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UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER

2016

PROGRAMME: B.SC. ABE

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) 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

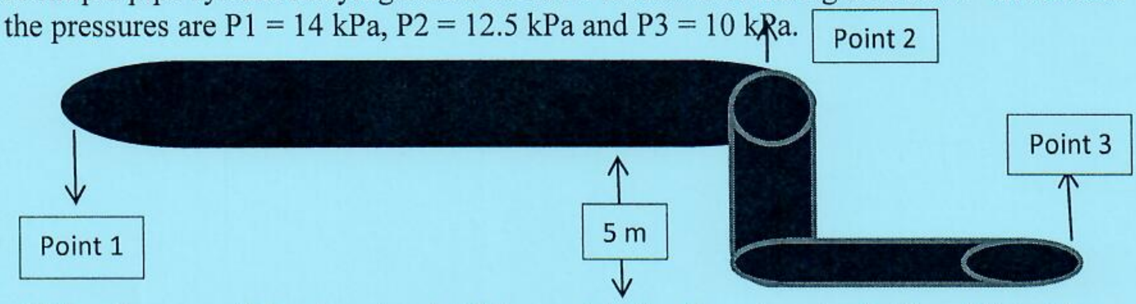
Calculate the following design parameters;

i) The total number of emitters required, {2 marks}

ii) The required emitter discharge, {3 marks}

iii) The length of lateral {5 marks}

c) A simple pipe system carrying a flow of 10 l/s 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 {6 marks}

iv) Determine the headloss between points 1 and points 3 {5 marks}

SECTION B: ANSWER ANY TWO QUESTIONS

QUESTION TWO

Famer Harris is a member of a large irrigation district which has as its water source a storage reservoir 60 km upstream from the entrance to the distribution system. He wants to irrigate a 65 hectare parcel of maize by center pivot. The crop water requirements since the last irrigation is estimated as 50 mm. Due to the expected uniformity of the center pivot system, an areal average of 55 mm of water will have to be applied to the field to ensure that all parts of the field receive a minimum of 50 mm. Estimated spray and wind drift losses are 8 percent of the water discharge through the sprinkler nozzles. Distribution losses from where the water enters the irrigation district in a canal to the head of Farmer Harris's field is estimated at 15 percent. Seepage and evaporation losses in the unlined canal between the storage reservoir and the entrance to the district distribution system are 45 percent.

a) Compute the required volume of water (in m^3);
   i) In the root zone {3 marks}
   ii) In the application surface {3 marks}
   iii) In the application device considering 8 percent spray and drift losses {3 marks}
   iv) Distribution system considering 15 percent distribution losses {3 marks}
   v) Extraction considering 45 percent seepage and evaporation losses {3 marks}

b) Compute the following efficiencies;
   i) Extraction efficiency {3 marks}
   ii) Conveyance efficiency {3 marks}
   iii) Application efficiency {3 marks}
   iv) Distribution pattern efficiency {3 marks}
   v) Irrigation system efficiency {3 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}

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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 15 percent deep percolation is acceptable. If the net irrigation requirement, i_n, is 7 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 = 0.4
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, $T_{0\text{-}L}$	{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}

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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

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

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

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

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

OPEN CHANNEL FLOW EQUATIONS

$$A = b_w y; A = (b_w + zy)y; P = b_w + 2y; P = b_w + 2y\sqrt{1+z^2}; R_h = \frac{b_w y}{b_w + 2y}$$

$$R_h = \frac{(b_w + zy)y}{b_w + 2y\sqrt{1+z^2}}; \; T_w = b_w; T_w = b_w + 2zy$$

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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