OCD030

UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

WESTERN INTERNATIONAL COLLEGE FZE

BENG(HONS) CIVIL ENGINEERING

TRIMESTER TWO EXAMINATION 2021/2022

WATER ENGINEERING AND THE ENVIRONMENT

MODULE NO: CIE6012

Date: Saturday 30th April 2022 **Time: 10:00 – 13:00**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions on this paper.

Answer ANY FIVE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Formula sheet / supplementary information is provided at the end of question paper.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

Q1

a) Describe the procedure for the prediction of open channel flow profiles and outline the problems associated with profile evaluation in natural channels.

(7 marks)

b) A long rectangular earthen channel 3.25m wide has a uniform flow depth of 2.5 m when the flow rate is $12m^3$ /s. The channel has a sluice gate which causes a hydraulic jump just downstream of the sluice gate. The depth of flow just upstream of the sluice gate rises to 3.0m and the depth of flow just downstream of the gate lowers to 0.85 m. Identify the profiles which exist upstream and downstream of the sluice gate in the above scenario. Use suitable sketches and specify the characteristics of profiles.

(13 marks)

Total 20 marks

Q2

a) Briefly explain the purpose and operation of the following treatment process units:

(i) Rapid Sand Filter

(4 marks)

(ii) Activated Sludge Process

(4 marks)

b) A water treatment plant receives soft upland water. Sketch a flow chart identifying the sequence of water treatment processes used in this scenario.

(8 marks)

c) Briefly explain the principles behind a ‘consent to discharge’ from a sewage treatment works.

(4 marks)

Total 20 marks

PLEASE TURN THE PAGE…..

Q3

a) With the aid of sketches, describe and annotate the Specific Energy (E-Y) graph and illustrate on how it can be used to explain alternate depths.

(8 marks)

b) A rectangular channel of 12 m wide has a flow rate of 75m^3/sec at a depth of 2.3 m. A bed hump is located in the channel. Determine the height of hump that would cause critical depth flow over the hump.

(12 marks)

Total 20 marks

Q4

a) An unlined trapezoidal irrigation channel is to be constructed in slightly rounded gravel with d50 21 mm, at a gradient of 1 in 1200. The channel has a base width of 1.75m and sides which slope at 2H:1V. Using the tractive force design method, determine the maximum permissible flowrate in the channel to avoid erosion. Use **Table 1** and **Figure 1** provided on page 9.

(12 marks)

b) Describe the function of energy dissipators in spillways and compare the different types by explaining the suitability of each.

(8 marks)

Total 20 marks

PLEASE TURN THE PAGE……

Q5

a) Critically evaluate the solid retention mechanisms used in a Combined Overflow Sewer System (CSO).

(8 marks)

b) A stilling pond CSO chamber of breadth 4.25m is designed for a combined sewerage system serves a population of 11200 and receives a peak storm flow of 3.2 m^3/s(Hydroworks). A 325mm diameter orifice is used to control the flow passing to the downstream sewer which is 450mm in diameter, has a k_s value of 1.5mm and is laid at a gradient of 1 in 133. The overflow weir crest height above the centre of the orifice is 1.9m. Using the information given below, check the adequacy of the control and evaluate the peak flow passing to the downstream sewer. HRS tables are provided under the supplementary information.

Assume **G = 210 l/h/d, I = 40 l/h/d. E = 1,27,000 l/d**

(12 marks)

Total 20 marks

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Q6

a) Estimate the peak flow during a 20-year flood event for a river with ungauged catchment characteristics using a synthetic, 10mm – 1 hour, unit hydrograph analysis with the data listed below. The base flow in the river is 10 m^3 /sec.

T_B = 5 hours

T_P = 2 hours

Q_P = 18 m^3 /sec.

The hourly depths of rainfall, for the chosen 5-hour event, are shown in the **Table 2** below. Complete the **Table 3** provided on page 10.

