UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2012/2013

COURSE NAME	:	HYDRAULICS
COURSE CODE	:	BFC 21103
PROGRAMME	:	2 BFF
EXAMINATION DATE	:	DECEMBER 2012/JANUARY 2013
DURATION	:	3 HOURS
INSTRUCTIONS	:	ANSWER ONLY **FIVE (5)** QUESTIONS FROM SIX QUESTIONS

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

Q1 (a) Explain briefly:

i. Bottom slope
ii. Hydraulic radius
iii. Prismatic channel
iv. Wetted parameter
v. Supercritical flow
vi. Subcritical flow

(6 marks)

(b) Justify the difference between
(i) Prismatic and non-prismatic channels
(ii) Rigid and mobile boundary channels

(6 marks)

(c) A triangular channel of apex angle 100° carries a discharge of 10.43 m3/s. Calculate the critical depth.

(8 marks)

Q2 (a) Discuss the condition that needs the convenient method to determine the normal depth if the flow rate was found always changed inside the open channel.

(5 marks)

(b) Water flows uniformly inside a triangular channel having sides slope 1(V) : 2(H), Chezy's coefficient of 65.3 $m^{0.5}/s$ and channel slope of 0.00042. The discharge of the flow is 12.3 m^3/s. Determine the normal depth for the flow using graph method.

(10 marks)

(c) Based on Q2 (b) verify whether the flow condition is subcritical, critical or supercritical flow.

(5 marks)

Q3 (a) State **FIVE (5)** usage of hydraulic jump in engineering practice area.

(5 marks)

(b) Visualize with the aid of sketch diagram the types of hydraulic jump that might occur.

(5 marks)

(c) A hydraulic jump occurred inside a rectangular channel with the flow rate of 17 m^3/s. This jump was planned to dissipate the power of 833385 watt and ratio of the conjugate depths is 0.333. Calculate :-

(i) Height of the jump
(ii) Name type of the jump
(iii) Width of the channel.

(10 marks)

Q4 (a) The gradually varied flow in open channel needs a number of assumptions have to be made in order to derive the basic equation. Briefly explains three of those assumptions

(6 marks)

(b) A rectangular canal (Figure Q4) has a width of 2.6 m, Manning's coefficient of 0.011 and a bed slope of 1:500 is having a flow with a normal depth of 1.45 m. A weir is built at the downstream end which raises the water depth to 2.65 m behind the structure. Determine:

(i) The flow rate and the critical depth of the flow
(ii) The distance, L using the Direct Integration Method.
(iii) The type of flow profile

(14 marks)

Q5 (a) There are many hydraulic structure was built for certain purposes and spillway one of it. Briefly explain

i. The function of spillway
ii. Name two main types of spillway and explain of each type clearly

(6 marks)

(b) Energy dissipator structures are built at the toe of the spillways to decrease the energy and thus reduce the damages. Energy dissipator structures are component of hydraulic structure that converts super critical flow into sub critical flow. One weir is proposed to be built with $H_1 = 36$ m and $H_0 = 8$ m. The flow discharge for the weir is 90 m^3/s, which passes through a spillway with the width of 10 m. Design a stilling basin at the downstream of the spillway as shown in (figure 5) in order to dissipate energy and thus protects the structure of the spillway by involving the design of block A, B and C for a stilling basin type III. Determine

i. the width of the basin
ii. the height, width and space between block for block A, B, and C
iii. the number of block A and block B

(14 marks)

Q6 (a) Using the aid of sketches, explain the concept of series and parallel pump.

(6 marks)

(b) Similarity laws help us interpret the results of model studies, by determining the relation between model and prototype. Briefly explain the differences between model and prototype

(4 marks)

(c) A Francis turbine produces 8560 kW at 550 rpm under a net head of 36 m with an overall efficiency of 88%. By assuming the same turbine under a net head of 55 m under homologous conditions. Calculate:-

i. the revolution per-minute (rpm),
ii. discharge and
iii. brake power

(10 marks)

S1 (a) Terangkan dengan ringkas:-

i. Kecerunan dasar
ii. Jejari hidraulik
iii. Saluran prismatik
iv. Ukur lilit basah
v. Aliran genting lampau
vi. Aliran sub-genting

(6 markah)

(b) Jelaskan perbezaan di antara:

(i) Saluran prismatik dan saluran bukan prismatik
(ii) Saluran sempadan tetap dan saluran sempadan bergerak

(6 markah)

(c) Satu saluran berbentuk segitiga mempunyai sudut 100°, mempunyai kadar alir sebanyak 10.43 m3/s. Tentukan ukur dalam kritikal bagi saluran ini.

