MINING ENGINEERING

About the Program

The Robert M. Buchan Department of Mining at Queen's has prepared global mining industry leaders for more than 120 years. It is today not only the largest mining department in Canada but among the largest in the world. In fact, Queen's mining engineers account for some 33 percent of all Canadian mining and mineral processing engineers who have graduated from Canadian universities.

As technology evolves and the global economy changes, our students and researchers play a key role in defining the state of the art in mining. In close collaboration with industry partners, our faculty and students work to make mining operations safer, more efficient, more productive, less impactful on the natural environment, and more cost effective.

Mining has close relationships with Mechanical and Geological Engineering through cross appointments of the Chair in Mine Mechanical Engineering and the Stollery Professorship in Mining and Geology. Graduate students benefit from courses in these departments, as well as courses in Civil, Chemical and Geological Engineering and Geography. The Department offers the degrees of Master of Applied Science (M.A.Sc.), Master of Engineering (M.Eng.) and Doctor of Philosophy (Ph.D.) with specializations in Mining Engineering and Mineral Extraction.

An engineering degree from The Robert M. Buchan Department of Mining at Queen's, with its excellent recognition internationally, equips graduates to become highly employable in the mining industry not only in Canada but worldwide.

Areas of Research

Faculty Member	Research Area
Laeeque Daneshmend	Machine Design, Equipment Maintenance, Maintenance Management, Reliability Analysis, Systems Modeling, Simulation and Control, Mining Automation, Telerobotics.
Ahmad Ghahreman	Hydrometallurgy and Biohydrometallurgy, Mineral Processing Wastes and their Remediation, Electrochemical Dissolution of Complex Minerals (fundamental studies), Flowsheet Design and Modeling.
Charlotte Gibson	Integration of mining and processing systems, machine learning applications in mineral processing and metallurgy, process development for minerals used in energy storage applications, oxide mineral flotation.
Anne Johnson	Management of Social Risk, Sustainability Reporting and Metrics, Mining Law and Policy, Community Relations.
Takis Katsabanis	Detonation Physics, Blasting, Fragmentation, Vibration.
Sadan Kelebek	Mineral Processing Technology, Process & Tailings Environment, Computer Assisted Process Analysis, Complex Sulphides and Pyrrhotite Rejection.
Julian Ortiz	Geostatistics, Stochastic Modeling of Ore Deposits, Sampling and QA QC, Geometallurgical Modelling.
Chris Pickles	Processes and the Environment, Advanced Pyrometallurgy, Process Engineering for Metals Extraction, Advanced Metals Extraction.
Asli Sari	Surface and Underground Mine Planning, Data Analysis, Machine Learning Applications in Mine Optimization, Fleet Management, Mine Automation.

Abbas Taheri	Engineering properties and Behaviors of Rocks, Backfill Material and Expansive Soils, Experimental Geomechanics, Modeling of surface and Underground Excavations, Soil stabilization and improvement methods, Deep and High-Stress Mining
Qian Zhang	GHG emission accounting and footprint analysis, Sustainable cities and infrastructure in life-cycle thinking, Transboundary air pollution and demand-side management, Integrated urban water management and water-energy-climate nexus, Valueadded-oriented resource efficiency for the circular economy, Trade-offs among Sustainable Development Goals (SDGs).

Departmental Facilities

The Robert M. Buchan Department of Mining is located in Goodwin Hall, which provides lecture, laboratory and study facilities. The on-campus laboratories include a Rock Mechanics laboratory, Mine Environment laboratory, Computer Planning facilities, and several Mineral Processing laboratories. The department also operates an Explosive Test Site in Hinchinbrooke Township, near Kingston. Laboratories are fully equipped for the programs offered. In addition, they include extensive equipment for advanced study and research in the various fields of major interest. The facilities allow undergraduate courses to be conducted in close proximity to graduate study and research. As a result, sound professional practice can be emphasized while the potential for future development is demonstrated.

Programs of Study

Applicants are accepted under the general regulations of the School of Graduate Studies and Postdoctoral Affairs. Applications to the M.Eng., M.A.Sc. and Ph.D. programs from other related engineering and science programs are encouraged. These would include, Mechanical Engineering, Geological Engineering, Civil Engineering and Physics programs for mining projects and Metallurgical Engineering, Chemical Engineering and Chemistry programs for mineral processing projects.

Funding

A minimum funding guarantee for eligible students at the Master's level of $ 25,000 and at the Ph.D. level of $ 25, 000 per year is available. M.Eng students are self-funded.

Teaching Assistantships may be offered to students throughout the academic year.

