KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (WATER AND ENVIRONMENTAL ENGINEERING)

SET 428: IRRIGATION ENGINEERING

DATE: Wednesday, 30th November, 2011 TIME: 8.00 a.m. – 10.00 a.m.

INSTRUCTIONS: Attempt question **ONE** and any other **TWO** questions.

QUESTION 1

a) Define the following terms as used in an irrigation system **(5 marks)**

i) Irrigation
ii) porosity
iii) project efficiency
iv) evapotranspiration irrigation
v) reference crop evapotranspiration

b) List the parameters that affect the selection of an irrigation system **(5 marks)**

c) A sample of moist soil having a wet mass of 1200g and a volume of 640cm^3 was dried in the oven and found to have a dry mass of 800g. Assume the water density as 1.00g/cm^3 and the particle density of the soil is 2.65g/cm^3. determine for this soil:

(i.) Gravimetric moisture content
(ii.) Volumetric moisture content
(iii.) Bulk density
(iv.) Porosity
(v.) Equivalent depth in mm of water contained in 1M- root zone depth

(9marks)

d) Discuss the factors that affect crop coefficient **(6 Marks)**

e) Draw a schematic diagram of a crop coefficient curve and briefly discuss the shape of the curve **(5 Marks)**

QUESTION 2

a) Using a suitable diagram describe the following types of irrigation systems **(6 marks)**

i) Furrow irrigation
ii) localised irrigation

f) A class A evaporation pan is maintained in a green environment in which the pasture surrounds the pan for 100M in the upwind direction. For a seven day period in August, 24 hour wind run measured at 1.5M height averages 235KM/d and the main daily relative humidity is 80%. Total pan evaporation for the seven day period is 54mm. **(7 Marks)**

(i.) What would you estimate as the equivalent water use for the grass in the same area over the period in mm/d?

(ii.) If the area discussed in this question is KU, what would you expect to be the irrigation depth for maize during the 7 day period if there was no rainfall?

b) A surface irrigation system has been designed for 5ha farm next to a small stream. It is estimated that at peak crop water use period, ETc will be 11mm/day. The design irrigation interval is 4 days. At each irrigation application 5 hours are required to replenish all the water used up by the crop and to fill the soil water reservoir up to field capacity. Conveyance efficiency for this system is 85% while combined distribution and application efficiency is estimated at 75%. The difference in elevation between the water level in the stream and the inlet into the main canal is 10m. Assuming negligible frictional head loss, determine the capacity and power requirement for a small portable pump for this system. Assume a pump efficiency of 60%. **(7marks)**

QUESTION 3

a) List the factors that should be considered when siting and maintenance of an evaporation pans **(4 marks)**

b) i) Define the term net depth of water application **(2 marks)**

ii) Given the following information for field irrigation:

Parameter	**Scheme**
Area	15ha
Soil type	Clay loam
Available soil moisture	100mm/m
Design root zone depth	0.7m
Allowable soil moisture depletion	0.5
Assumed field application efficiency	0.5
Assumed field canal efficiency	0.9
Assumed conveyance efficiency	0.9
Peak ET_{crop}	4mm/day

Determine the following:

i) gross depths of water application at the field and overall level

ii) irrigation frequency and irrigation cycle

iii) the system capacity if irrigation duration is 10 hours per day

(7marks)

c) Determine the spacing of tile drain to water for annual rainfall of 100cm, drainage coefficient is 1% to be drained in 24 hours, depth of impervious layer from land surface is 10m, depth of highest position of water table below land surface 1.5m, depth of drain below land surface is 2.0 m and permeability of soil = 6x10-6m/s **(7marks)**

QUESTION 4

a) Define the term Net Positive Sunction Head Requirement (NPSHR) **(2 marks)**

b) Calculate the NPSHA for a pump to operate at an elevation of 2000m. The frictional losses in the sunction pipe were calculated to be 0.7m and the suction inlet pipe is at 2000.4m and outlet at 2002.4m. take e as 0.58 **(3 marks)**

c) Describe the role played by soil infiltration rate in the design, management and operation of irrigation systems **(3marks)**

d) Briefly describe how infiltration rate of the soil is determined using a ring infiltrometer method. State what precautions should be taken in obtaining the data and why **(4marks)**

e) The following infiltration data were taken from a double ring infiltrometer test

Watch reading (Hr: min)	**Time interval (min)**	**Water level reading**	
		Before filling (Min)	**After filling (Min)**
9:25			100
	2		
9:27		97	100
	3		
9:30		96.5	101
	5		
9:35		96.5	100
	10		
9:45		93	99
	10		
9:55		93.5	100
	20		
10:15		93	100
	20		
10:35		95	100
	40		
11:15		93	101
	40		
11:55		94	100
	40		
12:35		93	

(i.) Draw a graph of basic infiltration rate and cumulative infiltration versus time.

