[ENG23]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BEng (HONS) CIVIL ENGINEERING

SEMESTER ONE EXAMINATION 2018/2019

WATER ENGINEERING & THE ENVIRONMENT

MODULE NO: CIE6012

PAST EXAMINATION PAPER

Date: Monday 14th January 2019 **Time: 10:00 – 13:00**

INSTRUCTIONS TO CANDIDATES:

There are TWO Sections, A and B.

Answer Section A in ONE Answer Booklet and Section B in the other.

Section A: Q1 to Q3 (Answer TWO Questions)

Section B: Q4 to Q6 (Answer TWO Questions from three)

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

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

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SECTION A - Answer TWO from Three Questions

Question 1

a) With the aid of diagrams, briefly explain what is meant by the term "unit hydrograph" and discuss its use in flood prediction.

(10 marks)

b) Estimate the peak flow during a 15 year flood event for the river Irwell using a synthetic, 10mm – 1 hour, unit hydrograph analysis with the data listed below. The base flow in the river is 9m^3/sec.

T_B = 6 hours
T_P = 2 hours
Q_P = 17m^3/sec

The hourly depths of rainfall, for the chosen 5 hour event, are shown in the table below. Unit hydrograph table Q1 is also provided.

1st hour	2nd hour	3rd hour	4th hour	5th hour
3.6mm	7.4mm	13.4mm	8.2mm	4.1

(15 marks)

Total 25 marks

Question 2

a) Discuss the types of sediment related problems facing the civil engineer.

(5 marks)

b) With the aid of diagrams describe the mechanics of sediment transport in rivers.

(8 marks)

c) A trapezoidal channel is to be constructed in a slightly angular coarse gravel, where d_{50} is 25mm, at a gradient of 1 in 900. The channel has a base width of 3.0m and sides which slope at 2.25H:1V. Using the tractive force method, determine the maximum permissible flow rate in the channel. Table Q2c and Graph Q2c are provided.

(12 marks)

Total 25 marks

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Question 3

a) Sketch a flow chart identifying the sequence of processes used in a typical raw water treatment works. **(8 marks)**

b) Sketch and briefly explain the purpose and operation of the following water and wastewater treatment processes:

i) A first stage rapid sand filter **(4 marks)**
ii) A DAF unit **(4 marks)**
iii) A storm tank **(4 marks)**

c) Briefly explain the principles behind a 'consent to discharge' from a sewage treatment works. **(5 marks)**

Total 25 marks

END OF SECTION A

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SECTION B: Answer TWO Questions from three

Question 4

a) Explain, using suitable diagrams, what happens across a broad crested weir in terms of 'specific energy' and 'momentum function' assuming a hydraulic jump forms just downstream of the weir.

(8 marks)

b) Sketch the water surface profile for a S2 flow

(5 marks)

c) A stilling basin, utilising a hydraulic jump to dissipate energy, is to be designed for a dam spillway. The maximum flood flow over the spillway is to be $54m^3$/sec, the spillway can be assumed to have a Manning 'n' value of 0.016. Choose what you consider to be an appropriate width and slope for the spillway and then determine a suitable weir height, above the stilling basin apron, to ensure the formation of a hydraulic jump.

(12 marks)

Total 25 marks

Question 5

a) Outline the objectives that an effective Combined Sewer Overflow should satisfy. Describe the design features which you would incorporate so as to optimise the performance of the overflow structure.

(12 marks)

b) A stilling pond overflow (CSO) chamber, breadth 3.6m, serves a population of 11,200 and receives a peak storm flow of $2.5m^3/s$. A 270mm 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 125. The overflow weir crest height above the centre of the orifice is 2.2m. Using the information given below check the adequacy of the control and determine the peak flow passing to the downstream sewer. HRS tables are provided.

G = 240 l/h/d
I = 40 l/h/d
E = 250,000 l/d

(13 marks)

Total 25 marks

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Question 6

a) With the aid of a suitable sketch describe the performance gained by using pumps in series.

(8 marks)

b) Water is pumped from a treatment works to a service reservoir through a 225mm diameter pipe which is 720m in length and has a roughness value k_S of 1.5mm. Three pumps connected in parallel are installed in the pumping station at the works. Each pump has the characteristics given below.

