2ND SEMESTER 2017/2018

UNIVERSITY OF SWAZILAND

MAIN EXAMINATION PAPER

PROGRAMME:	BACHELOR OF SCIENCE IN AGRONOMY, YEAR 2 BACHELOR OF SCIENCE IN AGRONOMY, YEAR 3
COURSE CODE:	CPR 204/CP308
TITLE OF PAPER:	PEDOLOGY
TIME ALLOWED:	TWO (2) HOURS
INSTRUCTIONS:	ANSWER ALL QUESTIONS

DO NOT OPEN THIS QUESTION UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR

QUESTION 1:

Data given below showed the morphological properties of a pedon classified as **fine-loamy, mixed, thermic, Calcic Paleargid**. **Table 1** and **2** showed the relevant chemical properties and Figure 1 showed the clay distribution in the soil profile. Two soil moisture regimes are recognized in the study area - a xeric regime and a xeric aridic transitional regime. Thermic is the dominant temperature regime in the study area. Mean winter air temperatures range from 5 ° to 98 ° C, and mean summer air temperature ranges from 22° to 29.8 ° C.

a. In the USDA Soil Taxonomy, which Soil Order does this pedon belong to? Give reasons for your answer **(2 marks)**

b. Define Xeric and Udic soil moisture regimes **(3 Marks)**?

c. In **Fig 1**, the Clay contents increased with depth. What is the name of this horizon and how was it formed **(8 marks)**? Calculate the base saturation (%) and the organic matter content (%) for each of these horizons **(12 marks)**.

Profiles description

Pedon 1

Classification	: fine-loamy, mixed, thermic, Calcic Paleargid
Location	: 200 m north-west of the Agricultural Research centre at Jordan University of Science and Technology
Vegetation	: barley
Landscape position	: alluvial plain
Slope	: 1–2% concave position
Parent material	: alluvium derived from limestone
Elevation	: 580 m a.s.l.
Colour	: on moist basis

Horizon depth (cm)

Ap	0–28	Reddish brown (5YR 4/4), silty clay loam, moderate medium granular and strong medium subangular blocky structure, slightly hard; friable, sticky, plastic; common medium roots; strongly effervescent; gradual boundary
Bk1	28–55	Yellowish red (5YR 4/6), silty clay loam, strong coarse angular blocky structure; very hard, firm, sticky, plastic; few fine roots; strongly effervescent; clear boundary
Bk2	55–90	Yellowish red (5YR 4/6), silty clay loam, strong coarse angular blocky structure; very hard, firm, sticky, plastic; very few fine roots; stage I calcium carbonate filaments, strongly effervescent; gradual boundary
Btkb1	90–115	Strong brown (7·5YR 4/6), silty clay loam, strong coarse angular blocky structure that breaks to strong medium subangular blocky; very hard, firm, very plastic, sticky; stage II calcium carbonate nodules; common thick clay films; no roots; violently effervescent; clear boundary
Btkb2	115–170	Reddish brown (5YR 4/3), silty clay loam, moderate medium subangular blocky structure; slightly hard, firm, slightly sticky, slightly plastic; stage II calcium carbonate; many thick clay films; violently effervescent; gradual boundary
Btkb3	170–220	Strong brown (7·5YR 5/6), clay, moderate medium angular blocky structure that breaks to moderate fine subangular blocky; hard, friable, sticky, plastic; violently effervescent; many thick clay films

Table 1. *Relevant soil chemical properties of the studied sites*

Horizon	Depth (cm)	pH*	EC (dS m^{-1})	OC	$CaCO_3$	Fe_2O_3
					%	
Pedon 1						
Ap	0–28	7·33	0·51	1·00	14·0	0·26
Bk1	28–55	7·91	0·28	0·55	19·4	0·24
Bk2	55–90	7·85	0·26	0·31	32·3	0·23
Btkb1	90–115	7·92	0·28	0·29	34·3	0·22
Btkb2	115–170	7·96	0·26	0·18	44·1	0·20
Btkb3	170–220	7·64	0·26	0·14	45·2	0·20