Registered full-time students who are in good academic standing with Queen's are eligible for a wide range of internal and external scholarship and bursary awards.

Faculty

Head
Ortiz , J.

Coordinator of Graduate Studies
Pickles, C.A.

Professor
Daneshmend, L.K.[1], Kelebek, S., Pickles, C.A.

Associate Professor
Ghahreman, A., Katsabanis, P.D., Ortiz, J.[2], Taheri, A.[3]

Assistant Professor
Gibson, C. E., Johnson, E.A., Sari, A., Zhang, Q.

Adjuncts
Davis, B., Hodge, R.A.

Emeritus Professor
Archibald, J.F., McKinnon, S.D.[4]

1. Noranda-Falconbridge Chair in Mine-Mechanical Engineering.
2. Stollery Professor in Mining Engineering and Geological Sciences and Geological Engineering.
3. Chair in Mine Design.
4. Former Chair in Mine Design

Programs

- Mining Engineering - Doctor of Philosophy (https://queensu-ca-public.courseleaf.com/graduate-studies/programs-study/mining-engineering/mining-engineering-phd/)
- Mining Engineering - Graduate Diploma in Social Performance Management in the Extractive Industries (https://queensu-ca-public.courseleaf.com/graduate-studies/programs-study/mining-engineering/mining-engineering---graduate-diploma-social-performance-management-extractive-industries/)
- Mining Engineering - Master of Applied Science (https://queensu-ca-public.courseleaf.com/graduate-studies/

programs-study/mining-engineering/mining-engineering-masc/)

- Mining Engineering - Master of Engineering (https://queensu-ca-public.courseleaf.com/graduate-studies/programs-study/mining-engineering/mining-engineering-meng/)

Courses

All courses are 3.0 credit units, except MINE 899 and 999, which are 6.0 credit units.

APSC 801 Master of Engineering Foundations
An introduction to the Master of Engineering (MEng) graduate studies program at Queen's University. The course provides students with essential administrative information, an introduction to information literacy within the Faculty of Engineering and Applied Science, as well as an overview of the various support services on campus. Additionally, the course contains several modules on professional and career skills. This non credit course is comprised of a number of individual modules, and its completion is a requirement to graduate from the MEng program. Graded on a Pass/Fail basis.
Prerequisite: Enrolment in the MEng program.
Exclusion: Students not enrolled in the MEng program.

APSC 810 Teaching and Learning in Engineering
This course is an introduction to learning principles and effective teaching in engineering, intended to prepare for roles like teaching assistant, university course instruction, or training in engineering industry. The course includes relevant theories of teaching and learning with practical elements like classroom management, designing sessions and assessments, signature engineering teaching approaches, and using digital pedagogies.

APSC 812 AI Ethics and Society
This course investigates the ethical implications of Artificial Intelligence (AI) as a social, technological and cultural phenomenon. Given the increasing use of intelligent systems for decision-making and autonomous control, it is essential that designers and developers are aware of the ethical and social implications that AI can have. The course materials will examine fundamental ethical principles related to the application of AI and investigate its influence in a number of industries including self-driving vehicles, healthcare, law and defense. The course will also examine the delicate balance between innovations in AI versus regulation, privacy, and individual rights. This course is graded on a Pass/Fail basis.

APSC 877 Engineering Project Management
The course will examine the essential skills and knowledge required for effective engineering project management. The foundational principles of project management including integration, scope, cost, time, human resources, stakeholders and procurement are examined. The course will be delivered online.
EXCLUSIONS: MECH 896, APSC 223

APSC 888 Engineering Innovation and Entrepreneurship
This course will help learners from across engineering develop an entrepreneurial mindset capable of turning problems into opportunities. Learners will investigate the relationships between innovation and industrial dynamics, and seek to understand the fundamental forces that drive the science and technology industries' evolution and industry life cycles.
EXCLUSION: CHEE 410

APSC 896 Engineering Leadership
The course is designed to develop a range of leadership skills essential for engineering professional practice. Students will explore their own leadership abilities and develop their competencies in areas such as managing conflict, team dynamics and developing others. The course content will be presented through lectures, case studies, panel discussions and other active learning activities.