Q (litres/s)	0	10	20	30	40
H (m)	32	30	26	19	10
E (%)	0	61	66	56	36
P (kW)	15	15.4	15.8	16.1	16.3

The difference in water levels between the tank at the treatment works and the service reservoir varies from 12m to 14m. Determine:

i.) The maximum possible flow to the works.

(14 marks)

ii.) The efficiency of the pumps and the total power consumed at this flow rate.

(3 marks)

Table Q6 is provided.

Total 25 marks

END OF QUESTIONS

Tables and formula sheets over the page….

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Time Period	**Rainfall (Relative to UH)**	**Unit hydrograph ordinates**					**Surface r/o + baseflow**
		U_1 =	**U_2 =**	**U_3 =**	**U_4 =**	**U_5 =**	
1	**P_1 =**						
2	**P_2 =**						
3	**P_3 =**						
4	**P_4 =**						
5	**P_5 =**						
6							
7							
8							
9							

Table Q1 **To be handed in with answer booklet** **Student ID No……………………………..**

Critical tractive force and mean velocity for different bed materials

Material	Size mm	Critical tractive force N/m^2	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

Table Q2c

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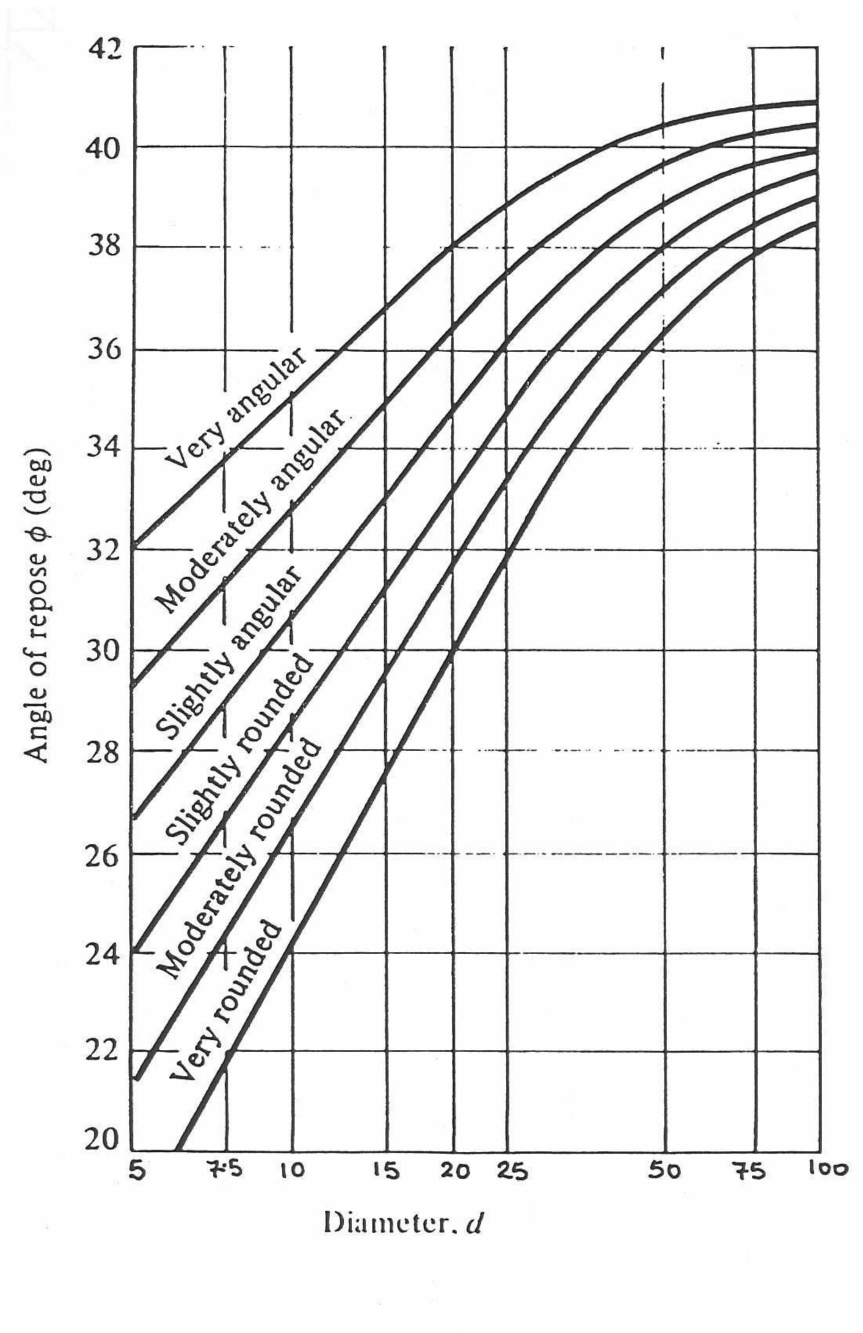