Table 2. *Extractable cations and cation exchange capacity (CEC) of the studied sites*

Horizon	Depth (cm)	Ca^{++}	Mg^{++}	K^+	Na^+	CEC
		cmol(+)kg^{-1}				
Pedon 1						
Ap	0–28	20·8	0·8	2·31	0·62	37·8
Bk1	28–55	19·1	1·6	1·13	0·66	37·9
Bk2	55–90	17·3	0·5	0·64	0·75	38·5
Btkb1	90–115	18·0	0·7	0·54	0·97	30·8
Btkb2	115–170	18·3	1·5	0·51	0·93	29·2
Btkb3	170–220	14·2	1·1	0·36	0·84	28·5

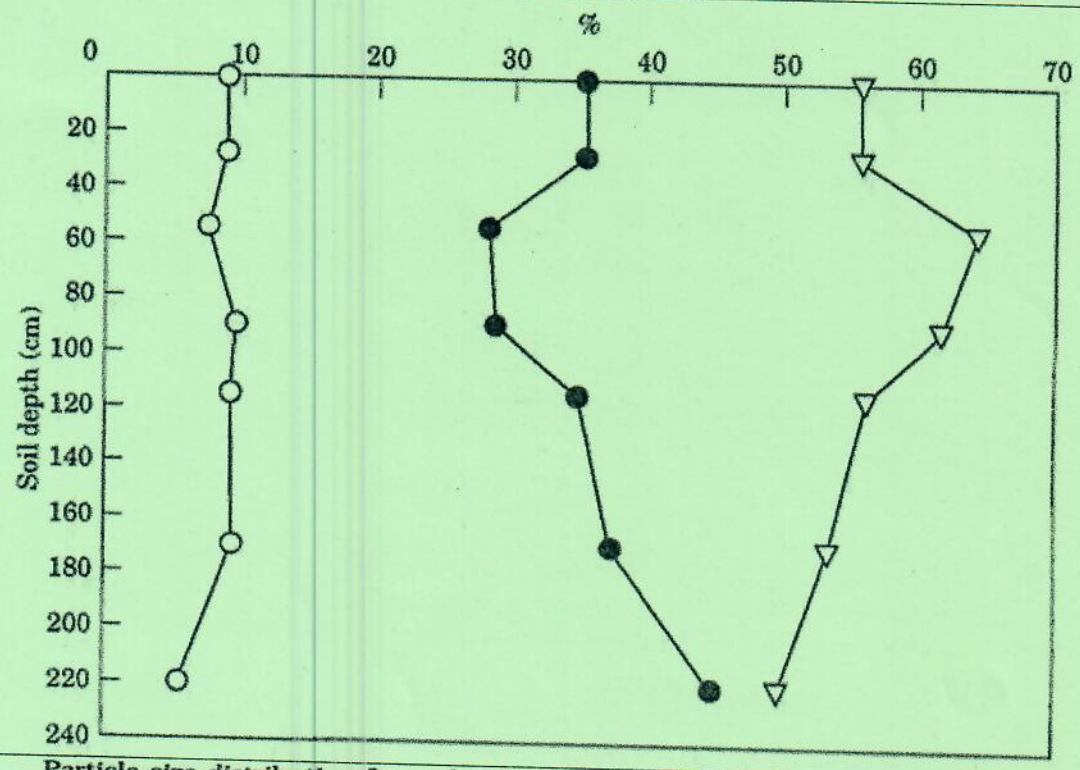

Fig1: Particle-size distribution for pedon 1. (○) = sand; (●) = clay; (▽) = silt.