Table 2 Rainfall data

Time(hour)	1	2	3	4	5
Rainfall (mm)	3.8	7.6	12	8.5	4.3

(14 marks)

b) Describe the procedures for 'Design flood estimation' using the unit hydrograph method.

(6 marks)

Total 20 marks

END OF QUESTIONS

PLEASE TURN THE PAGE FOR FORMULA SHEET…

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Formula sheet

$h_f = S_0 x$

$Q = A v$

$$v = \frac{1}{n}.R^{\frac{2}{3}}.S_0^{1/2}$$

$$E = y + \frac{v^2}{2g} = y + \frac{q^2}{2gy^2} = y + \frac{Q^2}{2gA^2}$$

$$y_c = \sqrt[3]{\frac{q^2}{g}} \quad ; \quad q = \frac{Q}{B}; \quad E_c = 1.5y_c; \quad v_c = \sqrt{gy_c} \quad ; \quad F_r = \frac{v}{\sqrt{gy}}$$

$$R = \frac{A}{P}$$

DWF=P.G+P.I+E

Formula A: Q= DWF+1360.P+2E

$$D = 0.815Q^{0.4}$$

$$Q_0 = C_d.A_0.\sqrt{2.g.H_0}$$

SUPPLEMENTARY INFORMATION CONTINUED OVER THE PAGE

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Supplementary Information continued

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ks = 1·500mm
i = 0·00015 to 0·004

ie hydraulic gradient =
1 in 6667 to 1 in 250

Water (or sewage) at 15° C
full bore conditions.