(8 markah)

S2 (a) Bincangkan keadaan yang memerlukan kaedah yang paling mudah untuk menentukan ukur dalam normal sekiranya kadar alir didapati sering berubah-ubah dalam saluran terbuka.

(5 markah)

(b) Air mengalir secara seragam dalam sebuah saluran segitiga dengan cerun tebing 1(V) : 2(H), pekali Chezy 65.3 $m^{0.5}/s$ dan cerun dasar saluran 0.00042. Kadar alir aliran air ini ialah 12.3 m^3/s. Tentukan ukur dalam normal aliran ini menggunakan kaedah graf.

(10 markah)

(c) Berdasarkan S2 (b) buktikan keadaan aliran sama ada alirannya subgenting, genting atau genting lampau.

(5 markah)

S3 (a) Nyatakan **lima (5)** kegunaan lompatan hidraulik dalam bidang praktik kejuruteraan.

(5 markah)

(b) Gambarkan dengan lakaran kasar jenis-jenis lompatan hidraulik yang mungkin berlaku.

(5 markah)

(c) Satu lompatan hidraulik berlaku dalam sebuah saluran segiempat tepat dengan kadar alir 17 m^3/s. Lompatan ini dirancang untuk melesapkan kuasa sebanyak 833385 watt dan nisbah ukur dalam jodohnya 0.333. Kirakan :-

(i) Tinggi lompatan
(ii) Namakan jenis lompatan yang terjadi
(iii) Lebar saluran ini.

(10 markah)

S4 (a) Untuk menerbitkan persamaan asas untuk aliran berubah secara beransur, beberapa andaian harus dibuat. Terangkan tiga daripada andaian-andaian tersebut.

(6 markah)

(b) Sebuah terusan mempunyai lebar 2.6m (rajah S4), dengan pekali Manning n = 0.011 dan kecerunan dasar 1:500 mengalirkan air pada ukurdalam normal 1.45 m. Sebuah empang dasar dibina pada satu titik untuk meninggikan ukurdalam aliran di hulu empangan kepada 2.65 m di belakang empang.
Tentukan;

i. Kadaralir per meter lebar dan kedalaman genting aliran
ii. Jarak, L dengan menggunakan Kaedah Kamiran Terus
iii. Jenis susuk aliran

(14 markah)

S5 (a) Terdapat banyak struktur hidraulik telah dibina untuk pelbagai kegunaan dan salah satunya adalah alur limpah. Terangkan dengan ringkas:-

i. Fungsi atau kegunaan alur limpah
ii. Dua jenis alur limpah dan jelaskan perbezaan diantara alur limpah yang dinyatakan

(6 markah)

(b) Struktur pelesapa tenaga selalu dibina dibahagian bawah alur limpah untk mengurangkan tenaga dan juga bagi mengurangkan kerosakan pada struktur. Pelesap tenaga adalah salah satu struktur hidraulik yang menukarkan aliran genting lampau kepada aliran sub-genting. Satu empang telah dicadangkan dibina bagi mengawal aliran yang mempunyai ketinggian $H_1 = 36$ m dan $H_0 = 8$. Saluran ini mempunyai kadar alir sebesar 90 m^3/s, yang melepasi empang yang mempunyai lebar dasar 10 m. Rekabentuk satu kolam takungan di hulu alur limpah seperti yang ditunjukkan dalam (rajah 5). Kolam ini dibina bertujuan untuk mengurangka/melesapkan tenaga dan juga untuk melindungi sturuktur alur limpah dengan pembinaan blok A, B, dan C jenis III. Tentukan

i. Panjang struktur kolam takungan
ii. Ketinggian, lebar dan jarak antara blok untuk blok A, B dan C
iii. Bilangan blok A dan blok B

(14 markah)

S6 (a) Dengan menggunakan lakaran yang sesuai, terangkan konsep pam sesiri dan pam selari

(6 markah)

(b) Konsep persamaan membantu dalam menterjemah keputusan dari model yang dijalankan. Konsep ini digunakan untuk menunjukkan perhubungan model dan prototaip. Terangkan dengan ringkas berbezaan antara model dan prototaip.

