UNIVERSITY OF BOLTON

SCHOOL OF THE BUILT ENVIRONMENT & ENGINEERING – RAK CAMPUS

BSc (HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2010/2011

HYDRAULICS

MODULE NO: BLT3014

Date: Monday 6 June 2011 **Time: 1.00 pm – 3.00 pm**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions.

Answer THREE questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 75 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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Module No. BLT3014

1. a) Sketch a flow chart identifying the sequence of processes used in a typical water treatment works. Show where in the process chemicals are added and state their purpose.

(8 marks)

b) Briefly explain the purpose and operation of the following wastewater treatment processes:

i) A percolating filter unit (3 marks)
ii) A primary sedimentation tank (3 marks)
iii) A storm tank (3 marks)

c) A venturi flume, throat width 0.8m is situated in the 1.5m wide inlet channel to a sewage treatment works. Under dry weather flow conditions, when the depth of flow at the throat has been recorded as 0.7m, a hydraulic jump forms downstream of the flume. Determine the flow rate under these conditions and the depths of flow upstream and downstream of the flume.State any assumptions that you have made. Undertake no more than **two** iterations per depth calculation.

(8 marks)

Total 25 marks

2. a) Explain, using suitable diagrams, what happens at a sluice gate in terms of 'specific energy' and 'momentum function' assuming a hydraulic jump forms just downstream of the sluice gate.

(8 marks)

b) A trapezoidal channel with a bed width of 2.2m, side slopes of 45º and a gradient of 1 in 350 conveys 8.9m^3/sec of water when the depth is 1.2m. Determine the flowrate when the depth is 1.5m.

(7 marks)

c) A 1.0m high broad crested weir is located in a long rectangular channel of width 2.6m. When a flowrate of 5.5m^3/sec passes through the channel a hydraulic jump forms just downstream of the weir. Determine the depth of flow just downstream of the weir and just downstream of the jump. State any assumptions you have made. Undertake no more than **two** iterations per depth calculation.

(10 marks)

Total 25 marks

Please turn the page

3. a) Sketch and annotate the gradually varying flow profiles which exist upstream and downstream of a broad crested weir situated in a mildly sloping channel, assuming critical depth flow occurs on the weir. Classify the profiles and explain the system you have used. (12 marks)

b) A long rectangular channel 3.0m wide, Manning 'n' value of 0.015, has a bed slope of 1 in 800 and a uniform flow depth of 1.45m when the flow rate is $8.37m^3$/sec. The channel has a free outfall at the downstream end where critical depth conditions may be considered to occur. Using a numerical integration technique, taking depth increments of 0.2m, determine the approximate surface profile upstream of the outfall. Table Q3 is provided.

(13 marks)

Total 25 marks

Please turn the page

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4. a) With the aid of a suitable sketch compare the performance of pumps in parallel with pumps in series.

(5 marks)

b) Water is pumped from a borehole where the water level is 14m below ground level. Three pumps mounted in series are used, each pump has the performance characteristics shown in the table below.

Q (l/s)	0	10	20	30	40
H (m)	16	14	11	7	2
E (%)	0	45	62	58	48

The pumps discharge through a 150mm diameter pipe, roughness k_S of 1.5mm and length 300m, into a tank where the water level is 8m above the ground level at the borehole. Determine the quantity of flow delivered to the tank and the approximate operational efficiency of the pumps. HRS tables and Table Q4 are provided.

(13 marks)

c) A centrifugal pump with an impeller size of 90mm has been tested and the following results obtained at an efficiency of 60%.

Speed	1200 revs/min
Discharge	6 litres/sec
Head	3m
Power input	2 Kw

Determine the discharge, operating head and power input for a geometrically similar pump with an impeller size of 150mm operating at a speed of 1000 revs/min at the same efficiency.

