UNIVERSITY OF SWAZILAND
FINAL EXAMINATION PAPER

PROGRAMME: ABE (4)

COURSE CODE: ABE 403

TITLE OF PAPER: IRRIGATION DESIGN AND MANAGEMENT

TIME ALLOWED: TWO (2) HOURS

SPECIAL MATERIAL REQUIRED: CALCULATOR, FORMULA SHEET, & INTAKE FAMILY TABLE

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY TWO OTHER QUESTIONS.

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SECTION ONE: COMPULSORY QUESTION

QUESTION ONE

a) Name four important parameters that affects the design of a furrow irrigation system. (8 marks)

b) Name three reasons for land drainage. (6 marks)

c) i) A Mango tree requires a gross depth of 80 mm per irrigation. If the rooting depth of mangoes is 1.8 m and the soil is a silty clay loam with a depth of 1.2 m and water holding capacity of 122 mm, Calculate the recommended Management Allowed Depletion if the irrigation system selected has an efficiency of 75% (3 marks)

ii) Calculate the daily water use of Papaw under the current irrigation conditions if the irrigation frequency is 8 days. (2 marks)

iii) Assuming that the selected irrigation system is a sprinkler with a stand time of 11 hours, a spacing of 9.2 m x 15.25m, calculate the unit discharge of each sprinkler in L/min. (3 marks)

iv) Assuming that the discharge coefficient, $K_d = 2.595$ for single nozzle sprinklers with 4.6 mm nozzles, calculate the sprinkler operating pressure. (2 marks)

v) If the lateral is 101 m long, calculate the lateral inlet pressure head, H_l for 50 mm aluminium pipe with an inside diameter of 48.3 mm, and 0.75 m high sprinkler risers (C = 130). (11 marks)

vi) How much area can be irrigated with the system? (2 marks)

vii) If a bore hole is to be used, what size pump must be selected assuming it is 60% efficient. (3 marks)

SECTION II: ANSWER ANY TWO QUESTIONS

QUESTION TWO

a) Derive Hooghoudt drain spacing equation for steady state flow to vertically walled open drains reaching an impervious layer (10 marks)

b) Corn is irrigated by a traveling sprinkler with water having an electrical conductivity of 2.1 dS/m. If the electrical conductivity of the average saturation extract of the soil root zone profile that would give a 10 % yield reduction is 2.5 dS/m,

i) Find the leaching requirement? (5 marks)

ii) If the area of the field is 16 ha, corn water requirement consumption is 5 mm/day, and the moisture to be replaced at each irrigation is 60 mm, calculate the gross depth when the irrigation efficiency is 75 %? (5 marks)

c) If the required irrigation period is 10 days in a 12 day interval, compute the system capacity, Q, when the system operating time per day is 20 hours. (5 marks)

d) Calculate the discharge, Q, of a rectangular channel if the width is 2.438 m, with a depth of flow of 0.610 m and the bed slope of 0.0004 m/m. Use a Manning's roughness coefficient of n = 0.015. (5 marks)

QUESTION THREE

a) Discuss five advantages and five disadvantages of trickle irrigation system. (10 marks)

b) Determine the required diameter for an orifice emitter in a turbulent flow regime with a design discharge of 10 L/h and operating pressure head of 10 m. Assume a value of 0.6 for the orifice coefficient. (5 marks)

c) A typical orchard is to be developed on a field with dimensions of 253 m by 439 m. The orchard will be irrigated using a trickle system laid out so that each tree is served by four emitters. The following design conditions are based on peak period requirements at full tree maturity.

Operating pressure head at the emitter = 10 m
Peak period crop water requirements = 5 mm/d
Distribution pattern efficiency = 92 percent
Operating time = 18 h/day

Additional design parameters are shown in the table below;

Type of crop	Row spacing (m)	Plants per hectare	Emitters per hectare	Lateral length m/ha
Ordinary orchard	6	250	500 - 1500	1900

Estimate the following design parameters;

i) Number of emitters required (5 marks)
ii) Required emitter discharge, L/hr (5 marks)
iii) Length of lateral, m (5 marks)

QUESTION FOUR

a) Assume that for a given soil the empirical constants for the Kostiakov equation with depth in cm and time in minutes are α= 0.7 and c = 0.21 and that 10 percent deep percolation is acceptable. If the net irrigation requirement, i_n, is 8 cm,

i) determine the net time of irrigation, T_n, and (3 marks)

i) the advance time required for the water to reach the end of the field, T_t.(2 marks)

b) Given the following furrow information;

Intake family	If = 0.3
Furrow length	L = 275 m
Furrow slope	S = 0.004 m/m
Furrow spacing	W = 0.75 m
Roughness coefficient	n = 0.04
Net irrigation depth	i_n = 75 mm
Furrow inflow rate	Q = 0.6 L/s

