Addis Ababa University
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering

Fundamentals of Geotechnical Engineering II (CEng2142)
Test 2

Name	Solution Key
ID No.	
Signature	
Section	
Exam Date:	20.05.2019

Instruction:

1) This examination is closed book and constitutes 10% of your final grade.
2) The time allowed for this exam is 1hour.
3) Please read the questions carefully and make sure you understand the facts before you begin answering. Write as legibly and concisely as possible.
4) Use the provided space properly to present you answer.

Question #	Weight [marks]	Score [marks]
1		60
2		40
		100%

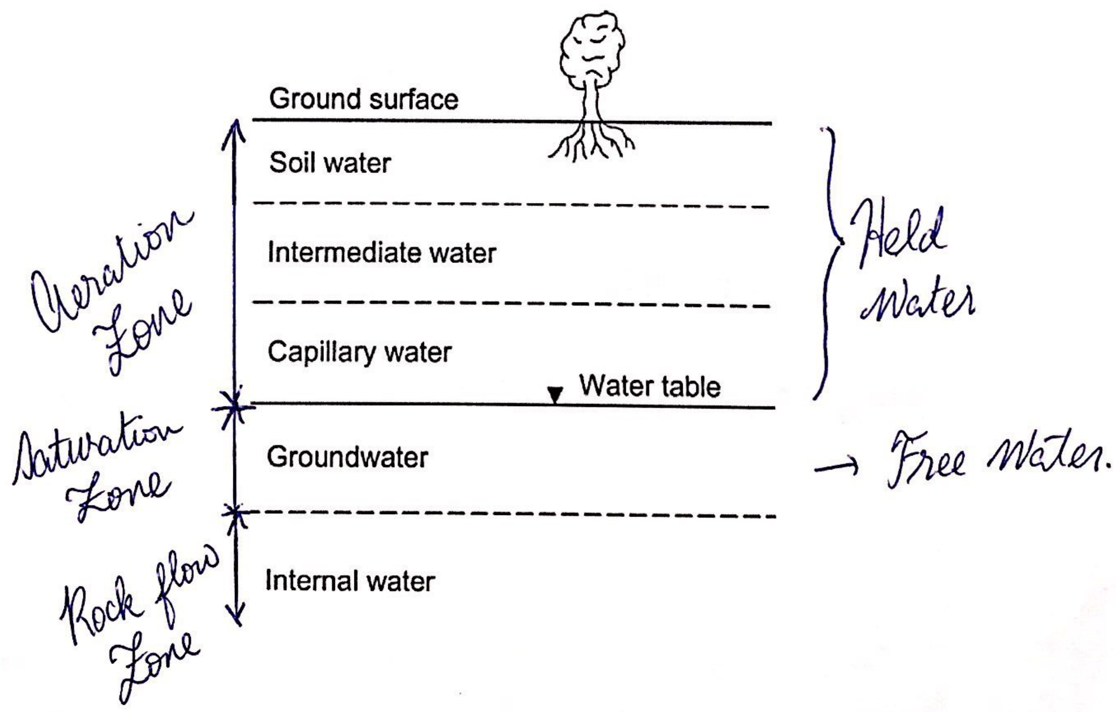
QUESTION 1: On Soil-Water, Permeability, and Seepage [60%]

1.1 Soil-Water Relationship

1.1.1 Explain the difference between infiltration, percolation and seepage. (6%)

Infiltration is a process by which water enters into the ground through a porous surface.	The term "percolation" is used to refer to the downward movement of water [after it has broken through the surface] under the influence of gravity.	Seepage refers to the general movement of water through a soil mass because of a hydraulic pressure gradient.

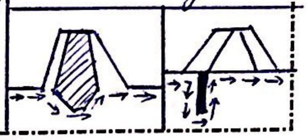
1.1.2 Label the different zones and/or belts associated with the different water types presented in the diagram. (4%)



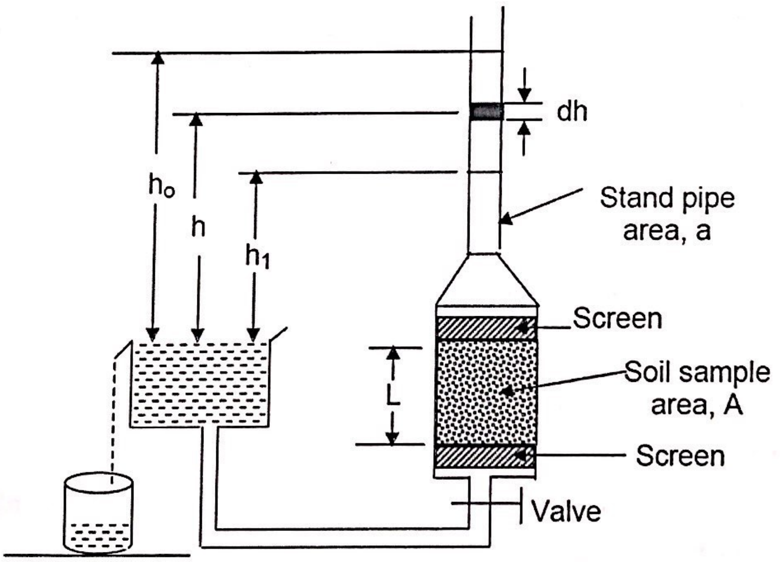
1.2 Permeability

1.2.1 What is the main purpose of constructing cut-offs for dams? Briefly present your explanation with a neat diagram. (5%)

Cut-offs are constructed underneath dams so as to lower uplift pressure by reducing the hydraulic gradient that is created when water starts being impounded in the upstream. As water is expected to move its way around the cut-off, its travel length increases, reducing its hydraulic gradient, i, owing to the inverse relation.