(7 marks)

Total 25 marks

END OF QUESTIONS

Please turn the page

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EQUATION SHEET

$Q = Av$

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

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

$$y_2 = 0.5y_1\left(\sqrt{1+8Fr_1^2} - 1\right) \; ; \quad Fr = \frac{v}{\sqrt{gy}}$$

$$v = C\sqrt{R\,S_o}$$

$$Q = AC\sqrt{RS_o} = \frac{A}{n}R^{\frac{2}{3}}S_0^{\frac{1}{2}}$$

$$\Delta x = \frac{\Delta E}{\left[s_o - \frac{v^2}{C^2 R}\right]_M} \qquad C^2 = \frac{1}{n^2}R^{1/3}$$

$$\frac{Q}{N D^3} = K_Q , \quad \frac{P}{\rho N^3 D^5} = K_P , \quad \frac{g H}{N^2 D^2} = K_H \qquad P = \rho gQH$$

$h_f = S_0 \times L \qquad H_T = h_f + h_S$

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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 l/s

Gradient	Pipe diameters in mm: 50	75	80	100	125	150	175	200	225	250	275	300
0.00015 1/ 6667	0.046	0.062	0.065	0.077	0.090	0.103	0.114	0.125	0.136	0.146	0.156	0.165
	0.090	0.275	0.329	0.604	1.108	1.814	2.748	3.936	5.400	7.162	9.243	11.664
0.00016 1/ 6250	0.048	0.065	0.068	0.080	0.093	0.106	0.118	0.130	0.140	0.151	0.161	0.171
	0.093	0.285	0.340	0.625	1.146	1.876	2.842	4.070	5.584	7.405	9.556	12.058
0.00017 1/ 5882	0.049	0.067	0.070	0.082	0.096	0.110	0.122	0.134	0.145	0.156	0.166	0.176
	0.096	0.294	0.351	0.646	1.183	1.936	2.933	4.200	5.761	7.640	9.859	12.440
0.00018 1/ 5556	0.051	0.069	0.072	0.085	0.099	0.113	0.126	0.138	0.149	0.160	0.171	0.181
	0.099	0.304	0.362	0.665	1.219	1.995	3.022	4.326	5.934	7.869	10.154	12.811
0.00019 1/ 5263	0.052	0.071	0.074	0.087	0.102	0.116	0.129	0.142	0.153	0.165	0.176	0.186
	0.102	0.312	0.373	0.684	1.254	2.052	3.108	4.449	6.102	8.091	10.440	13.172
0.00020 1/ 5000	0.054	0.073	0.076	0.090	0.105	0.119	0.133	0.145	0.158	0.169	0.180	0.191
	0.105	0.321	0.383	0.703	1.288	2.107	3.191	4.569	6.266	8.308	10.719	13.523
0.00022 1/ 4545	0.056	0.076	0.080	0.094	0.110	0.125	0.139	0.153	0.166	0.178	0.190	0.201
	0.111	0.338	0.403	0.739	1.353	2.214	3.353	4.799	6.581	8.725	11.257	14.201
0.00024 1/ 4167	0.059	0.080	0.084	0.099	0.115	0.131	0.146	0.160	0.173	0.186	0.198	0.210
	0.116	0.353	0.422	0.774	1.416	2.316	3.507	5.020	6.883	9.124	11.771	14.848
0.00026 1/ 3846	0.062	0.083	0.087	0.103	0.120	0.137	0.152	0.167	0.180	0.194	0.206	0.219
	0.121	0.369	0.440	0.807	1.476	2.414	3.655	5.231	7.172	9.507	12.264	15.470
0.00028 1/ 3571	0.064	0.087	0.091	0.107	0.125	0.142	0.158	0.173	0.187	0.201	0.214	0.227
	0.126	0.383	0.457	0.839	1.534	2.509	3.798	5.434	7.450	9.876	12.739	16.068
