UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER

2012

PROGRAMME: B.SC.

COURSE CODE: ABE 403/LUM 403

TITLE OF PAPER: IRRIGATION DESIGN AND MANAGEMENT

ALLOWED TIME: 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) Briefly explain five important factors for preliminary irrigation system design. {10 marks}

b) A trial configuration of a hand move sprinkler has a lateral running downslope from a mainline along a constant grade of 0.005 m/m. The design operating pressure of the nozzle is 350 kPa. The lateral has a length of 450 m between the first and last sprinkler.

i) Compute the maximum allowable headloss due to friction. {5 marks}

ii) Determine the required pipe diameter to maintain the actual headloss within the allowable limit if the sprinkler spacing is 12 m and the design discharge is 0.315 l/s per sprinkler. {5 marks}

c) A sprinkler system has a gross depth of irrigation required equal to 131 mm. The operating pressure at the sprinkler nozzle is 380 KPa. The area to be irrigated is 2 ha with a time of operation of 20 hrs. The overall pump efficiency is 70 percent. At full operation, the pump is taking water from a water table 23 m below the height of the sprinkler nozzle. The head losses up to the sprinkler nozzle are equivalent to 7.6 m of head.

i) What is the total pumping head? {2 marks}
ii) What is the system capacity? {3 marks}
iii) What size pump is required to meet the demand? {5 marks}

d) A drip irrigated orchard is to be developed with dimensions of 253 m by 439 m. the irrigation system will be laid out such that each tree is served by four emitters. The following design conditions are based on peak period requirements at full tree maturity. The operating pressure head at the emitter is 10 m. the peak period crop water requirements is 5 mm/d. the required distribution pattern efficiency is 92 percent and the operating time is 18 hrs/day. Additional information is summarized in the table below;

Type of crop	Row Spacing (m)	Plants per hectare	Emitters per hectare	Lateral length (m/ha)
Orchard	6	250	500-1500	1,900

Calculate the following design parameters;

i) The total number of emitters required, {2 marks}
ii) The required emitter discharge, {3 marks}
iii) The length of lateral {5 marks}

SECTION II: ANSWER ANY TWO QUESTIONS

QUESTION TWO

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

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) Compute the required length of a long-path emitter for a system with a design discharge of 4 L/h and operating pressure head of 10 m. Assume the standard value of 1.0×10^{-6} m^2/s for the kinematic viscosity of water. {15marks}

QUESTION THREE

a) Assume that for a given soil the empirical constants for the Kostiakov equation with depth in cm and time in minutes are $\alpha = 0.7$ 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}

iii) 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-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}

QUESTION FOUR

Given a sprinkler system designed for a tomato field;

The root depth, Z = 1.00 m, Lateral length = 101 m
The soil water holding capacity W_a = 122 mm/m
The Management Allowed Depletion, MAD = 40 %,
The irrigation Efficiency, E_a = 74 %
The crop consumptive use rate, U_d = 7.0 mm/d, sprinkler stand time = 11 hrs
The sprinkler spacing, S_e = 9.2 m, and S_l = 15.25 m

Calculate the following;

i) The recommended gross depth of application per irrigation, {3 marks}
ii) The irrigation frequency, {3 marks}
iii) The sprinkler application rate. {4 marks}
iv) The sprinkler operating pressure head, H_a, assuming K_d = 2.595 for single nozzle sprinklers with 3.6 mm nozzles {4 marks}
v) The total lateral flow rate, {5 marks}
vi) The number of sprinklers {2 marks}
vii) The lateral inlet pressure head, H_l for 50 mm aluminium pipe (C=130) with an inside diameter of 48.3 mm, and 0.75 m high sprinkler risers. {9 marks}

SOME USEFUL EQUATIONS

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

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

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

DRIP EQUATIONS

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

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

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

FURROW EQUATIONS

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

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

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

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

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