(4 markah)

(c) Turbin Francis menghasilkan tenaga sebesar 8560 kW pada 550 rpm dan tinggi turus 36 m dengan kecekapan keselurahan 88%. Dengan menganggapkan turbin dalam keadaan homolog dan mempunyai tinggi turus 55.1 Kirakan

i. putaran per-minit (rpm),
ii. kadar alir, dan
iii. kuasa brek

(10 markah)

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FIGURE/RAJAH

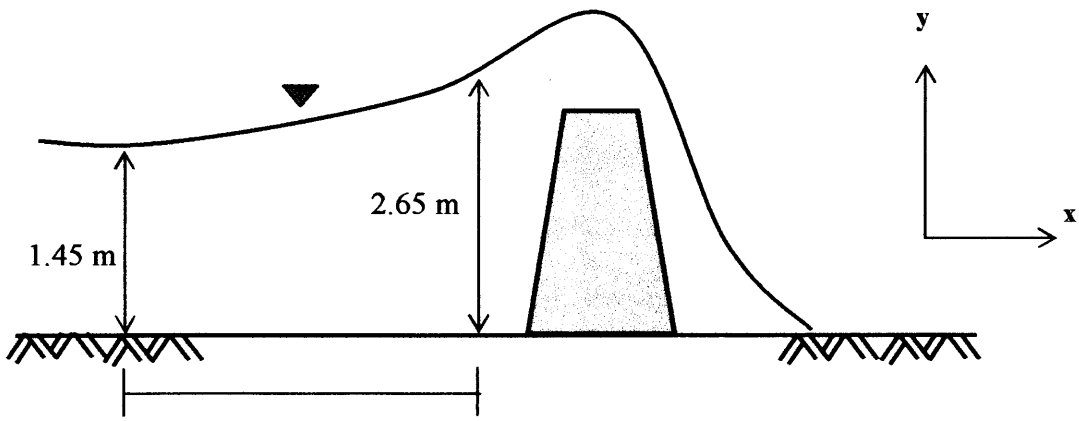
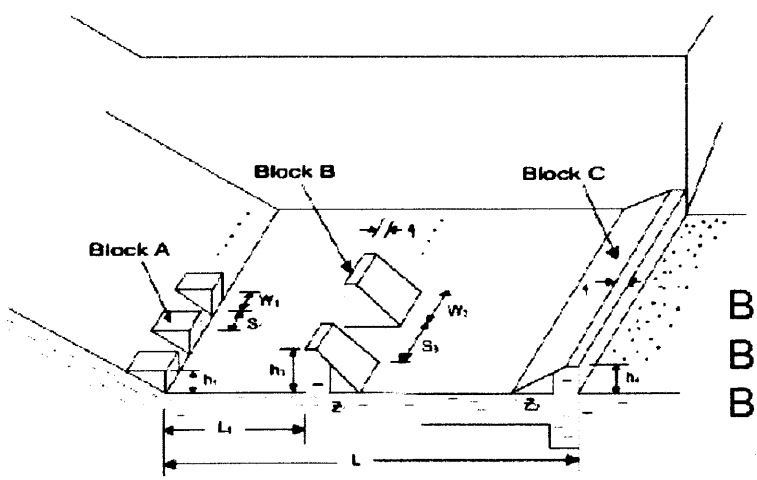


