UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER

2014

PROGRAMME: B.SC.

COURSE CODE: ABE 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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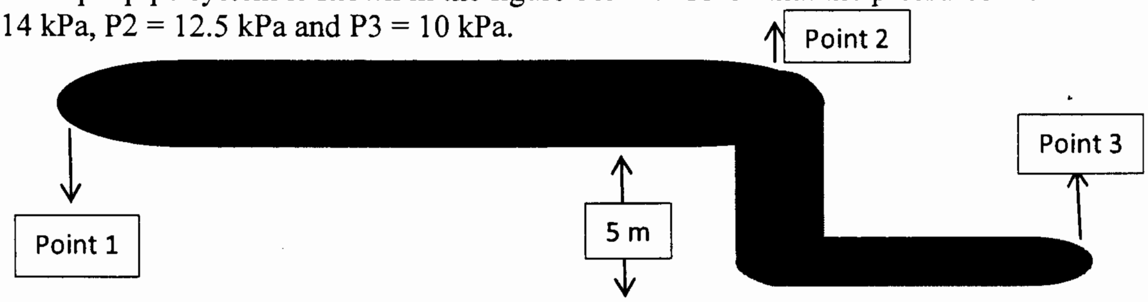
SECTION A: COMPULSORY QUESTION

QUESTION ONE

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

b) Consider the steady flow of water through a nozzle in which the upstream diameter D1 = 30cm and the nozzle reduces to a downstream diameter of D2 = 20 cm. If the flow rate through the nozzle is 4,800 liters per minute, compute the mean velocities for the upstream and downstream diameters respectively. {8marks}

c) A simple pipe system is shown in the figure below. Given that the pressures are P1 = 14 kPa, P2 = 12.5 kPa and P3 = 10 kPa.



If the diameter of the pipe at point 1 is equal to the diameter at point 2 and it is 60 mm and that at point 3 is 40 mm;

i) Determine the headloss between points 1 and points 2 {4 marks}
ii) How long is the pipe between points 1 and 2 {5 marks}
iii) Calculate the velocities between points 1 and points 2 {8 marks}
iv) Determine the headloss between points 1 and points 3 {5 marks}

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO

a) 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}

d) 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}

e) 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}

QUESTION THREE

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) A trapezoidal concrete canal is designed to carry 70 L/s. The canals channel has a bottom width of 30 cm, side slope z = 1.25, a water depth of 22.5 cm and a freeboard of 7.5 cm. Calculate;

i) the canal's cross sectional area {4marks}
ii) the wetted perimeter {3marks}
iii) the hydraulic radius {3marks}
iv) the surface slope {3marks}
v) If the canal is 862 m long, what is the expected headloss along the canal? {2marks}

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 $\alpha = 0.7$ 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, $T_{o\text{-}L}$ {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

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

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

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

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

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

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

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

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

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