NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

# FACULTY OF ENGINEERING AND SPATIAL SCIENCE
## DEPARTMENT OF MINING AND PROCESS ENGINEERING

| QUALIFICATION : BACHELORS OF ENGINEERING IN MINING ENGINEERING | |
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| QUALIFICATION CODE: BEMIN | LEVEL: 6 |
| COURSE CODE: RMC711S | COURSE NAME: ROCK MECHANICS |
| SESSION: JUNE 2022 | PAPER: THEORY |
| DURATION: 3 HOURS | MARKS: 100 |

| SECOND OPPORTUNITY QUESTION PAPER | |
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| EXAMINER(S) | Mallikarjun Rao Pillalamarry |
| MODERATOR: | Prof. Mapani Benjamin |

| INSTRUCTIONS |
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| 1. Answer all questions.<br>2. Read all the questions carefully before answering.<br>3. Marks for each question are indicated at the end of each question.<br>4. Please ensure that your writing is legible, neat and presentable. |

## PERMISSIBLE MATERIALS

1. Examination paper.
2. Tracing Paper
3. Mathematical Instruments

**THIS QUESTION PAPER CONSISTS OF 5 PAGES** (Including this front page)

**Instructions: Answer Question 1 and any 4 other questions. Excess questions will not be marked.**

**Question 1 is compulsory.**

**Time allowed: 3 hours**

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**Question 1** Short answer questions (20)

a) What is the major limitation with borehole breakout method in determining the in-situ stress direction?

b) How many equipment setups are required in HTPF method to define complete stress tensor of in-situ stresses?

c) Strength determined using the point load test, which part of the stress-strain curve it represents?

d) What is rock load factor in Terzaghi rock load rating system?

e) What strength parameters can be determined from unconfined compressive strength test?

f) What is the purpose failure criterion?

g) Why initial part of the stress-strain curve for rocks is not a straight line?

h) Excavation support ratio is function of which parameters?

i) Specify an instrument used to measure wall rock strength of a discontinuity?

j) What important assumption is made in hydraulic fracturing technique in situ stress measurement [1]

**Question 2** State of stress at a point in a rockmass is represented using following stress tensor.

$$\begin{bmatrix} 12 & 6 & 9 \\ 6 & 10 & 3 \\ 9 & 3 & 14 \end{bmatrix} \text{MPa}$$

a) Draw stress diagram (free body diagram) and indicate the stresses on it (5)

b) Determine the stresses on l, m, n reference axes have direction cosines relative to the x, y, z axes defined by [10] (10)

$$(l_x, l_y, l_z) = (0.0266, -0.6209, 0.7834)$$

$$(m_x, m_y, m_z) = (-0.8638, 0.3802, 0.3306)$$

$$(n_x, n_y, n_z) = (-0.5031, -0.6855, -0.5262)$$

c) Draw free body diagram of transformed stress tensor in the previous step (5)

**Question 3** Two planes of dip and dip direction/ dip angle 120/60 and 190/40 are known to intersect. Determine

a) The trend/plunge of their line of intersection (10)

b) Determine the acute angle between the two planes (10)

**Question 4**

a) Briefly discuss the effects of specimen end preparation on uniaxial compressive strength of intact rock specimen and how do you prepare the sample such that these effects are minimised? (12)

b) Figure 2 is the stress-strain curve was obtained from a uniaxial compressive strength test of a sandstone specimen. Determine average Elastic modulus, Poisson's ratio, peak strength and yield point load. (8)

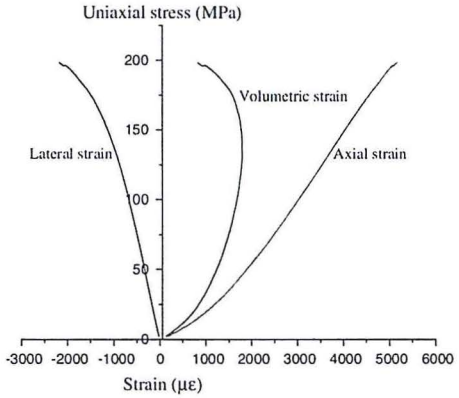


Figure 2

**Question 5**

a) Briefly discuss the principle behind Griffith failure criterion and its application to rock mechanics (8)

b) A porous sandstone has a uniaxial compressive strength of $\sigma_c$ = 75 MPa. The results of a series of triaxial compression tests plotted on shear stress–normal stress axes give a linear Coulomb peak strength envelope having a slope of 45°. (12)

Determine the axial stress at peak strength of a jacketed specimen subjected to a confining pressure of $\sigma_3$ = 10 MPa.

If the jacket had been punctured during the test, and the pore pressure had built up to a value equal to the confining pressure, what would the peak axial stress have been?

**Question 6**

a) What are the objectives of rockmass classification (6)

b) Briefly discuss about 'Q' system of rockmass classification (14)

## Additional Information

Matrix Rotation in 3D

$$\begin{bmatrix} \sigma_{ll} & \sigma_{lm} & \sigma_{lm} \\ \sigma_{lm} & \sigma_{mm} & \sigma_{mn} \\ \sigma_{ln} & \sigma_{mn} & \sigma_{nn} \end{bmatrix} = \begin{bmatrix} l_x & l_y & l_z \\ m_x & m_y & m_z \\ n_x & n_y & n_z \end{bmatrix} \begin{bmatrix} \sigma_{xx} & \sigma_{xy} & \sigma_{xz} \\ \sigma_{xy} & \sigma_{yy} & \sigma_{yz} \\ \sigma_{xz} & \sigma_{yz} & \sigma_{zz} \end{bmatrix} \begin{bmatrix} l_x & m_x & n_x \\ l_y & m_y & n_y \\ l_z & m_z & n_z \end{bmatrix}$$

Mohr Coulomb peak strength criterion

$$\sigma_1 = \frac{2c\ \cos\emptyset + \sigma_3(1+\sin\emptyset)}{1-\sin\emptyset}$$

Peak strength criterion with pore pressure is

$$p_w = \sigma_3 - \frac{(\sigma_1 - \sigma_3) - \sigma_c}{\left(\frac{1+\sin\emptyset}{1-\sin\emptyset} - 1\right)}$$

# Equal Area Net
# (Schmidt Net)