UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 4 Examination in Engineering: November 2017

Module Number: CE4302 **Module Name: Engineering Geology and Soil Mechanics**

[Three Hours]

[Answer **all questions**, each question carries ten marks]

Q1. Answer the following questions using the geological map shown in Figure Q1.1. The geological map shows a fault which displaces a coal seam. The apparent dip chart as shown in Figure Q1.2 may useful in the calculations.

a) Draw the structure contours on the geological map and deduce the dip angle and strike of the fault and of the coal seam.

[4.0 Marks]

b) Determine the amount of the throw of the fault.

[1.0 Marks]

c) Draw a geological cross-section along line XY.

[4.0 Marks]

c) Identify the type of fault.

[1.0 Marks]

Note: The geological map and the geological cross-section should be attached to the answer book

Q2. a) List different geological agents that assist weathering. Explain any two of them. How does differential weathering affect engineering structures?

[2.5 Marks]

b) In what respect, does sandstone differ from quartzite, shale from schist, and granite from gneiss? Give some explanation of the differences in each case.

[2.5 Marks]

c) What are the positive and negative effects of joints?

[2.5 Marks]

d) What are the geological properties of rocks forming foundations and abutments of dams and reservoirs? Briefly explain the suitability of three common rock types in Sri Lanka for dam foundations.

[2.5 Marks]

Q3. In an expressway construction project, it was decided to raise the finished road elevation by 4.0 m in order prevent possible flooding during the rainy season. Sub surface soil profile at the site consists of 3.7 m thick sand layer followed by 4.6 m thick medium stiff clay layer. Highly weathered rock is below the medium stiff clay layer. The water table is 3.7 m below the ground surface.

The void ratio and specific gravity of sand and medium stiff clay are shown in Table Q3.1. The coefficient of lateral earth pressure of sand and medium stiff clay can be taken as 0.5 and 0.4, respectively. The unit weight of water is 9.81 kN/m^3.

a) Draw the phase diagram and derive following equation with usual notations. Hence determine bulk unit weights of sand and medium dense clay.

i) Bulk unit weight of sand $\gamma = \dfrac{G_S\gamma_W}{(1+e)}$

ii) Bulk unit weight of medium stiff clay $\gamma = \dfrac{(G_S+e)\gamma_W}{(1+e)}$

[3.5 Marks]

b) Draw the total vertical stress, pore water pressure and effective vertical stress distributions to a depth of 8.3 m from the ground surface.

[2.5 Marks]

c) What would be the total lateral stress at a depth of 3.7 m and 8.3 m from the ground surface?

[2.0 Marks]

d) If unit weight of the fill material is 20 kN/m^3;

i) What would be the effective vertical stress at middle of the medium stiff clay layer immediately after fill has been placed?

[1.0 Marks]

ii) What would be the effective vertical stress at middle of the medium stiff clay layer many years after fill has been placed.

[1.0 Marks]

Q4. In order to restore a river embankment, a compacted soil volume of 50,000 m^3 is required. Based on the laboratory tests of soil from the excavation site, the water content, void ratio and specific gravity were determined as 10%, 0.60, and 2.80, respectively.

In order to develop compaction curve for the borrow material, a Standard Proctor Compaction test was performed in the laboratory on a soil sample obtained from the barrow pit and test results are depicted in Table Q4.1. The volume of the mould is 944 cm^3. You may use the unit weight of water as 9.81 kN/m^3.

a) i) Draw the compaction curve and determine the maximum dry unit weight and the optimum moisture content of the borrow material.

[3.0 Marks]

ii) Draw curves for 0 % and 5 % air voids line; hence estimate the air content corresponding to the maximum dry unit weight. You may use following equation with usual notations for calculations.

$$\gamma_d = \frac{(1-A)G_s\gamma_w}{(1+wG_s)}$$

[2.0 Marks]

b) It was planned to carry the borrow material to the construction site using a truck with a capacity of 5 m^3. The weight of the truck loaded to the full capacity is 6.5 tons. The embankment is constructed by compacting the soil after adding water so that the dry unit weight of soil after compaction is assumed as 20.0 kN/m^3, which is considered as the maximum dry unit weight of the barrow material. The water content after compaction becomes 12.5%.

i) Determine the degree of saturation, bulk unit weight, and dry unit weight of soil at the excavation site.

[1.5 Marks]

ii) Determine the total number of truck loads required for the construction.