Figure Q4/Rajah S4



Block A are chute blocks
Block B are baffle piers
Block C are end sills

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Figure Q5/Rajah S5

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FIGURE/RAJAH

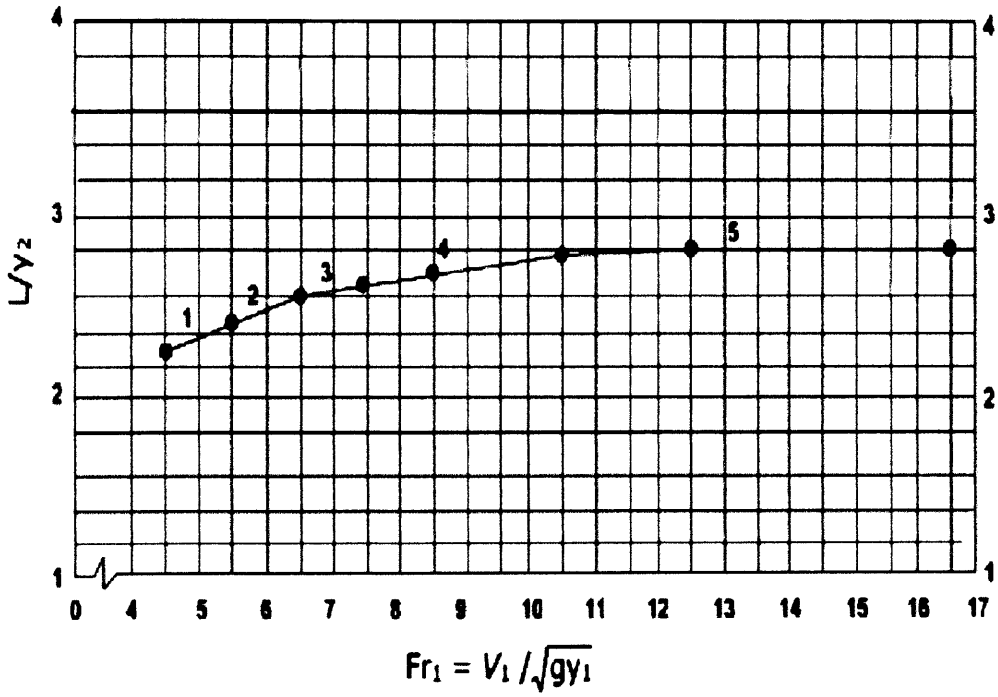

Chart Q5 L/y_2 vs Fr
Carta S5 L/y_2 vs Fr

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TABLE

Table to find F(u.N) and F(v.J) values

u \ N	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.02	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
0.04	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
0.06	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
0.08	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080	0.080
0.10	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
0.12	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
0.14	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140	0.140
0.16	0.161	0.161	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160
0.18	0.181	0.181	0.181	0.180	0.180	0.180	0.180	0.180	0.180	0.180
0.20	0.202	0.201	0.201	0.201	0.200	0.200	0.200	0.200	0.200	0.200
0.22	0.223	0.222	0.221	0.221	0.221	0.220	0.220	0.220	0.220	0.220
0.24	0.244	0.243	0.242	0.241	0.241	0.241	0.240	0.240	0.240	0.240
0.26	0.265	0.263	0.262	0.262	0.261	0.261	0.261	0.260	0.260	0.260
0.28	0.286	0.284	0.283	0.282	0.282	0.281	0.281	0.281	0.280	0.280
0.30	0.307	0.305	0.304	0.303	0.302	0.302	0.301	0.301	0.301	0.300
0.32	0.329	0.326	0.325	0.324	0.323	0.322	0.322	0.321	0.321	0.321
0.34	0.351	0.348	0.346	0.344	0.343	0.343	0.342	0.342	0.341	0.341
0.36	0.372	0.369	0.367	0.366	0.364	0.363	0.363	0.362	0.362	0.361
0.38	0.395	0.392	0.389	0.387	0.385	0.384	0.383	0.383	0.382	0.382