QUESTION 2:

Data given in **Table 3** showed the land characteristics of **six** pedons (CH1, CH2, & CH3 and ED1, ED2 & ED3) and in **Table 4** is the factor ratings of the land use requirements for growing maize crop (*Zea may* L).

a. Define the terms land quality, land characteristics and land use requirements (**6 marks**).
b. Pedons CH1, CH2, CH3, ED1, ED2 & ED3 were classified as Aeric Fluvaquents. At what level of Soil Taxonomy is this classification (**1 mark**)?
c. From the morphological & chemical properties presented, identify the Soil Moisture Regime that was used in classifying this soil and **identify** the Soil Order in the **USDA Soil Taxonomy (5 marks)**.
d. What diagnostic criteria can be used for identifying this Soil Order (**1 mark**)?
e. Evaluate Pedons – CH1, CH2 & CH3 for their suitability for maize cultivation. From these three pedons, what are the main limitations to growing maize crop and how can you ameliorate these limitations (**12 marks**).

Table 3: Land characteristics of selected pedons at Luyengo, Swaziland.

			Pedons					
Land Qualities	Land Characteristics	Units	CH1	CH2	CH3	ED1	ED2	ED3
Climate (c)								
	Rainfall	mm	1306	1306	1306	1130	1130	1130
	Solar Radiation	MJ Cm^{-2} day^{-1}	13.87	13.87	13.87	19.81	19.81	19.81
Soil Physical Characteristics								
	Soil Depth	cm	>66	>80	>75	>105	>121	>117
	Texture	%	SL	SL	SCL	SCL	C	SCL
Fertility Status (f)								
	pH (M KCL)		5.7	6.1	5.7	3.5	3.10	4.0
	Total N	%	5.56	0.13	0.17	0.08	0.08	0.09
	Organic carbon	%	0.90	1.78	2.32	1.52	1.63	2.12
a.	P (Bray)	$mg.kg^{-1}$	4.90	1.10	4.23	16.34	3.76	15.47
Fertility Status (s)								
	P (Olsen)	$mg.kg^{-1}$	2.45	0.55	2.15	8.17	1.88	7.74
	K	$cmol.kg^{-1}$	0.13	0.04	0.02	0.06	0.04	0.23
	Ca	$cmol.kg^{-1}$	7.35	4.65	2.96	1.10	2.66	1.77
	Mg	$cmol.kg^{-1}$	4.82	1.49	1.17	0.49	0.79	0.84
	CEC	$cmol.kg^{-1}$	7.85	10.43	7.58	7.34	11.39	7.96
Slope (s)								
		%	1-2	1-2	1-2	1-2	1-2	4-5

Key: CH 1, CH2, CH3, ED1, ED2 7 ED3= Aeric Fluvaquent.

Table 4: Factor ratings of land use requirements for maize crop.

Land Qualities	Land Characteristics	Unit	S1	S2	S3	N1	N2
Factor Ratings		%	95-85	85-60	60-20	40-20	20-0
Climate (c)*							
	Annual Rainfall	mm	>1400	1200-1400	950-1100	850-900	<850
	Solar Radiation	$MJ.Cm^{-2}.day^{-1}$	>478	478-358	358-239	358-120	any
Soil Physical Characteristics**							
	Soil Depth[a]	cm	>20	10-20	5-10	<5	any
	Clay[b]	%	50-25	25-15	15-5	≤15, ≥ 5	any
Fertility Status (f)							
	pH+	-	5.5-7.5	5.2-5.5	≤5.2, ≥8.2	≤5.2, ≥8.2	any
	Total N++	%	>0.2	.1-0.2	>0.05-0.1	<0.05	any
	Organic carbon++	%	2-3	1-2	3-4	>4	any
	P(Bray)++	$mg.kg^{-1}$	>20	15-20	10-15	<10	any
	P(Olsen)++	$mg.kg^{-1}$	>10	7.5-10	5-7.5	<5	any
	K++	$cmol.kg^{-1}$	>0.2	0.1-0.2	<0.1	<0.1	any
	Ca++	$cmol.kg^{-1}$	10-15	5-10	1-5	<1;>5	any
	Mg++	$cmol.kg^{-1}$	2-5	1-2	<1	<1;>5	any
	CEC(soil)++	$cmol.kg^{-1}$	>16	10-16	5-10	<5	any
Slope(s)		%	1-2	2-3	4-5	>5	any

a. Key:
b. C+60-L = Clay (>60%) to Loam, Sc= Sandy clay, Cm = Massive clay, S= Sand.
c. #Sources: * Sys (1985); **[a]Moormann and Dudal (1965); **[b] Clarke (1951); + Ponnamperuma (1994); ++ Tanaka and Yoshida (1976); +* Singh (1991)