0.00030 1/ 3333	0.067	0.090	0.094	0.111	0.130	0.147	0.164	0.179	0.194	0.208	0.222	0.235
	0.131	0.398	0.474	0.869	1.590	2.600	3.935	5.631	7.719	10.231	13.197	16.644
0.00032 1/ 3125	0.069	0.093	0.098	0.114	0.134	0.152	0.169	0.185	0.201	0.215	0.230	0.243
	0.135	0.411	0.490	0.899	1.644	2.688	4.068	5.821	7.979	10.575	13.640	17.203
0.00034 1/ 2941	0.071	0.096	0.101	0.118	0.138	0.157	0.174	0.191	0.207	0.222	0.237	0.251
	0.140	0.425	0.506	0.928	1.697	2.773	4.197	6.005	8.231	10.908	14.069	17.743
0.00036 1/ 2778	0.073	0.099	0.104	0.122	0.142	0.162	0.180	0.197	0.213	0.229	0.244	0.258
	0.144	0.437	0.522	0.956	1.748	2.856	4.322	6.183	8.475	11.232	14.486	18.269
0.00038 1/ 2632	0.076	0.102	0.107	0.125	0.146	0.166	0.185	0.202	0.219	0.235	0.251	0.266
	0.148	0.450	0.536	0.983	1.797	2.937	4.444	6.357	8.713	11.547	14.892	18.780
0.00040 1/ 2500	0.078	0.105	0.110	0.129	0.150	0.171	0.190	0.208	0.225	0.241	0.257	0.273
	0.152	0.462	0.551	1.010	1.846	3.016	4.563	6.527	8.945	11.854	15.287	19.277
0.00042 1/ 2381	0.080	0.107	0.112	0.132	0.154	0.175	0.195	0.213	0.231	0.248	0.264	0.280
	0.156	0.474	0.565	1.036	1.893	3.092	4.679	6.692	9.171	12.153	15.672	19.763
0.00044 1/ 2273	0.082	0.110	0.115	0.135	0.158	0.179	0.199	0.218	0.236	0.254	0.270	0.286
	0.160	0.486	0.579	1.061	1.939	3.167	4.792	6.853	9.392	12.445	16.048	20.237
0.00046 1/ 2174	0.084	0.113	0.118	0.138	0.162	0.183	0.204	0.223	0.242	0.259	0.276	0.293
	0.164	0.497	0.593	1.086	1.984	3.241	4.902	7.011	9.608	12.730	16.416	20.700
0.00048 1/ 2083	0.085	0.115	0.121	0.141	0.165	0.187	0.208	0.228	0.247	0.265	0.282	0.299
	0.168	0.508	0.606	1.110	2.028	3.312	5.010	7.165	9.819	13.010	16.776	21.154
0.00050 1/ 2000	0.087	0.118	0.123	0.144	0.169	0.191	0.213	0.233	0.252	0.271	0.288	0.306
	0.171	0.519	0.619	1.133	2.071	3.382	5.116	7.317	10.026	13.284	17.129	21.598
0.00055 1/ 1818	0.092	0.124	0.129	0.152	0.177	0.201	0.223	0.245	0.265	0.284	0.303	0.321
	0.180	0.546	0.650	1.191	2.175	3.552	5.372	7.682	10.525	13.945	17.980	22.671
0.00060 1/ 1667	0.096	0.129	0.135	0.159	0.185	0.210	0.234	0.256	0.277	0.297	0.316	0.335
	0.189	0.571	0.680	1.245	2.274	3.714	5.617	8.031	11.003	14.577	18.794	23.696
0.00065 1/ 1538	0.100	0.135	0.141	0.165	0.193	0.219	0.243	0.266	0.288	0.309	0.330	0.349
	0.197	0.595	0.709	1.298	2.370	3.869	5.851	8.366	11.461	15.183	19.575	24.679
0.00070 1/ 1429	0.104	0.140	0.147	0.172	0.201	0.227	0.253	0.277	0.299	0.321	0.342	0.363
	0.205	0.618	0.737	1.348	2.462	4.019	6.077	8.688	11.902	15.766	20.326	25.626
Coefficient for part-full pipes:	9	14	14	18	25	30	30	35	40	45	50	60