[2.0 Marks]

iii) Determine the total volume of water added to obtain the prescribed water content during the compaction assuming that evaporation of water is negligible.

[1.5 Marks]

Q5. There is a proposal to develop a class-C road in a rural area. In order to identify the sub grade material a series of laboratory tests have been conducted.

a) i) Briefly describe the sample preparation procedure for the hydrometer analysis test?

[2.0 Marks]

ii) What is meniscus correction? Briefly describe the test procedure to determine the meniscus correction.

[1.0 Marks]

b) Plasticity characteristics of the soil were determined using Atterbeg Limit test.

i) List 4 factors that influence the absorbed water film on the particles?

[1.0 Marks]

ii) Briefly explain the variation of state of fine-grained soil over moisture content with an aid of a sketch.

[1.0 Marks]

iii) What would be the purpose of calibration of liquid limit apparatus prior to the test?

[0.5 Marks]

c) Sieve analysis test results of the above soil are shown in Table Q5.1.

i) Plot the particle size distribution of this soil sample.

Note:- Particle size distribution can be drawn in the semi-log graph sheet (Figure Q5.1) provided and should be attached to the answer book.

[2.0 Marks]

ii) Classify the soil according to Unified Soil Classification System.

You may use the Unified Soil Classification Chart as shown in Table Q5.2 for the calculations

[2.5 Marks]

