

**King Abdulaziz University  
Faculty of Engineering  
Mining Engineering Department  
Undergraduate Program**

**ABET EC-2000  
COURSE BINDER**

**MINE 311  
Rock Mechanics I**

**PREPARED BY**

**Prof. Dr. MAHMOUD ABOUSHOOK**

**Fall 2007/2008**

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***DIVIDER 1: Course Design Data***

**Course Syllabus (ABET -2000 Format):**

**MinE 311: Rock Mechanics I (3: 3,0) – Fall 2007/ 2008**

**(Required Core Course)**

<b>Course Description</b>	Geological consideration; Physical properties of rocks. Engineering properties of rocks; Failure criteria of rock; Rock testing; Stress distribution around underground openings; Rock quality and design of rock supporting system; Principle of rock slopes; Computer application in rock mechanics.
<b>Prerequisite</b>	MinE 301 Principles of Mining Engineering; CE 270 Strength of Materials
<b>Textbook</b>	Franclin, J. A. & Maurice, B., 'Rock Engineering Applications', McGraw-Hill Book Co., 1991; Jaeger J. C. & Cook, N. G. W.' Fundamentals of Rock Mechanics' Chapman & Hall London, 1979. Jumikis, J. R., ' Rock Mechanics' 2 <sup>nd</sup> . Edition, Trans Tech Publications, Houston, 1983
<b>Course Learning Objectives (C.L.O.)</b>	<ol style="list-style-type: none"><li>1- Recognize geological consideration needed in rock mechanics course.</li><li>2- Determine physical properties of rock.</li><li>3- Analyze compressive strength of rock</li><li>4- Identify tensile strength of rock</li><li>5- Analyze shear strength of rock</li><li>6- Design an experimental model to correlate all the rock testing together.</li><li>7- Distinguish stress and strain analysis of rocks.</li><li>8- Evaluate stress distribution around underground openings.</li><li>9- Evaluate rock quality.</li><li>10- Design rock supporting system.</li><li>11- Outline principle of rock slope.</li><li>12- Apply some software which is available in network for rock mechanics applications.</li></ol>
<b>Topics (weeks)</b>	<ul style="list-style-type: none"><li>• Geological consideration (1).</li><li>• Physical properties of rocks (1).</li><li>• Engineering properties of rocks (2).</li><li>• Rock testing (2).</li><li>• Stress and strain analysis of rock (1).</li><li>• Stress distribution around underground openings (1.5).</li><li>• Rock quality and design rock supporting system (2).</li><li>• Principle of rock slopes (1).</li><li>• Computer application in rock mechanics (1.5)</li></ul>

Course Relationship to Program Outcomes	Program Outcomes											
	Highest attainable level of Learning	a	b	c	d	e	f	g	h	i	j	k
		3	3	-	-	-	-	2	-	2	-	3
<b>Class/ Lab Schedule</b>	The class meets twice a week as lectures (110 min. per class). Laboratory practice is performed at the rate of once a week (60 min).											
<b>Instructional Methods</b>	Lectures, Tutorials, Homework, Quizzes, Reports, Presentation Lab, and Computer applications, Projects											
<b>Course Contribution to Professional Component</b>	Engineering Science: 75% Engineering Design: 25%											
<b>Instructor</b>	Prof. Dr. Mahmoud Aboushook - <i>E-mail:</i> <a href="mailto:prof_dr_aboushook@yahoo.com">prof_dr_aboushook@yahoo.com</a> <i>Mob:</i> 0568265313 - Room 474											

## Course Learning Objectives– Program Outcomes Matrix

### MinE 311: Rock Mechanics I

Course Learning Objectives ( C.L.O. )	Program Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
1. Recognize geological consideration needed in rock mechanics course.	M								M		
2. Determine physical properties of rock.	H	H									H
3. Analyze compressive strength of rock.	H	H									H
4. Identify tensile strength of rock.	H	H									H
5. Analyze shear strength of rock.	H	H									H
6. Design an experimental model to correlate all the rock testing together	H	H					M				H
7. Distinguish stress and strain analysis of rocks.	H										H
8. Evaluate stress distribution around underground openings.	H								M		H
9. Evaluate rock quality.	M	H									H
10. Design rock supporting system.	H								M		H
11. Outline principle of rock slope.	H								M		H
12. Apply some software which is available in network for rock mechanics applications.	H						M		M		H
<b>Average</b>	H	H					M		M		H

H=3= High = Synthesis & Evaluation levels , M=2= Medium = Application & Analysis Levels , L=1= Low = knowledge & Comprehension Levels

### Program Outcomes

- a. an ability to apply knowledge of mathematics, science, and engineering fundamentals.
- b. an ability to design and conduct experiments, and to critically analyze and interpret data.
- c. an ability to design a system, component or process to meet desired needs.
- d. an ability to function in multi-disciplinary teams.
- e. an ability to identify, formulate and solve engineering problems.
- f. an understanding of professional and ethical responsibility.
- g. an ability for effective oral and written communication.
- h. the broad education necessary to understand the impact of engineering solutions in a global and societal context.
- i. a recognition of the need for, and an ability to engage in life-long learning.
- j. a knowledge of contemporary issues.
- k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

