

Part 1.

Max. points for each question is 6 p (5 x 6 =30 points).

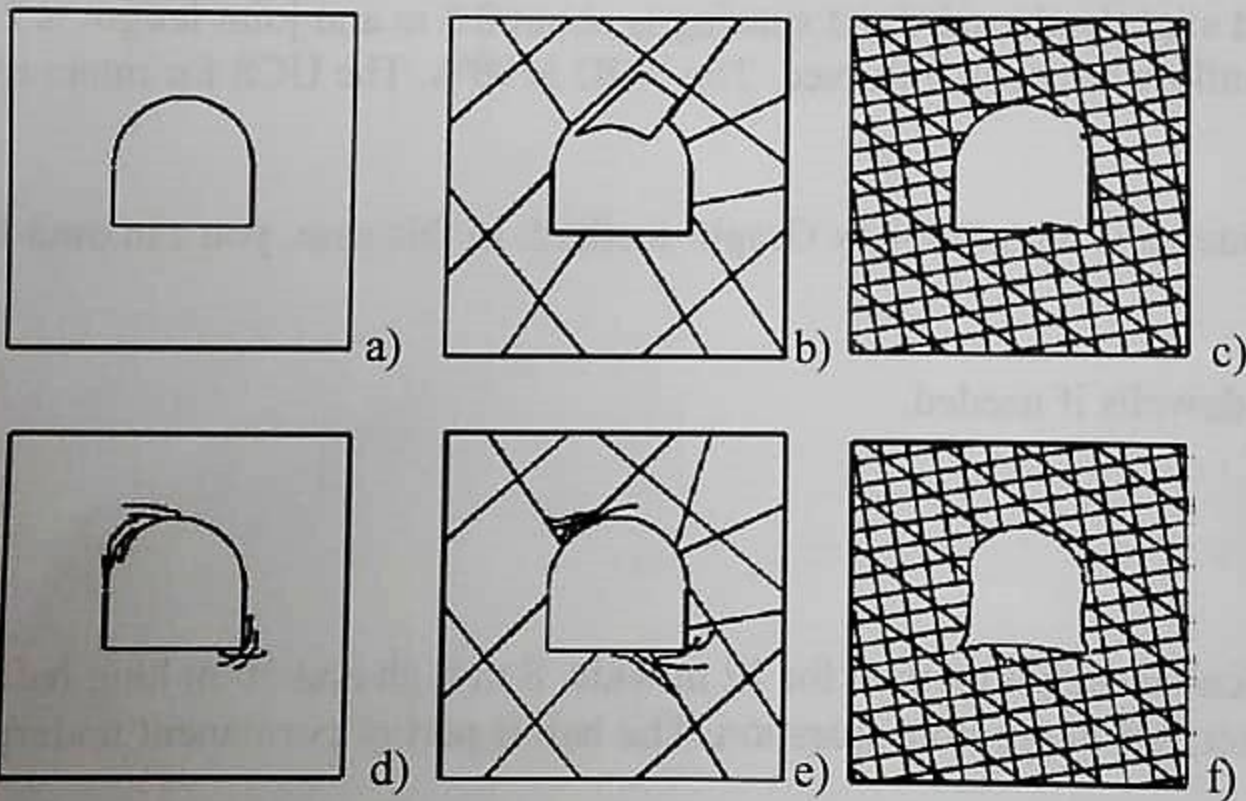
1) The Mohr-Coulomb failure criterion can be expressed as follows:

$$\tau = c + \sigma_n \tan \phi$$

Name and explain Mohr-Coulomb parameters with units and describe how these parameters can be defined in laboratory.

2) Structurally controlled instability and failure. What is meant by this? Tell about factors that may lead to structural failure? How can the risk for structural instability be assessed for a given tunnel?

3) Describe the rock conditions, stress conditions and types of failure in the following figures a-f.



4) How would you monitor a large slope that is known to be unstable.

5) Explain the main purposes of numerical modelling in rock mechanics. Highlight these purposes by examples.

Part 2. Use of course material, your own notes, exercise papers etc. and calculator allowed.

Note 1. No phones, computers etc. are allowed in the exam!

Note 2. Loaning any material (including calculators) from other students during the exam is strictly forbidden!

6) A stope with rectangular cross-section, with vertical walls and horizontal roof is planned in 600 m depth. The stope width is 18 m, height 27 m and length 60 m. The rock is gabbro-type, coarse grained with density of 3000 kg/m^3 . The in-situ horizontal/vertical stress ratio is 2 and the longitudinal axis of the stope is to the East (090). There are three joint sets (dip direction/dip):

085/20

170/60

300/50

Joint surfaces are planar, rough and slightly altered. Joint spacing is about 0.5 m and joint length is 2 - 5 m. Only minor local groundwater inflow has been observed. The RQD is 90%. The UCS for intact rock samples is 125 MPa.

Estimate the stability of roof and sidewalls with Stability Graph -method. In this case, you can omit the short endwalls of the stope.

Design cablebolting for roof and sidewalls if needed.

(15 p)

7) Design reinforcement with applicable design method for 12 m wide, 8 m high and 30 m long hall at 600 m depth in same rock mass described in previous question. The hall is part of permanent underground workshop.

(5 p)