

MINE3630

Rock Breakage

Term 3, 2021



Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Joung Oh	joung.oh@unsw.edu.au	available by appointment	159k, OMB	029385500 2

School Contact Information

School of Minerals and Energy Resources
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[Engineering Student Services](#)

E: mere.teaching@unsw.edu.au

W: www.engineering.unsw.edu.au/minerals-energy-resources

Course Details

Units of Credit 6

Summary of the Course

This course covers the principal methods of rock breakage used in mining including machine mining, drilling and blasting. Machine mining encompasses rock cutting principles, cutting with picks and discs, the design of cutter heads, effect of wear, assessment of rock cuttability, impact breakage and ripping. Drilling encompasses the methods of drilling used in mining and the impact of drilling parameters on performance and selection and costing of drilling equipment. Blasting encompasses the chemistry of explosives and mechanics of explosive-rock interaction, selection of commercial explosives, explosive charging techniques, initiation and delay systems, blast design principles for surface and underground mines, safety, environmental and regulatory management and blast performance assessment and analysis. The course introduces how an emerging rock breakage technology can be applied to mining and illustrates the application of simulation of drill and blast technique to the blast design for surface and underground mines.

Course Aims

This course aims to equip the student with knowledge and skills to design and select appropriate rock breakage techniques for different mining applications.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Examine the various methods of rock breakage	PE1.1
2. Select and evaluate appropriate methods of drilling and rock breakage for given in-situ rock conditions and mining systems	PE1.3
3. Apply fundamental principles to the design and selection of safe and efficient rock breakage with consideration of emerging technology opportunities	PE1.5
4. Identify relevant requirements for the security, storage and handling of explosives	PE2.1

Teaching Strategies

This course will be delivered mainly through formal lectures with the combination of active learning tutorials.

Additional Course Information

Course Completion

Course completion requires submission of all assessment items; failure to submit all assessment items

can result in the award of an Unsatisfactory Failure (UF) grade for the Course. Please note, a competency hurdle of 50% is applied to the final assessment.

Assumed Knowledge

This course assumes that a student:

- is currently enrolled in the Mining Engineering single degree program or a Mining Engineering double degree program at UNSW; and
- has satisfactorily completed all the courses in Stages 1 to 3 of the Mining Engineering single degree program or equivalent in the Mining Engineering double degree program and is in the final Stage/Year of the program; and
- has successfully completed MINE3430 Mining Systems; and
- has a sound knowledge of mining terms and systems and has had previous exposure to mining operations through industry employment and/or field trips.

Attendance

To pass this course it is expected that you will attend at least 80% of tutorials and lectures. Failure to meet the specified attendance requirements of the course may result in the award of an Unsatisfactory Failure (UF) grade for the Course.

Attendance will be recorded when applicable. Normally, there is no make-up work for poor attendance. If you have misadventure or ill-health, please contact your course coordinator soon as possible. The attendance requirement is not meant to be punitive. It is included because participation is an important part of achieving the course outcomes.