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u \ N	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
0.40	0.418	0.414	0.411	0.408	0.407	0.405	0.404	0.403	0.403	0.402
0.42	0.442	0.437	0.433	0.430	0.428	0.426	0.425	0.424	0.423	0.423
0.44	0.465	0.460	0.456	0.452	0.450	0.448	0.446	0.445	0.444	0.443
0.46	0.480	0.483	0.479	0.475	0.472	0.470	0.468	0.466	0.465	0.464
0.48	0.514	0.507	0.502	0.497	0.494	0.492	0.489	0.488	0.486	0.485
0.50	0.539	0.531	0.525	0.521	0.517	0.514	0.511	0.509	0.508	0.506
0.52	0.565	0.557	0.550	0.544	0.540	0.536	0.534	0.531	0.529	0.528
0.54	0.592	0.582	0.574	0.568	0.563	0.559	0.556	0.554	0.551	0.550
0.56	0.619	0.608	0.599	0.593	0.587	0.583	0.579	0.576	0.574	0.572
0.58	0.648	0.635	0.626	0.618	0.612	0.607	0.603	0.599	0.596	0.594
0.60	0.676	0.663	0.653	0.644	0.637	0.631	0.627	0.623	0.620	0.617
0.61	0.691	0.678	0.667	0.657	0.650	0.644	0.639	0.635	0.631	0.628
0.62	0.706	0.692	0.680	0.671	0.663	0.657	0.651	0.647	0.643	0.640
0.63	0.722	0.707	0.694	0.684	0.676	0.669	0.664	0.659	0.655	0.652
0.64	0.738	0.722	0.709	0.698	0.690	0.683	0.677	0.672	0.667	0.664
0.65	0.754	0.737	0.724	0.712	0.703	0.696	0.689	0.684	0.680	0.676
0.66	0.771	0.753	0.738	0.727	0.717	0.709	0.703	0.697	0.692	0.688
0.67	0.787	0.769	0.754	0.742	0.731	0.723	0.716	0.710	0.705	0.701
0.68	0.804	0.785	0.769	0.757	0.746	0.737	0.729	0.723	0.718	0.713
0.69	0.822	0.804	0.785	0.772	0.761	0.751	0.743	0.737	0.731	0.726
0.70	0.840	0.819	0.802	0.787	0.776	0.766	0.757	0.750	0.744	0.739
0.71	0.858	0.836	0.819	0.804	0.791	0.781	0.772	0.764	0.758	0.752
0.72	0.878	0.855	0.836	0.820	0.807	0.796	0.786	0.779	0.772	0.766
0.73	0.898	0.874	0.854	0.837	0.823	0.811	0.802	0.793	0.786	0.780
0.74	0.918	0.892	0.868	0.854	0.840	0.827	0.817	0.808	0.800	0.794
0.75	0.940	0.913	0.890	0.872	0.857	0.844	0.833	0.823	0.815	0.808
0.76	0.961	0.933	0.909	0.890	0.874	0.861	0.849	0.839	0.830	0.823
0.77	0.985	0.954	0.930	0.909	0.892	0.878	0.866	0.855	0.846	0.838
0.78	1.007	0.976	0.950	0.929	0.911	0.896	0.883	0.872	0.862	0.854
0.79	1.031	0.998	0.971	0.940	0.930	0.914	0.901	0.889	0.879	0.870
0.80	1.056	1.022	0.994	0.970	0.950	0.934	0.919	0.907	0.896	0.887
0.81	1.083	1.046	1.017	0.992	0.971	0.954	0.938	0.925	0.914	0.904
0.82	1.110	1.072	1.041	1.015	0.993	0.974	0.958	0.945	0.932	0.922
0.83	1.139	1.099	1.067	1.039	1.016	0.996	0.979	0.965	0.952	0.940
0.84	1.171	1.129	1.094	1.064	1.040	1.019	1.001	0.985	0.972	0.960
0.85	1.201	1.157	1.121	1.091	1.065	1.043	1.024	1.007	0.993	0.980
0.86	1.238	1.192	1.153	1.119	1.092	1.068	1.048	1.031	1.015	1.002
0.87	1.272	1.223	1.182	1.149	1.120	1.095	1.074	1.055	1.039	1.025
0.88	1.314	1.262	1.228	1.181	1.151	1.124	1.101	1.081	1.064	1.049
0.89	1.357	1.302	1.255	1.216	1.183	1.155	1.131	1.110	1.091	1.075