MINE 800 Mining Systems and Processes
This course provides an overview of mining systems and processes and is intended to be presented to graduate students and professionals interested in the mining industry. The course is given in modules by faculty and spans a range of topics from mining to mineral processing with emphasis being placed on mining methods, methods of rock breakage, review of ground stability, ventilation, materials handling, mineral beneficiation, economic and environmental assessments, and corporate social responsibility. Three-term hours. (3.0 credit units)

MINE 801 Community Aspects of Mineral Resource Development
This course provides students with a thorough understanding of community issues associated with mineral resource development. It provides context and examples to demonstrate how the industry response to these issues has changed over time. The business case for a disciplined approach to community engagement and relationship building is outlined. It introduces the topics of community development, community engagement, and indigenous issues which are further explored in subsequent courses. Fall term. E.A. Johnson. (3.0 credit units)

MINE 803 Community Engagement and Mining
This course extends the exploration of a range of community development and community engagement domains, techniques and skills, relating to social technique,

participatory approach to community development planning and programming; the use of partnerships as a vehicle for participatory development; social impact assessment; community engagement planning; program monitoring and evaluation. It expands and reinforces the participant's understanding of how the application of professional approaches and methods can assist communities and companies to build sustainable, organized relationships and structures within the broader context of mining and development practice, locally, nationally, and globally. Winter term. E.A. Johnson (3.0 credit units)

MINE 804 Mining Projects and Indigenous Peoples
This course examines the social, political and economic relationships that exist between Indigenous Peoples and external parties in the development of commercial mining operations. The course will review specific social, political and economic issues arising from the engagement of Indigenous Peoples with the minerals industry, and the skill sets and knowledge base that are critical to negotiating positive relationships between Indigenous Peoples and mining companies. Winter term. E.A. Johnson (3.0 credit units)

MINE 812 Underground Mining
This course provides a comprehensive discourse of all aspects of underground mining. It is designed to provide engineers with full knowledge to develop strategic and tactical mine planning and to incorporate all aspects of underground mining, including method selection, design, planning, scheduling, development and production. Classification methodologies are introduced to permit selection of a mining method based on orebody characteristics. The program includes description and application of underground mining methods, equipment selection and basic requirements. Layout and design of underground mine development and production and related equipment requirements are presented. Support services, including ground control, ventilation, dewatering, backfill, compressed air are introduced. (3.0 credit units)

MINE 814 Advanced Ventilation and Environmental Mine Engineering
The development of basic airflow models and complex ventilation networks are discussed in depth, and practical design studies using computerized techniques are developed. Topics related to ventilation calculation and design include: mine regulations and engineering design criteria, basic and complex circuit evaluation and design, natural ventilation, fan selection, auxiliary ventilation design, ventilation surveys and ventilation economics. The total environment of mines and air quality control are studied in detail, and include mine gases, mine dust, heat control and radiation hazard and control in mines. Three term-hours, lectures. (3.0 credit units)

MINE 817 Advanced Explosives Technology
Detonation theory and its applications. Topics include: Detonation theory, equations of state, experimental techniques for measuring explosive properties, initiation and sensitivity, shaped charges, metal working with explosives, commercial explosives, metal loaded explosives, dust explosions, pressure desensitization, numerical methods. Three term-hours, lectures. (3.0 credit units)

MINE 818 Rock Mechanics
Theories and application of rock mechanics principles in underground and open pit mine design are discussed. General areas of concentration include assessment of elastic for rock; the determination and influence of in-situ stress on excavation stability; evaluation of ground movement, subsidence and convergence; review of rock slope stability factors and mitigation techniques for stabilization; and assessment of contemporary and innovative measures for ground support provision in underground mines. Three term-hours. (3.0 credit units)

MINE 819 Numerical modelling in mining geomechanics

This course introduces numerical modelling methods used in mining geomechanics. The basic theory and use of finite difference, finite element, boundary element continuum and discrete particle discontinuum codes will be reviewed with the objective of providing an understanding of the mathematical basis for each method, and their major differences. The emphasis will be on building and interpreting models. Three term-hours, lectures.

MINE 820 Topics in Drilling and Blasting
Rock failure in blasting. Topics include fragmentation, influence of joints and rock structure, theory of fracturing and crack propagation, cratering, blasting-induced vibrations and damage, wall control techniques, numerical methods. Three term- hours, lectures. Winter term; P. Katsabanis. (3.0 credit units)

MINE 821 Hydrometallurgy and electrometallurgy: Theory and practice
This lecture- and seminar-based course covers the advanced topics about hydrometallurgy and electrometallurgy. The course involves the theory of leaching, solid liquid separation, solvent extraction and ion exchange, chemical precipitation and electrometallurgy. In addition, several process options and flowsheets for the recovery of selected base metals (copper, zinc and nickel)and gold will be presented. Each student will perform a literature survey, write a report and present on a topic of interest. Three term-hours, lectures. (3.0 credit units)

MINE 825 Advanced Rock Mechanics

This course comprehensively explores the fundamental principles, mechanisms, and advanced design methods in rock mechanics. This course aims to equip students with a deeper understanding of rock behavior, failure mechanisms, and cutting-edge experimental techniques. Moreover, it will focus on practical applications in geotechnical engineering, emphasizing ground control strategies in rock slopes, waste dumps and underground mining. By navigating diverse geological settings, students will develop the proficiency to ensure safety and efficacy in excavation endeavors. Ultimately, this course fosters a comprehensive understanding of rock engineering's theoretical underpinnings and their practical implications in real-world scenarios. (3.0 credit units).