QUESTION 3:

The soil classification of Swaziland was by Murdoch (1968) and has two levels: soil sets and soil series.

d. Define the terms soil sets and soil series and give **two examples** each (**5 marks**).
e. Itemize and explain the **four criteria** that were used in separating soil series (**8 marks**).
f. Given the following soil sets/series as shown in the **Table 5** below, give brief descriptions of these soil sets/series and identify at least **two major** limitations in them (**12 marks**).

Table 5: Soil sets/series, descriptions and limitations of selected soils in Swaziland

Soil sets/series	Brief descriptions	Limitations
R		
W		
S		
T		
K		
Z		

QUESTION 4:

Selected characteristics of some wetland soils in Swaziland are provided in **Table 6** (morphological properties) and **Table 7** (chemical properties).

a. Itemize **five morphological** features/properties that can be used to classify these three soil types (**10 marks**).
b. Estimate the Delta pH (Δ pH) for all these horizons. What is the implication of these values for managing these soils for crop production (**5 marks**)?
c. What is/are the chemical properties to look for when this pedons are to be classified for agro-technology transfer of information (**4 marks**)
g. Mention **three** features can be used to distinguish these soil types/pedons: **Entisols, Ultisol** and **Alfisols (6 marks)**?

Table 6: Morphological properties of selected wetland soils in Swaziland

Horizons	Depths (cm)	Colour (moist)	Boundary	Texture	Structure	Consistence	Quartz stones	Concretions	Roots	Drainage	Mottles
Pedon ED1 :											
APg	0-10	7.5YR 4/0	Cw	SCL	SAB	lo	-None	many	m.m	WD	few
A12g	10-35	7.5YR 4/0	Cw	SL	Sg	fr	-	-	f.f	PD	many
C1g	35-65	10YR 5/2	As	S	Sg	non-st	-	-	f.f	ID	many
C2g	65-75	5Y 3/2	W	S	Ma	non-st	-	-	-	ID	many
C3g	75-90	2.5 Y 4/2	Cw	S	Sg	non-st	-	many	-	ID	-
C4g	90+	10YR 4/6	-	SL	Ma	wet-st	-	many	-	ID	-
Pedon ED2 :											
APg	0-7	5YR 4/1	Cw	SCL	SAB	wet-st	-	-	m	PD	-
A12g	7-23	5YR 4/1	Cw	CL	SAB	wet-st	-	-	m	ID	ma.dis
Cg	23-64	7.5YR 8/2	Cw	SCL	SAB	sl.st	-	-	m.f	ID	-
C1g	64-79	10YR 5/8	Cw	SCL	Ma	st	-	-	-	ID	med.man
C2g	79-94	10YR 5/8	-	CL	Ma	st	-	-	-	ID	med.man
C3g	94-121	10YR 5/3	-	L	Ma	v.st	-	-	-	ID	-
Pedon ED3 :											
APg	0-6	5Y 4/1	Cs	SCL	Ma	st	-	-	m	WD	med.fw
A12g	6-23	5Y 4/1	Cs	SL	Ma	v.st	-	-	f	WD	-
Cg	23-44	7.5YRN 4/0	Cs	LS	Ma	v.st	-	-	v.f	WD	-
C1g	44-87	10YR 4/4	-	S	Sg	fr	-	-	-	PD	co.med
C2g	87-102	7.5 YR 6/4	-	SL	Ma	st	-	-	-	PD	coa.med
C3g	102-120	10YR 5/6	-	L	Ma	v.st	-	-	-	PD	ma.dis

