UNIVERSITY OF GREATER MANCHESTER

OFF CAMPUS DIVISION

WESTERN INTERNATIONAL COLLEGE, RAS AL KHAIMAH

BENG (HONS) CIVIL ENGINEERING

SEMESTER ONE RESIT EXAMINATION 2025/26

APPLIED WATER ENGINEERING

MODULE NO: CIE6022

Date: Saturday, 24th January 2026 **Time: 10:00am – 1:00pm**

INSTRUCTIONS TO CANDIDATES:

This is an open book examination. You are allowed to bring one A4 sheet, written on both sides.

There are FIVE (5) questions on this paper.

Answer any FOUR (4) 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 the question paper.
All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

QUESTION 1

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

(8 marks)

b) A long rectangular earthen channel 12 m wide has a uniform flow depth of 2.5 m when the flow rate is 36 m^3 /s. The channel has a weir located at the downstream end which causes the depth of flow just upstream of the weir to rise to 3.0 m.

(i) Explain the classification system used for free surface profiles in open channel flow.

(8 marks)

(ii) Identify the profile which exist upstream of the weir in the above scenario. Use suitable sketches.

(9 marks)

[TOTAL 25 MARKS]

QUESTION 2

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

(i) Activated Sludge Process

(4 marks)

(ii) Grit Separation Unit

(4 marks)

Question 2 continued over the page

Question 2 continued

b) A sewage treatment plant receives sewage from a combined sewerage system. Sketch a flow chart identifying the sequence of sewage treatment processes used in this scenario, if it rains frequently throughout the year.

(11 marks)

c) Compile the factors influencing the impact of the effluent on the quality of the receiving water as per EA directives.

(6 marks)

[TOTAL 25 MARKS]

QUESTION 3

a) A stilling pond overflow (CSO) chamber, breadth 3.6 m, serves a population of 12500 and receives a peak storm flow of 2.5 m^3/s. A 270 mm diameter orifice is used to control the flow passing to the downstream sewer which is 500 mm in diameter, has a Ks value of 1.5 mm and is laid at a gradient of 1 in 250. The overflow weir crest height above the centre of the orifice is 2.2 m. 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 under the supplementary information.

Assume **G = 240 l/h/d, I = 40 l/h/d, E = 1,27,000 l/d**

(15 marks)

b) Outline the functions of storm sewage overflow and briefly discuss Constituent parts of a CSO

(10 marks)

[TOTAL 25 MARKS]

Please turn the Page

QUESTION 4

The aquifer supplying water to the town of Hogwarts is rapidly nearing the end of its useful life and it is proposed to obtain a new supply from the river Dribble which is 1.8 km distant. A screened side intake weir structure is to be built into the bank of the river at a level that will necessitate the construction of a ponding weir to ensure adequate water levels for supply.

Design Requirements

(i) Determine the maximum and minimum flows in the river and the abstraction rate Q required.

(10 marks)

(ii) Compute the crest level of the ponding weir to give the required flow Q in minimum river flow conditions and calculate the flow over both weirs in maximum river flow conditions.

(15 marks)

<u>Design Information</u>

River at the point of abstraction

Bed level 421.5m AOD
Breadth 17m
Bed slope 1 in 700
Maximum recorded depth 4.90m
Minimum recorded depth 2.10m
Manning coefficient 0.060

Intake Weir

Intake weir breadth 2.5m
Intake weir level 424.5m AOD
Base level 422.5m AOD
Ponding weir Bank level 427.0m AOD
C_D (screen) 0.9

Population 150,000
Water Consumption 160 litres/head/day
$Q = C_d 1.7\, BH^{3/2}$

[TOTAL 25 MARKS]

Please turn the page

QUESTION 5

a) With the aid of sketches, describe and annotate the Momentum graph and how it can be used to explain conjugate depths. Illustrate your answer by specifying the saline features of the M-y curve.

(7 marks)

b) A stilling basin, utilising a hydraulic jump to dissipate energy, is to be designed for a dam spillway of width 10 m. The maximum flood flow over the spillway is to be 54 m^3/sec and the spillway can be assumed to have a Manning 'n' value of 0.016. Choose what you consider to be an appropriate 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)

c) Illustrate the critical tractive force theory using an appropriate diagram and explain its significance on the stability of unlined channels.

(6 marks)

[Total 25 Marks]

END OF QUESTIONS

PLEASE TURN THE PAGE FOR SUPPLEMENTARY INFORMATION

Formulae sheet

$$h_f = S_0 \times L$$

$$Qw = 1.7\, B H_w^{3/2}$$

$$y_2 = \frac{y_1}{2}\sqrt{\left(1 + 8{F_{r1}}^2\right)} - 1$$

$$Q = AV$$

$$Q = \frac{A}{n}.R^{\frac{2}{3}}.{S_0}^{\frac{1}{2}}$$

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

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

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

$$v_c = \sqrt{gy_c} \quad ; \quad F_r = \frac{v}{\sqrt{gy}}$$

$$DWF = P.G + P.I + E$$

$$\underline{Formula\ A: Q = DWF + 1360.P + 2E}$$

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

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

$$Ho = 1.2\, D_i + r$$

HRS Tables provided over the page

HRS Tables

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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 m³/s

Gradient	Pipe diameters in mm: 350	375	400	450	500	525	600	675	700	750	800	825
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

HRS Tables continued over the page

HRS Tables

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	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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