velocities in m/s
discharges in m^3/s

Gradient	350	375	400	450	500	525	600	675	700	750	800	825
	Pipe diameters in mm:											
0.00015	0.183	0.192	0.200	0.216	0.232	0.239	0.261	0.281	0.288	0.301	0.314	0.320
1/ 6667	0.018	0.021	0.025	0.034	0.045	0.052	0.074	0.101	0.111	0.133	0.158	0.171
0.00016	0.189	0.198	0.207	0.223	0.239	0.247	0.269	0.291	0.298	0.311	0.325	0.331
1/ 6250	0.018	0.022	0.026	0.036	0.047	0.053	0.076	0.104	0.115	0.138	0.163	0.177
0.00017	0.195	0.204	0.213	0.230	0.247	0.255	0.278	0.300	0.307	0.321	0.335	0.341
1/ 5882	0.019	0.023	0.027	0.037	0.048	0.055	0.079	0.107	0.118	0.142	0.168	0.182
0.00018	0.201	0.210	0.219	0.237	0.254	0.262	0.286	0.309	0.316	0.331	0.345	0.351
1/ 5556	0.019	0.023	0.028	0.038	0.050	0.057	0.081	0.111	0.122	0.146	0.173	0.188
0.00019	0.207	0.216	0.226	0.244	0.261	0.270	0.294	0.317	0.325	0.340	0.354	0.361
1/ 5263	0.020	0.024	0.028	0.039	0.051	0.058	0.083	0.114	0.125	0.150	0.178	0.193
0.00020	0.212	0.222	0.232	0.250	0.268	0.277	0.302	0.326	0.334	0.349	0.363	0.371
1/ 5000	0.020	0.025	0.029	0.040	0.053	0.060	0.085	0.117	0.128	0.154	0.183	0.198
0.00022	0.223	0.233	0.243	0.263	0.281	0.291	0.317	0.342	0.350	0.366	0.381	0.389
1/ 4545	0.021	0.026	0.031	0.042	0.055	0.063	0.090	0.122	0.135	0.162	0.192	0.208
0.00024	0.233	0.244	0.254	0.275	0.294	0.304	0.331	0.357	0.366	0.383	0.399	0.407
1/ 4167	0.022	0.027	0.032	0.044	0.058	0.066	0.094	0.128	0.141	0.169	0.200	0.217
0.00026	0.242	0.254	0.265	0.286	0.306	0.316	0.345	0.372	0.381	0.398	0.415	0.423
1/ 3846	0.023	0.028	0.033	0.046	0.060	0.068	0.098	0.133	0.147	0.176	0.209	0.226
0.00028	0.252	0.264	0.275	0.297	0.318	0.329	0.358	0.387	0.396	0.414	0.431	0.440
1/ 3571	0.024	0.029	0.035	0.047	0.062	0.071	0.101	0.138	0.152	0.183	0.217	0.235
0.00030	0.261	0.273	0.285	0.308	0.330	0.340	0.371	0.400	0.410	0.428	0.446	0.455
1/ 3333	0.025	0.030	0.036	0.049	0.065	0.074	0.105	0.143	0.158	0.189	0.224	0.243
0.00032	0.270	0.282	0.294	0.318	0.341	0.352	0.383	0.414	0.423	0.443	0.461	0.470
1/ 3125	0.026	0.031	0.037	0.051	0.067	0.076	0.108	0.148	0.163	0.196	0.232	0.251
0.00034	0.278	0.291	0.304	0.328	0.351	0.363	0.395	0.427	0.437	0.456	0.476	0.485
1/ 2941	0.027	0.032	0.038	0.052	0.069	0.078	0.112	0.153	0.168	0.202	0.239	0.259
0.00036	0.286	0.300	0.313	0.338	0.362	0.373	0.407	0.439	0.449	0.470	0.490	0.499
1/ 2778	0.028	0.033	0.039	0.054	0.071	0.081	0.115	0.157	0.173	0.208	0.246	0.267
0.00038	0.294	0.308	0.321	0.347	0.372	0.384	0.418	0.451	0.462	0.483	0.503	0.513
1/ 2632	0.028	0.034	0.040	0.055	0.073	0.083	0.118	0.161	0.178	0.213	0.253	0.274
0.00040	0.302	0.316	0.330	0.356	0.381	0.394	0.429	0.463	0.474	0.495	0.516	0.527
1/ 2500	0.029	0.035	0.041	0.057	0.075	0.085	0.121	0.166	0.182	0.219	0.260	0.281
0.00042	0.310	0.324	0.338	0.365	0.391	0.404	0.440	0.475	0.486	0.508	0.529	0.540
1/ 2381	0.030	0.036	0.042	0.058	0.077	0.087	0.124	0.170	0.187	0.224	0.266	0.289
0.00044	0.317	0.332	0.346	0.374	0.400	0.413	0.450	0.486	0.497	0.520	0.542	0.553
1/ 2273	0.031	0.037	0.043	0.059	0.079	0.089	0.127	0.174	0.191	0.230	0.272	0.295
0.00046	0.324	0.339	0.354	0.382	0.409	0.423	0.461	0.497	0.509	0.532	0.554	0.565
1/ 2174	0.031	0.037	0.044	0.061	0.080	0.091	0.130	0.178	0.196	0.235	0.279	0.302
0.00048	0.331	0.347	0.362	0.391	0.418	0.432	0.471	0.508	0.520	0.543	0.566	0.577
1/ 2083	0.032	0.038	0.045	0.062	0.082	0.093	0.133	0.182	0.200	0.240	0.285	0.309
0.00050	0.338	0.354	0.369	0.399	0.427	0.441	0.481	0.518	0.531	0.555	0.578	0.589
1/ 2000	0.033	0.039	0.046	0.063	0.084	0.095	0.136	0.186	0.204	0.245	0.291	0.315
0.00055	0.355	0.372	0.388	0.419	0.448	0.463	0.504	0.544	0.557	0.582	0.606	0.618
1/ 1818	0.034	0.041	0.049	0.067	0.088	0.100	0.143	0.195	0.214	0.257	0.305	0.331
0.00060	0.371	0.388	0.405	0.437	0.468	0.483	0.527	0.568	0.582	0.608	0.634	0.646
1/ 1667	0.036	0.043	0.051	0.070	0.092	0.105	0.149	0.203	0.224	0.269	0.319	0.345
0.00065	0.387	0.404	0.422	0.456	0.488	0.503	0.549	0.592	0.606	0.633	0.660	0.673
1/ 1538	0.037	0.045	0.053	0.072	0.096	0.109	0.155	0.212	0.233	0.280	0.332	0.360
0.00070	0.401	0.420	0.438	0.473	0.506	0.523	0.570	0.614	0.629	0.657	0.685	0.698
1/ 1429	0.039	0.046	0.055	0.075	0.099	0.113	0.161	0.220	0.242	0.290	0.344	0.373
	Coefficient for part-full pipes:											
	60	70	70	80	90	100	110	120	130	140	150	150