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 l/s

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continued

Gradient	Pipe diameters in mm: 50	75	80	100	125	150	175	200	225	250	275	300
0.00075 1/ 1333	0.108	0.145	0.152	0.178	0.208	0.236	0.262	0.286	0.310	0.333	0.354	0.375
	0.212	0.641	0.764	1.397	2.550	4.163	6.295	8.999	12.327	16.329	21.051	26.539
0.00080 1/ 1250	0.112	0.150	0.157	0.184	0.215	0.244	0.270	0.296	0.320	0.344	0.366	0.388
	0.219	0.663	0.790	1.444	2.636	4.303	6.505	9.299	12.739	16.873	21.752	27.422
0.00085 1/ 1176	0.115	0.155	0.162	0.190	0.222	0.251	0.279	0.305	0.330	0.354	0.378	0.400
	0.226	0.684	0.815	1.490	2.719	4.438	6.710	9.591	13.137	17.401	22.432	28.278
0.00090 1/ 1111	0.119	0.159	0.167	0.195	0.228	0.259	0.287	0.314	0.340	0.365	0.389	0.412
	0.233	0.704	0.839	1.534	2.800	4.570	6.908	9.874	13.524	17.913	23.092	29.109
0.00095 1/ 1053	0.122	0.164	0.172	0.201	0.235	0.266	0.295	0.323	0.350	0.375	0.400	0.423
	0.240	0.724	0.863	1.578	2.879	4.698	7.101	10.149	13.901	18.412	23.734	29.918
0.00100 1/ 1000	0.125	0.168	0.176	0.206	0.241	0.273	0.303	0.332	0.359	0.385	0.410	0.434
	0.246	0.744	0.886	1.620	2.955	4.822	7.289	10.417	14.268	18.897	24.359	30.705
0.00110 1/ 909	0.132	0.177	0.185	0.217	0.253	0.286	0.318	0.348	0.377	0.404	0.430	0.456
	0.259	0.781	0.930	1.701	3.102	5.062	7.651	10.934	14.975	19.833	25.564	32.223
0.00120 1/ 833	0.138	0.185	0.194	0.226	0.264	0.299	0.332	0.364	0.394	0.422	0.450	0.476
	0.271	0.817	0.973	1.778	3.243	5.292	7.997	11.428	15.651	20.727	26.715	33.674
0.00130 1/ 769	0.144	0.193	0.202	0.236	0.275	0.312	0.346	0.379	0.410	0.440	0.468	0.496
	0.282	0.851	1.014	1.853	3.379	5.512	8.329	11.902	16.299	21.584	27.820	35.065
0.00140 1/ 714	0.149	0.200	0.209	0.245	0.286	0.324	0.360	0.393	0.426	0.457	0.486	0.515
	0.293	0.884	1.053	1.924	3.509	5.723	8.648	12.358	16.923	22.410	28.883	36.404
0.00150 1/ 667	0.155	0.207	0.217	0.254	0.296	0.335	0.372	0.407	0.441	0.473	0.504	0.533
	0.304	0.916	1.091	1.993	3.634	5.928	8.957	12.798	17.525	23.206	29.908	37.696
0.00160 1/ 625	0.160	0.214	0.224	0.262	0.306	0.347	0.385	0.421	0.455	0.488	0.520	0.551
	0.314	0.947	1.127	2.060	3.755	6.125	9.255	13.223	18.107	23.976	30.900	38.946
0.00170 1/ 588	0.165	0.221	0.231	0.271	0.316	0.357	0.397	0.434	0.470	0.504	0.536	0.568
	0.324	0.977	1.163	2.125	3.873	6.317	9.544	13.636	18.671	24.723	31.862	40.157
0.00180 1/ 556	0.170	0.228	0.238	0.279	0.325	0.368	0.408	0.447	0.483	0.518	0.552	0.585
	0.334	1.006	1.198	2.187	3.987	6.503	9.824	14.036	19.219	25.447	32.795	41.333
0.00190 1/ 526	0.175	0.234	0.245	0.286	0.334	0.378	0.420	0.459	0.497	0.533	0.567	0.601
	0.343	1.034	1.231	2.249	4.099	6.684	10.097	14.426	19.752	26.152	33.703	42.476
0.00200 1/ 500	0.180	0.240	0.251	0.294	0.343	0.388	0.431	0.471	0.510	0.547	0.582	0.617
	0.353	1.061	1.264	2.308	4.207	6.860	10.363	14.805	20.271	26.839	34.588	43.590
0.00220 1/ 455	0.189	0.252	0.264	0.308	0.360	0.407	0.452	0.495	0.535	0.574	0.611	0.647
	0.370	1.114	1.327	2.423	4.415	7.200	10.876	15.537	21.271	28.163	36.293	45.738
0.00240 1/ 417	0.197	0.264	0.276	0.322	0.376	0.426	0.473	0.517	0.559	0.599	0.638	0.676
	0.387	1.165	1.387	2.533	4.615	7.524	11.365	16.235	22.227	29.428	37.922	47.790
0.00260 1/ 385	0.205	0.275	0.287	0.336	0.392	0.443	0.492	0.538	0.582	0.624	0.665	0.704
	0.403	1.213	1.445	2.638	4.806	7.836	11.835	16.906	23.144	30.641	39.484	49.758
0.00280 1/ 357	0.213	0.285	0.298	0.349	0.407	0.460	0.511	0.559	0.604	0.648	0.690	0.731
	0.419	1.260	1.500	2.739	4.990	8.135	12.287	17.551	24.026	31.808	40.988	51.652
0.00300 1/ 333	0.221	0.295	0.309	0.361	0.421	0.477	0.529	0.578	0.626	0.671	0.715	0.757
	0.434	1.305	1.554	2.837	5.168	8.424	12.723	18.173	24.877	32.935	42.438	53.479
0.00320 1/ 313	0.229	0.305	0.319	0.373	0.435	0.493	0.546	0.598	0.646	0.693	0.738	0.782
	0.449	1.349	1.606	2.931	5.339	8.704	13.145	18.775	25.701	34.024	43.841	55.246
0.00340 1/ 294	0.236	0.315	0.329	0.385	0.449	0.508	0.563	0.616	0.666	0.715	0.761	0.806
	0.463	1.391	1.656	3.023	5.506	8.975	13.554	19.358	26.499	35.080	45.201	56.959
0.00360 1/ 278	0.243	0.324	0.339	0.396	0.462	0.523	0.580	0.634	0.686	0.736	0.783	0.829
	0.477	1.432	1.705	3.112	5.668	9.238	13.951	19.925	27.274	36.105	46.522	58.623
0.00380 1/ 263	0.250	0.333	0.349	0.407	0.475	0.537	0.596	0.652	0.705	0.756	0.805	0.852
	0.490	1.472	1.753	3.198	5.825	9.494	14.337	20.476	28.028	37.102	47.806	60.240
Coefficient for part-full pipes:	14	20	20	25	35	40	45	50	60	70	70	80

