NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF CIVIL AND WATER ENGINEERING

IRRIGATION SYSTEMS DESIGN
TCW 3204

Supplementary Examination Paper
August 2015

This examination paper consists of 3 pages

Time Allowed: **3 hours**

Total Marks: **100**

Special Requirements: NONE

Examiner's Name: MR T. THEBE

INSTRUCTIONS

1. Answer ALL questions
2. Each question carries 25 marks

MARK ALLOCATION

QUESTION	MARKS
1.	25
2.	25
3.	25
4.	25
5.	25
TOTAL	100

QUESTION 1

1. You are given the following details for the designing of a suitable drip irrigation system in a low rainfall area with a reliable groundwater supply:

The area targeted for irrigation is 40 ha. The soils are sandy loams with a maximum infiltration rate of 18 mm/hr. The soil available water is 120 mm/m. Maize with a maximum crop height of 2 m, rooting zone depth of 0.7 m, peak water requirement of 6 mm/day, and allowable soil moisture depletion of 50% is to be grown during the dry season when there is no effective rainfall. The maximum wind speed is 12 km/hr. Two boreholes with a maximum safe yield of 140 m^3/hr supply water to an uncovered 250 m^3 plastered brick reservoir that is located at the top edge of the field (15 m from the beginning of the field). Field slope is 2% from the location of the reservoir to the bottom edge of the field. Electricity supply is available at the reservoir. Adequate semi-skilled and unskilled labour is available for system operation.

Design a drip irrigation system for the 40 ha rectangular field with your chosen field dimensions, complete with a bill of quantities and clearly stated assumptions. A common maize crop spacing is 0.3 m within rows and 0.9 m between rows. **[25 marks]**

QUESTION 2

2a). Propose an alternative travelling gun irrigation system for the irrigation of the same field given in question 1. Assume a maize spacing of 0.9 m between rows, and 0.3 m within rows. State any other assumptions that you make. **[15 marks]**

2b). Compare the two systems and state the system that would be more preferable to the client (farmer) focusing on water resources, pumping cost, capital cost, prospective yields. **[10 marks]**

QUESTION 3

3ai). Design a concrete-lined irrigation main canal to carry 250 m^3/hr from a take-off point that is at an elevation of 97 m above a reference datum to a point that is the canal field turnout at an elevation of 95 m above a reference datum at a distance of 1 km away from the take-off point. Assume that the canal follows a straight line and that the ground slope is uniform along the full length of the canal. Assume a roughness co-efficient, *n*, of 0.016. Ignore the take-off and turn-out structural details. **[13 marks]**

3aii). State the material and equipment requirements for the construction of your given design with given assumptions about each material type, presenting a bill of quantities. **[5 marks]**

3b). Is it possible to replace the concrete-lined main canal stated above with a PVC pipe main line of an acceptable and available size? Base your answer on appropriate calculations. **[7 marks]**

QUESTION 4

4a). Explain the system design challenges posed by group-managed irrigation systems compared to individually-managed systems. **[5 marks]**

4b). Compare the relative advantages and disadvantages of different methods used to determine crop water requirements for the purposes of designing irrigation systems. **[8 marks]**

4c). Discuss the importance and usefulness of irrigation system performance evaluations in the context of re-designing and operating irrigation systems. **[12 marks]**

QUESTION 5

5a). A 0.9 m contracted rectangular weir is constructed to measure flow in a lined secondary canal where water is being diverted from the main canal to irrigate a block of fields that measure 45 ha. These fields are irrigated using surface irrigation methods over a 6 day cycle during day-time hours not exceeding 12 hours. The soil available water is 130 mm/m. Wheat with a maximum crop height of 0.85 m, rooting zone depth of 0.9 m, peak water requirement of 6.2 mm/day, and allowable soil moisture depletion of 50% is to be grown during the dry season when there is no effective rainfall. Assuming a 50% overall system efficiency from the take-off point to on-field use, calculate the amount of water diverted and the design water depth measured at the weir. **[15 marks]**

5b). Discuss the methods and approaches used in the calculation of land leveling requirements in the design of surface irrigation systems and the key factors for consideration in land leveling operations. **[10 marks]**

END OF QUESTION PAPER

ANNEX A – USEFUL FORMULAE FOR PRESSURIZED IRRIGATION SYSTEM DESIGN

Christiansen's: *m* co-efficient = 1.852 for Hazen-Williams equation

$$F = \frac{1}{m+1} + \frac{1}{2N} + \frac{\sqrt{m-1}}{6N^2}$$

$$F' = \frac{2N}{2N-1}\left(\frac{1}{m+1} + \frac{\sqrt{m-1}}{6N^2}\right)$$

Number of sprinklers, N	F	F'
2	0.64	0.52
3	0.53	0.44
4	0.49	0.41
5	0.46	0.40
6	0.44	0.39
7	0.43	0.38
8	0.42	0.38
9	0.41	0.37
10	0.40	0.37
12	0.39	0.37
14	0.39	0.36
16	0.38	0.36
18	0.38	0.36
20	0.38	0.36
25	0.37	0.36
30	0.37	0.36
35	0.37	0.36
40	0.36	0.36
50	0.36	0.35

Hazen-Williams:

$$h_f = K\frac{LQ^{d_1}}{D^{d_2}}$$

where:

L = the length of pipe, m;
Q = the flow in L/s;
D = the inside diameter of the pipe, mm;
K = $1.21 \times 10^{10}\, C^{-1.852}$ *where C is the pipe roughness coefficient* (assume 140 for PVC and 120 for aluminium)*;*
$d_1 = 1.852$ *and* $d_2 = 4.87$

For travelling rain guns:

$$d_{gross} = q_s / (vW_T)$$

where W_T is the width of the travel lane (i.e. the distance between travel lanes) and *v* is the linear velocity of the sprinkler cart.

$$h_l = kV^2 / 2g$$

where h_l *= the loss, k = the loss coefficient,* $V^2/2g$ *= the velocity head.*
The loss coefficients in the sprinkler cart and hose-reel cart were found to be 1.76 and 3.91, respectively.