



**UNIVERSITY OF SWAZILAND**

**MAIN EXAMINATION PAPER**

**PROGRAMMES:**

- B. SC. IN AGRONOMY, YEAR 2**
- B. SC. IN AGRICULTURAL & BIOSYSTEMS ENGINEERING, YEAR 2**
- B. SC. IN AGRICULTURAL EDUCATION, YEAR 2**
- B. SC. IN AGRICULTURAL EXTENSION, YEAR 2**
- B. SC. IN ANIMAL SCIENCE, YEAR 2**
- B. SC. IN ANIMAL SCIENCE (DAIRY), YEAR 2**
- B. SC. IN HORTICULTURE, YEAR 2**

**COURSE CODE: CPR 205**

**TITLE OF PAPER: INTRODUCTORY TO SOIL SCIENCE**

**TIME ALLOWED: 2 HOURS**

**INSTRUCTIONS:**

- 1. ANSWER ALL QUESTIONS IN SECTIONS A, B AND C.**
- 2. ANSWER JUST ONLY ONE QUESTION IN SECTION D.**
- 3. PLEASE USE THE TEMPLATES PROVIDED (I.E. TABLES 1, 2 & 3) FOR YOUR ANSWERS.**

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

## SECTION A (10 MARKS)

Circle and write the correct answer(s) in your examination script(s)

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- Which of the following soil pH values is most desirable to maximize the plant availability of all essential elements in the soil? (Circle correct answer).
    - pH 6.5
    - pH 4.5
    - pH 7.5
    - pH 8.5
  - What is the base saturation percentage at pH 7 of a soil that contains the following amounts of exchangeable elements:  $\text{Ca}^{2+}=0.2$ ;  $\text{Mg}^{2+}=0.2$ ;  $\text{K}^+=0.1$ ;  $\text{Na}^+=0.0$ ;  $\text{Al}^{3+}=0.5$ ;  $\text{CEC}_7=1.0$  (all units  $\text{cmol}_c \text{ kg}^{-1}$ )?
    - 20%
    - 40%
    - 50%
    - all of the above.
  - Which of the following ions is responsible for alkali problems? (Circle correct answer(s)).
    - $\text{Na}^+$
    - $\text{Al}^{3+}$
    - $\text{K}^+$
    - All of above
  - Which of the following landscape positions is most likely to most rapidly erode? (Circle correct answer(s))
    - Crest
    - Toe-slope
    - Bottomland
    - Shoulder
  - The "weathering" of rocks and minerals refers to \_\_\_\_\_
    - their physical breakup into smaller particles and their chemical alteration into dissolved ions and new types of minerals
    - the formation of soil horizon distinctions because of the effects of rain, snow, freezing temperatures, heat, atmospheric pressure, and other weather-related conditions
    - the joining of basic elements in the earth's crust to form the minerals found in igneous rocks
    - all of the above are correct
    - none of the above \_\_\_\_\_

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SECTION B

Given the values of percentage sand, silt and clay contents below (Table 1), use the Soil Textural Triangle given (Fig 1) to determine the soil texture (20 Marks).

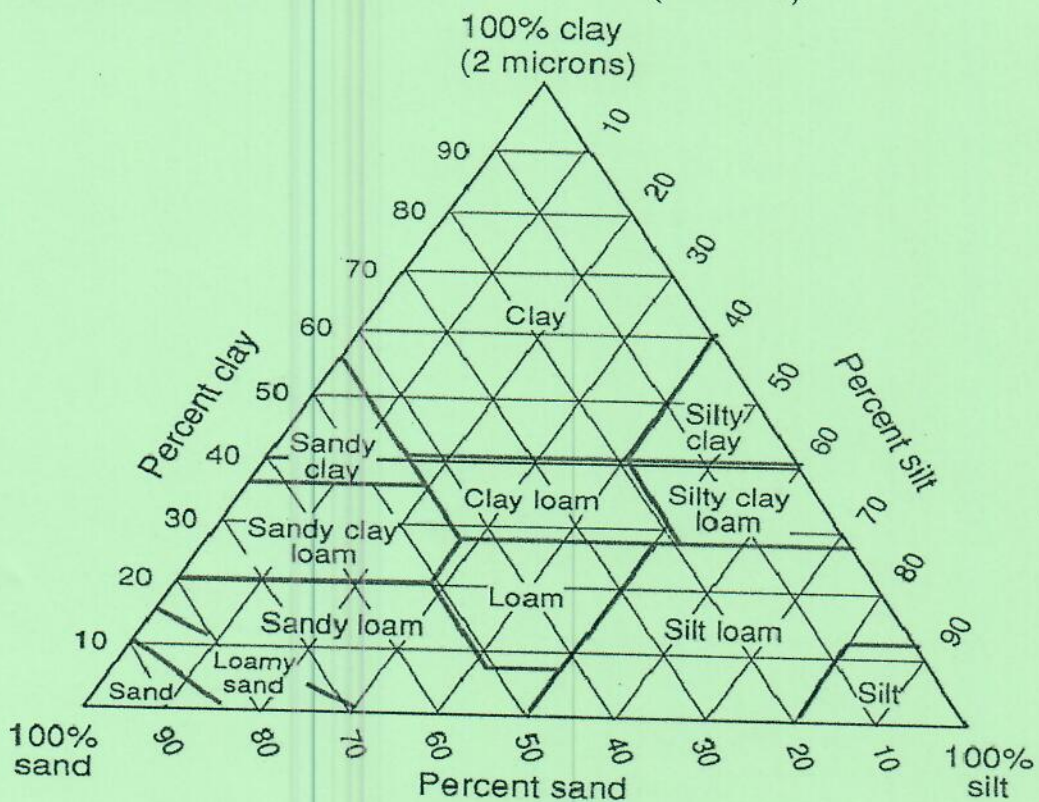


Fig 1: Soil Textural Triangle

(Source: <http://www.jsu.edu/dept/geography/mhill/phylabtwo/lab12/soiltextdiagf.html>)