ks = 1·500mm   i < 0·004

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ks = 1·500mm
i = 0·00015 to 0·004

ie hydraulic gradient = 1 in 6667 to 1 in 250

Water (or sewage) at 15° C
full bore conditions.

velocities in m/s
discharges in m^3/s

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continued

Gradient	Pipe diameters in mm: 350	375	400	450	500	525	600	675	700	750	800	825
0.00075	0.416	0.435	0.454	0.490	0.524	0.541	0.590	0.636	0.651	0.681	0.709	0.723
1/ 1333	0.040	0.048	0.057	0.078	0.103	0.117	0.167	0.228	0.251	0.301	0.356	0.387
0.00080	0.429	0.449	0.469	0.506	0.542	0.559	0.609	0.657	0.673	0.703	0.733	0.747
1/ 1250	0.041	0.050	0.059	0.080	0.106	0.121	0.172	0.235	0.259	0.311	0.368	0.399
0.00085	0.443	0.463	0.483	0.522	0.559	0.577	0.628	0.678	0.694	0.725	0.755	0.770
1/ 1176	0.043	0.051	0.061	0.083	0.110	0.125	0.178	0.242	0.267	0.320	0.380	0.412
0.00090	0.456	0.477	0.497	0.537	0.575	0.593	0.647	0.697	0.714	0.746	0.777	0.793
1/ 1111	0.044	0.053	0.063	0.085	0.113	0.128	0.183	0.250	0.275	0.330	0.391	0.424
0.00095	0.468	0.490	0.511	0.552	0.591	0.610	0.665	0.717	0.734	0.767	0.799	0.815
1/ 1053	0.045	0.054	0.064	0.088	0.116	0.132	0.188	0.256	0.282	0.339	0.402	0.435
0.00100	0.481	0.503	0.525	0.566	0.606	0.626	0.682	0.735	0.753	0.787	0.820	0.836
1/ 1000	0.046	0.056	0.066	0.090	0.119	0.135	0.193	0.263	0.290	0.348	0.412	0.447
0.00110	0.504	0.528	0.550	0.594	0.636	0.657	0.716	0.772	0.790	0.825	0.860	0.877
1/ 909	0.049	0.058	0.069	0.095	0.125	0.142	0.202	0.276	0.304	0.365	0.432	0.469
0.00120	0.527	0.552	0.575	0.621	0.665	0.686	0.748	0.806	0.825	0.862	0.898	0.916
1/ 833	0.051	0.061	0.072	0.099	0.131	0.149	0.211	0.289	0.318	0.381	0.452	0.490
0.00130	0.549	0.574	0.599	0.647	0.692	0.714	0.778	0.839	0.859	0.898	0.935	0.954
1/ 769	0.053	0.063	0.075	0.103	0.136	0.155	0.220	0.300	0.331	0.397	0.470	0.510
0.00140	0.570	0.596	0.622	0.671	0.719	0.742	0.808	0.871	0.892	0.932	0.971	0.990
1/ 714	0.055	0.066	0.078	0.107	0.141	0.161	0.228	0.312	0.343	0.412	0.488	0.529
0.00150	0.590	0.617	0.644	0.695	0.744	0.768	0.837	0.902	0.923	0.965	1.005	1.025
1/ 667	0.057	0.068	0.081	0.111	0.146	0.166	0.237	0.323	0.355	0.426	0.505	0.548
0.00160	0.610	0.638	0.665	0.718	0.769	0.793	0.864	0.932	0.954	0.997	1.038	1.059
1/ 625	0.059	0.070	0.084	0.114	0.151	0.172	0.244	0.333	0.367	0.440	0.522	0.566