Assessment

Quiz

- The in-semester quiz for the machine mining module may be either paper-based or conducted on-line using Moodle in the School of Mining Engineering Computer Laboratory, OMB Rm 48.
- The quiz will be scheduled during the normal lecture period or either on a Thursday or Friday in the nominated week between 10am and 2pm.
- The duration of the quiz will be approximately 60 minutes. Students should make provision in the diary to be available during these periods in the nominated weeks.
- Non-attendance at the Quiz will result in a zero mark. No supplementary quiz will be scheduled.
- The Quiz will cover the various learning outcomes as defined in the Course Outline and the material outlined in the Learning Guides.
- The Quiz will include a combination of multiple answer, short answer and calculation style questions selected at random from a bank of questions.
- Normal university regulations for examinations will apply to the Quiz.
- Students must also bring to the Quiz a Quiz Summary Sheet (QSS). Preparation of the QSS is regarded as a key part of the learning process and so students are strongly encouraged to prepare their own QSS. Requirements of the QSS are:
 - it must be the student's own work;
 - it must be a single A4 sheet of paper with notes placed on both sides of the sheet;
 - the sheet must contain only handwritten notes and diagrams. It must NOT contain any typed, photocopied or computer generated information;
 - it must be the individual student's own work written in pencil and/or pen. A photocopy is NOT allowed;
 - there are no constraints on the size or amount of information that can be included; and
 - the student's name and signature must be placed in the top right hand corner of the QSS with the statement "I declare this QSS is all my own work."
- If a QSS does not comply with all of these requirements then it may be confiscated and the student will not have recourse to the QSS during the Quiz. Academic Misconduct procedures may also be applied.
- The QSS must be surrendered at the end of the Quiz. The QSS will be checked but will not be assessed, so students can elect to submit a blank QSS. Students who do not submit a QSS will get zero marks for the Quiz.
- The QSS will not returned to students. Students are advised to make a copy for their own use.
- Students should bring to the Quiz:
 - calculator,
 - pen and pencil,
 - the Quiz Summary Sheet and
 - their Student ID card.

A blank sheet of paper for workings will be provided.

Group Work

Students should form teams of three (3) students per team and advise the Course Convenor of the Team Name and student members of the team by no later than Friday in Week 2. Any student who is not in a team after this time will be assigned to a team by the Course Convenor.

See the section on Group Work - Peer Assessment in the section on University Policies for further details on the requirements and process of peer assessment in the group project assignment.

Formal Exam

An exam in the formal examination period at the end of semester will be held on material covered in the Drilling and Blasting modules of the course. The examination will be closed book, all necessary formulae will be provided on the exam paper.

Full marks for an assignment or examination question can be obtained where:

- The numerical 'result' is substantiated by an 'answer' comprising a complete mathematical working with appropriate definitions, assumptions, explanations and sketch diagrams at each stage.
- The result is numerically correct, with the correct units, magnitude and sign.
- The appropriate number of significant figures have been reported in the result and the accuracy of the result has not been compromised by rounding errors.
- Where appropriate, there is some discussion of the reliability and applicability of the result in the relevant engineering context.
- The answers to purely descriptive questions, which do not require any calculation and do not have a numerical result, should clearly and comprehensively address the specific question, supported by appropriate diagrams, graphs, formulae, examples and cited references.

A key ability of an engineer is to recognise when a numerical result 'looks wrong' and then go back over the work to check the input data, assumptions, and calculations.

These typical maximum marks apply where the following errors occur:

- There is a minor calculation or transcription error, but otherwise the answer is satisfactory and the result is consistent and apparently reasonable: 70 to 90%
- The answer is satisfactory but the result is compromised by one of more of the following: is inaccurate due to rounding errors, has incorrect or no units, has the wrong magnitude, has the wrong sign: 60 to 80%
- There is a minor calculation or transcription error but, although the answer is satisfactory, the result is clearly unreasonable: 40 to 60%
- The result is correct but there is little or no mathematical working with appropriate definitions, assumptions, explanations and sketch diagrams at each stage: 30 to 50%
- The question has been misunderstood, an inappropriate mathematical working has been applied but the result is consistent and apparently reasonable: 20 to 40%
- The question has been misunderstood, an inappropriate mathematical working has been applied and the result is clearly unreasonable: 0 to 30%
- The input data have been transcribed correctly, but there has been no serious attempt to answer the question 0 to 10%
- A descriptive answer, although substantially correct, is padded with waffle and irrelevant material: 60 to 80%
- A descriptive answer is very brief and clearly deficient: 30 to 60%
- A descriptive answer merely comprises a re-statement of the question with something like "... is very important" added at the end: 0 to 10%

The following assessment criteria provide both a framework for students when preparing major assignments in the course as well as a guideline for assessors when marking an assignment. The student is advised to review the relevant framework before undertaking their assignment.

