National Exams December 2009

04-Env-A3, Geotechnical and Hydrogeological

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

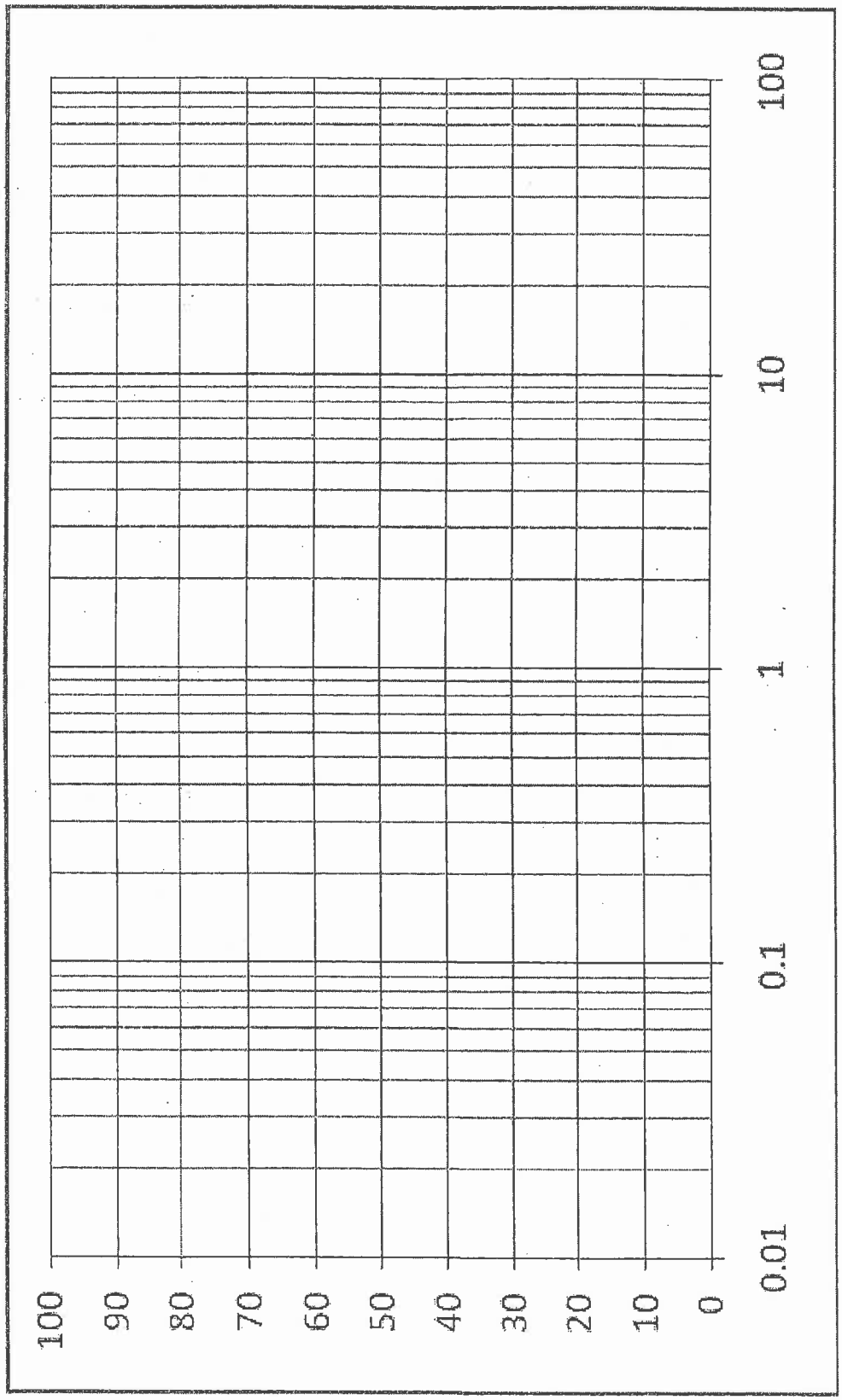
3. Four (4) questions constitute a complete exam paper.
   The first four questions as they appear in the answer book will be marked.