Graph Q2c

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Flow (l/s)								
H for one pump alone								
H for three pumps in parallel								
h_f for one pump								
h_f for three pumps								
H_T for one pump								
H_T for three pumps								

Table Q6. **To be handed in with answer book** **Candidates ID...**

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continued

ks = 1·500mm
i = 0·004 to 0·1

ie hydraulic gradient =
1 in 250 to 1 in 10

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

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

Gradient	Pipe diameters in mm: 350	375	400	450	500	525	600	675	700	750	800	825
0.00400 1/ 250	0.967	1.012	1.055	1.139	1.219	1.257	1.370	1.477	1.511	1.579	1.645	1.678
	0.093	0.112	0.133	0.181	0.239	0.272	0.387	0.528	0.582	0.698	0.827	0.897
0.00420 1/ 238	0.991	1.037	1.081	1.167	1.249	1.289	1.404	1.513	1.549	1.618	1.686	1.719
	0.095	0.115	0.136	0.186	0.245	0.279	0.397	0.542	0.596	0.715	0.848	0.919
0.00440 1/ 227	1.015	1.061	1.107	1.194	1.278	1.319	1.437	1.549	1.586	1.657	1.726	1.760
	0.098	0.117	0.139	0.190	0.251	0.286	0.406	0.554	0.610	0.732	0.868	0.941
0.00460 1/ 217	1.038	1.085	1.132	1.221	1.307	1.349	1.469	1.584	1.621	1.694	1.765	1.800
	0.100	0.120	0.142	0.194	0.257	0.292	0.415	0.567	0.624	0.748	0.887	0.962
0.00480 1/ 208	1.060	1.109	1.156	1.248	1.335	1.378	1.501	1.618	1.656	1.731	1.803	1.838
	0.102	0.122	0.145	0.198	0.262	0.298	0.424	0.579	0.637	0.765	0.906	0.983
0.00500 1/ 200	1.082	1.132	1.180	1.274	1.363	1.407	1.532	1.652	1.691	1.766	1.840	1.876
	0.104	0.125	0.148	0.203	0.268	0.304	0.433	0.591	0.651	0.780	0.925	1.003
0.00550 1/ 182	1.135	1.187	1.238	1.336	1.430	1.476	1.607	1.733	1.773	1.853	1.930	1.968
	0.109	0.131	0.156	0.212	0.281	0.319	0.454	0.620	0.682	0.819	0.970	1.052
0.00600 1/ 167	1.186	1.240	1.293	1.396	1.494	1.541	1.679	1.810	1.852	1.936	2.016	2.056
	0.114	0.137	0.163	0.222	0.293	0.334	0.475	0.648	0.713	0.855	1.014	1.099
0.00650 1/ 154	1.235	1.291	1.346	1.453	1.555	1.605	1.748	1.884	1.928	2.015	2.099	2.140
	0.119	0.143	0.169	0.231	0.305	0.347	0.494	0.674	0.742	0.890	1.055	1.144
0.00700 1/ 143	1.281	1.340	1.398	1.508	1.614	1.665	1.814	1.956	2.001	2.091	2.178	2.221
	0.123	0.148	0.176	0.240	0.317	0.361	0.513	0.700	0.770	0.924	1.095	1.187
0.00750 1/ 133	1.327	1.387	1.447	1.561	1.671	1.724	1.878	2.024	2.072	2.165	2.255	2.299
	0.128	0.153	0.182	0.248	0.328	0.373	0.531	0.724	0.797	0.956	1.134	1.229
0.00800 1/ 125	1.370	1.433	1.494	1.613	1.726	1.781	1.940	2.091	2.140	2.236	2.329	2.375
	0.132	0.158	0.188	0.256	0.339	0.385	0.548	0.748	0.824	0.988	1.171	1.270
0.00850 1/ 118	1.413	1.477	1.541	1.662	1.779	1.836	2.000	2.156	2.206	2.305	2.401	2.448
