**FIFTH YEAR SECOND SEMESTER EXAMINATIONS**

**FOR**

**BACHELOR OF SCIENCE IN CIVIL AND STRUCTURAL ENGINEERING**

**COURSE CODE:** **554E**

**COURSE NAME:** **IRRIGATION ENGINEERING II** **TIME: 3 hours**

**INSTRUCTIONS**

Answer Question **ONE** and **ANY** other **THREE (3)** questions

**QUESTION ONE (40 MARKS)**

A mature citrus orchard will be drip-irrigated (drip emitters) using a single lateral per row of trees in a 132-ha field area. Other information:

- Tree spacing is 6.0 x 6.0 m.
- Peak daily ET is $U_d$ = 5.1 mm/day.
- Seasonal water requirement: U = 660 mm.
- Effective rain, peak-use period: 1.5 mm/day (average, w/ 90% probability)
- Residual soil water in the spring: assume zero.
- Soil water holding capacity is 175 mm/m (medium texture).
- Irrigation water quality: $EC_w$ = 0.89 dS/m.
- Root zone depth is 1.5 m.
- Shaded area is 78%.
- Emitter equation:

$$q = 0.28P^{0.481}$$

for q in lph; and P in kPa.

- Nominal emitter flow rate: $q_a$ = 3.85 lph.
- Manufacturer's emitter coefficient of variation: 0.0487.
- Average wetted width at 3.85 lph: w = 2.01 m.
- Outlets per emitter: one.

• Use an MAD of 20%.

1. Select an appropriate emitter spacing, $S_e$. (1 Mark)
2. Determine the number of emitters per tree, $N_p$. (2 Marks)
3. Calculate percent wetted area, $P_w$. (2 marks)
4. Calculate maximum net depth to apply per irrigation, $d_x$. (2Marks)
5. Calculate the average peak daily “transpiration” rate, $T_d$. (2Marks)
6. Calculate the maximum irrigation interval, $f_x$. If $f_x \geq 1$ day, use f’ = 1day. (2Marks)
7. Calculate the net depth per irrigation, $d_n$. (1Marks)
8. Select a reasonable target EU value. (2Marks)
9. Determine $(EC_e)_{max}$. (2Marks)
10. Determine the transmission ratio, $T_r$. (1Marks)
11. Calculate the leaching requirement, $LR_t$. (2Marks)
12. Calculate the gross depth to apply per irrigation, d. (2Marks)
13. Calculate the gross volume of water per tree per day, G. (1Marks)
14. Calculate $h_a$, corresponding to $q_a$ = 3.85 lph, in m of water head. (2Marks)
15. Calculate the water application time, $T_a$. (2Marks)
16. Select the number of stations, $N_s$. (1Marks)
17. Determine the minimum number of emitters per tree, $N_p$’. (2Marks)
18. Calculate the system coefficient of variation, $\nu_s$. (1Marks)
19. Calculate the minimum allowable emitter flow rate, $q_n$. (2Marks)
20. Calculate the allowable subunit pressure head variation, $\Delta H_s$. (1Marks)
21. Calculate the system capacity, $Q_s$. (2Marks)
22. Calculate the total gross seasonal depth to apply, $D_g$. (1Marks)
23. Calculate the gross seasonal volume of irrigation water, $V_s$. (2Marks)
24. Calculate the required number of operating hours per season, $O_t$. (2Marks)

**QUESTION TWO (15 MARKS)**

Suppose you applied the economic pipe sizing method. What if you were using the Hazen-Williams equation and based all your calculations on a system capacity of 100 lps, but now you realize a calculation mistake was made, and the system capacity should really be 115 lps.

A section flow rate, q, (threshold between two adjacent pipe sizes) was 50 lps, but now it needs to be adjusted for the new system capacity of 115 lps.

What is the new section flow rate for this system capacity?

**QUESTION THREE (15 MARKS)**

A rectangular field of strawberries will be trickle irrigated. The laterals are 380-m long in the direction of the 17.8-mm inside diameter PE laterals. Nominal emitter flow rate is 2.75 lph at a pressure head of 11.5 m. The emitters are in-line, without any barbs, spaced at 0.4 m along the lateral hose, which lies along a uniform ground slope of 0.761%. The strawberries are spaced at 0.5 m in the field rows. The emitter exponent is x = 0.544, and the system flow rate is 8.05 lps.

1. Determine the optimal manifold location. (2 marks)
2. Determine the location of the minimum downhill lateral pressure. (3 Marks)
3. Calculate the required lateral inlet pressure head, $H_l$. (5 Marks)
4. Calculate the minimum uphill lateral pressure head, $(H_n')_{uphill}$. (5 Marks)

**QUESTION FOUR (15 MARKS)**

a. Outline three materials used for lining drainage channel (3 Marks)
b. Describe four causes of water logging in an agricultural farm (2 Marks)
c. Outline two methods for controlling salinity in soil (3 marks)
d. With the aid of sketches describe the following methods of irrigation (4 Marks)
   i. Border irrigation
   ii. Furrow irrigation
   iii. Sprinkler irrigation
   iv. Drip irrigation
e. Outline any two methods of land reclamation (3 marks)

**QUESTION FIVE (15 MARKS)**

A trickle irrigation system with a manifold inflow rate of 8.4 lps has an allowable subunit pressure head variation of $\Delta H_s = 4.72$ m. The calculated pressure variation along the lateral pipes is $\Delta H_l = 2.44$ m, and the total length of the manifold will be 290 m. There is a uniform ground slope of 1.73% in the manifold direction. The following PVC pipe sizes are available:

| Size (inches) | I.D. (inches) |
|---|---|
| 1.5 | 1.610 |
| 2.0 | 2.067 |
| 2.5 | 2.469 |
| 3.0 | 3.068 |
| 4.0 | 4.000 |
| 6.0 | 6.000 |

1. Design the manifold, using up to four different pipe diameters. (3 Marks)
2. Use the attached friction loss curves for the six available pipe sizes. (3 Marks)
3. Determine appropriate manifold pipe sizes and lengths. (3 marks)
4. Do not allow the maximum velocity in each pipe size to exceed 2.0 m/s. (3 Marks)
5. Do your work neatly for full credit on this problem. (3 Marks)