(ii.) Predicted cumulative depth of infiltration in mm at t = 5 hours

(iii.) Infiltration rate in mm/hr at a time of 5 hours

(iv.) What type of soil do you expect this to be?

(v.) How long will it take to apply 150mm of water by irrigation?

(8marks)

QUESTION 5

a) Explain why sprinkler irrigation is preferred to other methods of irrigation and compare surface irrigation and sprinkler irrigation. **(5marks)**

b) Design a sprinkler irrigation system for a square 10 hectare field to irrigate the entire area within 10 days period. Not more than 16 hours per day are available for moving the pipe and sprinkling. The required depth of irrigation is 5cm and the water application ate is not to exceed 0.75cm/hr. A 30m deep well located in the centre of the field will provide the following discharge drawdown relationship: 12.2 L/s at 15 m and 15.8 L/sec at 20m.
Design the system for an average pressure of $3Kg/cm^3$ at the sprinkler nozzle. The highest point in the field is 1.25m above the well site and 1m risers are needed for the sprinklers. Assuming a pump efficiency of 60% and supposing that the engine will finish 60% of its rated output for continuous operation, determine the rated output for a water cooled internal combustion engine. **(15marks)**

IRRIGATION AND DRAINAGE ENGINEERING

KEY FORMULAE

1\. $\theta_v = V_w/(V_s+V_a+V_w)$; 2. $\rho_b = M_s/(V_a+V_s+V_w)$; 3. $\rho_b = (1-N)\rho_s$;

4\. $N = (V_a+V_v)/(V_s+V_a+V_w)$; 5. $N = 1-(\rho_b/\rho_s)$; 6. $\theta_v = \theta_m[\rho_b/\rho_w]$

7\. $I = c(t)^{\alpha}$ 8. $I = S_p(t)^{0.5} + A_p(t)$ 9. $T = z + p + p_{os}$

10\. $ET_r = a + b[p(0.46T + 8.13)]$ 11. $a = 0.0043(RH_{min}) - n/N - 1.41$ 12. $U_{2m} = U_z[2.0/z]^{0.2}$

13\. $b = 0.82 - 0.0041(RH_{min}) + 1.07(n/N) + 0.066(U_{day}) - 0.006(RH_{min})(n/N) - 0.0006(RH_{min})(U_{day})$

14\. $I = (1/LP)[V_{in} - V_{out} - V_s]$; 15. $P = 0.265[Qn/(S)^{0.5}]^{0.425} + 0.227$; 16. $UC_H = 1 - [2/\pi]^{0.5}(s/x)$

17\. $V_s = (L/0.305)[2.947[Qn/S^{0.5}]^{0.735} - 0.0217]$; 18. $UC_C = 1 - \sum[abs(xi - x]/(nx)$

19\. $Q = 2.778[i_g(A)]/[N_{op}(T_{op}]$ 20. $H_L = [\theta(H_a) - H_e]/L$ 21. $H_{L-ac} = F[H_{L-eq}]$;

22\. $h_f = kL[(Q/C)^{1.852}/D^{4.87}]$ 23. $F = 1/(m+1) + 1/2N + (m-1)^{0.5}/6N^2$;

24\. $F = [2N/(2N-1)](1/(m+1) + (m-1)^{0.5}/6N^2)$; 25. $H_m = H_a + [0.75(H_L + H_e) + H_r]9.81kPa/m$;

26\. $H_i = H_n + h_{f-in} + H_{e-in} + H_{v-in}$; 27. $TDH_i = H_i + h_{f-pi} + H_{e-si} + h_{f-si} + (v_i)^2/2g$; 28. $H_{v-i} = (v_i)^2/2g$;

29\. $R_N = vD/(1000\nu)$ 30. $f = h_f/[(L/D)(v^2/2g)]$ 31. $q = 3.6(A)C_o(2gH)^{0.5}$

