NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF INDUSTRIAL TECHNOLOGY
DEPARTMENT OF CIVIL AND WATER ENGINEERING
BACHELOR OF ENGINEERING (HONOURS) DEGREE

PART III SECOND SEMESTER FINAL EXAMINATIONS - MAY 2011

IRRIGATION SYSTEM DESIGN -TCW 3204

TOTAL MARKS = 100
TIME =3 HOURS

INSTRUCTIONS

ANSWER ANY FOUR (4) QUESTIONS

QUESTION 1

(a) Define the following terms:
  (i) Field capacity
  (ii) Permanent wilting point
  (iii) Available water
  (iv) Readily available water
  (v) Total soil water potential

[10 Marks]

(b) Discuss the adaptability, advantages and disadvantages of sprinkler irrigation.

[10 Marks]

(c) For Zimbabwean conditions, the lateral spacing recommended is 50% (8 - 16km/hr) or 7 knots. What are the three types of sprinkler spacing that can be used and comment on the conditions applicable to each type.

[5 Marks]

QUESTION 2

(a) Many surface irrigation systems are ineffective and inefficient. Explain the factors that lead to this inefficiency.

[8 Marks]

(b) Discuss an advantage of surface irrigation over pressurized irrigation methods.

[3 Marks]

(c) As an Engineer in a big irrigation company, you have been assigned to look into the expansion of your operations in a district of a neighbouring country. What factors would you consider in the planning of this new irrigation project and what recommendations are you likely to give to your company.

[14 Marks]

QUESTION 3

(a) Describe three methods used to measure in-situ soil moisture and their applicability. For each method listed, give two advantages and disadvantages of the method.

[13 Marks]

(b) A furrow irrigation system has the following design parameters:

Field capacity	= 30% by weight
Permanent wilting point	= 15% by weight
Root zone	= 1.2 m
Roughness coefficient	= 0.04
Furrow length	= 260 m
Furrow spacing	= 0.75 m
Furrow slope	= 0.004m/m
Adjusted wetted perimeter of furrow	= 0.45 m

Intake family and furrow advance coefficient, a=1.196; b = 0.748; c = 7.0; f = 7.97 and g = 2.556×10^{-4}.

Compute:

(i) The average infiltration

(ii) Deep percolation

(iii) Losses due to surface runoff as a depth

(iv) The distribution efficiency

[12 Marks]

QUESTION 4

(a) Representativeness of any soil moisture observation point taken in the field is limited. Discuss this statement.

[6 Marks]

(b) Given a soil with the following characteristics (Table 1), calculate the depth to which 8 cm of infiltrated water would penetrate.

[10 Marks]

Table 1 Soil characteristics

Layer	Depth (cm)	θ_{fc}	θ_v
1	0-30	0.34	0.20
2	30-76	0.4	0.33
3	76 +	0.3	0.24

(c) A lateral sprinkler down slope has the following characteristics:

Slope = 0.004
Nozzle operating pressure = 400 kPa
Length of lateral, L = 500 m

Determine its maximum allowable head loss. Assume that the first sprinkler is at a distance, SL (full lateral spacing) from the main line. The total number of nozzles on the lateral is 20 and m = 1.852 in Hazen-Williams Equation.

[9 Marks]

QUESTION 5

(a) Define soil water infiltration and discuss the factors that influence it under irrigation.

[15 Marks]

(b) The following meteorological data was obtained on a particular day at Goetz Station in Bulawayo near a maize crop field at the peak of its vegetative growth.

Minimum temperature = 12 ^{O}C
Maximum temperature = 35 ^{O}C
Mean day time wind speed at a height of 4.5 m = 329 km/day
Net radiation = 7 mm/day
Maximum relative humidity = 60 %
Minimum relative humidity = 35 %
Temperature related factor = 0.7
Adjustment factor, C = 1.01

(i) Compute the reference evapotranspiration (ET_o) using the FAO Modified Penman's method.

[7 Marks]

(ii) Estimate the maize crop water requirements at the peak of its vegetative growth.

[3 Marks]

Helpful Equations

$$T_{avg} = \frac{0.0929}{fxL\left[\frac{0.305}{L}\right]^2}\left[(\beta - 1)e^{\beta} + 1\right]$$

$$i_{avg} = \left[a(T_{0-L})^b + c\right]\frac{P}{W}$$

$$i_{avg} = \left[a(T_{CO} - T_{avg})^b + c\right]\frac{P_{cut-back}}{W} + \left[\left(a(T_{avg})^b + c\right)\right]\frac{P_1 - P_2}{W}$$

$$i_g = \frac{60}{WL}\left[Q(T_t) + Q_{CB}(T_n)\right] \quad ; \qquad T_n = \left[\frac{i_n\left(\frac{W}{P}\right) - C}{a}\right]^{1/b} \text{, min}$$

$$P = 0.265\left[\frac{Qn}{S^{0.5}}\right]^{0.425} + 0.227$$

$$F = \frac{1}{m+1} + \frac{1}{2N} + \frac{(m-1)^{0.5}}{6N^2} \quad ; \qquad ET_O = a + b\left[p(0.46T + 8.13)\right]$$

$$ET_O = c\left[\frac{\Delta}{\Delta + \gamma}R_n + \frac{\gamma}{\Delta + \lambda}f(u)\Delta e\right] \text{ mm/day; } ET_{crop} = 25.4kc_i\,\frac{1.8t + 32}{100}\,p \text{ mm/month}$$

$$e_s = 6.108e^x \text{, mb; } x = \frac{19.8374T_{mean} - 0.00831T_{mean}^2}{T_{mean} + 273.16} \text{ ; } \quad e_a = \frac{e^o(T_{min})\frac{RH_{max}}{100} + e^o(T_{max})\frac{RH_{min}}{100}}{2}$$

millibar (mb) 1 mbar = 0.1 kPa

Table 2. Friction factor, F for a lateral at full lateral spacing from the mainline

	Velocity related term exponent, m		
Number of nozzles	**m=1.852**	**m=1.90**	**m=2.0**
20	0.376	0.370	0.359
22	0.374	0.368	0.356
24	0.372	0.366	0.354
26	0.370	0.364	0.353
30	0.367	0.362	0.350

END