The criteria listed for each item of assessment and the descriptions contained therein are not intended to be prescriptive nor is it an exhaustive list. Rather it should be viewed as a framework to guide the student as to the type of information and depth of coverage that is expected to be evident in an assignment; the framework illustrates for example what would distinguish an excellent achievement from a poor achievement.

The student should be cognisant that a range of factors are often being assessed in any one assignment; not just whether the final results are numerically correct. Consideration is given to other relevant elements that contribute to the Learning Outcomes of the course as well as the Graduate Attributes of the overall degree program.

The student is cautioned against merely using the assessment criteria as a checklist. When assessing an assignment, elements in the framework will be examined in terms of quality and creativity. Hence ensuring all elements are merely covered in an assignment is often not sufficient in itself and will not automatically lead to full marks being awarded. Other factors such as how the student went about presenting information, how an argument was structured and/or the elements supporting a particular recommendation or outcome are also important.

Finally the framework can also be used to provide feedback to a student on their performance in an assignment. Periodically the criteria are reviewed and updated, consequently changes may be made to the framework to improve their effectiveness in achieving both these objectives.

Note: Reference to RWG in the assessment criteria refers to the MEA Report Writing Guide.

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Online Quiz: Machine Mining	30%	will be scheduled Thursday or Friday morning in the Week 4.	1, 2, 3, 4
2. Seminar Presentation	10%	Will be scheduled during the normal lecture period in the week 8 or 9	1, 2, 3, 4
3. Group Assignment	25%	15/10/2021 05:00 PM	1, 2, 3, 4
4. Final Exam	35%	Not Applicable	1, 2, 3, 4

Assessment 1: Online Quiz: Machine Mining

Start date: will be scheduled Thursday or Friday morning in the Week 4.

Assessment length: 60 minutes

Due date: will be scheduled Thursday or Friday morning in the Week 4.

To assess all aspects of machine mining covered in the class.

Feedback provided via the learning management system (LMS)

Assessment criteria

Multiple-choice questions.

Assessment 2: Seminar Presentation

Start date: Will be scheduled during the normal lecture period in the week 8 or 9

Due date: Will be scheduled during the normal lecture period in the week 8 or 9

15 minutes presentation and 5 minutes Q/A

Group work

Feedback provided via the learning management system (LMS)

Assessment criteria

The criteria is given to students with seminar presentation topics.

Assessment 3: Group Assignment

Due date: 15/10/2021 05:00 PM

Group report to prepare blast designs, costing and other analyses for a given surface or underground mining operation

Feedback provided via the learning management system (LMS)

Assessment criteria

The detailed criteria is provided on the Moodle.

Assessment 4: Final Exam

2 hours.

Cover Drill and Blast content.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

Course Schedule

UNSW Wk	Activity	Content	Presenter
1	Lecture + In class activity	<p>Course outline and course orientation. Content, course profile, learning objectives, orientation to teaching and learning, activity based learning, outline of resources, how to utilise the resources, methods of assessment, graduate attribute, how to get help, nature of feedback session, what students are expected to learn. Rationale (why we are going to this approach),</p> <ul style="list-style-type: none"> • Outline of learning outcomes for machine mining. • Types of rock cutting tools and machines. The mechanics of rock breakage with a mechanical indenter. 	JO
2	Lecture + In class activity	<p><i>Design Objective 1:</i> To analyse the effectiveness of the design of a cutterhead on a pick cutting machine for a continuous miner, longwall shearer and roadheader.</p> <ul style="list-style-type: none"> • Impact of design variables and rock mass properties on rock cutting performance. • Concept of specific energy & cutting efficiency. • Tool interaction; spacing-to-depth ratio • Impact of wear on cutting performance with consideration of the quartz content of rock and cutting tool metallurgy 	JO
3	Lecture + In class activity	<p><i>Design Objective 2:</i> To design the cutterhead on disc cutting machine for a tunnel boring machine and raiseborer.</p> <ul style="list-style-type: none"> • Models and empirical results linking major design variables and machine cutting performance for disc cutting tools. • Tool interaction; spacing-to-depth ratio • Assessing cuttability • Rippability, impact breakage of rock 	JO
4	Lecture + In class activity	<ul style="list-style-type: none"> • The role of blasting in the mining process <ul style="list-style-type: none"> ◦ Why do we blast rock? ◦ Impact of blasting on the end-to-end mining value chain ◦ Overview of blasting process • Drill pattern design <ul style="list-style-type: none"> ◦ Bench surveying and data collection techniques 	BG