32\. $q = 0.11384(A)[2g(HD/fL)]^{0.5}$; 33. $q = 0.11384(A)[2g\sqrt{HD/fL})]^{0.5}$; 34. $f = 64/R_N$

35\. $1/\sqrt{f} = 2\log(D/\varepsilon) + 1.14$; 36. $U_e = 100[1.0 - (1.27/n)C_v]\, q_{min}/q_{avg}$; 37. $q_{var} = 100[1-q_{min}/q_{max}]$

38\. $q = k(H)^x$; 39. $h_f = 6.377fl(Q^2/D^5)$; 40. $Ns = 0.2108N(Q^{0.5}/H^{0.75})$

41\. $P = [Q(H)(Sg)]/[0.102(E)]$; 42. $P = [Q(H)(Sg)]/[4634(E)]$; 43. $TDH + h_{fix} + h_{var}$;

44\. $P = [Q(H)(Sg)]/[278.04(E)]$; 45. $P = [Q(H)(Sg)]/[3960(E)]$; 46. $NPSH_a = P_{atmos} - z_s - h_{fs} - P_v$;

47\. $E_{series} = [Q_{series}(H_A + H_B)]/[0.102(P_A + P_B)$; 48. $E_{para} = [H_{para}(Q_A + Q_B)]/[0.102(P_A + P_B)]$;

49\. $SAR = [Na^+]/[(Ca^{2+} + Mg^{2+})/2]^{0.5}$; 50. $LF = D_d/D_i = (D_i - ET_c)/D_i = EC_{iw}/EC_d$;

51\. $q = (8K_2dh)/L^2 + (4K_1 h^2)/L^2$; 52. $d = D/[(8D/\pi L)\ln(D/u) + 1]$; 53. $d = \pi L/[8\ln(L/u)]$;

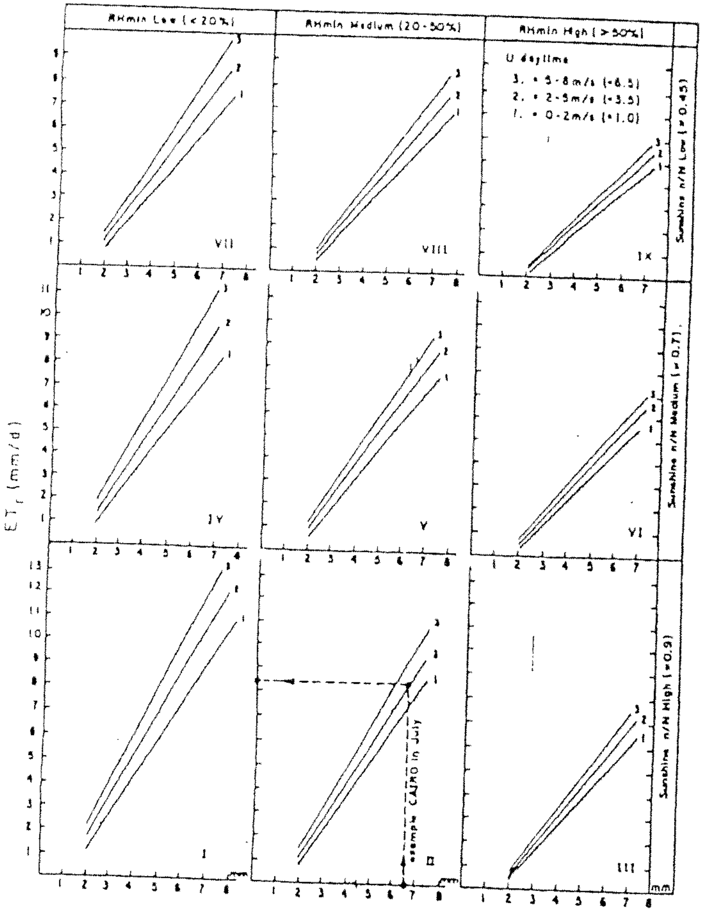

Figure II – Example of graphical solution for ET, using FAO modified Blaney-Criddle method. (From Doorenbos and Pruitt, 1977.)

Table 2

Percent of annual daylight hours per month from latitude 46° south to 60° north.