Key:Boundary: cw= clear wavy, w= wavy, As= abrupt smooth., Structure: SAB=subangular blocky, Sg= single grain, Ma= massive, Consistence:lo= loose, fr= friable, non-st= non-sticky, wet-st= wet-sticky, st=sticky, v.st=very sticky, sl-st=slightly-sticky, Roots: f.f= few fine,v.f= very fine, f=fine, Mottles: medium.few, med.man= medium many, co.med= common medium, coa.med= coarse medium, ma.dis= many distinct, Drainage: ID= impeded drainage, WD= well drained, PD= poorly drained, Textural class= TC: SCL= sandy clay loam, SL= sandy loam, S=sand, CL=clay loam, LS=loamy sand, L= loam.

Table 7: Chemical properties of selected wetland soils, Swaziland

Depth (cm)	Horizons	pH		0rg.C (%)	Total N (%)	P (Bray) mg.kg^{-1}	Exchangeable Bases (cmol.kg^{-1})				-----cmol kg^{-1}-------	
		H_20	KCl				K	Ca	Mg	Na	Exch. Ac	ECEC
Pedon ED 1:												
0-10	Apg	4.9	3.5	1.27	0.09	7.10	0.03	1.07	0.35	0.21	1.81	3.47
10-35	A12g	4.2	3.7	0.26	0.02	8.60	0.03	0.34	0.20	0.23	1.35	2.25
35-65	C1g	4.6	3.5	0.26	0.02	9.60	0.04	0.56	0.28	0.15	1.27	2.30
65-75	C2g	4.9	3.5	0.27	0.02	4.30	0.02	0.53	0.15	0.19	1.19	2.08
75-90	C3g	4.8	3.5	0.25	0.02	7.50	0.05	0.16	0.13	0.16	1.43	1.88
90+	C4g	4.4	3.3	0.25	0.03	1.50	0.05	1.68	0.72	0.16	1.81	4.42
Pedon ED 2:												
0-7	Apg	4.6	3.1	0.93	0.07	5.30	0.05	1.37	0.50	0.20	1.93	4.05
7-23	A12g	4.5	3.0	0.41	0.03	1.80	0.01	1.31	0.35	0.17	2.19	4.03
23-64	C1g	4.9	3.5	0.28	0.03	1.73	0.01	1.30	0.44	0.11	1.45	3.34
64-79	C2g	5.0	3.7	0.21	0.02	1.20	0.03	1.39	0.67	0.21	1.06	3.35
79-94	C3g	4.9	3.4	0.30	0.03	0.80	0.02	2.24	1.06	0.19	1.59	5.27
94-121	C4g	4.8	3.3	0.31	0.03	0.55	0.03	2.54	0.18	0.18	1.52	5.47

Depth (cm)	Horizons	pH	pH	Org. C (%)	Tot. N (%)	P Bray (mg.kg^{-1})	Exchangeable Cations ---------- (cmol.kg^{-1})----------				---- cmol.kg^{-1}-------	
		Water	KCl				K	Ca	Mg	Na	Exc. Ac	ECEC
Pedon ED 3 :												
0-6	Apg	5.6	4.1	2.27	0.14	20.2	0.32	2.34	1.07	0.31	0.39	4.43
6-23	A12g	5.0	3.6	0.26	0.02	8.10	0.04	0.37	0.19	0.16	1.45	2.25
23-44	C1g	4.8	3.7	0.27	0.02	7.10	0.01	0.34	0.15	0.14	1.02	1.66
44-87	C2g	5.0	4.1	0.12	0.01	2.90	0.02	0.25	0.12	0.12	0.47	0.98
87-102	C3g	5.2	3.8	0.25	0.03	0.80	0.06	2.39	1.02	0.18	1.25	4.90
102-120	C4g	4.6	3.3	0.32	0.03	1.70	0.10	3.13	1.26	0.22	1.58	6.29

Org. C= organic carbon; Exch.Ac= Exchangeable acidity; ECEC= Effective Cation Exchange Capacity