## Course Calendar

<b>Week</b>	<b>Lesson</b>	<b>Lecture Topic</b>
<b>1st</b>	<b>1</b>	Geological consideration
	<b>2</b>	Continue
<b>2<sup>nd</sup></b>	<b>1</b>	Physical properties of rocks
	<b>2</b>	Continue
<b>3<sup>rd</sup></b>	<b>1</b>	Engineering properties of rocks
	<b>2</b>	Continue
<b>4<sup>th</sup></b>	<b>1</b>	Continue
	<b>2</b>	Continue
<b>5<sup>th</sup></b>	<b>1</b>	Rock testing
	<b>2</b>	Continue
<b>6<sup>th</sup></b>	<b>1</b>	Continue
	<b>2</b>	Continue
<b>7<sup>th</sup></b>	<b>1</b>	Mid Exam
	<b>2</b>	Stress and strain analysis of rocks
<b>8<sup>th</sup></b>	<b>1</b>	Continue
	<b>2</b>	Stress distribution around underground openings
<b>9<sup>th</sup></b>	<b>1</b>	Continue
	<b>2</b>	Continue
<b>10<sup>th</sup></b>	<b>1</b>	Rock quality and design rock supporting system
	<b>2</b>	Continue
<b>11<sup>th</sup></b>	<b>1</b>	Continue
	<b>2</b>	Continue
<b>12<sup>th</sup></b>	<b>1</b>	Principle of rock slopes
	<b>2</b>	Continue
<b>13<sup>th</sup></b>	<b>1</b>	Computer application in rock mechanics
	<b>2</b>	Continue
<b>14<sup>th</sup></b>	<b>1</b>	Continue
	<b>2</b>	Final Exam.



**Course Articulation Matrix:**

**MinE 311: Rock Mechanics I**

Course Learning Objectives (C.L.O.)	Program Outcomes											Assessment Tools					
	a	b	c	d	e	f	g	h	i	j	k	T1	T2	T3	T4	T5	T6
1- Recognize geological consideration needed in rock mechanics course.	2								2					R1 (5)		MQ1 (6)	
2- Determine physical properties of rock.	3	3									3	HW1 (2)				MQ2 (6)	
3- Analyze compressive strength of rock.	3	3									3		QZ1 (2)			MQ3 (6)	
4- Identify tensile strength of rock.	3	3									3		QZ2 (2)			MQ4 (6)	
5- Analyze shear strength of rock.	3	3							2		3	HW2 (2)				MQ5 (6)	
6- Design an experimental model to correlate all the rock testing together	3	3					2				3	HW3 (2)			P1 (5)		
7- Distinguish stress and strain analysis of rocks.	3										3		QZ3 (2)				FQ1 (6)
8- Evaluate stress distribution around underground openings.	3								2		3	HW4 (2)					FQ2 (6)
9- Evaluate rock quality.	2	3									3			R2 (5)			FQ3 (6)
10- Design rock supporting system.	3								2		3	HW5 (2)					FQ4 (6)
11- Outline principle of rock slope.	3								2		3		QZ4 (2)				FQ5 (6)
12- Apply some software which is available in network for rock mechanics applications.	3						2		2		3		QZ5 (2)		P2 (5)		
<b>Average</b>	3	3					2		2		3	(10)	(10)	(10)	(10)	(30)	(30)

T1 = Home Works (10) / 100 , T2 = Quizzes (10) / 100 , T3 = Reports& Presentations (10) / 100 ,

T4 = Projects (10) / 100 , T5 = Mid Exam (30) / 100 , T6 = Final Exam (30) / 100

3= High = Synthesis & Evaluation levels , 2= Medium = Application & Analysis Levels , 1= Low = knowledge & Comprehension Levels

**Performance Targets (Passing Criteria):**

60% of the class student's score over 100% in each course learning objective and each program outcome.

***DIVIDER 2: Course Assessment Data***

**Indirect Assessment Tool**

**Surveys of Course Learning Objectives& Instructional Tools**

**Course: MinE311 – Rock Mechanics I**

**Fall 2007/2008**

<i>Upon the completion of this course how do you rank your ability to do the following:</i>		Poor	Fair	Adequate	Good	V. Good	Excellent
		0	1	2	3	4	5
C.L.O.1	Recognize geological consideration needed in rock mechanics course.						
C.L.O.2	Determine physical properties of rock.						
C.L.O.3	Analyze compressive strength of rock.						
C.L.O.4	Identify tensile strength of rock.						
C.L.O.5	Analyze shear strength of rock.						
C.L.O.6	Design an experimental model to correlate all the rock testing together						
C.L.O.7	Distinguish stress and strain analysis of rocks.						
C.L.O.8	Evaluate stress distribution around underground openings.						
C.L.O.9	Evaluate rock quality.						
C.L.O.10	Design rock supporting system.						
C.L.O.11	Outline principle of rock slope.						
C.L.O.12	Apply some software which is available in network for rock mechanics applications.						

<i>There were 3 Instructional Methods used in this course. Please indicate how important each of these tools was in helping you to attain the course learning objectives.</i>		Negative Value	No Value	Some Value	Important	Very Important	Vital
		0	1	2	3	4	5
1	Lectures						
2	Tutorial						
3	Oral Presentation						
4	Homework						
5	Quizzes						
6	Labs						
7	Project						
8	Reports						
9	Computer Application						

## Course Evaluation Survey



DEPARTMENT  
OF Mining Engineering  
Indirect Assessment of Program Outcomes  
Course Evaluation Survey

COURSE( MinE311) - SECTION (01) -  
SEMESTER (1st) - YEAR 2007/20008

		0	1	2	3	4	5
		Not at all	Somewhat	Moderately	Reasonably	Highly	Ext. highly
<b>Please complete this questionnaire and tick the box that is most appropriate to your answer. This will help us to improve the service we provide to you and other students. Your answers and comments are confidential.</b>							
1	Course Objectives were clear to me						
2	The Course was beneficial						
3	Resources/facilities (equipment, classroom, lab,etc) were satisfactory						
4	The textbook was beneficial						
5	Lectures were well planned and well executed						
6	The assessment of the course work was reasonable						
7	Timing to submit the course work was suitable						
8	Overall, I recommend other students to take this course						
<b>The most interesting subject was:</b>							
<b>Please list some positive aspects of this course:</b>							
1:							
2:							
<b>Please list items that could be improved in the following course offering</b>							
1:							
2:							

## **Results of Indirect Assessment Tools**

**Direct Assessment Tools**

*(Copies Question Papers of HW, Exams, etc....)*

- How to determine the following physical properties of rock:
  - Density; Water content; Porosity; Permeability; Hardness; Abrasion Index; Slack Durability; Wave Velocity

- Three different rock samples with a cylindrical shape have the following:

Sample No.	Mass ( $m_t$ ) (g)	Diameter (d) (cm)	Height (h) (cm)
1	120	4.5	2.8
2	150	5	3
3	247	5.6	4.8

From the table above, calculate the density of each sample?

