UNIVERSITY OF SWAZILAND

SUPPLEMENTARY EXAMINATION PAPER

2015

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 ONE: COMPULSORY QUESTION

QUESTION ONE

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

b) Water flows in a pipe at a velocity of 1.5 m/s. If the discharge is measured to be 11.8 l/s, what is the diameter of the pipe? (4 marks)

c) Consider a steady flow of water through a nozzle in which the upstream diameter D1 = 30 cm reduces to a downstream diameter of D2 = 20 cm. For a flow rate of 8 L/s, compute the mean velocities for the upstream and downstream diameters. (6 marks)

d) A soil has an available moisture content of 80 mm/m. A sprinkler system is to be designed to irrigate cotton. Based on climatic data, the peak period crop water requirement is 11 mm/d. The soil is a light sand with a total depth of 1.7 m. The management allowed depletion is 60 %. The maximum crop rooting depth is 3 m.

i) compute the irrigation interval. (6 marks)

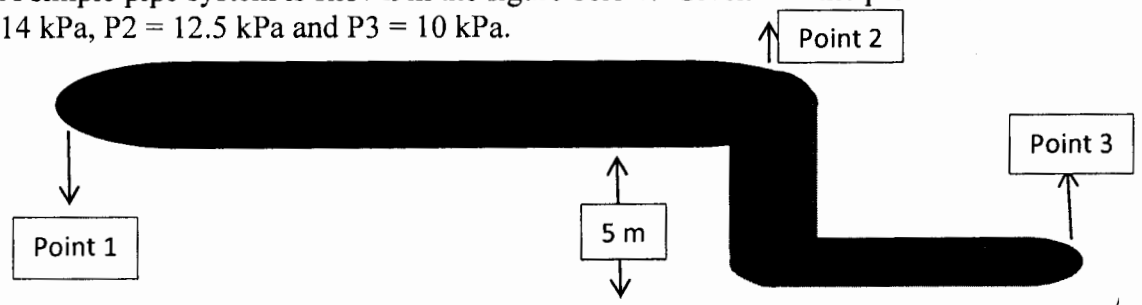
ii) If the irrigated area is 10 ha, and the sprinkler stand time is 12 hrs, compute the system capacity. (4 marks)

e) 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. What size pump is required to meet the demand if the head losses up to the sprinkler nozzle are equivalent to 7.6 m of head? (10 marks)

SECTION II: ANSWER ANY TWO QUESTIONS

QUESTION TWO

a) 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 {4 marks}
iii) Calculate the velocities between points 1 and points 2 {6 marks}
iv) Determine the headloss between points 1 and points 3 {4 marks}

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b) A trapezoidal canal is designed to carry 70 L/s. Using a concrete lined (n = 0.014) channel having a 30 cm bottom width, z = 1.25, water depth 22.5 cm, and free board of 7.5 cm. Calculate the;
   i) cross-sectional area, (3 marks)
   ii) wetted perimeter, (2 marks)
   iii) hydraulic radius, and (2 marks)
   iv) the surface slope (So). (3 marks)
   v) If the canal is 862 m long, what is the head loss along the canal. (2 marks)

QUESTION THREE

a) A trial configuration of a hand move sprinkler system 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 310 kPa. The lateral has a length of 400 m between the first and last sprinkler.
   i) Compute the maximum allowable headloss due to friction. (10 marks)

   ii) Determine the required pipe diameter to maintain actual headloss within the allowable limit. The sprinkler spacing is 12 m. The design discharge per nozzle is 0.315 l/s. (10 marks)

b) A centrifugal pump is to be installed at a site with an elevation of 400 m (P_{atm} = 9.9 m) where it will be required to pump water at 30°C (P_v = 0.43 m). The water source is exposed to the atmosphere and the friction losses on the suction side of the pump are estimated at 0.6 m. The net positive suction head required from the manufacturer's specification is 5.2 m.
   i) Compute the maximum height that the centreline of the pump intake may be placed above the level of the water source. (5 marks)

   ii) if a safety factor of 0.6 m is required, determine the maximum allowable height of the pipe center line. (5 marks)

QUESTION FOUR

a) 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)

b) i) Name any four factors that affect the design of a furrow system (4 marks)
   ii) Name any five head parameters that are important in the design of a mainline system (5 marks)
   iii) Sugarcane sometimes show sign of wilting even when the soil is wet. What are the possible explanation for this phenomenon. (6 marks)

c) A drip emitter discharges 3.0 L/h at a head of 5.0 m. The same emitter discharges 4.0 L/h when the head is 10 m. Find the discharge exponent, x; the discharge coefficient, K_d, and the head at which q = 5.0 L/h. (10 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

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

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

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

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

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

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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