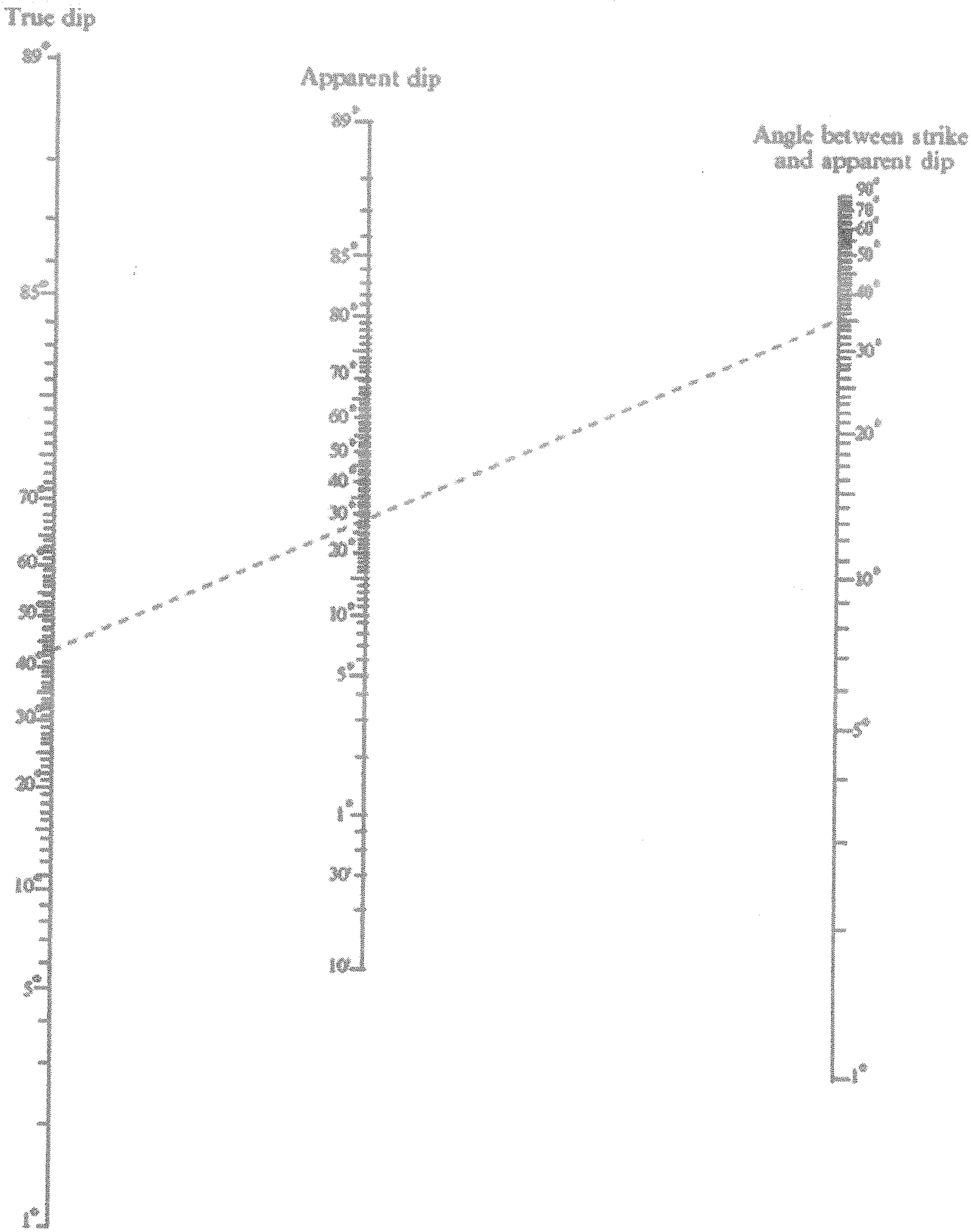


Figure Q1.2 – Apparent dip chart

Table Q3.1 – Physical properties of sub surface soil

	Sand	Medium stiff clay
Void ratio	0.61	0.48
Specific gravity	2.66	2.66

Table Q4.1 Standard Proctor Compaction test results

Water content (%)	9.30	11.59	12.66	14.52	16.22	19.29
Mass of soil (g)	1783.2	2074.5	2157.0	2107.2	2076.5	2020.0

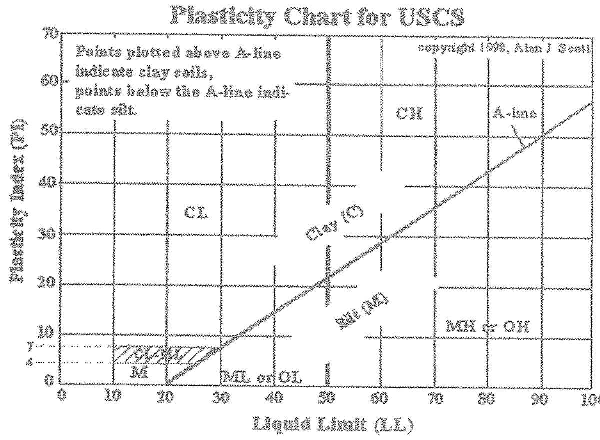
Table 5.1 – Sieve analysis test results

Sieve size (mm)	Mass of sieve (g)	Mass of sieve + retained soil (g)
20.0	1476	1476
12.5	1227	1280
9.5	1196	1235
6.3	1147	1259
5.6	1155	1200
4.75	1213	1247
4.0	1147	1202
2.36	564	743
1.7	555	687
1.18	521	633
0.85	500	599
0.6	491	569
0.425	465	504
0.25	434	445
0.075	402	408
Pan	355	355

Table Q5.2 - The Unified Soil Classification (USC) chart and Plasticity chart

Description			Group symbol	Laboratory criteria			
				Fines (%)	Grading	Plasticity	Notes
Coarse grained {more than 50% larger than 63 □m BS or No. 200 US sieve size} > 0.075 mm	Gravels {more than 50% of coarse fraction of gravel size} > 4.75 mm	Well graded gravels, sandy gravels, with little or no fines	GW	0 - 5	C_u> 4 1 < C_c< 3		Dual symbols. If 5 -12 % fines. Dual symbols if above A-line and 4 < PI < 7 $C_u = \frac{D_{60}}{D_{10}}$ $C_c = \frac{D_{30}^2}{D_{10} x D_{60}}$
		Poorly graded gravels, sandy gravels, with little or no fines	GP	0 - 5	Not satisfying GW requirements		
		Silty gravels, silty sandy gravels	GM	> 12		Below A-line or PI < 4	
		Clayey gravels, clayey sandy gravels	GC	> 12		Above A-line and PI > 7	
	Sands {more than 50% of coarse fraction of sand size} 4.75 – 0.075 mm	Well graded sands, gravelly sands, with little or no fines	SW	0 - 5	C_u> 6 1 < C_c< 3		
		Poorly graded sands, gravelly sands, with little or no fines	SP	0 - 5	Not satisfying SW requirements		
		Silty sands	SM	> 12		Below A-line or PI < 4	
		Clayey sands	SC	> 12		Above A-line and PI > 7	
Fine grained {more than 50% smaller than 63 µm BS or No. 200 US sieve size} < 0.075 mm	Silts and Clays {Liquid Limit less than 50}	Inorganic silts, silty or clayey fine sands, with slight plasticity	ML	Use plasticity chart			
		Inorganic clays, silty clays, sandy clays of low plasticity	CL	Use plasticity chart			
		Organic silts and organic silty clays of low plasticity	OL	Use plasticity chart			
	Silts and Clays {Liquid Limit greater than 50}	Inorganic silts of high plasticity	MH	Use plasticity chart			
		Inorganic clays of high plasticity	CH	Use plasticity chart			
		Organic clays of high plasticity	OH	Use plasticity chart			
Highly organic soils		Peat and other highly organic soils	Pt				