- Three different rock samples with a cylindrical shape have the following:

Sample No.	Wet Mass ( $m_{ws}$ ) (g)	Dry Mass ( $m_s$ ) (g)
1	150	100
2	180	150
3	350	247

From the table above, calculate the Water Content of each sample?

- Three different rock samples with a cylindrical shape have the following:

Sample No.	Volume ( $V_t$ ) ( $\text{cm}^3$ )	Water Required to Complete Saturation ( $V_v$ ) ( $\text{cm}^3$ )
1	44.5	10
2	58.9	15
3	118.2	40

From the table above, calculate the porosity of each sample?

- Two different rock samples have the following:

Sample No.	Density (g/cm <sup>3</sup> )	Average reading of Schmidt hammer
1	2.5	35
2	2	40

For the table above, calculate the compressive strength in kg/cm<sup>2</sup> of each sample?

- Two different rock samples have entered the Los Angeles Machine and the following data have been record in this table:

Sample No.	Original Mass (kg)	Resulting Mass in +12mm Sieve (kg)
1	5	3
2	5	2

From the table above, calculate the percent loss?

- Two different rock samples have been tested for slack durability and the following data have been record in this table:

Sample No.	Original Mass (g)	Resulting Mass above drum (g)
1	100	80
2	100	40

From the table above, calculate the slack durability of each sample?

- Three different rock samples have been tested for permeability and the following data have been record in the following table:

Sample No.	h1 (m)	h2 (m)	Q (L/s)	d (cm)	L (m)
1	17	8	0.2	10	2
2	18	4.5	0.1	20	3
3	16	3	0.3	14	1

From the table above, calculate the coefficient of permeability of each sample?



- Describe and analyze shear strength of rock?
- Show the value of C and  $\Phi$  for the test table below by drawing Mohr Circles?

Test	$\sigma_3$ (MPa)	$\sigma_1$ (MPa)
1	0	41.2
2	1	52.6
3	3	74.1
4	5	90.3
5	10	122
6	15	151
7	20	172

- From the table below,

find  $\sigma_n$  and  $\tau$  for each case (analytically and graphically).

- Case	$\sigma_1$ (MPa)	$\sigma_3$ (MPa)	$\theta$ (Degree)
1	50	5	30
2	40	0	10
3	100	20	40

After executing the required rock testing in the lab., Complete all the missed data in shown following tables:

- Measured Dimensions of Breccia Sample:

Name	Variable	Value
Diameter	d	
Height	h	
Dry Mass	$m_{dry}$	
Saturated Mass	$m_{sat.}$	

- Calculations:

Name	Variable	Value
Area	A	
Volume	V	
Mass of Water	$m_w$	
Density	$\rho$	
Porosity	n	
Void Ratio	e	
Water Content	Water Content	

- Measured Stress and Strain

Axial Force (P) (Kg)	Axial Deformation ( $\Delta L$ ) (mm)	Strain ( $\epsilon$ ) ( $\Delta L/h$ )	Stress ( $\sigma$ ) (P/A) (kg/cm <sup>2</sup> )
3500	3.5		
6500	7.5		
8800	15		
7500	20		
4000	30		

After complete the above table draw stress – strain curve and find out the compressive strength & modulus of elasticity?

- Point load testing

Maximum Force (P)	$I_{s(50)}$	$\sigma_c$	$\sigma_t$
750 kg			

- Brazilian Test

Maximum Force (P)	$\sigma_t$
3000 kg	

- Schmidt Hammer Test

R1	R2	R3	R4	R5	Average	$\sigma_t$
35	34	36	38	37		

- Slack Durability Test

Mass of the sample before the test P1	Mass of the sample after the test P2	Percent Loss %	$\sigma_t$
46.45 gm	49.28 gm		

- How to distribute stress around circular excavations (analytical & graphically) and how to determine the safest distance to drive another opening.
  
- Circular tunnel: 750m deep, 10m diameter,  $\gamma = 26 \text{ kN/m}^3$  and  $\theta = 0^\circ$  show the stresses distribution away from the opening and determine the safest distance to drive another opening when  $k = 0.3$  &  $k = 0.8$

- What are the types of rock bolts?
  
- What are the steps of inserting rock bolts?
  
  
- Describe the shotcrete application in underground mining?

- Outline the following:

- Uniaxial compression test.
- Stages of Stress – Strain Curve.
- Rock Deformation during the different stages of stress- strain curve.
- Types of Strain.

- Three rock cylindrical samples have been applied to a compression force and the following data were measured:

Sample	Original Length (cm)	Original Radius (cm)	Resulting Length (cm)	Resulting Radius (cm)	$\sigma$ (MPa)
1	10	4	9.2	4.1	1750
2	8	5	7.65	5.07	500
3	13	7	12.4	7.15	2000

From the table above calculate of each sample the following:

- I) Longitudinal Strain?
- II) Lateral Strain?
- III) Poisson Ratio?
- IV) Young's Modulus?

- Identify the Tensile Strength of a Rock?
  
- Correlate between Point Load Index and Strength?
  
- Give some examples of Point Load Index for Different Types of Rocks?
  
- Give some notes about the engineering classification of intact rock based on compressive strength

- Determine stress distribution around a circular opening by Kirsch Equations?