0.00170	0.629	0.658	0.686	0.740	0.792	0.818	0.891	0.961	0.983	1.027	1.071	1.092
1/ 588	0.060	0.073	0.086	0.118	0.156	0.177	0.252	0.344	0.378	0.454	0.538	0.584
0.00180	0.647	0.677	0.706	0.762	0.816	0.842	0.917	0.989	1.012	1.057	1.102	1.123
1/ 556	0.062	0.075	0.089	0.121	0.160	0.182	0.259	0.354	0.389	0.467	0.554	0.601
0.00190	0.665	0.695	0.725	0.783	0.838	0.865	0.942	1.016	1.040	1.087	1.132	1.154
1/ 526	0.064	0.077	0.091	0.125	0.165	0.187	0.266	0.364	0.400	0.480	0.569	0.617
0.00200	0.682	0.714	0.744	0.803	0.860	0.887	0.967	1.043	1.067	1.115	1.162	1.185
1/ 500	0.066	0.079	0.094	0.128	0.169	0.192	0.273	0.373	0.411	0.493	0.584	0.633
0.00220	0.716	0.749	0.781	0.843	0.902	0.931	1.014	1.094	1.119	1.170	1.219	1.243
1/ 455	0.069	0.083	0.098	0.134	0.177	0.202	0.287	0.391	0.431	0.517	0.613	0.664
0.00240	0.748	0.782	0.816	0.881	0.943	0.973	1.060	1.143	1.169	1.222	1.273	1.298
1/ 417	0.072	0.086	0.103	0.140	0.185	0.211	0.300	0.409	0.450	0.540	0.640	0.694
0.00260	0.779	0.815	0.849	0.917	0.981	1.013	1.103	1.190	1.217	1.272	1.325	1.351
1/ 385	0.075	0.090	0.107	0.146	0.193	0.219	0.312	0.426	0.469	0.562	0.666	0.722
0.00280	0.808	0.845	0.882	0.952	1.019	1.051	1.145	1.235	1.264	1.320	1.376	1.403
1/ 357	0.078	0.093	0.111	0.151	0.200	0.228	0.324	0.442	0.486	0.583	0.691	0.750
0.00300	0.837	0.875	0.913	0.985	1.055	1.088	1.186	1.278	1.308	1.367	1.424	1.452
1/ 333	0.081	0.097	0.115	0.157	0.207	0.236	0.335	0.457	0.503	0.604	0.716	0.776
0.00320	0.865	0.904	0.943	1.018	1.089	1.124	1.225	1.320	1.351	1.412	1.471	1.500
1/ 313	0.083	0.100	0.118	0.162	0.214	0.243	0.346	0.472	0.520	0.624	0.739	0.802
0.00340	0.891	0.932	0.972	1.049	1.123	1.159	1.262	1.361	1.393	1.456	1.516	1.546
1/ 294	0.086	0.103	0.122	0.167	0.221	0.251	0.357	0.487	0.536	0.643	0.762	0.827
0.00360	0.917	0.959	1.001	1.080	1.156	1.193	1.299	1.401	1.434	1.498	1.561	1.591
1/ 278	0.088	0.106	0.126	0.172	0.227	0.258	0.367	0.501	0.552	0.662	0.784	0.851
0.00380	0.943	0.986	1.028	1.110	1.188	1.225	1.335	1.439	1.473	1.539	1.603	1.635
1/ 263	0.091	0.109	0.129	0.176	0.233	0.265	0.377	0.515	0.567	0.680	0.806	0.874
Coefficient for part-full pipes:	90	100	110	120	130	140	150	200	200	200	200	200

ks = 1·500mm   i < 0·004

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Supplementary Information continued

Table 1.