Compute the following design parameters;

i) The advance time, T_t (3 marks)
ii) The adjusted wetted perimeter, P (3 marks)
iii) The net infiltration time, T_n (2 marks)
iv) The design cutoff time, T_{co} (2 marks)
v) The gross application depth, i_g (2 marks)
vi) The average infiltration time, $T_{o\text{-}L}$ (4 marks)
vii) The average infiltration depth, i_{avg} (3 marks)
viii) The surface runoff, d_{ro} (2 marks)
ix) The deep percolation depth, d_{dp} (2 marks)
x) The distribution pattern efficiency, e_d (2 marks)

SOME USEFUL EQUATIONS

$$d = \frac{d_n}{(\frac{Ea}{100})}, \quad d = \frac{0.9 * d_n}{(1.0 - LR) * Ea/100}, \quad Q_s = K\frac{A * d}{f * T}, \quad h_f = F_y * \frac{L}{D} * \frac{V^2}{2g}$$

$$J = \frac{h_f}{\frac{L}{100}} = K(\frac{Q}{C})^{1.852} D^{-4.87}, \quad R_y = K * \frac{Q}{D}, \quad P_s = \frac{\rho g Q H}{\aleph}$$

$$F = \frac{1}{b+1} + \frac{1}{2N} + \frac{(b-1)^{0.5}}{6N^2}, \quad H_l = H_a + \frac{3h_f}{4} + \frac{1\Delta H_e}{2} + H_r, \quad NPSHa = P_{atm} - P_v - h_{fs} - Z$$

DRIP EQUATIONS

$$R_n = \frac{V * D}{1000 * \vartheta}, \quad f = \frac{h_f}{\frac{L}{D} * \frac{V^2}{2g}}, \quad q = 3.6 * A * Co * (2gH)^{0.5}$$

$$q = 0.11384 * A * \left[2g(\frac{HD}{f * L})\right]^{0.5}, \quad q = 0.11384 * A * \left[2g(\frac{\sqrt{H}D}{f * L})\right]^{0.5}$$

$$f = 64/R_n, \quad \frac{1}{\sqrt{f}} = 2Log\left(\frac{D}{\epsilon}\right) + 1.14, \quad q = k * H^x, \quad U_e = 100\left[1.0 - \frac{1.27}{n} * C_v\right] * \frac{q_{min}}{q_{avg}}$$

FURROW EQUATIONS

$T_{co} + T_d = T_r - T_L$, $E_a = \frac{Z_{req} L}{Q_0 T_{co}}$, $P = 0.265 \left[\frac{Q * n}{S^{0.5}}\right]^{0.425} + 0.227$; $i = [at^b + c]\frac{P}{W}$

$T_t = \frac{x}{f} exp\left[\frac{g * x}{Q * S^{0.5}}\right]$; $T_n = \left[\frac{i_n\left(\frac{W}{P}\right) - c}{a}\right]^{1/b}$; $T_o = T_{co} - T_t$

$T_{co} = T_t + T_n$; $\beta = \frac{g * x}{Q * S^{0.5}}$; $i_g = \frac{i_n}{\frac{e_d}{100}}$; $i_g = \frac{60 * Q * T_{co}}{WL}$

$$T_{0-x} = T_{co} - \frac{0.0929}{f(x)\left[\frac{0.305\beta}{x}\right]^2}[(\beta - 1)\exp(\beta) + 1], \quad d_{ro} = i_g - i_{avg}; \; d_{dp} = i_{avg} - i_n$$

Table 1. Intake family and advance coefficients for depth of infiltration in mm, time in minutes, and length in meters.

Intake Family	a	b	c	f	g * 10^{-4}
0.05	0.5334	0.618	7.0	7.16	1.088
0.10	0.6198	0.661	7.0	7.25	1.251
0.15	0.7110	0.683	7.0	7.34	1.414
0.20	0.7772	0.699	7.0	7.43	1.578
0.25	0.8534	0.711	7.0	7.52	1.741
0.30	0.9246	0.720	7.0	7.61	1.904
0.35	0.9957	0.729	7.0	7.70	2.067
0.40	1.064	0.736	7.0	7.79	2.230
0.45	1.130	0.742	7.0	7.88	2.393
0.50	1.196	0.748	7.0	7.97	2.556
0.60	1.321	0.757	7.0	8.15	2.883
0.70	1.443	0.766	7.0	8.33	3.209
0.80	1.560	0.773	7.0	8.50	3.535
0.90	1.674	0.779	7.0	8.68	3.862
1.00	1.786	0.785	7.0	8.86	4.188
1.50	2.284	0.799	7.0	9.76	5.819
2.00	2.753	0.808	7.0	10.65	7.451