Latitude 0° North	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
0	8.50	7.66	8.49	8.21	8.50	8.22	8.50	8.49	8.21	8.50	8.22
5	8.32	7.57	8.47	8.29	8.65	8.41	8.67	8.60	8.23	8.42	8.07
10	8.13	7.47	8.45	8.37	8.81	8.60	8.86	8.71	8.25	8.34	7.91
15	7.94	7.36	8.43	8.44	8.98	8.80	9.05	8.83	8.28	8.26	7.75
20	7.74	7.25	8.41	8.52	9.15	9.00	9.25	8.96	8.30	8.18	7.58
25	7.53	7.14	8.39	8.61	9.33	9.23	9.45	9.09	8.32	8.09	7.40
30	7.30	7.03	8.38	8.72	9.53	9.49	9.67	9.22	8.33	7.99	7.19
32	7.20	6.97	8.37	8.76	9.62	9.59	9.77	9.27	8.34	7.95	7.11
34	7.10	6.91	8.36	8.80	9.72	9.70	9.88	9.33	8.36	7.90	7.02
36	6.99	6.85	8.35	8.85	9.82	9.82	9.99	9.40	8.37	7.85	6.92
38	6.87	6.79	8.34	8.90	9.92	9.95	10.10	9.47	8.38	7.80	6.82
40	6.76	6.72	8.33	8.95	10.02	10.08	10.22	9.54	8.39	7.75	6.72
42	6.63	6.65	8.31	9.00	10.14	10.22	10.35	9.62	8.40	7.69	6.62
44	6.49	6.58	8.30	9.06	10.26	10.38	10.49	9.70	8.41	7.63	6.49
46	6.34	6.50	8.29	9.12	10.39	10.54	10.64	9.79	8.42	7.57	6.36
48	6.17	6.41	8.27	9.18	10.53	10.71	10.80	9.89	8.44	7.51	6.23
50	5.98	6.30	8.24	9.24	10.68	10.91	10.99	10.11	8.46	7.45	6.10
52	5.77	6.19	8.21	9.29	10.85	11.13	11.20	10.12	8.49	7.39	5.93
54	5.55	6.08	8.18	9.36	11.03	11.38	11.43	10.26	8.51	7.30	5.74
56	5.30	5.95	8.15	9.45	11.22	11.67	11.69	10.40	8.53	7.21	5.54
58	5.01	5.81	8.12	9.55	11.46	12.00	11.98	10.55	8.55	7.10	5.31
60	4.67	5.65	8.08	9.65	11.74	12.39	12.31	10.70	8.57	6.98	5.04
South											
0	8.50	7.66	8.49	8.21	8.50	8.22	8.50	8.49	8.21	8.50	8.22
5	8.68	7.76	8.51	8.15	8.34	8.05	8.33	8.38	8.19	8.56	8.37
10	8.86	7.87	8.53	8.09	8.18	7.86	8.14	8.27	8.17	8.62	8.53
15	9.05	7.98	8.55	8.02	8.02	7.65	7.95	8.15	8.15	8.68	8.70
20	9.24	8.09	8.57	7.94	7.85	7.43	7.76	8.03	8.13	8.76	8.87
25	9.46	8.21	8.60	7.84	7.66	7.20	7.54	7.90	8.11	8.86	9.04
30	9.70	8.33	8.62	7.73	7.45	6.96	7.31	7.76	8.07	8.97	9.24
32	9.81	8.39	8.63	7.69	7.36	6.85	7.21	7.70	8.06	9.01	9.33
34	9.92	8.45	8.64	7.64	7.27	6.74	7.10	7.63	8.05	9.06	9.42
36	10.03	8.51	8.65	7.59	7.18	6.62	6.99	7.56	8.04	9.11	9.51
38	10.15	8.57	8.66	7.54	7.08	6.50	6.87	7.49	8.03	9.16	9.61
40	10.27	8.63	8.67	7.49	6.97	6.37	6.76	7.41	8.02	9.21	9.71
42	10.40	8.70	8.68	7.44	6.85	6.23	6.64	7.33	8.01	9.26	9.82
44	10.54	8.78	8.69	7.38	6.73	6.08	6.51	7.25	7.99	9.31	9.94
46	10.69	8.86	8.70	7.32	6.61	5.92	6.37	7.16	7.96	9.37	10.07

TABLE 5 Correction factor 'F' for friction losses in aluminium pipes with multiple outlets.