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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 l/s

Gradient	Pipe diameters in mm: 50	75	80	100	125	150	175	200	225	250	275	300
0.00400	0.256	0.342	0.358	0.418	0.487	0.551	0.612	0.669	0.723	0.776	0.826	0.875
1/ 250	0.503	1.511	1.799	3.282	5.978	9.743	14.713	21.013	28.762	38.074	49.057	61.816
0.00420	0.263	0.351	0.367	0.428	0.499	0.565	0.627	0.686	0.741	0.795	0.846	0.896
1/ 238	0.516	1.549	1.844	3.365	6.127	9.986	15.080	21.536	29.478	39.021	50.277	63.353
0.00440	0.269	0.359	0.376	0.439	0.511	0.579	0.642	0.702	0.759	0.814	0.867	0.917
1/ 227	0.528	1.586	1.888	3.445	6.273	10.224	15.438	22.047	30.177	39.946	51.468	64.854
0.00460	0.275	0.367	0.384	0.449	0.523	0.592	0.656	0.718	0.776	0.832	0.886	0.938
1/ 217	0.540	1.622	1.931	3.523	6.416	10.456	15.788	22.547	30.860	40.850	52.633	66.320
0.00480	0.281	0.375	0.393	0.458	0.534	0.605	0.671	0.733	0.793	0.850	0.905	0.959
1/ 208	0.552	1.658	1.973	3.600	6.555	10.683	16.130	23.035	31.529	41.735	53.773	67.756
0.00500	0.287	0.383	0.401	0.468	0.545	0.617	0.685	0.748	0.809	0.868	0.924	0.978
1/ 200	0.564	1.692	2.014	3.675	6.692	10.905	16.466	23.514	32.184	42.602	54.889	69.162
0.00550	0.301	0.402	0.421	0.491	0.572	0.648	0.718	0.785	0.849	0.911	0.970	1.026
1/ 182	0.592	1.776	2.114	3.857	7.022	11.443	17.276	24.671	33.766	44.695	57.585	72.558
0.00600	0.315	0.420	0.440	0.513	0.598	0.677	0.750	0.820	0.887	0.951	1.013	1.072
1/ 167	0.618	1.856	2.209	4.030	7.337	11.956	18.051	25.776	35.278	46.695	60.161	75.802
0.00650	0.328	0.438	0.458	0.534	0.623	0.704	0.781	0.854	0.924	0.990	1.054	1.116
1/ 154	0.644	1.933	2.301	4.197	7.640	12.448	18.794	26.836	36.728	48.614	62.632	78.915
0.00700	0.341	0.454	0.475	0.555	0.646	0.731	0.811	0.887	0.959	1.028	1.095	1.159
1/ 143	0.669	2.007	2.389	4.357	7.931	12.922	19.508	27.856	38.123	50.460	65.009	81.910
0.00750	0.353	0.470	0.492	0.574	0.669	0.757	0.840	0.918	0.993	1.064	1.133	1.200
1/ 133	0.693	2.078	2.474	4.511	8.212	13.379	20.198	28.840	39.470	52.241	67.303	84.799
0.00800	0.365	0.486	0.508	0.593	0.691	0.782	0.867	0.948	1.025	1.099	1.170	1.239
1/ 125	0.716	2.147	2.556	4.661	8.484	13.822	20.865	29.792	40.772	53.964	69.522	87.594
0.00850	0.376	0.501	0.524	0.612	0.713	0.806	0.894	0.978	1.057	1.133	1.207	1.278