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n \ N	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
0.90	1.401	1.343	1.294	1.253	1.218	1.189	1.163	1.140	1.120	1.103
0.91	1.452	1.389	1.338	1.294	1.257	1.225	1.197	1.173	1.152	1.133
0.92	1.505	1.438	1.351	1.340	1.300	1.266	1.236	1.210	1.187	1.166
0.93	1.564	1.493	1.435	1.391	1.348	1.311	1.279	1.251	1.226	1.204
0.94	1.645	1.568	1.504	1.449	1.403	1.363	1.328	1.297	1.270	1.246
0.950	1.737	1.652	1.582	1.518	1.467	1.423	1.385	1.352	1.322	1.296
0.960	1.833	1.741	1.665	1.601	1.545	1.497	1.454	1.417	1.385	1.355
0.970	1.969	1.866	1.780	1.707	1.644	1.590	1.543	1.501	1.464	1.431
0.975	2.055	1.945	1.853	1.773	1.707	1.649	1.598	1.554	1.514	1.479
0.980	2.164	2.045	1.946	1.865	1.783	1.720	1.666	1.617	1.575	1.536
0.985	2.294	2.165	2.056	1.959	1.880	1.812	1.752	1.699	1.652	1.610
0.990	2.477	2.333	2.212	2.106	2.017	1.940	1.873	1.814	1.761	1.714
0.995	2.792	2.621	2.478	2.355	2.250	2.159	2.070	2.008	1.945	1.889
0.999	3.523	3.292	3.097	2.931	2.788	2.663	2.554	2.457	2.370	2.293
1.000	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
1.001	3.317	2.931	2.640	2.399	2.184	2.008	1.856	1.725	1.610	1.508
1.005	2.587	2.266	2.022	1.818	1.679	1.506	1.384	1.279	1.188	1.107
1.010	2.273	1.977	1.757	1.572	1.419	1.291	1.182	1.089	1.007	0.936
1.015	2.090	1.807	1.602	1.428	1.286	1.166	1.065	0.978	0.902	0.836
1.020	1.961	1.711	1.493	1.327	1.191	1.078	0.982	0.900	0.828	0.766
1.03	1.779	1.531	1.340	1.186	1.060	0.955	0.866	0.790	0.725	0.668
1.04	1.651	1.410	1.232	1.086	0.967	0.868	0.785	0.714	0.653	0.600
1.05	1.552	1.334	1.150	1.010	0.896	0.802	0.723	0.656	0.598	0.548
1.06	1.472	1.250	1.082	0.948	0.838	0.748	0.672	0.608	0.553	0.506
1.07	1.404	1.195	1.026	0.896	0.790	0.703	0.630	0.569	0.516	0.471
1.08	1.346	1.139	0.978	0.851	0.749	0.665	0.596	0.535	0.485	0.441
1.09	1.295	1.099	0.935	0.812	0.713	0.631	0.563	0.506	0.457	0.415
1.10	1.250	1.050	0.897	0.777	0.681	0.601	0.536	0.480	0.433	0.392
1.11	1.209	1.014	0.864	0.746	0.652	0.575	0.511	0.457	0.411	0.372
1.12	1.172	0.981	0.833	0.718	0.626	0.551	0.488	0.436	0.392	0.354
1.13	1.138	0.950	0.805	0.692	0.602	0.529	0.468	0.417	0.374	0.337
1.14	1.107	0.921	0.780	0.669	0.581	0.509	0.450	0.400	0.358	0.322
1.15	1.078	0.892	0.756	0.647	0.561	0.490	0.432	0.384	0.343	0.308
1.16	1.052	0.870	0.734	0.627	0.542	0.473	0.417	0.369	0.329	0.295
1.17	1.027	0.850	0.713	0.608	0.525	0.458	0.402	0.356	0.317	0.283
1.18	1.003	0.825	0.694	0.591	0.509	0.443	0.388	0.343	0.305	0.272
1.19	0.981	0.810	0.676	0.574	0.494	0.429	0.375	0.331	0.294	0.262
1.20	0.960	0.787	0.659	0.559	0.480	0.416	0.363	0.320	0.283	0.252
1.22	0.922	0.755	0.628	0.531	0.454	0.392	0.341	0.299	0.264	0.235
1.24	0.887	0.725	0.600	0.505	0.431	0.371	0.322	0.281	0.248	0.219