1.2.2 For the following schematic of a falling-head permeameter, derive an expression for estimating the coefficient of permeability using the parameters (designations) in the diagram. (10%)



$$Q = k \cdot i \cdot A \cdot t \Leftrightarrow dQ = k \cdot i \cdot A \cdot dt \quad , i = h/_L$$

$$dQ = -a \cdot dh$$

$$\Rightarrow -a\,dh = \frac{kh}{L} \cdot A \cdot dt$$

$$\Rightarrow -a \int_{h_0}^{h_1} \frac{1}{h}\, dh = \frac{kA}{L} \int_{t_0}^{t_1} dt$$

$$a \log_e \frac{h_0}{h_1} = \frac{kA}{L} [t_1 - t_0]$$

$$k = \frac{aL}{A \cdot [t_1 - t_0]} \log_e \frac{h_0}{h_1}$$

1.2.3 Mention the five assumptions made to apply Laplace's partial differential as a potential solution to address the two-dimensional flow definition. Explain the implications of making these assumptions. (10%)

Flow is Inviscid	* viscous forces (and hence, shearing stresses) are neglected.
Darcy's law is valid	* Flow is laminar
Soil is homogeneous.	* soil material type does not change across the physical scope of study.
Soil and water are incompressible	* Volume change is not considered.
Irrotational flow is neglected	* No vorticity.

1.2.4 A test boring was performed at an elevation of 925 m above m.s.l where the water table was found 8 m below the ground surface. A piezometer, installed 3.2 km downstream showed the phreatic surface to be at an elevation of 907 m above msl. An aquifer of almost uniform thickness of 15 m was observed between these two points. If the quantity of flow was measured 3mm³/s per unit width, compute the coefficient of permeability and comment on the most probable soil type using Cassagrande and Fadum's recommendation. (15%)

Cassagrande and Fadum's Coefficient of permeability

Coefficient of permeability k in cm per sec

	10^{2}	10^{1}	1.0	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}
Drainage	Good							Poor		Practically impervious		
Soil types	Clean sand		Clean sands, clean sand, and gravel mixtures			Very fine sands, organic inorganic silts, mixtures of sand, silt and clay, glacial till stratified clay deposited, etc.				"Impervious" soils, e.g.homogenous clays below zone of weathering.		
					"Impervious" soils modified by effects of vegetation and weathering.							

▷ Upstream head = 925m − 8m = 917m.

▷ Downstream " = 907 m.

▷ Head Difference = 917 − 907 = 10m.

$Q = 3\times10^{-9}\,m^3/s$

$A = 15\,m^2$, per unit width

$Q = k\cdot i\cdot A \iff k = \frac{Q}{i\cdot A}$; $i = \frac{10}{3.2\times10^{-3}} = 3.125\times10^{-3}$

$k = \frac{3\times10^{-9}\,m^3/s}{3.125\times10^{-3}\times15m^2} = 0.064\times10^{-6}\,m/s$

$= 6.4\times10^{-8}\,m/s \rightarrow 6.4\times10^{-6}\,cm/s$.

Drainage : POOR

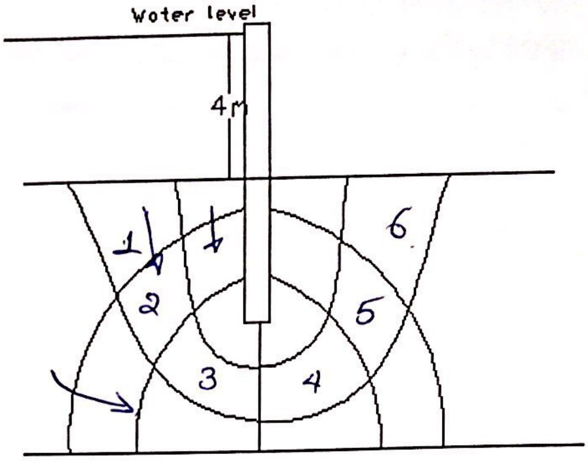
Soil Type : Very fine sands/Inorganic or organic silts, mixtures of sand, silt and clay ...