4. Each question is of equal value.

1. Table 1 below summarizes the measurements taken as a result of a grain-size analysis of a soil.
    a. Plot the grain-size distribution curve for the soil on the attached graph paper and submit this with your test booklet.
    b. Determine d_{10}, d_{50} and d_{60} for the sample.
    c. Classify the soil according to the soil classification system of your choice.
    d. The material below is to be used in a fill application where water is likely to flow through it. To prevent particles of this material being moved, it will be underlain with an additional filter soil. Determine the necessary specifications for the filter material if it must meet the following specifications:
        i. Filter must not contain any material > 80 mm
        ii. The filter should not have a fines content of more than 5%
        iii. The grading of the filter should have the same approximate shape as the soil it is protecting.
        iv. The d_{15} of the filter should be between $4xd_{15}$ of the soil and $4xd_{85}$ of the soil.

Table 1: Results of Grain-Size Analysis

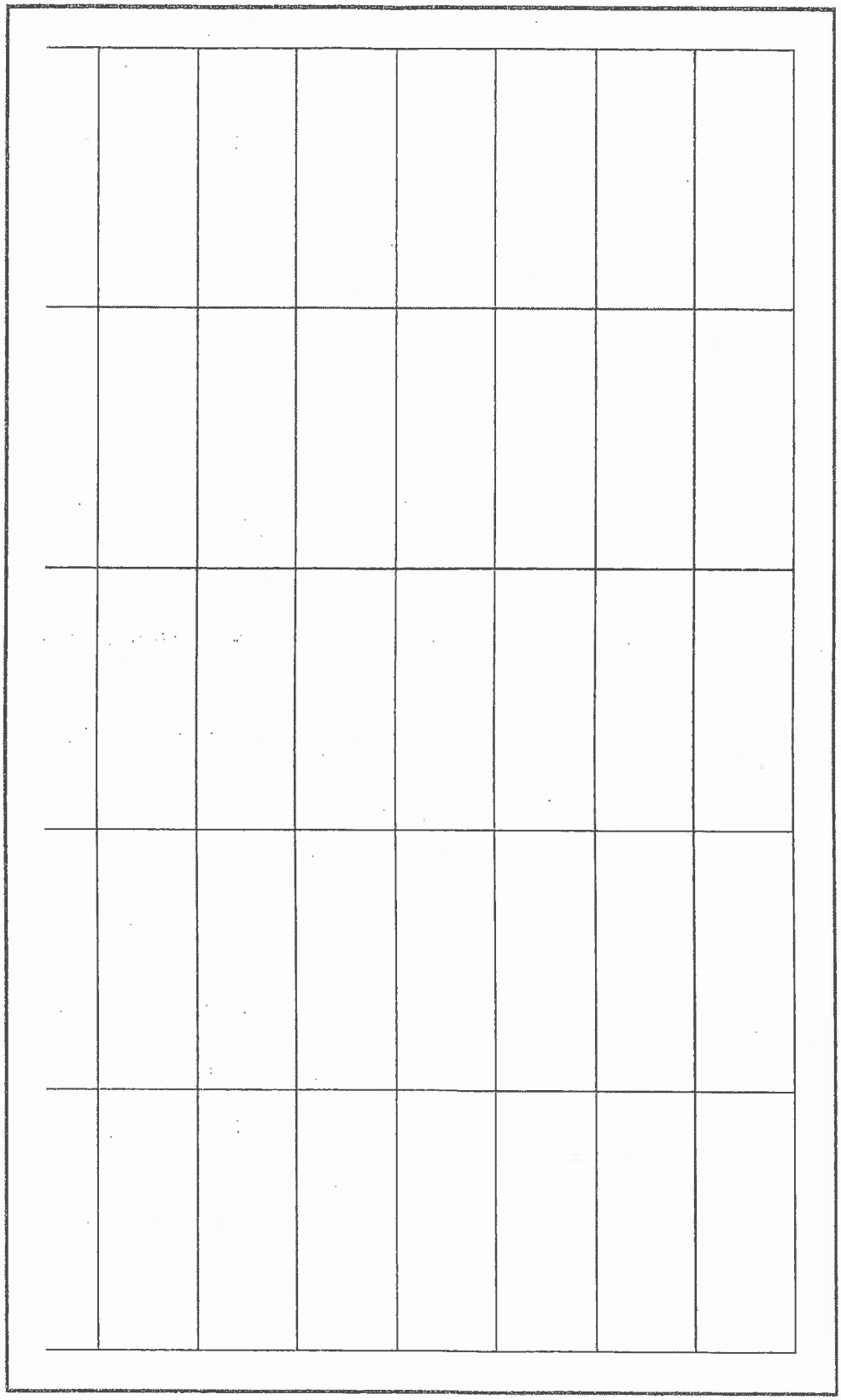
Sieve Size (mm)	Mass retained (g)			
3.35	0.0			
2.00	2.6			
1.18	12.5			
0.600	57.7			
0.425	62.0			
0.300	34.2			
0.212	18.7			
0.150	12.7			
0.063	13.1			
Pan	3.9			


