THE PAPUA NEW GUINES UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF MINING ENGINEERING

2022 FIRST SEMESTER EXAMINATION

Third Year Mining Engineering

MN313 – GEOMECHANICS & ENGINEERING GEOLOGY

DATE: WEDNESDAY 8th JUNE 2022

TIME: 12:50 P.M.

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATE:

1. You have ten minutes to read this question paper. You **SHOULD NOT** begin writing during this period.

2. There are **2 (Two) Sections** in this Paper. **Section 1: Geology. Section 2: Geomechanics.** You are to Read instructions for each section before attempting questions in each section.

3. Marks for each question is as indicated. **ALL** questions carry a maximum as indicated. **Section 1. 50 marks & Section 2. 50 marks**

4. **ALL** answers must be written on the answer booklet provided. No other written materials will be accepted.

5. Write your **NAME** and **STUDENT NUMBER** clearly on the **ANSWER BOOK. DO THIS NOW.**

SECTION 1. ENGINEERING GEOLOGY

INFORMATION FOR CANDIDATE:

Section 1 (50%):

Engineering Geology has four parts (50%)

Part A Multiple Choice Questions (10 marks)

Part B Matching Questions (5 marks)

Part C Short Answer Questions (20 marks)

Part D Long Answer Question(s) (15 marks)

SECTION 1: ENGINEERING GEOLOGY

PART A   MULTIPLE CHOICE   (10 MARKS)

Questions 1-10, write the letter corresponding to the correct answer on your answer sheet

Q1. Ground investigation involves

   A. Geological and geomorphic mapping
   B. Use of information from reports and maps
   C. Test pits, trenching, drilling and augering
   D. PSDs and strength tests

Q2. When an RQD index is taken, what are we measuring?

   A. The spacing of joints in a rock mass
   B. The quantitative estimate of the quality of a rock mass taken from drill core
   C. The intact rock strength
   D. The compressive strength of a rock

Q3. In terms of its silicate bonds, silicon and oxygen create what type of bond?

   A. Double chain
   B. Framework silicate
   C. Single chain
   D. Independent tetrahedra

Q4. The color left behind when a mineral is scratched against a porcelain plate is known as

   A. Hardness
   B. Lustre
   C. Streak
   D. Cleavage

Q5. Plutonic rocks are

   A. Igneous rocks
   B. A combination of metamorphic and igneous rocks
   C. Sedimentary rocks
   D. A combination of metamorphic and sedimentary rocks

Q6. Mafic rocks are

   A. Generally light colored
   B. Silica poor
   C. Contain minerals like quartz and muscovite
   D. Obsidian and Basalt

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Q7. In terms of engineering properties, which description best describes metamorphic rocks

    A. Anisotropic/isotropic, variable strength, variable aggregate quality
    B. Isotropic, strong, good aggregate
    C. Anisotropic, strong, good aggregate
    D. Anisotropic, variable strength, poor aggregate

Q8. Rocks tend to deform plastically at depth and in a brittle manner near the earth's surface

    A. True
    B. False

Q9. Pressure is stress where forces act equally in all directions

    A. True
    B. False

Q10. What is a Dome?

    A. An upward bending or rocks
    B. A circular fold in which layers of rock rise from a central point
    C. A circular fold in which layers of rock fall away from a central point
    D. A fold that results in a local steeping on the dip of strata

PART B   MATCHING   (5 MARKS)

Questions 11-15; match column II with column I by writing the letter of the correct answer on your answer sheet

Example:

	Column I	Column II
Question 0	Strata	A.
Question 00		B. Layers of sedimentary rock

Answer: Question 0   B
                Question 00   A

	Column I	Column II
Q11	Slope stability is reduced by	A. Normal fault
Q12	A fault with dominant dip slip displacement	B. Transform fault
Q13	A fault in which the hanging wall has gone up with respect to the footwall	C. Thrust fault

Q14	A fault with a very small angle of inclination between fault plane and vertical plane	D. Water
Q15	A strike slip fault is also called	E. Reverse fault

PART C   SHORT ANSWERS   (20 MARKS)

Questions 16-25 require a short explanation or description. Each question is worth 2 marks.