Plasticity Chart for USCS



Primary letter		Secondary letter	
G	Gravel	W	Well graded
S	Sand	P	Poorly graded
M	Silt	M	With non-plastic fines
C	Clay	C	With plastic fines
O	Organic soil	L	Of low plasticity (LL < 50)
Pt	Peat	H	Of high plasticity (LL > 50)

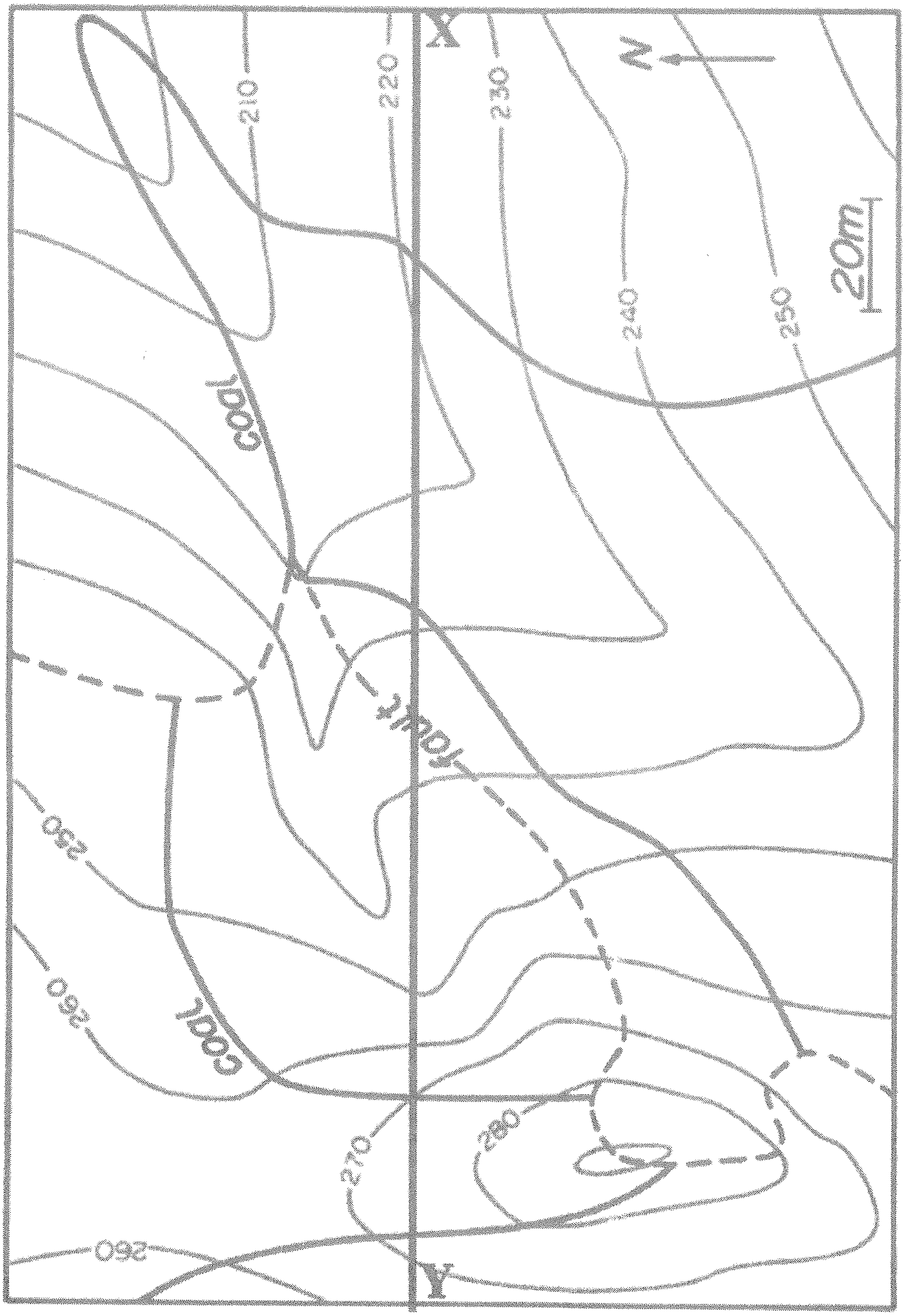


Figure Q1.1 Geological Map

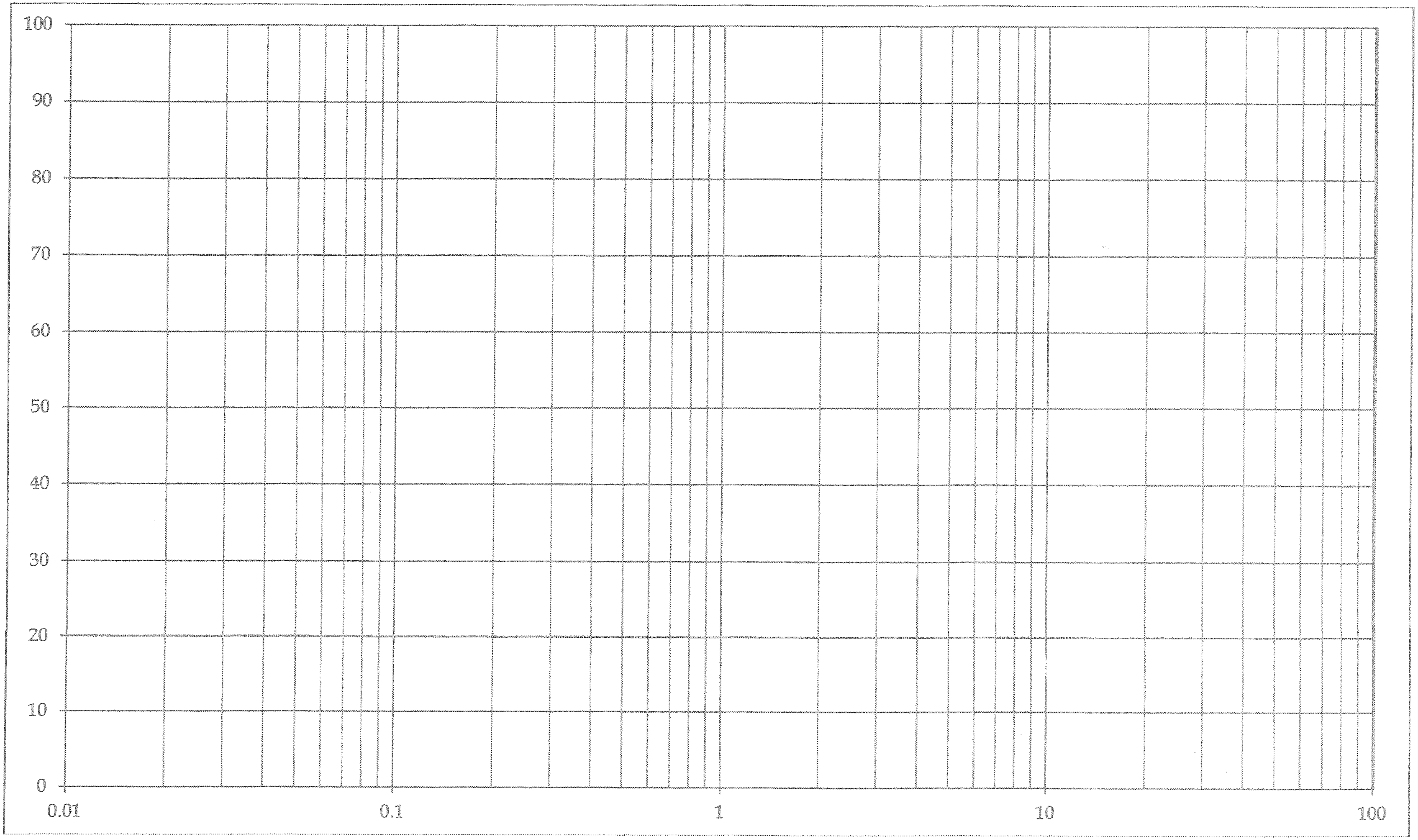


Figure Q5.1 - Semi-log graph sheet