MINE 828 Seismicity in Mines
This course provides a broad overview of seismicity in mines, ranging from its causes, source mechanisms, waveform analysis, influence of geological factors including stresses, monitoring systems, analysis of seismic data, and applications of seismic data analysis in mining geomechanics and mine design. Familiarity with principles of rock mechanics and structural geology are assumed for the course. Three term-hours; lectures. (3.0 credit units)

MINE 832 Flotation Science and Technology
Roles and applications of flotation in the mining industry, tailings management, recycling and environmental clean-up are discussed. The topics include both interfacial aspects such as wettability, electrical double layer theories, dispersioncoagulation/flocculation, reagent interactions, as well as the engineering aspects such as sampling/mass balancing, kinetics and circuit design. Primary examples of technologies related to processing of sulphide ores, non-sulphide ores, salts, coals and tar sands are covered. The course includes laboratory sessions on selected topics. Three term hours plus 3 lab sessions; Fall and/or Winter term. S. Kelebek.

MINE 834 Advanced Geostatistics for Modelling Uncertainty in the Earth Sciences
This course introduces the theory and practice of advanced geostatistics to characterize the uncertainty in spatially distributed attributes in the Earth Sciences. The course presents tools and modelling workflows, including multiGaussian simulation, indicator simulation, and multiplepoint statistics. Multivariate techniques will also be reviewed, and examples will be provided in a mining context. The audience is engineers and geoscientists from all relevant engineering and applied science disciplines who have an interest in models of Earth systems. Fall or Winter term. J. Ortiz. (3.0 credit units)

MINE 835 Applied Machine Learning
This course introduces the theory and practice of machine learning for graduate engineering students. The course presents tools for analysis and prediction using machine learning techniques, including regression, support vector machines, hidden Markov models, ensemble methods, supervised and unsupervised learning. The course will be focused on the fundamentals of these techniques, the advantage, disadvantage and usage context of each technique, and their application in the engineering field. Engineering examples for each topic will be provided. Winter term. Y. A. Sari. (3.0 credit units)
PREREQUISITE: Students must have taken a probability and statistics course (e.g. MTHE 367 or equivalent.)

MINE 836 Mineral Processing and the Environment
The objective of this course is to provide an introduction to mineral processing unit operations with regards to final product production. Process selection criteria will be highlighted including economics, efficiency, and geographic location. Environ mental issues associated with producing metals from a variety of ore types will be examined including tailings treatment/impoundment methods and pyrometallurgical and hydrometallurgical refining techniques. Three term-hours, fall and/or winter term, lectures. S. Kelebek. (3.0 credit units)

MINE 838 Project Decision-making in Extractive Metallurgy
The goal of this course is to provide an opportunity for students to use information from their undergraduate courses to make decisions on projects of the type that they may face in their future careers. The course will analyze actual project case histories in mining and process metallurgy and evaluate them from technical, economic, and risk perspectives. The objective of each case will be to confront the student and/or group with a decision point similar to that faced in the actual situation. The students will work individually and/or in small groups in an interactive tutorial setting to develop each case for class presentation. There will also be opportunities for interaction with invited experts from industry. The course will show students how to use the key evaluation tools for objective project and process decision-making in mining and process metallurgy. Three term-hours, lectures. (3.0 credit units)

MINE 839 Advanced Pyrometallurgy
In this course, pyrometallurgical technologies for metals extraction are discussed and evaluated. This includes basic thermodynamics, solution thermodynamics and alternative standard states. Models of metallurgical solutions are examined. Stability diagrams are utilized to understand processes and predominance area diagrams are used to explain roasting. Current research areas in pyrometallurgy are discussed with emphasis on energy and the environment.