Q16. What do we mean when we say that a rock has **anisotropic** properties?

Q17. Explain the term **diagenesis**

Q18. Explain the term **plastic deformation** in rocks

Q19. Define **confining stress**

Q20. Why are earthquakes generated near the edges of plates?

Q21. In what way is a mineral different from a rock?

Q22. What process leads to convection in the mantle?

Q23. Differentiate between a joint and a fault

Q24. Explain what site investigation is

Q25. What is a rock mass?

PART D   LONG ANSWERS   (15 MARKS)

Question 26; read the question carefully and answer accordingly. It is worth 15 marks

Q26. The sense of stress determines the type of fault that forms, and we usually categorize that sense of stress in three different ways.

    i. Describe each of these stresses with diagrams

    ii. Correlate each type of stress with the relevant plate boundary and provide a brief explanation alongside

SECTION 2. GEOMECHANICS

INFORMATION FOR CANDIDATE:

1. You have ten minutes to read this question paper. You **SHOULD NOT** begin writing during this period.

2. There are **4 (Four) Questions** altogether. You are to answer **ALL 4 (Four)** questions

3. Marks for each question is as indicated. **ALL** questions carry a maximum of **25 marks**.

4. **ALL** answers must be written on the answer booklet provided. No other written materials will be accepted.

5. Write your **NAME** and **STUDENT NUMBER** clearly on the **ANSWER BOOK. DO THIS NOW.**

Question 1 *(25 marks)*

(a) With aid of sketches, graph, equation etc.. where necessary define the following:

  i)   Micro and macro crack propagation in a UCS test
  ii)   Elastic plastic deformation and brittle failure
  iii) Elastic plastic deformation and perfectly elastic deformation
  iv)   Average Youngs Modulus and Tangent Youngs Modulus
  v)   Rock failure Mode

.... 10 marks

(b) Draw a complete stress strain curve for a rock specimen with load cycles in the elastic and plastic regions and explain elastic, strength, plastic, pore closure, strain softening and other behavior of rock deformation

.... 10 marks

(c) A rock specimen was compressed in a rock testing machine having strain measuring device. The average modulus of elasticity of the rock was read as 31.5 GPa at a stress level of 22.8 MPa. Calculate the change in strain if the stress level is increased by 17.5 %.

.... 5 marks

Question 2 *(25 marks)*

(a) In a uniaxial compression test of a rock sample the following strains were observed using dial gauge.

Load (force) (N)	Axial Def (Y) (x10^{-2})mm	Lat Def (X) (x10^{-2})mm
0	58	73
5000	87	75
10000	102	76
15000	114	78
20000	128	82
25000	139	84
30000	153	88
35000	168	94
40000	181	98
45000	199	108
50000	269	151

If the specimen is cylindrical with 6 cm diameter, length of 11.5 cm (and one microstrain is 0.000001 strain unit), then plot the given stress strain results and estimate the Average Young's modulus, and Poison's ratio.

.... 20 marks

(b) Discuss how you would obtain the volumetric strain for a given stress level. Convert the sets of result above Q2(a) into volumetric strain and plot the results of stress versus volumetric strain on the same graph as (a).