- In the table below, find the missed data?:

Depth	a = r	Density	K	$\theta$	$\sigma_v$	$\sigma_\theta$	$\sigma_r$	$\tau_{r\theta}$
m	m	kn/m <sup>3</sup>		Degree	MPa	MPa	MPa	MPa
910	17	29	1.4	60	26.39			
860	15	25	0.88	50	21.5			
750	10	26	0.3	0	19.5			
500	9	20	0.2	48	10			



- What are the types of rock slope?
  
- Describe the applications of rock slope in engineering field?
  
- What are the failure types of failure of rock slope?
  
- Estimate rock slope failure by rock mass rating

- Give some summarized notes about the applied software used for the following subjects:

Stress distribution, Slope stability and Rock supporting

- Present a report summarize the important geological consideration in rock mechanics.

The principle following subjects should contain in the report:

- Definition and Types of Rock
- Rock Cycle
- Classification of Igneous, Sedimentary and Metamorphic Rocks
- Elements that effect in the weakness of rock texture
- Roles of Rock Joints in Rock Mass Behavior Rock Identification
- Types of rock discontinuities
- Difference between rock material and rock mass
- Composition of rock mass
- Inhomogeneity and Anisotropy of rock
- Ground water flow in rock material
- Types of Problematic (Special) rock:

- Represent a report summarize the evaluation of the quality of rocks and design the required supports they need in order to work safely by seeing different methods

The report should contain the following subjects:

- Rock Mass Property and Classification
- Parameters of Rock Mass
- Rock Mass Classification
- Rock Quality Designation (RQD)
- Active Span and Stand-Up Time
- Rock Mass Rating (RMR)
- Rock Quality and RMR
- Rock Tunnel Designed By RMR
- RMR and Rock Mass Quality
- Q-System
- Rock Quality and Required Support for Tunnel Designed

In this Project each student has to apply different rock tests on a breccia sample, such as Unconfined Compression test, Point Load, Schmidt Hammer, Slack Durability Test and Brazilian Test, in order to measure the compressive and tensile strength by these different tests.

The student should work in a team work to find out how to correlate all the four tests results.

The student should use spread sheet to interpolate the results as well as each student his point of view about the final results.

In this Project each student must research from the network or from other resources about the available software which use in rock mechanics field.

The student should present to the other student the methodology of using any software that he can be obtained

**First Question**

Give a brief answers about the following points:  
 Rock Types – Rock Discontinuity – Problematic Rocks

**Second Question**

A rock sample has the following measurements:

Height= 140 mm - Diameter = 70 mm - Saturation weight = 1110 gm. – Dry weight = 1000 gm

Determine the following properties:

- Density in ton / m<sup>3</sup> - Water Content at saturation state - Void ratio - Porosity
- Permeability in cm/sec

(If the difference in head pressures = 2 m and flow rate= 0. 25 m<sup>3</sup>/min)

**Third Question**

The following results obtained from compression simple test on the sample of previous question:

Axial force Kg	750	1500	3000	6000	5000	3000
Axial deformation mm	3	5	14	25	35	55

Analyze compressive strength in function of strain and find out modulus of elasticity

**Fourth Question**

A rock sample of the same type of the rock in above question has 50mm of diameter and the required point load force to sample failure was 1500 kg.

Find tensile strength stress of this rock and compare it with the compressive strength obtained by point load test and by compression test.

**Fifth Question**

Find Mohr envelope of shear strength and tensile strength for a three rock samples of the same types in above questions with the following conditions:

Sample 1		Sample 2		Sample 3	
$\sigma_3$ Mpa	$\sigma_1$ Mpa	$\sigma_3$ Mpa	$\sigma_1$ Mpa	$\sigma_3$ Mpa	$\sigma_1$ Mpa
1	5	2	8	4	14

Also find out normal and shear stresses on an inclined plane of 30 degree from the horizontal in each rock sample (graphically for all samples and analytical for sample 3 only). Is there any relation with the previous question's results?

**First Question**

Explain and analyze Mohr – Coulomb Failure Criteria of Rock materials?

**Second Question**

At a depth of 1000 m, a 5- meter circular tunnel is driven in rock having the following properties:

- Density = 2.5 t/m<sup>3</sup>
- A rock sample having a diameter of 5 cm and a length of 10 cm needs to 10 ton to break it on its length direction and 3 ton on its diameter direction.

Determine stress distribution around the tunnel, and Examine if the strength of the rock will be capable to carry the induced stresses around the tunnel boundary only if  $\sigma_1 / \sigma_3 = 2$

**Third Question**

Explain and analysis the evaluation of rock quality

**Fourth Question**

How do you determine rock pressure on the support of the previous tunnel and how to design rock support by two different systems within the following characteristics (Assume any missed data):

- One meter of rock coring consists of 8 rock pieces as follows: 3 pieces of length 15 cm ; 2 pieces of length 20 cm and 3 pieces of length 5 cm.
- Discontinuity spacing = 2 m
- Rough surface is slight
- Wetted condition
- Strike is perpendicular to tunnel axis and driven with 40 degree
- Joint set is two
- Filling material are sand and crushed rock
- Shear zone is single

**Fifth Question**

Define and analyze types of rock slopes and estimate rock slope stability in the case of same condition of question no. 4



**Results of Direct Assessment Tools**  
*(From Software)*

**End of Semester Course assessment and Improvement Report**  
*(From Software)*

***DIVIDER 3: Supported program Outcomes "a"***

**Outcome 3.a:**

*an ability to apply knowledge of mathematics, science,  
And engineering fundamentals.*

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Instructional Methods used to address the outcome "a":**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

As seen from the course articulation matrix, this outcome is addressed through the following course learning objectives as well as assessment tools& activities:

