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UNIVERSITY OF SWAZILAND
FINAL EXAMINATION PAPER

PROGRAMME: BSC ABE 4

COURSE CODE: ABE 403

TITLE OF PAPER: IRRIGATION DESIGN AND MANAGEMENT

TIME ALLOWED: TWO (2) HOURS

SPECIAL MATERIAL REQUIRED: NONE

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY TWO OTHER QUESTIONS.

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SECTION I COMPULSORY

QUESTION 1

a) Draw a clearly labelled crop coefficient (K_c) curve. **[5 marks]**

b) Explain why a heat-unit based K_c curve may accurately estimate crop evapotranspiration when compared to K_c curve based on days elapsed. Also mention why such an assumption may not hold. **[10 marks]**

c) Explain the conditions under which the Penman-Monteith Equation may better estimate evapotranspiration than either the Blaney-Criddle or Hargreaves equations. **[5 marks]**

d) Explain how the Bowen Ratio Energy Balance System is used for direct measurement of evapotranspiration. **[10 marks]**

e) Describe any one approach of determining dependable rainfall, and discuss why it is important in the design of an irrigation system. **[10 marks]**

SECTION II ANSWER ANY TWO QUESTIONS

QUESTION 2

a) Describe the filtration system, providing a clear description of the various types of filters normally used and how they can be maintained to keep them at maximum performance. **[15 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) Compute the required length of a long-path emitter for a system with a design discharge of 4 L/h and operating pressure of 10 m. Assume the standard value of 1.0×10^{-6} m^2/s for the kinematic viscosity of water. **[10 marks]**

QUESTION 3

a) Clearly describe the Low energy precision application (LEPA) system for irrigation. **[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 pump is an important device in irrigation. Explain:

i) its function **[2 marks]**

ii) why pumps may be connected either in series or in parallel. **[3 marks]**

iii) If the total pumping head required for a system is 38 m and the discharge is 15 L/s, calculate the power required, assuming 80 % efficiency. **[5 marks]**

QUESTION 4

a) Using diagrams showing the pattern of water application, explain how the operating pressure affects system uniformity. **[15 marks]**

b) Describe how one can determine the sprinkler system uniformity using a grid of sprinklers, clearly explaining the equations used in the test.

[15 marks]

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F values for pipes with outlets

Table 1: 'F' Factors for sprinkler lateral design

Number of outlets	F	Number of outlets	F	Number of outlets	F
1	1	16	.365	31	.349
2	.625	17	.363	32	.349
3	.518	18	.361	33	.348
4	.469	19	.360	34	.348
5	.440	20	.359	35	.347
6	.421	21	.358	36	.347
7	.408	22	.357	37	.346
8	.398	23	.356	38	.346
9	.391	24	.355	39	.345
10	.385	25	.354	40	.345
11	.380	26	.353	50	.343
12	.376	27	.352	60	.342
13	.373	28	.351	70	.341
14	.370	29	.350	80	.340
15	.367	30	.350	90	.339

Headloss equations

The Hazen-Williams and Scobey equations are given by:

$$h_f = KL\frac{Q^{d_1}}{D^{d_2}}$$

Where h_f = the friction loss in a pipe that conveys the flow throughout the length, m
L = the length of pipe, m
Q = the flow in L/s
D = the inside diameter of the pipe, mm

The value of K varies for the two equations. For the Hazen-Williams equation, $K = 1.21 \times 10^{10}\, C^{1.852}$ where C is the pipe roughness coefficient. The exponents are given by $d_1 = 1.852$ and $d_2 = 4.85$ for Hazen-Williams equations. For the Scobey method $K = 4.10 \times 10^6 K_s$ where K_s is Scobey's coefficient of retardation and the exponent values are $d_1 = 1.9$ and $d_2 = 4.9$.

On average a roughness coefficient (C) of 130 is assumed for most materials.