Table 1: Percentage Sand, Silt and Clay Contents from a soil at Luyengo, Swaziland

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil Texture Classification
0-20	26	35	39	
21-45	89	7	4	
46-76	64	19	17	
77-90	9	7	85	
90-120	14	45	41	
0-20	5	87	41	
21-45	5	87	8	
46-76	8	35	57	
77-90	40	8	52	
90-120	37	32	31	

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SECTION C (25 MARKS) (PROVIDE YOUR ANSWERS IN THE SPACES BELOW)

- 1). Distinguish between particle density and bulk density. Is there any relationship between these two soil properties? Please, show using an equation.
  
  
  
  
  
  
  
  
  
  
- 2). Soil texture is one of the single most important soil properties of the soil. Mention four soil properties that this will affect.
  
  
  
  
  
  
  
  
  
  
- 3). Explain the difference between soil texture and soil structure. What is the link, if any, between the two terms?
  
  
  
  
  
  
  
  
  
  
- 4). What is isomorphous substitution? Out of the following two clay minerals, Kaolinite (1:1 Clay mineral) and Vermiculite (2:1 Clay Minerals), which of these will have higher isomorphous substitution?
  
  
  
  
  
  
  
  
  
  
- 5). Mention three properties that can be used to describe soil color on the field and use a simple diagram to indicate the axis of two of these properties.

SECTION D (45 MARKS)

ANSWER JUST ONLY ONE QUESTION HERE (I.E. IN THIS SECTION)

1. Given the data of the **FIVE** pedons in Table 2 below, calculate the following for each of the horizons (45 Marks):
- (i) Clay contents in (%)
  - (ii) Silt: clay ratio
  - (iii) Convert available P (mg/kg) to parts per million (ppm)
  - (iv) Base saturation percentage (BSP) using the CEC values given
  - (v) Delta pH ( $\Delta$ pH)

2a. What is cation exchange capacity (CEC) and what is the importance of this soil property for a sustained crop production? (5 marks)?

2b. Distinguish between CEC and the Effective Cation Exchange Capacity (ECEC) (5 marks).

What are the sources of negative charges in the soil (5 marks)?

2c. In the Table 3 below are five types of soil colloids. Indicate in the blanks spaces the clay mineral type, size ( $\mu$ m), shape, surface area and approximate net charge (30 marks).

Table 2: Physico-chemical properties of selected soils at the Faculty of Agriculture, Luyengo, University of Swaziland (45 marks)

(USE THE TEMPLATE ON THE NEXT PAGE FOR YOUR ANSWER)

Pedon/ Soil Order	Horizon	pH		Sand Silt Clay (%)			cmol/kg					Av. P (mg/kg)
		KCl	H <sub>2</sub> O	Sand	Silt	Clay	Na	Ca	Mg	K	CEC	
<i>Entisol</i>	Ap	5.7	5.8	56.4	20	-----	0.19	0.0004	0.23	2.24	3.19	3.5
	A	6	6.1	52.4	24	-----	0.17	0.0003	0.15	2.26	3.66	14.5
<i>Inceptisol</i>	Ap	5.1	6.4	56.4	30	-----	0.17	0.0003	1.81	2.35	4.48	2.19
	A	4.8	6.5	52.4	24	-----	0.27	0.0003	0.18	2.04	3.21	1.40
<i>Afisol</i>	Ap	5.8	6.5	48.4	22	-----	0.33	0.0006	0.74	2.62	3.81	7.7
	A	5.5	6.1	56.4	22	-----	0.2	0.0005	0.61	2.40	5.26	10.5
<i>Ultisols</i>	Ap	4.7	6.5	44.4	40	-----	0.24	0.0001	0.14	2.21	6.80	0.82
	A	4.6	5.4	72.4	10	-----	0.17	0.0001	0.23	2.33	4.80	0.88
<i>Mollisol</i>	Ap	5.3	6	64.4	16	-----	0.23	0.0001	0.20	1.81	5.53	1.11

Key: CEC=cation exchange capacity; Na= sodium; Ca= calcium; Mg= magnesium; K= potassium; P= phosphorus; KCl= potassium chloride; H<sub>2</sub>O= water  
 BSP= Base Saturation Percentage (%); Av.P= Available P

Table 2: Physico-chemical properties of selected soils at the Faculty of Agriculture, Luyengo, University of Swaziland (45 marks)

(USE THE TEMPLATE BELOW TO ANSWER QUESTION 1)

Pedon/ Soil Order	Horizon	-----(%)----- Clay	Silt/ Clay ratio	Av.P (ppm)	BSP (%)	A <sub>pH</sub>
<i>Entisol</i>	Ap					
	A					
<i>Inceptisol</i>	Ap					
	A					
<i>Alfisol</i>	Ap					
	A					
<i>Ultisols</i>	Ap					
	A					
<i>Mollisol</i>	Ap					

Key: CEC=cation exchange capacity; Na= sodium; Ca= calcium; Mg= magnesium; K= potassium; P= phosphorus; KCl= potassium chloride; H<sub>2</sub>O= water; BSP= Base Saturation Percentage (%); Av.P= Available P

Table 3: Properties of selected soil colloids  
(USE THE TEMPLATE BELOW TO ANSWER QUESTION 2)

Colloids	Type	Size (µm)	Surface Area	Interlayer spacing (nm)	Net Charge (cmol/kg)
Smectite					
Vermiculite					
Chlorite					
Kaolinite					
Humus					

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