1.3 Seepage

A sheet pile wall retains 4m water as shown in the figure below, assuming the coefficient of permeability of the underlying soil to be 5 x 10^{-5} m/s,

a) Calculate the head loss at the bottom tip of the sheet pile wall.

b) Calculate the flow rate per day. (10%)



$N_f = 3$ $N_D = 6$ $k = 5\times10^{-5}$ m/s $\Delta h = 4m.$

a) Head loss per equipotential line is

$= \frac{\Delta h}{N_D} = 4m/6 = 2/3 m$ drop per one equipotential line.

b The sheet pile tip [bottom tip] is located 3 drops away from the maximum head, 4m,

i.e $head_{tip} = 4m - \frac{2}{3}[3] = \underline{2m}$

b) $Q = k \cdot \frac{N_f}{N_d} \cdot H = 5\times10^{-5} m/s \times \frac{3}{6} \times 4m = 1\times10^{-4} m^3/s$, per unit width.

=> Per day... $[1\times10^{-4} \times 60 \times 60 \times 24]\ m^3/day$

$= 86,400\times10^{-4} = \underline{8.64 m^3/day}$

QUESTION 2: On Compaction

[40%]

2.1 During sample preparation for compaction test, one of the key issues that you must address for your experiment is making sure that the moisture you provide is evenly distributed throughout the sample. What are the potential challenges that you might face in this regard, and how do you solve it (in addition to thorough mixing)? (5%)

The challenge with even moisture distribution is that lumps form (especially for very fine materials) and mixing the soil with water will only result in making these lumps moist on the surface. A solution for this is using fresh samples after (customarily) three or four trials, taken from the same soil mass.

2.2 Briefly discuss the difference between standard proctor density test and modified proctor density test. Which of the two tests would you choose for a fill behind retaining walls? Why? (10%)

	Standard Proctor Compaction	Modified Proctor Compaction
Different	Drop Height -> 305mm	457 mm.
Different	Hammer Weight -> 5.5 lbs	10 lbs
Different	# of Layers -> 3	5
Same	number of blows -> 25	25

Answer :- Standard Compaction.
The added compaction effort in modified compaction approach will only result in ① more soil mass to exert additional lateral pressure and ② more cost incurred so as to meet its added standard. So, as long the soil mass is adequately compacted for its expected functionality requirements, standard compaction is fine.

2.3 A Proctor compaction test was conducted in a bid to estimate the maximum dry density of a soil in a road project. It yielded the following results. (25%)

Trials	1	2	3	4	5	6
Measured Mass (gm.)	1558.9	1616.64	1684	1703.2	1751.4	1645.5
Moisture Content (%)	16	18	20	22	24	28

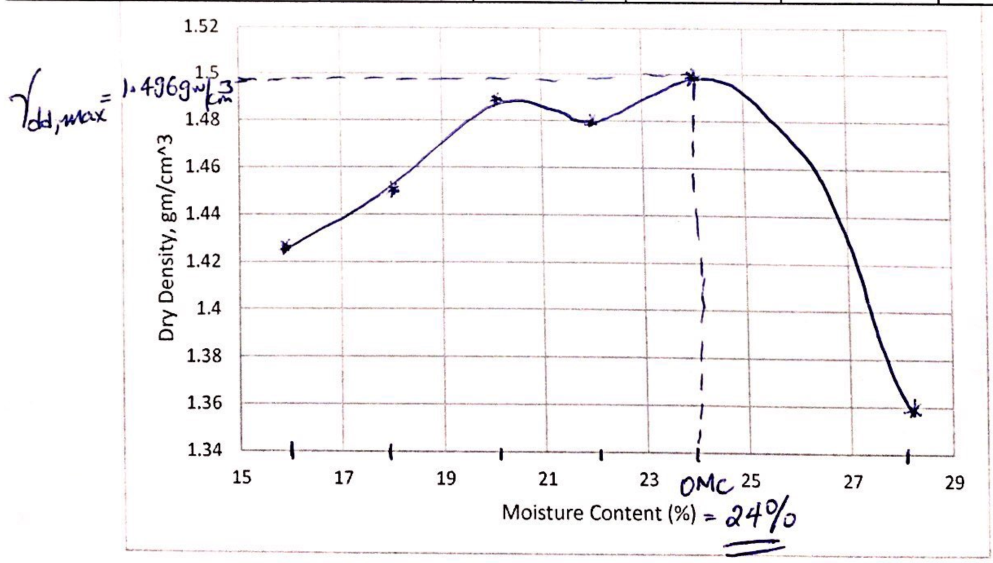
If the volume of the sampler is 944 cm^3, plot the dry density vs moisture content curve and determine

a) the optimum moisture content and the corresponding dry density;

b) the dry density expected on the field;

c) comment on the shape of the compaction curve and categorize the soil sample as per Lee & Seudkamp's (1972) suggestion.

Trials	1	2	3	4	5	6
[gm/cm^3] Bulk Density	1.65	1.71	1.78	1.80	1.85	1.74
[gm/cm^3] Dry Density	1.425	1.45	1.49	1.479	1.496	1.36



Field Density	Soil Category
= 95%(1.496) = 1.429 gm/cm^3	Soil Type 'C'