No. of sprinklers on lateral	Correction factor F when: 1st sprinkler is one sprinkler interval from main	Correction factor F when: 1st sprinkler is ½ sprinkler interval from main	Number of sprinklers on lateral	Correction factor F when: 1st sprinkler is one sprinkler interval from main	Correction factor F when: 1st sprinkler is ½ sprinkler interval from main
1	1.000	1.000	16	0.365	0.345
2	0.625	0.500	17	0.363	0.344
3	0.518	0.422	18	0.361	0.343
4	0.469	0 393	19	0.360	0.343
5	0.440	0.378	20	0.359	0.342
6	0.421	0.369	22	0.357	0.341
7	0.408	0.363	24	0.355	0.341
8	0.398	0.358	26	0.353	0.340
9	0.391	0.355	28	0.351	0.340
10	0.385	0.353	30	0.350	0.339
11	0.380	0.351	35	0.347	0.338
12	0.376	0.349	40	0.345	0.338
13	0.373	0.348	50	0.343	0.337
14	0.370	0.347	100	0.338	0.337
15	0.367	0.346	> 100	0.335	0.335

TABLE 7 **Friction loss in metres per 100 metres in main lines of portable aluminium pipes with couplings**

(Based on Scobey's formula, K_s 0.40 and 9 metres pipe lengths)

[Adapted from Hurd (1969)]

Flow litres/sec	*Diameter of pipe* 7.5 cm	10.0 cm	12.5 cm	15.0 cm	17.5 cm	20.0 cm	25.0 cm
2.52	0.658	0.157					
3.15	1.006	0.239					
3.79	1.423	0.339					
4.42	1.906	0.449	0.150				
5.05	2.457	0.584	0.193				
5.68	3.073	0.731	0.242				
6.31	3.754	0.893	0.295	0.120			
7.57	5.307	1.263	0.417	0.170			
8.83	7.113	1.693	0.560	0.227			
10.10	9.169	2.182	0.721	0.293			
11.36	11.47	2.729	0.967	0.366			
12.62	14.01	3.333	1.102	0.448	0.209		
13.88	16.79	3.996	1.321	0.537	0.251		
15.14	19.81	4.713	1.558	0.633	0.296		
16.41	23.06	5.488	1.814	0.737	0.344		
17.67	26.55	6.316	2.089	0.849	0.397		
18.93	30.27	7.203	2.381	0.967	0.452	0.235	
20.19	34.22	8.142	2.092	1.094	0.511	0.265	
21.45	38.39	9.133	3.020	1.227	0.573	0.298	
22.72	42.80	10.18	3.366	1.368	0.639	0.332	
23.98	47.43	11.29	3.731	1.516	0.708	0.368	
25.24	52.28	12.44	4.113	1.671	0.781	0.399	0.136
26.50		13.65	4.513	1.833	0.857	0.445	0.149
27.76		14.57	4.930	1.988	0.936	0.486	0.163
29.03		16.23	5.364	2.179	1.019	0.529	0.177
30.29		17.59	5.815	2 363	1.104	0.573	0.192
31.55		19.01	6.284	2.554	1.193	0.620	0.208
34.70		22.79	7.532	3.060	1.430	0.742	3.249
37.86		26.88	8.886	3.611	1.687	0.876	0.294
41.01		31.30	10.35	4.204	1.965	1.020	0.342
44.17		36.04	11.91	4.839	2.262	1.174	0.394
47.32		41.08	13.58	5.517	2.520	1.339	0.449
50.48			15.35	6.237	2.915	1.513	0.507
53.63			17.22	6.999	3.271	1.698	0.569
56.79			19.20	7.801	3.6 6	1.893	0.635
59.94			21.28	8.645	4.041	2.097	0.703
63.10			23.45	9.530	4.454	2.312	0.775
69.49			28.11	11.42	5.338	2.771	0.929
75.72			31.75	13.58	6.298	3.269	1.096
82.03				15.69	7.333	3.886	1.277
88.34				18.06	8.441	4.382	1.470
94.65				20.59	9.624	4.996	1.675
101.0				23.28	10.88	5.648	1.894
107.3				26.12	12.21	6.337	2.125
114.0					13.63	7.064	2.369
120.0					15.08	7.829	2.625
126.0					16.62	8.630	2.894

Note: Where 6.1 m sections of pipes are used, *increase* values shown in Table by 7.0 per cent. Where 12.2 m sections of pipe are used, *decrease* values shown in the Table by 3.0 per cent.