		<ul style="list-style-type: none"> ◦ Drilling equipment selection to match conditions ◦ Drill pattern design • Activity <ul style="list-style-type: none"> ◦ Using software to design a drill pattern 	
5	Lecture + In class activity	<ul style="list-style-type: none"> • Explosives concepts <ul style="list-style-type: none"> ◦ Types of explosives ◦ Bulk explosive selection for different conditions ◦ Mechanics of explosives for rock breakage ◦ Logistics and safety • Loading/charging design <ul style="list-style-type: none"> ◦ Stemming for blast containment ◦ Energy distribution ◦ Decking • Activity <ul style="list-style-type: none"> ◦ Using software to design loading 	BG
6	Flexibility week	N/A	N/A
7	Lecture + In class activity	<ul style="list-style-type: none"> • Timing <ul style="list-style-type: none"> ◦ Non-electric and electronic timing techniques ◦ Timing analysis using angle of initiation, burden relief and maximum instantaneous charge • Activity <ul style="list-style-type: none"> ◦ Using software to time a blast • Special blasting techniques: Coal <ul style="list-style-type: none"> ◦ Cast blasting ◦ Stand-off for coal protection ◦ Muckpile shaping for dozers, shovels and draglines ◦ Coal seam modelling techniques ◦ Explosives selection to minimise fume ◦ Buffer blasting to prevent coal loss 	BG
8	Lecture + In class activity	<ul style="list-style-type: none"> • Special blasting techniques: Metals <ul style="list-style-type: none"> ◦ Ore zone identification techniques ◦ Muckpile shaping to minimise dilution ◦ High powder factor blasting to optimise fragmentation • Special blasting techniques: Quarries <ul style="list-style-type: none"> ◦ Front row burden control to prevent flyrock ◦ Timing and loading techniques for vibration control ◦ Front row decking for airblast control ◦ Presplits/midsplits for wall control • Activity <ul style="list-style-type: none"> ◦ Adjust blast design to manage environmental impact (vibration/airblast) 	BG
9	Lecture + In class	<ul style="list-style-type: none"> • Blasting in underground coal mines 	DC

	activity	<ul style="list-style-type: none"> ◦ Legislation and security • Underground metals blasting concepts <ul style="list-style-type: none"> ◦ Horizontal development blasting ◦ Production ring blasting 	
10	Lecture + In class activity	<ul style="list-style-type: none"> • Emerging technologies for blasting <ul style="list-style-type: none"> ◦ Hyperspectral sensing for ore classification ◦ Differential energy loading based on smart drill data ◦ Automation in drilling and blasting ◦ Artificial intelligence for blast optimisation • Blasting review <ul style="list-style-type: none"> ◦ Overview of the concepts learned ◦ Class discussion and deep dives on areas of interest to students 	BG