Critical tractive force and mean velocity for different bed materials

Material	Size mm	Critical tractive force N/m²	Approximate mean velocity m/sec	Manning's coefficient of roughness
Sandy loam (non-colloidal)		2·0	0·50	0·020
Silt loam (non-colloidal)		2·5	0·60	0·020
Alluvial silt (non-colloidal)		2·5	0·60	0·020
Ordinary firm loam		3·7	0·75	0·020
Volcanic ash		3·7	0·75	0·020
Stiff clay (very colloidal)		1·22	1·15	0·025
Alluvial silts (colloidal)		12·2	1·15	0·025
Shales and hard-pans		31·8	1·85	0·025
Fine sand (non-colloidal)	0·062−0·25	1·2	0·45	0·020
Medium sand (non-colloidal)	0·25−0·5	1·7	0·50	0·020
Coarse sand (non-colloidal)	0·5−2·0	2·5	0·60	0·020
Fine gravel	4−8	3·7	0·75	0·020
Coarse gravel	8−64	14·7	1·25	0·025
Cobbles and shingles	64−256	44·0	1·55	0·035
Graded loam and cobbles (non-colloidal)	0·004−64	19·6	1·15	0·30
Graded silts to cobbles (colloidal)	0−64	22·0	1·25	0·30

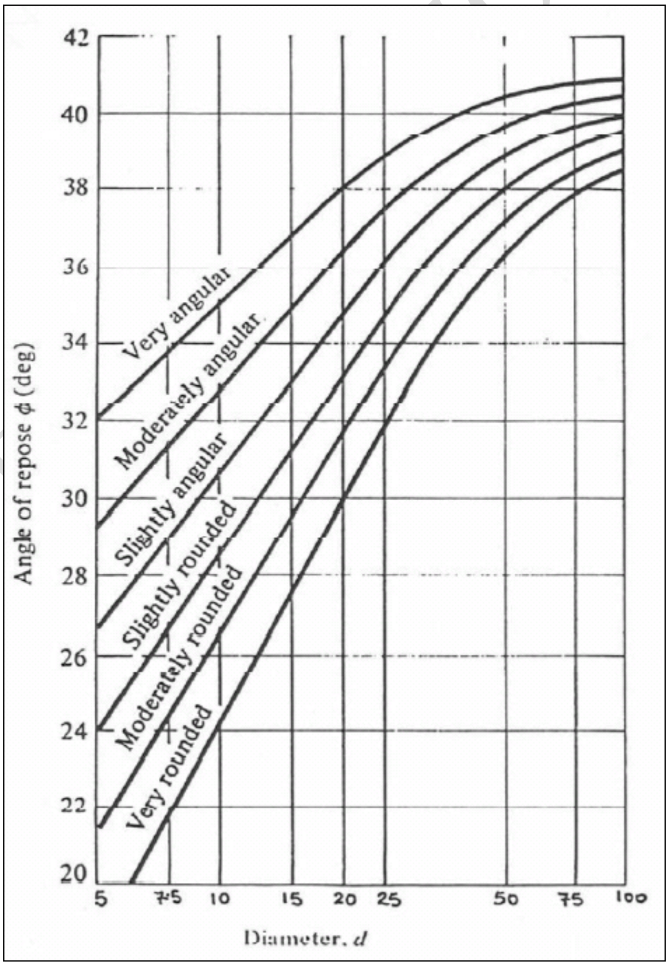

Figure 1.

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Supplementary Information continued

Table 3

Time Period	Rainfall (Relative to UH)	Unit hydrograph ordinates				Surface runoff +Base flow
		u_1=	u_2=	u_3=	u_4=	
1						
2						
3						
4						
5						
6						
7						
8						

To be handed in with answer booklet

Student ID No……………………………

END OF PAPER