	0.136	0.163	0.194	0.264	0.349	0.397	0.565	0.771	0.849	1.018	1.207	1.309
0.00900 1/ 111	1.454	1.520	1.585	1.711	1.831	1.889	2.058	2.218	2.270	2.372	2.471	2.520
	0.140	0.168	0.199	0.272	0.359	0.409	0.582	0.794	0.874	1.048	1.242	1.347
0.00950 1/ 105	1.494	1.562	1.629	1.758	1.881	1.941	2.114	2.279	2.333	2.437	2.539	2.589
	0.144	0.173	0.205	0.280	0.369	0.420	0.598	0.816	0.898	1.077	1.276	1.384
0.01000 1/ 100	1.533	1.603	1.672	1.804	1.930	1.992	2.169	2.339	2.393	2.501	2.605	2.656
	0.147	0.177	0.210	0.287	0.379	0.431	0.613	0.837	0.921	1.105	1.309	1.420
0.01100 1/ 91	1.608	1.682	1.753	1.892	2.025	2.089	2.276	2.453	2.510	2.623	2.732	2.786
	0.155	0.186	0.220	0.301	0.398	0.452	0.643	0.878	0.966	1.159	1.373	1.489
0.01200 1/ 83	1.680	1.757	1.832	1.976	2.115	2.182	2.377	2.562	2.622	2.740	2.854	2.910
	0.162	0.194	0.230	0.314	0.415	0.472	0.672	0.917	1.009	1.210	1.435	1.556
0.01300 1/ 77	1.748	1.829	1.907	2.057	2.202	2.272	2.474	2.667	2.730	2.852	2.971	3.029
	0.168	0.202	0.240	0.327	0.432	0.492	0.700	0.954	1.050	1.260	1.493	1.619
0.01400 1/ 71	1.815	1.898	1.979	2.135	2.285	2.358	2.568	2.768	2.833	2.960	3.083	3.144
	0.175	0.210	0.249	0.340	0.449	0.510	0.726	0.991	1.090	1.308	1.550	1.681
0.01500 1/ 67	1.879	1.965	2.049	2.210	2.365	2.441	2.658	2.866	2.933	3.064	3.192	3.254
	0.181	0.217	0.257	0.352	0.464	0.528	0.752	1.025	1.129	1.354	1.604	1.740
0.01600 1/ 62	1.940	2.029	2.116	2.283	2.443	2.521	2.746	2.960	3.029	3.165	3.297	3.361
	0.187	0.224	0.266	0.363	0.480	0.546	0.776	1.059	1.166	1.398	1.657	1.797
0.01700 1/ 59	2.000	2.092	2.181	2.354	2.519	2.599	2.830	3.051	3.122	3.262	3.398	3.465
	0.192	0.231	0.274	0.374	0.495	0.563	0.800	1.092	1.202	1.441	1.708	1.852
0.01800 1/ 56	2.059	2.153	2.245	2.422	2.592	2.674	2.913	3.140	3.213	3.357	3.497	3.566
	0.198	0.238	0.282	0.385	0.509	0.579	0.824	1.123	1.237	1.483	1.758	1.906
0.01900 1/ 53	2.115	2.212	2.306	2.488	2.663	2.748	2.993	3.226	3.301	3.449	3.593	3.664
	0.203	0.244	0.290	0.396	0.523	0.595	0.846	1.154	1.270	1.524	1.806	1.958
Coefficient for part-full pipes:	120	130	140	150	200	200	200	250	250	250	300	300

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Formula sheet

$$\tau_s = \tau_b \sqrt{1 - \frac{\sin^2 \theta}{\sin^2 \phi}}$$

$$y = \frac{\tau_b}{9810 \times S_O} \quad \text{or} \quad y = \frac{\tau_s}{9810 \times 0.76 \times S_O}$$

Formula A = DWF + 1360P + 2E

DWF = PG + I + E

$D_{Min} = 0.815\ Q^{0.4}$

$Q_O = 0.6\ A_O(2gH_O)^{1/2}$

$Q_W = 1.7\ B\ H_W^{\ 3/2}$

Chamber width = 2.5 D_{Min}

Chamber length = 7 D_{Min}

Weir height = 1.2 D

$$y_2 = \frac{y_1}{2}\left(\sqrt{1 + 8{Fr_1}^2} - 1\right)$$

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