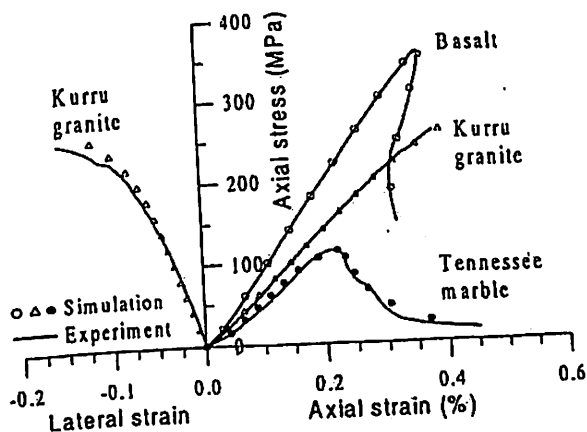... 5 marks

Question 3 (25 marks)

(a) A rock specimen of 75 mm diameter and 155 mm height is uniaxially compressed. It undergoes an axial deformation of 0.0327 mm and lateral diametrical deformation of 0.0067 mm.

i) Calculate the Poisson's ratio of the rock and the Youngs Modulus of the rock at 104 MPa Stress level.

.... 5 marks

ii) Incidentally an excavation is to be created in this rock, at a depth of 957 m below the surface. If the overlaying rock is homogeneous and having a density (Unit weight) of 60 kN/m³, calculate the pre-mining stresses, i.e vertical stress and horizontal stress. (Assuming that horizontal stress is 1/3 of the vertical stress)

.... 5 marks

Figure 1

b) From the above, (figure 1) stress strain curve of three (3) different rock types, discuss the following:
i) Estimate the strength of each rock (give values) .... ((5 Marks)
ii) Which rocks exhibit elastic deformation and which rocks exhibit elastic- plastic deformation and discuss why. .... (10 Marks)

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Question 4 *(25 marks)*

The original Hoek & Brown failure criterion has been modified since the original formulation was presented in 1980, and has been updated several times, but for intact rock, the formular is almost the same and is given in *Eqn 1*:

$$\sigma_1 = \sigma_3 + \sigma_{ucs}\sqrt{m_i \frac{\sigma_3}{\sigma_{ucs}} + 1} \quad \ldots\ldots Eqn.\ 1:$$

Where σ_1 and σ_3 are the major and minor principal stresses, respectively; σ_{ucs} is the unconfined compressive strength (UCS); and m_i is a material constant for the intact rock.

a) If you are involved in an open pit slope design project that requires a series of uniaxial compressive test and needed to determine the failure criteria of that particular rock using the above *Eqn. 1.*, then simplify and re-define the above Hoek & Brown equation to suit your scope of work.

 .... 10 marks

b) You designed a pillar support in an underground mine. The change in rock response in the stressed pillar are shown in **Figure 2** below.

 i) Discuss the failure mode/type experienced by the pillar..... 5 marks
 ii) Discuss which pillar is potentially dangerous and why. ..... 5 marks
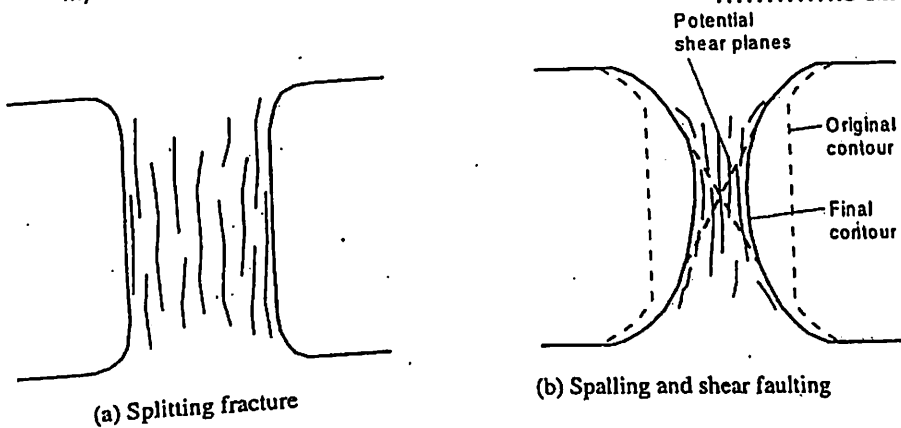 iii) Discuss your design approach to increase safety of the dangerous pillar
 ....5 Marks

(a) Splitting fracture

(b) Spalling and shear faulting

Figure 2