<b>Course: MinE311 –Rock Mechanics I</b>								
<b>Course Learning Objectives addressing the Outcome "a"</b>		<b>Level of Learning Achieved (LOL)</b>	<b>Assessment Tools&amp; Activities</b>					
			<b>Homework</b>	<b>Quizzes</b>	<b>Reports&amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>	<b>Final Exam</b>
C.L.O.1	Recognize geological consideration needed in rock mechanics course.	3			X		X	
C.L.O.2	Determine physical properties of rock.	3	X				X	
C.L.O.3	Analyze compressive strength of rock.	3		X			X	
C.L.O.4	Identify tensile strength of rock.	3		X			X	
C.L.O.5	Analyze shear strength of rock.	3	X				X	
C.L.O.6	Design an experimental model to correlate all the rock testing together	3	X			X		
C.L.O.7	Distinguish stress and strain analysis of rocks.	3		X				X
C.L.O.8	Evaluate stress distribution around underground openings.	3	X					X
C.L.O.9	Evaluate rock quality.	2			X			X
C.L.O.10	Design rock supporting system.	3	X					X
C.L.O.11	Outline principle of rock slope.	3		X				X
C.L.O.12	Apply some software which is available in network for rock mechanics applications.	3		X		X		

3= High = Synthesis & Evaluation levels,  
2= Medium = Application & Analysis Levels  
1= Low = knowledge & Comprehension Levels

**Course Materials used to address outcome "a"**

Materials used to address outcome "a" are shown in appendix A& B.

**Indirect Courses Assessment Program Outcomes Students' Survey**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Outcome 3.a**

**an ability to apply knowledge of mathematics, science, and engineering fundamentals**

<i>How do you rate the contribution of this course to increase your ability to do the following:</i>		0	1	2	3	4	5
		Poor	Fair	Adequate	Good	V. Good	Excellent
<b>a.1</b>	Use math in solution of mining engineering problems						
<b>a.2</b>	Use science in solution of mining engineering problems						
<b>a.3</b>	Use engineering principles (ex. from fluid mechanics, dynamics, strength of materials, etc.) in solution of mining engineering problems.						

## Direct Assessment Tools for Outcome "a"

Course: MinE311  
Rock Mechanics I  
Fall 2007/2008

Course Learning Objectives addressing the Outcome "a"		Course: MinE311 –Rock Mechanics I					
		Assessment Tools & Activities					
		Homework	Quizzes	Reports & Presentations	Projects	Mid. Exam	Final Exam
C.L.O.1	Recognize geological consideration needed in rock mechanics course.			R1		MQ1	
C.L.O.2	Determine physical properties of rock.	HW1				MQ2	
C.L.O.3	Analyze compressive strength of rock.		QZ1			MQ3	
C.L.O.4	Identify tensile strength of rock.		QZ2			MQ4	
C.L.O.5	Analyze shear strength of rock.	HW2				MQ5	
C.L.O.6	Design an experimental model to correlate all the rock testing together	HW3			P1		
C.L.O.7	Distinguish stress and strain analysis of rocks.		QZ3				FQ1
C.L.O.8	Evaluate stress distribution around underground openings.	HW4					FQ2
C.L.O.9	Evaluate rock quality.			R2			FQ3
C.L.O.10	Design rock supporting system.	HW5					FQ4
C.L.O.11	Outline principle of rock slope.		QZ4				FQ5
C.L.O.12	Apply some software which is available in network for rock mechanics applications.		QZ5		P2		

**Results of Direct and Indirect Assessment Tools for Outcome "a"**

**Student's work samples addressing the outcome "a"**

Student's work addresses the outcome "a" will be found through the following materials (as shown in e Appendix A):

HW 1 to 5

QZ 1 to 5

R1 and R2

P1 and P2

MQ 1 to 5

FQ 1 to 2



***DIVIDER 4: Supported program Outcomes "b"***

**Outcome 3.b:**

***An ability to design and conduct experiments, and to critically analyze and interpret data***

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Instructional Methods used to address the outcome "b":**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

As seen from the course articulation matrix, this outcome is addressed through the following course learning objectives as well as assessment tools& activities:

<b>Course: MinE311 –Rock Mechanics I</b>								
<b>Course Learning Objectives addressing the Outcome "b"</b>		<b>Level of Learning Achieved (LOL)</b>	<b>Assessment Tools&amp; Activities</b>					
			<b>Homework</b>	<b>Quizzes</b>	<b>Reports&amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>	<b>Final Exam</b>
C.L.O.2	Determine physical properties of rock.	<b>3</b>	<b>x</b>				<b>x</b>	
C.L.O.3	Analyze compressive strength of rock.	<b>3</b>		<b>x</b>			<b>x</b>	
C.L.O.4	Identify tensile strength of rock.	<b>3</b>		<b>x</b>			<b>x</b>	
C.L.O.5	Analyze shear strength of rock.	<b>3</b>	<b>x</b>				<b>x</b>	
C.L.O.6	Design an experimental model to correlate all the rock testing together	<b>3</b>	<b>x</b>			<b>x</b>		
C.L.O.9	Evaluate rock quality.	<b>3</b>			<b>x</b>			<b>x</b>

**3= High = Synthesis & Evaluation levels,  
2= Medium = Application & Analysis Levels  
1= Low = knowledge & Comprehension Levels**

**Course Materials used to address outcome "b"**

Materials used to address the above mentioned course learning objectives are also used to address the outcome. The outcomes which are corresponding to the course materials are shown in appendix A& B.