1/ 118	0.738	2.214	2.635	4.806	8.747	14.250	21.512	30.715	42.034	55.634	71.673	90.303
0.00900	0.387	0.516	0.540	0.630	0.734	0.830	0.920	1.006	1.088	1.166	1.242	1.315
1/ 111	0.760	2.279	2.712	4.946	9.002	14.666	22.139	31.611	43.259	57.255	73.761	92.933
0.00950	0.398	0.530	0.555	0.647	0.754	0.853	0.946	1.034	1.118	1.199	1.276	1.351
1/ 105	0.781	2.342	2.788	5.083	9.251	15.071	22.750	32.482	44.451	58.832	75.792	95.491
0.01000	0.408	0.544	0.569	0.664	0.774	0.875	0.971	1.061	1.147	1.230	1.309	1.386
1/ 100	0.802	2.404	2.861	5.216	9.493	15.465	23.345	33.331	45.612	60.368	77.770	97.983
0.01100	0.429	0.571	0.597	0.697	0.812	0.918	1.018	1.113	1.203	1.290	1.374	1.454
1/ 91	0.841	2.522	3.002	5.473	9.960	16.225	24.491	34.967	47.850	63.329	81.583	102.786
0.01200	0.448	0.597	0.624	0.728	0.848	0.959	1.064	1.163	1.257	1.348	1.435	1.519
1/ 83	0.879	2.636	3.137	5.718	10.406	16.951	25.586	36.530	49.988	66.158	85.226	107.375
0.01300	0.466	0.621	0.650	0.758	0.883	0.999	1.107	1.210	1.309	1.403	1.494	1.581
1/ 77	0.916	2.744	3.266	5.954	10.834	17.648	26.637	38.029	52.039	68.871	88.721	111.776
0.01400	0.484	0.645	0.674	0.787	0.916	1.037	1.149	1.256	1.358	1.456	1.550	1.641
1/ 71	0.951	2.849	3.390	6.180	11.246	18.318	27.648	39.472	54.012	71.482	92.083	116.012
0.01500	0.501	0.668	0.698	0.815	0.949	1.073	1.190	1.301	1.406	1.508	1.605	1.699
1/ 67	0.984	2.950	3.510	6.399	11.643	18.964	28.623	40.864	55.916	74.001	95.328	120.099
0.01600	0.518	0.690	0.721	0.842	0.980	1.109	1.229	1.344	1.453	1.557	1.658	1.755
1/ 62	1.017	3.047	3.626	6.610	12.027	19.590	29.567	42.210	57.758	76.437	98.466	124.051
0.01700	0.534	0.711	0.744	0.868	1.010	1.143	1.267	1.385	1.498	1.605	1.709	1.809
1/ 59	1.049	3.142	3.739	6.815	12.400	20.196	30.481	43.515	59.543	78.799	101.507	127.882
0.01800	0.550	0.732	0.766	0.893	1.040	1.176	1.304	1.425	1.541	1.652	1.759	1.862
1/ 56	1.079	3.234	3.848	7.014	12.761	20.784	31.369	44.782	61.276	81.092	104.460	131.602
0.01900	0.565	0.752	0.787	0.918	1.069	1.209	1.340	1.465	1.584	1.697	1.807	1.913
1/ 53	1.109	3.323	3.954	7.208	13.113	21.357	32.232	46.014	62.961	83.322	107.332	135.220
Coefficient for part-full pipes:	18	25	30	35	45	50	60	70	80	90	100	110

ks = 1·500mm   i < 0·1

School of the Built Environment & Engineering – RAK Campus
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Hydraulics
Module No. BLT3014