Resources

Prescribed Resources

REFERENCE RESOURCES

1. Reference Materials

- ISEE Blasters Handbook. Society of Explosives Engineers Inc. 18th edition, 2011 (International Society of Explosives Engineers: Cleveland, USA).
- Blasting principles for open pit mining and theoretical foundations. William Hustrulid. Rotterdam: A.A. Balkema, 1999.
- Practical Blasting Fundamentals, International Society of Explosives Engineers
- Drilling and blasting of rocks. Carlos Lopez Jimeno, Emilio Lopez Jimeno, Francisco Javier Ayala Carcedo. , Rotterdam, Ne.: A.A. Balkema, c1995.
- Open Pit Blast Design – analysis and optimisation, JKMRRC Monograph 1, University of Queensland, 1996.
- Rock Excavation Handbook, Sandvik Tamrock Corporation, 1999
- Rock Blasting and Explosives Engineering. Per-Anders Persson, Roger Holmberg, Jaimin Lee., Boca Raton, Fla.: CRC Press, 1994.
- Underground Mining Methods: Engineering Fundamentals and International Case Studies. Hustrulid, WA, Bullock, R. (ed.), 2001. (Society for Mining Metallurgy & Exploration: Littleton), 728p.
- SME Mining Engineering Handbook, 2011, Peter Darling (ed.), ISBN 978 0 87335 264 2
- Cost Estimation Handbook for the Australian Mining Industry, AusIMM
- www.austlii.edu.au – for all Acts & Regulations for all states and territories

2. Other Resources

Other material that should be referred to in conjunction with this Course Outline include:

- Learning Guide: Machine Mining
- Learning Guide: Drilling
- Learning Guide: Blasting
- Module Reader – Machine Mining: Elements of Machine Mining

3. Online Resources

There are numerous articles / information sources on reservoir engineering on the web. Many of them are sound, but many are either very lightweight or contain errors. Be very careful in your choice of web sources. Remember, UNSW librarians are usually happy to help you locate articles or make suggestions regarding possible material to help you in your academic work. You can also access basic online help at <http://www.library.unsw.edu.au/>

4. Report Writing Guide

The School has a Report Writing Guide (RWG) available. A copy of this is available on the course Moodle site.

Recommended Resources

UNSW Minerals and Energy Resources Engineering provides blended learning using the on-line Moodle LMS (Learning Management System).

It is essential that you have access to a PC or notebook computer. Mobile devices such as smart phones and tablets may compliment learning, but access to a PC or notebook computer is also required. Note that some specialist engineering software is not available for Mac computers.

Mining Engineering Students: OMB G48
Petroleum Engineering Students: TETB LG34 & LG 35

Course Evaluation and Development

Forum will be used to better communicate with students.

Submission of Assessment Tasks

The School has developed a guideline to help you when submitting a course assignment.

We encourage you to retain a copy of every assignment submitted for assessment for your own record either in hardcopy or electronic form.

All assessments must have an assessment cover sheet attached.

Course completion

Course completion requires submission of all assessment items. Failure to submit all assessment items may result in the award of an Unsatisfactory Failure (UF) grade for the Course unless special consideration has been submitted and approved. Please note, a competency hurdle of 50% is applied to the final assessment.

Late Submission of an Assignment

Full marks for an assignment are only possible when an assignment is received by the due date.

We understand that at times you may not be able to submit an assignment on time, and the School will accommodate any fair and reasonable extension. We would recommend you review the UNSW Special Consideration guidelines – see section below.

Late submission will not be accepted and will be considered as no submission.

Special Consideration

You can apply for special consideration through [The Nucleus Student Hub](#) when illness or other circumstances interfere with your assessment performance. Sickness, misadventure or other circumstances beyond your control may:

- Prevent you from completing a course requirement
- Keep you from attending an assessable activity
- Stop you submitting assessable work for a course
- Significantly affect your performance in assessable work, be it a formal end-of-semester examination, a class test, a laboratory test, a seminar presentation or any other form of assessment

We ask that you please contact the Course Convenor immediately once you have completed the special consideration application, no later than one week from submission.

More details on special consideration can be found at: www.student.unsw.edu.au/special-consideration

Student Support

The University and the Faculty provide a wide range of support services for students, including:

- Library training and support services - www.library.unsw.edu.au

- UNSW Learning Centre - www.lc.unsw.edu.au
- Counselling support - www.counselling.unsw.edu.au

Equitable Learning Services aims to provide all students with a free and confidential service that provides practical support to ensure that your health condition doesn't adversely affect your studies.
<https://student.unsw.edu.au/els>

Academic Honesty and Plagiarism

Your lecturer and the University will expect your submitted assignments are truly your own work. UNSW has very clear guidelines on what plagiarism is and how to avoid it. Plagiarism is using the words or ideas of others and presenting them as your own. Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. The University has adopted an educative approach to plagiarism and has developed a range of resources to support students. All the details on plagiarism, including some useful resources, can be found at www.student.unsw.edu.au/plagiarism.