**Indirect Courses Assessment Program Outcomes Students' Survey**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Outcome 3.b**

**an ability to design and conduct experiments, as well as to analyze and interpret data.**

<i>This course has increased my ability to:</i>		0	1	2	3	4	5
		Poor	Fair	Adequate	Good	V. Good	Excellent
<b>b.1</b>	Design an experiment (i.e., choose the appropriate equipment / instrumentation, select the proper range / values of the free variables to measure the corresponding values of the dependent variables).						
<b>b.2</b>	Conduct an experiment (i.e., familiarize myself with the equipment, calibrate the instruments to be used, and follow the proper procedure to collect the data).						
<b>b.3</b>	Analyze experimental data (i.e., carry out the necessary calculations, perform error analysis, and tabulate / plot the results using appropriate choice of variables and software).						
<b>b.4</b>	Interpret data (i.e., Critically observe a given set of experimental results in tabular or graphical form and draw conclusions regarding the variation of the parameters involved).						

**Direct Assessment Tools for Outcome "b"**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

<b>Course Learning Objectives addressing the Outcome "b"</b>		<b>Course: MinE311 –Rock Mechanics I</b>					
		<b>Assessment Tools &amp; Activities</b>					
		<b>Homework</b>	<b>Quizzes</b>	<b>Reports &amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>	<b>Final Exam</b>
C.L.O.2	Determine physical properties of rock.	HW1				MQ2	
C.L.O.3	Analyze compressive strength of rock.		QZ1			MQ3	
C.L.O.4	Identify tensile strength of rock.		QZ2			MQ4	
C.L.O.5	Analyze shear strength of rock.	HW2				MQ5	
C.L.O6	Design an experimental model to correlate all the rock testing together	HW3			P1		
C.L.O9	Evaluate rock quality.			R2			FQ3

**Results of Direct and Indirect Assessment Tools for Outcome "b"**

**Student's work samples addressing the outcome "b"**

Student's work addresses the outcome "b" will be found through the following materials (as shown in e Appendix A):

HW 1, 2, 3

QZ 1 and 2

R2

P1

MQ 2 to 5

FQ 3

***DIVIDER 5: Supported program Outcomes "g"***

**Outcome 3.g:**

***An ability for effective oral and written communication***

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Instructional Methods used to address the outcome "g"**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

As seen from the course articulation matrix, this outcome is addressed through the following course learning objectives as well as assessment tools& activities:

		<b>Course: MinE311 –Rock Mechanics I</b>						
<b>Course Learning Objectives addressing the Outcome "g"</b>		<b>Level of Learning Achieved (LOL)</b>	<b>Assessment Tools&amp; Activities</b>					
			<b>Homework</b>	<b>Quizzes</b>	<b>Reports&amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>	<b>Final Exam</b>
C.L.O6	Design an experimental model to correlate all the rock testing together	<b>2</b>	<b>x</b>			<b>x</b>		
C.L.O.12	Apply some software which is available in network for rock mechanics applications.	<b>2</b>		<b>x</b>		<b>x</b>		

**3= High = Synthesis & Evaluation levels,  
2= Medium = Application & Analysis Levels  
1= Low = knowledge & Comprehension Levels**

**Course Materials used to address outcome "g"**

Materials used to address the above mentioned course learning objectives are also used to address the outcome. The outcomes which are corresponding to the course materials are shown in appendix A& B.



**Indirect Courses Assessment Program Outcomes Students' Survey**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Outcome 3.g:**

**An ability for effective oral and written communication**

<i>How do you rate the contribution of this course to increase your ability to do the following:</i>		0	1	2	3	4	5
		Poor	Fair	Adequate	Good	V. Good	Excellent
<b>g.1</b>	Produce well-organized reports, following guidelines						
<b>g.2</b>	Use clear and correct language and terminology while describing experiments, projects, or solutions to engineering problems						
<b>g.3</b>	Describe accurately in a few paragraphs a project / experiment performed, the procedure used, and the most important results when writing abstracts or summaries						
<b>g.4</b>	Give well-organized presentations, following guidelines						

**Direct Assessment Tools for Outcome "g"**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

<b>Course: MinE311 –Rock Mechanics I</b>						
<b>Course Learning Objectives addressing the Outcome "g"</b>		<b>Assessment Tools&amp; Activities</b>				
		<b>Homework</b>	<b>Quizzes</b>	<b>Reports&amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>
<b>C.L.O6</b>	Design an experimental model to correlate all the rock testing together	<b>HW3</b>			<b>P1</b>	
<b>C.L.O.12</b>	Apply some software which is available in network for rock mechanics applications.		<b>QZ5</b>		<b>P2</b>	

**Results of Direct and Indirect Assessment Tools for Outcome "g"**

**Student's work samples addressing the outcome "g"**

Student's work addresses the outcome "g" will be found through the following materials (as shown in e Appendix A):

HW 3

QZ 5

P1 and P2

***DIVIDER 6: Supported program Outcomes "i"***

**Outcome 3.i:**

***a recognition of the need for, and an ability to  
engage in life-long learning***

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Instructional Methods used to address the outcome "i":**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

As seen from the course articulation matrix, this outcome is addressed through the following course learning objectives as well as assessment tools& activities:

<b>Course: MinE311 –Rock Mechanics I</b>								
<b>Course Learning Objectives addressing the Outcome "i"</b>		<b>Level of Learning Achieved (LOL)</b>	<b>Assessment Tools&amp; Activities</b>					
			<b>Homework</b>	<b>Quizzes</b>	<b>Reports&amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>	<b>Final Exam</b>
C.L.O.1	Recognize geological consideration needed in rock mechanics course.	2			X		X	
C.L.O.5	Analyze shear strength of rock.	2	X				X	
C.L.O.8	Evaluate stress distribution around underground openings.	2	X					X
C.L.O.10	Design rock supporting system.	2	X					X
C.L.O.11	Outline principle of rock slope.	2		X				X
C.L.O.12	Apply some software which is available in network for rock mechanics applications.	2		X		X		

3= High = Synthesis & Evaluation levels,  
2= Medium = Application & Analysis Levels  
1= Low = knowledge & Comprehension Levels

**Course Materials used to address outcome "i"**

Materials used to address the above mentioned course learning objectives are also used to address the outcome. The outcomes which are corresponding to the course materials are shown in appendix A& B.