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 l/s

8
continued

Gradient	Pipe diameters in mm: 50	75	80	100	125	150	175	200	225	250	275	300
0.02000 1/ 50	0.580 1.138	0.772 3.410	0.807 4.058	0.942 7.396	1.096 13.456	1.240 21.914	1.375 33.073	1.503 47.214	1.625 64.603	1.742 85.494	1.854 110.130	1.963 138.743
0.02200 1/ 45	0.608 1.195	0.810 3.578	0.847 4.257	0.988 7.759	1.150 14.116	1.301 22.989	1.442 34.695	1.577 49.528	1.704 67.768	1.827 89.682	1.945 115.523	2.059 145.536
0.02400 1/ 42	0.636 1.248	0.846 3.738	0.885 4.448	1.032 8.106	1.202 14.747	1.359 24.016	1.507 36.244	1.647 51.738	1.780 70.792	1.908 93.682	2.032 120.675	2.151 152.026
0.02600 1/ 38	0.662 1.300	0.881 3.892	0.921 4.631	1.075 8.439	1.251 15.352	1.415 25.001	1.569 37.730	1.714 53.859	1.853 73.693	1.987 97.520	2.115 125.618	2.239 158.251
0.02800 1/ 36	0.687 1.349	0.914 4.040	0.956 4.807	1.115 8.760	1.298 15.934	1.468 25.949	1.628 39.159	1.779 55.899	1.924 76.483	2.062 101.212	2.195 130.373	2.324 164.241
0.03000 1/ 33	0.711 1.397	0.947 4.182	0.990 4.977	1.155 9.069	1.344 16.496	1.520 26.863	1.685 40.539	1.842 57.868	1.991 79.176	2.134 104.775	2.272 134.961	2.405 170.021
0.03200 1/ 31	0.735 1.443	0.978 4.320	1.023 5.141	1.193 9.368	1.389 17.040	1.570 27.748	1.741 41.873	1.903 59.772	2.057 81.781	2.205 108.221	2.347 139.399	2.484 175.611
0.03400 1/ 29	0.758 1.488	1.008 4.454	1.054 5.300	1.230 9.657	1.431 17.566	1.619 28.605	1.795 43.166	1.961 61.617	2.120 84.305	2.273 111.561	2.419 143.701	2.561 181.029
0.03600 1/ 28	0.780 1.531	1.038 4.584	1.085 5.455	1.265 9.939	1.473 18.078	1.666 29.437	1.847 44.422	2.018 63.409	2.182 86.756	2.339 114.804	2.490 147.877	2.635 186.289
0.03800 1/ 26	0.801 1.574	1.066 4.710	1.115 5.605	1.300 10.212	1.514 18.575	1.712 30.247	1.898 45.643	2.074 65.152	2.242 89.140	2.403 117.958	2.558 151.939	2.708 191.406
0.04000 1/ 25	0.822 1.615	1.094 4.833	1.144 5.751	1.334 10.479	1.553 19.059	1.756 31.035	1.947 46.832	2.128 66.849	2.300 91.462	2.466 121.030	2.625 155.895	2.778 196.389
0.04200 1/ 24	0.843 1.655	1.121 4.953	1.173 5.894	1.367 10.739	1.592 19.532	1.800 31.805	1.995 47.993	2.181 68.505	2.357 93.726	2.527 124.026	2.690 159.754	2.847 201.250
0.04400 1/ 23	0.863 1.694	1.148 5.071	1.200 6.033	1.400 10.993	1.629 19.993	1.842 32.555	2.042 49.125	2.232 70.121	2.413 95.938	2.586 126.951	2.753 163.522	2.914 205.996
0.04600 1/ 22	0.882 1.733	1.174 5.185	1.227 6.170	1.431 11.241	1.666 20.444	1.884 33.290	2.088 50.233	2.282 71.701	2.467 98.099	2.644 129.811	2.815 167.205	2.980 210.635
0.04800 1/ 21	0.901 1.770	1.199 5.297	1.254 6.303	1.462 11.484	1.702 20.886	1.924 34.008	2.133 51.316	2.332 73.247	2.520 100.214	2.701 132.610	2.876 170.809	3.044 215.174