100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100

2. A sandy clay soil sample was collected in the field and returned to the lab for a shear box (direct shear) test. The specimen in the box had dimensions of 60x60 mm and the results of the test are given in the table below.
    a. Determine the apparent cohesion and angle of friction of the soil (a sheet of graph paper is supplied with this question that may be of use – submit this with your answer booklet if you use it.)
    b. Discuss the accuracy of the results
    c. What other options are there for determining the shear strength parameters for soils and when might they be more appropriate than the approach used here?

Table 2: Shear Box Test Results

Normal Load (N)	Shear Load at Failure (N)			
108	172			
202	227			
295	266			
390	323			
484	374			
576	425			



3. A geological investigation is being made for the construction of a landfill site in some non-cohesive soils. Sampling consists of the use of a split spoon sampler with inside and outside diameters of 35 and 50 mm. Samples are collected as the sampler is being advanced and 150 mm long sections saved for later analysis. Soil particles have already been determined to have a density of 2.64 gm/cm^3. In addition, number of blows required to advance the tool 300 mm has been measured prior to taking the sample and has been found to be 75 blows with a standard hammer at the depth of interest. Determine:
    a. Soil bulk density
    b. Soil dry density
    c. Porosity of soil
    d. Degree of saturation
    e. Estimated relative density of the material

4. Source water protection requirements for wells in the area you are hoping to develop a well field in are expected to limit the amount of pumping allowed at a well. Firstly, within a 100 m radius of the well you are limited to a draw down of no more than 10 cm. Secondly, within the 2-year time of travel, development will be restricted and you need to identify this area. The aquifer you are going to use is a surficial aquifer in a sandy material (k = 75 m/d, n = 0.35) with a water table 4 m below the ground surface with a thickness of 4 m. It has a slight movement from east to west of 0.1 m/day. The well is proposed to pump 2 million liters per day. Groundwater recharge in the area is 100 mm/year. For this question clearly state any assumptions made to complete the question.
    a. What is the approximate area the well will draw from?
    b. What is the expected draw down at the 100 m distance – does it meet the requirement in the question?
    c. How far away from the well is the 2-year time of travel?
    d. If the soils above the aquifer have mean saturation levels of 30%, what additional travel time is there from the ground surface to the water table for a potential contaminant?

5. You are responsible for designing the cover of a 1 km^2 landfill to protect against infiltration of rainwater into the land fill. Your plan calls for a relatively coarse layer of loam on top to encourage plant growth and thus protect against erosion and a second layer below of clay to discourage the movement of the water into the landfill. Both layers are 0.4 m thick and the clay has an effective hydraulic conductivity 1/10 that of the loam. The loam has a conductivity of 1 m/day. Both materials have been delivered to the site. The contractor has suggested that, to save on construction costs, that he simply spread the clay on ½ of the site at a thickness of 0.8 m and spread the loam on the remaining ½ of the site also at a thickness of 0.8 m. His argument is that it is the same amount of material and that the overall infiltration will be the same since the section of the landfill with double the clay thickness will have much less infiltration into the landfill than the area covered by loam and the differences will balance out. He can also easily develop sufficient plant growth on both materials to discourage erosion.

   Discuss the contractor's position and demonstrate, with calculations as appropriate, how his arguments are or are not valid with respect to the overall infiltration into the landfill.

6. A long (> 100 m) slope is being designed for an excavation with a slope of 1:1.5 (V:H). A weak layer has been identified in the soil profile along the slope at a depth of 1.8 m in the soil. The soil has a unit weight of 18 kN/m^3 with a drained shear strength of 50 kN/m^2.
   a. What is the safety factor against sliding for this slope?
   b. If the water table were to rise up to this level, how would this change the factor of safety?
   c. If the factor of safety was unacceptable, suggest changes that would improve the factor of safety of the slope against sliding.