All Mining Engineering students are required to complete a student declaration for academic integrity which is outlined in the assignment cover sheets. By signing this declaration, you agree that your work is your own original work.

If you need some additional support with your writing skills, please contact the Learning Centre or view some of the resources on their website: www.lc.unsw.edu.au. The Learning Centre is designed to help you improve your academic writing and communication skills. Some students use the Centre services because they are finding their assignments a challenge, others because they want to improve an already successful academic performance.

Academic Information

Course Results

For details on UNSW assessment policy, please visit: www.student.unsw.edu.au/assessment

In some instances your final course result may be withheld and not released on the UNSW planned date. This is indicated by a course grade result of either:

- LE – indicates you have not completed one or more items of assessment; or
- WD – indicates there is an issue with one or more assignment; or
- WC – which indicates you have applied for Special Consideration due to illness or misadventure and the course results have not been finalised.

In either event it would be your responsibility to contact the Course Convener as soon as practicable but no later than five (5) days after release of the course result. If you don't contact the convener on time, you may be required to re-submit an assignment or re-sit the final exam and may result in you failing the course. You would also have a NC (course not completed) mark on your transcript and would need to re-enroll in the course.

Studying a course in the School of Minerals and Energy Resources Engineering at UNSW

Report writing guide

The School has a [Report Writing Guide \(RWG\)](#) available. A copy of this is available on the course Moodle site.

Computing Resources and Internet Access Requirements

UNSW Minerals and Energy Resources Engineering provides blended learning using the on-line Moodle LMS (Learning Management System). Also see - Transitioning to Online Learning: www.covid19studyonline.unsw.edu.au

It is essential that you have access to a PC or notebook computer. Mobile devices such as smart phones and tablets may compliment learning, but access to a PC or notebook computer is also required. Note that some specialist engineering software is not available for Mac computers.

- Mining Engineering Students: OMB G48
- Petroleum Engineering Students: TETB LG34 & LG 35

It is recommended that you have regular internet access to participate in forum discussion and group work. To run Moodle most effectively, you should have:

- broadband connection (256 kbit/sec or faster)
- ability to view streaming video (high or low definition UNSW TV options)

More information about system requirements is available at www.student.unsw.edu.au/moodle-system-requirements

Accessing Course Materials Through Moodle

Course outlines, support materials are uploaded to Moodle, the university standard Learning Management System (**LMS**). In addition, on-line assignment submissions are made using the assignment dropbox facility provided in Moodle. All enrolled students are automatically included in Moodle for each course. To access these documents and other course resources, please visit: www.moodle.telt.unsw.edu.au

How We Contact You

At times, the School or your course convenors may need to contact you about your course or your enrolment. Your course convenors will use the email function within Moodle or we will contact you on your @student.unsw.edu.au email address.

We understand that you may have an existing email account and would prefer for your UNSW emails to be redirected to your preferred account. Please see instructions on how to redirect your UNSW emails: "[How can I forward my emails to another account?](#)"

How You Can Contact Us

We are always ready to assist you with your inquiries. To ensure your question is directed to the correct person, please use the email address below for:

- Enrolment or other admin questions regarding your program: <https://unswinsight.microsoftcrmportals.com/web-forms/>
- Course inquiries should be directed to the Course Convenor

Image Credit

Synergies in Sound 2016

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering problem solving	✓
PE2.2 Fluent application of engineering techniques, tools and resources	
PE2.3 Application of systematic engineering synthesis and design processes	
PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	
PE3.2 Effective oral and written communication in professional and lay domains	
PE3.3 Creative, innovative and pro-active demeanour	
PE3.4 Professional use and management of information	
PE3.5 Orderly management of self, and professional conduct	
PE3.6 Effective team membership and team leadership	