



**UNIVERSITY OF ESWATINI  
FINAL EXAMINATION PAPER**

**PROGRAMME: BSC ABE 4**

**COURSE CODE: ABE402**

**TITLE OF PAPER: IRRIGATION DESIGN AND MANAGEMENT**

**TIME ALLOWED: TWO (2) HOURS**

**SPECIAL MATERIAL REQUIRED: CALCULATOR**

**INSTRUCTIONS: ANSWER QUESTION ONE AND ANY TWO  
OTHER QUESTIONS.**

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## SECTION I COMPULSORY

## QUESTION 1

- a) The Penman Monteith (P-M) equation has been recommended as a more accurate method for calculating reference evapotranspiration ( $ET_o$ ) when compared to models like the Blaney-Criddle, Hargreaves and others. However, the P-M equation requires more weather data to accurately calculate  $ET_o$ . What are the parameters that are required to be recorded at a weather station to help in the calculation of  $ET_o$ ? Explain how each parameter is significant in the process of evapotranspiration? [20 marks]
- b) Explain the components to be considered when determining the total head in order to correctly size a pump for a sprinkler system. [10 marks]
- c) i) Equations 1 and 2 are used to adjust the friction loss for pipes with various outlets. Explain why the adjustment is necessary, and how one decides whether to use Equation 1 or 2. [5 marks]

$$F = \frac{1}{m+1} + \frac{1}{2N} + \frac{\sqrt{m-1}}{6N^2} \quad \text{Equation 1}$$

$$F' = \frac{2N}{2N-1} \left( \frac{1}{m+1} + \frac{\sqrt{m-1}}{6N^2} \right) \quad \text{Equation 2}$$

- ii) Using the appropriate equation, calculate the adjustment factor for a lateral with 10 sprinklers, and sprinkler flow rate of  $0.8 \text{ L s}^{-1}$ . The spacing from the main line to the first sprinkler is 6 m, and spacing between subsequent sprinklers is 12 m. Assume the friction loss was calculated using the Hazen-Williams equation, where  $m = 1.852$ . [5 marks]

**SECTION II ANSWER ANY TWO QUESTIONS****QUESTION 2**

- a) The tensiometer is one of the instruments commonly used in irrigation water management. Explain in detail how it works, how it can be used for irrigation scheduling (when to irrigate and how much to irrigate). Also discuss its advantages and disadvantages.

**[20 marks]**

- b) The following results were obtained from a uniformity test of a sprinkler irrigation system. The results below are given in mm.

80	70	68	74
78	66	68	70
52	56	54	64
74	60	56	86
80	70	64	86

- i) Determine the Christiansen's coefficient of uniformity (CU).

**[6 marks]**

- ii) Given that the irrigation requirement was 70 mm, calculate the irrigation adequacy.

**[4 marks]****QUESTION 3**

- a) Describe the following types of sprinkler irrigation systems:

- (i) Hand move sprinkler
- (ii) Centre pivot
- (iii) Gun type sprinkler
- (iv) Linear move

**[16 marks]**

- b) Below is an extract from an executive summary of a study carried out to determine the feasibility of establishing a 2000 ha irrigation scheme in the Lowveld part of Eswatini. The developers need some clarification on this report, read and explain the few points where clarification is sought.

“The predominant soil in the area is a deep clay loam. 10% of the area is reportedly having infiltration problems. The soil was sampled to be tested for some specific parameters such as electrical conductivity, pH, and some elemental contents of the soil (sodium, magnesium and calcium). The 10% portion, which was soil A, was found to be sodic, having a sodium absorptive ratio (SAR) of 4.89, exchangeable sodium percentage (ESP) of 18 and an extract electrical conductivity of 3.2. There is bound to be infiltration problems with these values also considering the nature of the soil (clay loam), it requires a good structure for it to have good drainage, which is made impossible by the higher level of sodium in the soil. Using water with electrical conductivity of just 0.9 dS/m results in severe reduction in rate of infiltration. The pH is also high (8.9) which render some nutrients unavailable to plants. A recommended action to solve this problem is amending the soil with gypsum. A total of 1836 tonnes will be required for the 200 ha.

To avoid accumulation of salts with the use of water with salinity of 0.9 dS/m, additional water over and above the net irrigation is required to leach down salts. However, with sprinkler having a field application efficiency of 0.7, calculations suggested no need for additional water for leaching”.

Explain;

i) the concepts of SAR and ESP, how they relate to each other and how they are used to determine the suitability of the soil for crop production.

[4 marks]

ii) and how water of lower electrical conductivity would result in severe reduction in rate of infiltration

[4 marks]

iii) the chemical composition of gypsum and how it can achieve the intended purpose when added to the soil

[3 marks]

iv) why there would be no need of additional water for leaching in the situation above?

[3 marks]

**QUESTION 4**

- a) Filtration is an important process in drip irrigation system. Without the filtration process, emitters can be blocked, resulting in non-uniformity of application and reduced production. Describe the types of filters that may be used in drip irrigation system. **[15 marks]**
- b) Explain the significance of the following factors in the design of a drip irrigation system:
- (i) Soil type
  - (ii) Topography
  - (iii) Climate
  - (iv) Water quality
  - (v) Proposed crop
- [15 marks]**