Three term-hours, lectures. Fall term. C.A. Pickles (3.0 credit units)

MINE 851 Risk Analysis for Industrial Asset Management, Health and Safety
This course covers the analytical techniques and tools which form the foundations required for effective life-cycle management of physical assets, as well as for occupational health and safety management systems. The course uses risk analysis as the primary lens to investigate and evaluate a broad range of industrial challenges, ranging from equipment reliability and maintenance planning strategies, through to identification and mitigation of workplace health and safety hazards. Selected topics in industrial hygiene, including exposure limits, are surveyed. Methodologies covered include Failure Mode, Effects, and Criticality Analysis (FMECA), Reliability Centred Maintenance (RCM), and Internal Responsibility Systems (IRS) for Safety Management. Three term-hours, lectures. Winter term. L.K. Daneshmend. (3.0 credit units)

MINE 852 Mine Mechanization and Automation
Objectives, constraints, and methodologies for mechanization and automation. Modelling and simulation of mining processes and equipment. Equipment monitoring. Production monitoring. Navigation and automatic guidance of mobile equipment, including inertial navigation and GPS. Dispatching and scheduling systems. Mine-wide communications systems. SCADA (Supervisory control and data acquisition) systems. Teleoperation and Telerobotics technologies. Machine design in the context of mechanization and automation; reliability and maintainability. Technology transfer issues. Case studies of both surface and underground mines. (3.0 credit units)

MINE 860 Selected Topics in Mining Engineering
This course is intended for students at both the Masters and Doctoral levels who already have a good background in fundamental topics related to their research or course-based programs of study, and who are interested in broadening their exposure to other subject areas of mining engineering that are not offered through existing graduate courses. Topics will focus on either mining, mineral processing or mine-mechanical-related areas of mining engineering, and will be presented through lectures, seminar presentations, open classroom discussion and self-directed independent study. The specific course content to be taught to students will be posted in writing at the beginning of each term in which this course will be given, and the deliverable will be presented publicly at the end of the term, and will take the form of a lecture, bibliographic review, proof of concept or other deemed appropriate by the supervisor. Marking for the course will be assessed on the basis of student assignments, written reports and classroom presentations. Fall and/or Winter term. (3.0 credit units)

MINE 865 Directed Research
This course is intended for students at both the Masters and Doctoral levels who already have a good background in fundamental topics related to their research or course-based programs of study. The course is created by a professor in agreement with a student to explore an area of common interest that may have the potential of adding to the student's research thesis topic. The course deliverable may consist of a final report, a lecture, a short research project, a paper, a prototype, or a computer code. Fall and/or Winter term. (3.0 credit units)

MINE 881 Mining Systems
This course reviews the processes involved in a mining operation in the context of efficiencies in the use of resources, energy and water. The engineering design stages and unit operations are discussed from a systems perspective. Case studies illustrate factors for success and failure of projects. Fall term. This course is exclusively online. (3.0 credit units)
EXCLUSIONS: MNTC 305/MINE 800.

MINE 882 Advanced Mineral Economics
Mineral economics spans theory, industry knowledge, government policies, finance and investment. Students will explore topics in foundational economic theories, regulation of the industry, tools and applications, feasibility assessment and disclosure, project evaluation, and changes needed in tools and practices to better integrate sustainability. Fall term. This course is exclusively online. (3.0 credit units)

MINE 885 Mineral Processing
This course presents the unit operations in mineral processing, and discusses process selection criteria, considering new available technologies. Equipment selection, efficiencies, and performance are analyzed in light of product requirements for subsequent metallurgical operations. Techno-economic and environmental aspects are discussed. (3.0 credit units)

MINE 897 Graduate Seminar
M.A.Sc students give a seminar in the second year of their program and Ph.D. students in their fourth year. A seminar is a presentation of a student's graduate research and consists of a 30 to 40 minute talk followed by about ten minutes of questions. The seminar is evaluated by both the graduate students enrolled in the course and the Faculty. Students must submit the title of their talk, an extended abstract, and a short biography one week before their presentation to the Graduate Assistant at mine.grad@queensu.ca. There are

also invited speakers. This is a noncredit course which each student must pass successfully.

MINE 898 Master's Project
This course is for M.Eng. students only. Before the student registers in the course the student must identify a potential supervisor and provide them with a statement of their area of interest or the subject of a project they would like to do. The project can be computer based or laboratory based. The supervisor and the student often agree upon a project of mutual interest. The final deliverable should be in the form of a technical paper and should consist of the typical sections found in a paper. The method of evaluation of the technical paper is at the discretion of the supervisor. (3.0 credit units)

MINE 899 Master's Thesis Research

MINE-999 Ph.D. Thesis Research

Courses for the Graduate Diploma in Social Performance Management in the Extractive Industries

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EXCLUSIONS: MNTC 305/MINE 800.