**Indirect Courses Assessment Program Outcomes Students' Survey**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Outcome 3-i:**

a recognition of the need for, and an ability to engage in life-long learning

<i>In this course:</i>		0	1	2	3	4	5
		Poor	Fair	Adequate	Good	V. Good	Excellent
<b>i.1</b>	I was encouraged and taught how to learn new material and find information on my own						
<b>i.2</b>	I was encouraged and taught how to reflect on my learning process and identify my strengths and weaknesses						
<b>i.3</b>	I was encouraged to participate in professional society activities and events						
<b>i.4</b>	I became aware that to stay current in today's world, I must continue my education by attending short courses, workshops, seminars, conferences or graduate school						
<b><i>This course has increased my ability to:</i></b>							
<b>I.5</b>	Access information from a variety of sources						
<b>i.6</b>	Read critically and assess the quality of information available (ex. question the validity of information, including that from the internet, textbooks or teachers)						
<b>i.7</b>	Analyze new content by breaking it down, asking key questions, comparing and contrasting, recognizing patterns, and interpreting information						
<b>i.8</b>	Model by estimating, simplifying, making assumptions and approximations						

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

		<b>Course: MinE311 –Rock Mechanics I</b>					
		<b>Assessment Tools &amp; Activities</b>					
<b>Course Learning Objectives addressing the Outcome "i"</b>		<b>Homework</b>	<b>Quizzes</b>	<b>Reports &amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>	<b>Final Exam</b>
C.L.O.1	Recognize geological consideration needed in rock mechanics course.			R1		MQ1	
C.L.O.5	Analyze shear strength of rock.	HW2				MQ5	
C.L.O.8	Evaluate stress distribution around underground openings.	HW4					FQ2
C.L.O.10	Design rock supporting system.	HW5					FQ4
C.L.O.11	Outline principle of rock slope.		QZ4				FQ5
C.L.O.12	Apply some software which is available in network for rock mechanics applications.		QZ5		P2		

**Results of Direct and Indirect Assessment Tools for Outcome "i"**



**Student's work samples addressing the outcome "i"**

Student's work addresses the outcome "i" will be found through the following materials (as shown in e Appendix A):

HW 2 , 4 , 5

QZ 4 , 5

R1

P2

MQ 1 , 5

FQ 2 , 4 , 5

***DIVIDER 7: Supported program Outcomes "k"***

**Outcome 3-k:**

*an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Instructional Methods used to address the outcome "k":**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

As seen from the course articulation matrix, this outcome is addressed through the following course learning objectives as well as assessment tools& activities:

<b>Course: MinE311 –Rock Mechanics I</b>							
<b>Course Learning Objectives addressing the Outcome "k"</b>		<b>Level of Learning Achieved (LOL)</b>	<b>Assessment Tools&amp; Activities</b>				
			<b>Homework</b>	<b>Quizzes</b>	<b>Reports&amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>
C.L.O.2	Determine physical properties of rock.	<b>3</b>	<b>x</b>				<b>x</b>
C.L.O.3	Analyze compressive strength of rock.	<b>3</b>		<b>x</b>			<b>x</b>
C.L.O.4	Identify tensile strength of rock.	<b>3</b>		<b>x</b>			<b>x</b>
C.L.O.5	Analyze shear strength of rock.	<b>3</b>	<b>x</b>				<b>x</b>
C.L.O.6	Design an experimental model to correlate all the rock testing together	<b>3</b>	<b>x</b>			<b>x</b>	
C.L.O.7	Distinguish stress and strain analysis of rocks.	<b>3</b>		<b>x</b>			<b>x</b>
C.L.O.8	Evaluate stress distribution around underground openings.	<b>3</b>	<b>x</b>				<b>x</b>
C.L.O.9	Evaluate rock quality.	<b>2</b>			<b>x</b>		<b>x</b>
C.L.O.10	Design rock supporting system.	<b>3</b>	<b>x</b>				<b>x</b>
C.L.O.11	Outline principle of rock slope.	<b>3</b>		<b>x</b>			<b>x</b>
C.L.O.12	Apply some software which is available in network for rock mechanics applications.	<b>3</b>		<b>x</b>		<b>x</b>	

**3= High = Synthesis & Evaluation levels,**  
**2= Medium = Application & Analysis Levels**  
**1= Low = knowledge & Comprehension Levels**

**Course Materials used to address outcome "k"**

Materials used to address the above mentioned course learning objectives are also used to address the outcome. The outcomes which are corresponding to the course materials are shown in appendix A.& B

**Indirect Courses Assessment Program Outcomes Students' Survey**

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Outcome 3-k:**

**an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice**

<i>How do you rate the contribution of this course to increase your ability to do the following:</i>		0	1	2	3	4	5
		Poor	Fair	Adequate	Good	V. Good	Excellent
<b>k1</b>	State-of-the-art tools and practices used in industry through plant visits and presentations by practicing engineers						
<b>K.2</b>	Use modern equipment and instrumentation to perform experiments						
<b>k.3</b>	Perform web-based research						
<b>k.4</b>	Use Word and Excel to produce high quality technical reports						
<b>K5</b>	Use Power Point to give high quality oral presentation						
<b>k.6</b>	Use computer simulations to conduct parametric studies						
<b>k.7</b>	Use state-of-the-art technology for engineering system design, control, and analysis						