0.05000 1/ 20	0.920 1.807	1.224 5.407	1.280 6.434	1.492 11.721	1.737 21.318	1.964 34.711	2.178 52.377	2.380 74.762	2.573 102.286	2.757 135.350	2.935 174.339	3.107 219.620
0.05500 1/ 18	0.965 1.896	1.284 5.672	1.343 6.749	1.566 12.296	1.822 22.362	2.060 36.411	2.284 54.941	2.496 78.420	2.698 107.290	2.892 141.971	3.079 182.866	3.259 230.361
0.06000 1/ 17	1.009 1.980	1.341 5.926	1.403 7.050	1.635 12.845	1.904 23.360	2.152 38.034	2.386 57.390	2.607 81.916	2.819 112.071	3.021 148.297	3.216 191.013	3.404 240.623
0.06500 1/ 15	1.050 2.062	1.396 6.169	1.460 7.340	1.702 13.371	1.981 24.316	2.240 39.592	2.484 59.740	2.714 85.268	2.934 116.657	3.145 154.365	3.347 198.827	3.543 250.466
0.07000 1/ 14	1.090 2.140	1.449 6.402	1.516 7.618	1.767 13.877	2.057 25.237	2.325 41.090	2.578 62.000	2.817 88.494	3.045 121.070	3.264 160.203	3.474 206.346	3.677 259.937
0.07500 1/ 13	1.128 2.216	1.500 6.628	1.569 7.886	1.829 14.366	2.129 26.126	2.407 42.536	2.668 64.182	2.916 91.607	3.152 125.328	3.378 165.836	3.596 213.601	3.807 269.075
0.08000 1/ 13	1.166 2.289	1.550 6.846	1.621 8.146	1.889 14.839	2.199 26.985	2.486 43.935	2.756 66.291	3.012 94.617	3.256 129.446	3.489 171.285	3.714 220.618	3.932 277.914
0.08500 1/ 12	1.202 2.359	1.598 7.058	1.671 8.397	1.948 15.297	2.267 27.818	2.563 45.290	2.841 68.336	3.105 97.535	3.356 133.437	3.597 176.565	3.829 227.419	4.053 286.480
0.09000 1/ 11	1.237 2.428	1.644 7.263	1.719 8.642	2.004 15.742	2.333 28.626	2.637 46.606	2.924 70.321	3.195 100.368	3.453 137.313	3.701 181.693	3.940 234.023	4.171 294.798
0.09500 1/ 11	1.271 2.495	1.689 7.463	1.767 8.879	2.059 16.175	2.397 29.413	2.710 47.887	3.004 72.252	3.283 103.124	3.548 141.082	3.803 186.680	4.048 240.446	4.285 302.888
0.10000 1/ 10	1.304 2.560	1.733 7.658	1.813 9.111	2.113 16.596	2.459 30.179	2.780 49.133	3.082 74.133	3.368 105.808	3.641 144.754	3.902 191.537	4.154 246.701	4.396 310.768
	Coefficient for part-full pipes:											
	20	35	35	45	50	70	80	90	100	110	120	130

ks = 1·500mm i < 0·1

School of the Built Environment & Engineering – RAK Campus
BSc (Hons) Civil Engineering
Semester Two Examination 2010/2011
Hydraulics
Module No. BLT3014

<table>
<tr><th>y (m)</th><th>A (m^2)</th><th>P (m)</th><th>R (m)</th><th>c^2 (m/s^2)</th><th>V (m/s)</th><th>$v^2/2g$ (m)</th><th>E (m)</th><th>v^2/c^2R</th><th>$(v^2/c^2R)_m$</th><th>$(s_o - v^2/c^2R)_m$</th><th>ΔE (m)</th><th>Δx (m)</th><th>Σx</th></tr>
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Table Q3. **To be handed in with answer book** **Candidates ID...**

School of the Built Environment & Engineering – RAK Campus
BSc (Hons) Civil Engineering
Semester Two Examination 2010/2011
Hydraulics
Module No. BLT3014

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

Table Q4. **To be handed in with answer book** **Candidates ID..**