DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

GEOTHERMAL TRAINING AND RESEARCH INSTITUTE

UNIVERSITY EXAMINATIONS 2021-2022

END OF SEMISTER EXAMINATIONS

MASTER OF SCIENCE IN GEOTHERMAL ENERGY TECHNOLOGY

GET 3003 – Geotechnical & Petro-Physical Characterization of Geothermal Rocks

DATE: TIME: 3 HOURS

INSTRUCTIONS

This paper contains FOUR questions

i) Attempt QUESTION (1) and any other TWO questions
ii) ALL QUESTIONS carry 20 Marks
iii) Use a scientific non-programmable calculator
iv) Erasers, pens and pencils will be required
v) ALL workings should be shown on the provided answer booklets
vi) Cell phones and any written materials are NOT allowed in the examination room

---

QUESTION 1

a) The stress in a granitic rock mass has been measured by the hydraulic fracturing technique. Two tests were conducted in a vertical borehole: one test at a depth of 500 m, and the other test at a depth of 1000 m. The results were as follows:

Depth (m)	**Break down Pressure, P_b (MPa)**	**Shut-in Pressure, P_s (MPa)**
500	14.0	8.0
1000	24.5	16.0

(i) Given that the tensile strength, σ_1, of the rock is 10 MPa estimate and list the values of $\boldsymbol{\sigma_1, \sigma_2, \sigma_3}$, at the two depths. (State all of the assumptions you have have made in order to produce these estimates)

(8 Marks)

(ii) Comment on whether the two sets of results are consistent with each other, and justify your reasons for the statement. Are the results in agreement with trends exhibited by collated worldwide data? **(4 Marks)**

b) With aid of sketches, describe the following modes of rock failure and a suitable laboratory test for each:

(i) Flexure
(ii) Direct Tension
(iii) Compression failure (crushing)
(iv) Shear failure

(8 Marks)

QUESTION 2

a) How long does it takes for water, subjected to a 10-m head difference, to pass horizontally through a 5 m length of fractured limestone with an isotropic conductivity, *K*, of 1 x 10^{-4} m/s. **(5 Marks)**

b) If a rock has a permeability of 1 millidarcy, how much water will flow through it per unit of time and area under a gradient of unity? (The water temperature is 20°C.)

(3 Marks)

c) In a series of triaxial compression tests on a sandstone, the following represent the stresses at peak load conditions

Test	**σ_3 (MPa)**	**σ_1 (MPa)**
1	1.0	9.2
2	5.0	28.0
3	9.5	48.7
4	15.0	74.0

Determine values of S_i; and ϕ that best fit the data.

(12 Marks)

QUESTION 3

a) The Commonwealth Scientific and Industrial Research Organization (CSIRO) overcoring gauge test is one of direct methods used to determine insitu struess in rocks.

(i) With aid of Sketches, please describe this method

(8 Marks)

(ii) Comment on its merits and demerits

(4 Marks)

b) A Phonolite core composed of quartz and feldspar grains with calcite cement is 80 mm in diameter and 160 mm long. On saturation in water, its wet weight is 21.42 N; after oven drying its weight is 20.31 N. Calculate its wet unit weight, its dry unit weight, and its porosity.

(8 Marks)

QUESTION 4

a) Explain the difference between porosity and permeability. Also explain how each impact flow capacity of reservoir

(4 Marks)

b) Describe the effect of confining pressure to rock strength and with reasons, suggest a suitable failure criterion to model this effect.

(5 Marks)

c) With aid of sketches, describe rock stress strains behaviour with increasing deviatoric axial stress. Label and describe the processes in the six (6) zones/ points in detail.

(11 Marks)