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

		<b>Course: MinE311 –Rock Mechanics I</b>					
		<b>Assessment Tools &amp; Activities</b>					
<b>Course Learning Objectives addressing the Outcome "k"</b>		<b>Homework</b>	<b>Quizzes</b>	<b>Reports &amp; Presentations</b>	<b>Projects</b>	<b>Mid. Exam</b>	<b>Final Exam</b>
C.L.O.2	Determine physical properties of rock.	HW1				MQ2	
C.L.O.3	Analyze compressive strength of rock.		QZ1			MQ3	
C.L.O.4	Identify tensile strength of rock.		QZ2			MQ4	
C.L.O.5	Analyze shear strength of rock.	HW2				MQ5	
C.L.O.6	Design an experimental model to correlate all the rock testing together	HW3			P1		
C.L.O.7	Distinguish stress and strain analysis of rocks.		QZ3				FQ1
C.L.O.8	Evaluate stress distribution around underground openings.	HW4					FQ2
C.L.O.9	Evaluate rock quality.			R2			FQ3
C.L.O.10	Design rock supporting system.	HW5					FQ4
C.L.O.11	Outline principle of rock slope.		QZ4				FQ5
C.L.O.12	Apply some software which is available in network for rock mechanics applications.		QZ5		P2		

**Results of Direct and Indirect Assessment Tools for Outcome "k"**

**Student's work samples addressing the outcome "k"**

Student's work addresses the outcome "k" will be found through the following materials (as shown in e Appendix A):

HW 1 to 5

QZ 1 to 5

R2

P 1 and P 2

MQ 2 to 5

FQ 1 to 5



***DIVIDER 8: Appendices***

**Course: MinE311  
Rock Mechanics I  
Fall 2007/2008**

**Appendix A:**

**Student's Work**

# Home Works

<b>Student's Work</b>	<b>Addressing Course Learning Objective</b>	<b>Addressing Outcomes</b>
HW1	CLO2	[ a & b , k ]
HW2	CLO5	[ a , b , i , k ]
HW3	CLO6	[ a , b , g , k ]
HW4	CLO8	[ a , i , k ]
HW5	CLO10	[ a , i , k ]

Here, there are

All the student homework's

# Quizzes

<b>Student's Work</b>	<b>Addressing Course Learning Objective</b>	<b>Addressing Outcomes</b>
QZ1	CLO3	[ a , b , k ]
QZ2	CLO4	[ a , b , k ]
QZ3	CLO7	[ a , k ]
QZ4	CLO11	[ a , i , k ]
QZ5	CLO12	[ a , g , i , k ]

Here, there are

All the student quizzes'

# Reports & Presentations

<b>Student's Work</b>	<b>Addressing Course Learning Objective</b>	<b>Addressing Outcomes</b>
R1	CLO1	[ a , i ]
R2	CLO9	[ a , b , k ]

Here, there are

All the student reports'



# Projects

<b>Student's Work</b>	<b>Addressing Course Learning Objective</b>	<b>Addressing Outcomes</b>
P1	CLO6	[ a , b , g , k ]
P2	CLO12	[ a , b , g , i , k ]

Here, there are

All the student projects'

# Mid. Exam.

<b>Student's Work</b>	<b>Addressing Course Learning Objective</b>	<b>Addressing Outcomes</b>
MQ1	CLO1	[ a & i ]
MQ2	CLO2	[ a , b , k ]
MQ3	CLO3	[ a , b , k ]
MQ4	CLO4	[ a , b , k ]
MQ5	CLO5	[ a , b , i , k ]

Here, there is

The student's answer of the mid. term exam.

# Final Exam.

<b>Student's Work</b>	<b>Addressing Course Learning Objective</b>	<b>Addressing Outcomes</b>
FQ1	CLO7	[ a & k ]
FQ2	CLO8	[ a , i , k ]
FQ3	CLO9	[ a , b , k ]
FQ4	CLO10	[ a , i , k ]
FQ5	CLO11	[ a , i , k ]

Here, there is

The student's answer of the final exam.

**Appendix B:**

**Course Materials**

Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
1st	1	<b>Geological consideration</b>	CLO1	[ a , i ]
	2	Continue		

Here, there are

The instructor's materials of the first topic lectures





Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
2 <sup>nd</sup>	1	<b>Physical properties of rocks</b>	CLO2	[ a , b , k ]
	2	Continue		

Here, there are

The instructor's material of the second topic lectures



Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
3 <sup>rd</sup>	1	<b>Engineering properties of rocks</b>	CLO3 , 4 , 5	[ a , b , i , k ]
	2	Continue		
4 <sup>th</sup>	1	Continue		
	2	Continue		

Here, there are

The instructor's material of the third topic lectures



Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
5 <sup>th</sup>	1	<b>Rock testing</b>	CLO6	[ a , b , g , k ]
	2	Continue		
6 <sup>th</sup>	1	Continue		
	2	Continue		

Here, there are

The instructor's material of the fourth topic lectures



Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
7 <sup>th</sup>	2	<b>Stress and strain analysis of rocks</b>	CLO7	[ a , k ]
8 <sup>th</sup>	1	Continue		

Here, there are

The instructor's material of the fifth topic lectures





Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
8 <sup>th</sup>	2	<b>Stress distribution around underground openings</b>	CLO8	[ a , i , k ]
9 <sup>th</sup>	1	Continue		
	2	Continue		

Here, there are

The instructor's material of the sixth topic lectures



Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
10 <sup>th</sup>	1	<b>Rock quality and design rock supporting system</b>	CLO9 , 10	[ a , b , i , k ]
	2	Continue		
11 <sup>th</sup>	1	Continue		
	2	Continue		

Here, there are

The instructor's material of the seventh topic lectures



Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
12 <sup>th</sup>	1	<b>Principle of rock slopes</b>	CLO11	[ a , i , k ]
	2	Continue		

Here, there are

The instructor's material of the eighth topic lectures



Week	Lesson	Lecture Topic	Addressing Course Learning Objective	Addressing Outcomes
13 <sup>th</sup>	1	<b>Computer application in rock mechanics</b>	CLO12	[ a , g , i , k ]
	2	Continue		
14 <sup>th</sup>	1	Continue		