.E., Trivedi, N.C., Barker, J.M., and Krukowski, S.T.(2009).Industrial minerals and rocks commodities, Market, and Uses, &Edition, Society for Mining, Metallurgy and Exploration, Inc. USA
7. Ciullo, P. A,1996 INDUSTRIAL MINERALS AND THEIR USES, Noyes Publication

Additional References:

Prasad, N. (2021). *Geology of Industrial Rocks and Minerals*. CRC Press.

Chatterjee, K.K. (2004). *Uses of Industrial Minerals, Rocks, and Freshwater Pearls*. New Age International.

British Geological Survey Reports on Industrial Minerals.

USGS Reports and Statistics on Industrial Minerals.

Journals: *Industrial Minerals*, *Mineral Economics*, *Resources Policy*.

3. Advanced Computer Programing

Description:

This course covers the principles, selection, and integration of sensors and actuators in engineering applications. Topics include types of sensors, signal conditioning, actuator technologies, and system interfacing. Applications in robotics, automation, and control are explored. Practical sessions provide hands-on experience in configuring sensors and actuators.

Objectives:

Learning Outcomes:

- Identify and select appropriate sensors and actuators for specific applications.
- Design signal conditioning circuits for sensor data acquisition.
- Integrate sensors and actuators into mechatronic systems.
- Analyze and troubleshoot sensor-actuator networks.
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References:

4. Advanced Research Methodology and Academic Writing

Description:

This course covers advanced research methodologies, emphasizing their application in petroleum and mining engineering. It introduces students to research problem identification, research design, data collection techniques, statistical analysis, and the use of research software. The academic writing component focuses on structuring research papers, thesis writing, technical reports, and scientific publications. The ethical aspects of research, plagiarism prevention, and referencing styles will be explored. The course also includes practical sessions on literature review techniques, research proposal preparation, and manuscript writing for scientific journals.

Objectives:

This course aims to:

- Provide students with an advanced understanding of research methodologies relevant to mining engineering.
- Develop students' skills in designing and conducting research studies, including problem identification, hypothesis formulation, and data collection.
- Train students in qualitative and quantitative research techniques, including statistical analysis.
- Enhance students' ability to critically review scientific literature and construct a well-organized research proposal.
- Strengthen academic writing skills, focusing on technical reports, journal articles, and thesis writing.
- Familiarize students with ethical considerations and plagiarism avoidance in research.
- Develop students' ability to effectively present and publish their research findings.

Learning Outcomes:

Upon completion of this course the M.Sc. students will be able to:

- Comprehend and apply various research methodologies in mining engineering.
- Formulate well-structured research questions, objectives, and hypotheses.
- Conduct systematic literature reviews and synthesize existing research findings.
- Select and implement appropriate research designs, sampling techniques, and data analysis methods.
- Apply advanced statistical methods to analyze and interpret data.

- Write high-quality academic papers, reports, and theses using proper academic conventions.
- Demonstrate knowledge of research ethics, including citation standards and plagiarism avoidance.
- Prepare research proposals and manuscripts suitable for publication in indexed journals.
- Effectively present research findings using scientific communication techniques.

References:

Primary Textbooks:

1. Creswell, J. W. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th Ed.). SAGE Publications.
2. Day, R. A., & Gastel, B. (2020). *How to Write and Publish a Scientific Paper* (9th Ed.). Cambridge University Press.
3. Kothari, C. R. (2019). *Research Methodology: Methods and Techniques* (4th Ed.). New Age International.
4. Montgomery, D. C. (2020). *Design and Analysis of Experiments* (10th Ed.). Wiley.

Supplementary References:

5. Yin, R. K. (2018). *Case Study Research and Applications: Design and Methods* (6th Ed.). SAGE Publications.
6. Walliman, N. (2022). *Research Methods: The Basics* (2nd Ed.). Routledge.
7. Belcher, W. L. (2019). *Writing Your Journal Article in 12 Weeks: A Guide to Academic Publishing Success*. University of Chicago Press.

Online Resources & Journals:

- Elsevier's *Journal of Mining Science*
- *International Journal of Mining Engineering and Mineral Processing*
- IEEE Xplore Digital Library

5. Advanced Mining Geophysics II

Description:

Electrical Methods:

Resistivity method:

Introduction and principles, Ohm's law and archie's law, Semi-infinite medium, Factors affecting resistivity, Electrode Array, Schlumberger, winner and others, Vertical electrical sounding (VES), Constant separation traversing (CST), Quantitative approach, Geo-electric sections, 2D survey principles.

Self-Potential (SP) method:

Introduction and brief history, Theory, Limitation, Equipment, Conducting a survey, Topographic and Magnetic storm problems, Interpretations.

Ground Penetrating Radar (GPR) Method:

GPR Principles, Propagation and reflection of radio waves, Antenna directivity patterns, Depth penetration, Relation to Reflection Seismics, GPR operation, GPR acquisition modes, Application, Equipment, Interpretations.

Radioactive Method:

Radioactive Decay, Radioactive Minerals, Radiation Measured Units, Radiation Sources, Artificial and Natural Resources, Radio nuclides Series Minerals, Field activities, Interpretations.

Objectives:

This course provides a structured exploration of how physical phenomena are applied to subsurface investigations at both local and regional scales. At this stage, students are expected to have a fundamental understanding of geology, which they do, along with a strong grasp of general physics and mathematics, both essential for studying geophysics.

Students will develop a thorough understanding of various geophysical techniques, each based on specific rock properties such as density, electric conductivity and radiation properties. The course is designed to equip students with the skills needed to acquire, process, and interpret geophysical data within a geological framework. By the end of the course, they will be capable of selecting appropriate methods to address different geological challenges.

Learning outcomes:

Students will explore the significance of various given geophysical methods, including resistivity, self-potential, ground-penetrating radar, and radiometric techniques, in investigating subsurface structures. By evaluating different geological scenarios, they will learn to identify and apply the most suitable geophysical method for solving specific geological challenges, such as resource exploration and structural mapping. Additionally, they will gain insight into the essential role of geophysics in mining engineering and mineral exploration, highlighting its importance in optimizing resource extraction and management.

References:

- Reynolds, J.M. (1997), An Introduction to Applied and Environmental Geophysics: John Wiley and Sons. 796p.
- Dorbin, M.B. (1976-1983), Introduction to Geophysical Prospecting: McGraw Hill book comparison. 630p.