APPENDIX 1

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TABLE

m \ N	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
1.26	0.855	0.692	0.574	0.482	0.410	0.351	0.304	0.265	0.233	0.205
1.28	0.827	0.666	0.551	0.461	0.391	0.334	0.288	0.250	0.219	0.193
1.30	0.800	0.644	0.530	0.442	0.373	0.318	0.274	0.237	0.207	0.181
1.32	0.775	0.625	0.510	0.424	0.357	0.304	0.260	0.225	0.196	0.171
1.34	0.752	0.605	0.492	0.408	0.342	0.290	0.248	0.214	0.185	0.162
1.36	0.731	0.588	0.475	0.393	0.329	0.278	0.237	0.204	0.176	0.153
1.38	0.711	0.567	0.459	0.378	0.316	0.266	0.226	0.194	0.167	0.145
1.40	0.692	0.548	0.444	0.365	0.304	0.256	0.217	0.185	0.159	0.138
1.42	0.674	0.533	0.431	0.353	0.293	0.246	0.208	0.177	0.152	0.131
1.44	0.658	0.517	0.417	0.341	0.282	0.236	0.199	0.169	0.145	0.125
1.46	0.642	0.505	0.406	0.330	0.273	0.227	0.191	0.162	0.139	0.119
1.48	0.627	0.493	0.394	0.320	0.263	0.219	0.184	0.156	0.133	0.113
1.50	0.613	0.480	0.383	0.310	0.255	0.211	0.177	0.149	0.127	0.108
1.55	0.580	0.451	0.358	0.288	0.235	0.194	0.161	0.135	0.114	0.097
1.60	0.551	0.425	0.335	0.269	0.218	0.179	0.148	0.123	0.103	0.087
1.65	0.525	0.402	0.316	0.251	0.203	0.165	0.136	0.113	0.094	0.079
1.70	0.501	0.381	0.298	0.236	0.189	0.153	0.125	0.103	0.086	0.072
1.75	0.480	0.362	0.282	0.222	0.177	0.143	0.116	0.095	0.079	0.065
1.80	0.460	0.349	0.267	0.209	0.166	0.133	0.108	0.088	0.072	0.060
1.85	0.442	0.332	0.254	0.198	0.156	0.125	0.100	0.082	0.067	0.055
1.90	0.425	0.315	0.242	0.188	0.147	0.117	0.094	0.076	0.062	0.050
1.95	0.409	0.304	0.231	0.178	0.139	0.110	0.088	0.070	0.057	0.046
2.00	0.395	0.292	0.221	0.169	0.132	0.104	0.082	0.066	0.053	0.043
2.10	0.369	0.273	0.202	0.154	0.119	0.092	0.073	0.058	0.046	0.037
2.20	0.346	0.253	0.186	0.141	0.107	0.083	0.065	0.051	0.040	0.032
2.3	0.326	0.235	0.173	0.129	0.098	0.075	0.058	0.045	0.035	0.028
2.4	0.308	0.220	0.160	0.119	0.089	0.068	0.052	0.040	0.031	0.024
2.5	0.292	0.207	0.150	0.110	0.082	0.062	0.047	0.036	0.028	0.022
2.6	0.277	0.197	0.140	0.102	0.076	0.057	0.043	0.033	0.025	0.019
2.7	0.264	0.188	0.131	0.095	0.070	0.052	0.039	0.029	0.022	0.017
2.8	0.252	0.178	0.124	0.089	0.065	0.048	0.036	0.027	0.020	0.015
2.9	0.241	0.168	0.117	0.083	0.060	0.044	0.033	0.024	0.018	0.014
3.0	0.230	0.159	0.110	0.078	0.056	0.041	0.030	0.022	0.017	0.012
3.5	0.190	0.128	0.085	0.059	0.041	0.029	0.021	0.015	0.011	0.008
4.0	0.161	0.104	0.069	0.046	0.031	0.022	0.015	0.010	0.007	0.005
4.5	0.139	0.087	0.057	0.037	0.025	0.017	0.011	0.008	0.005	0.004
5.0	0.122	0.076	0.048	0.031	0.020	0.013	0.009	0.006	0.004	0.003
6.0	0.098	0.060	0.036	0.022	0.014	0.009	0.006	0.004	0.002	0.002
7.0	0.081	0.048	0.028	0.017	0.010	0.006	0.004	0.002	0.002	0.001
8.0	0.069	0.040	0.022	0.013	0.008	0.005	0.003	0.002	0.001	0.001
9.0	0.060	0.034	0.019	0.011	0.006	0.004	0.002	0.001	0.001	0.000
10.0	0.053	0.028	0.016	0.009	0.005	0.003	0.002	0.001	0.001	0.000
20.0	0.023	0.018	0.011	0.006	0.002	0.001	0.001	0.000	0.000	0.000

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EQUATIONS/PERSAMAAN

$$Fr = \frac{V}{\sqrt{gD}} \qquad J = \frac{N}{(N-M+1)} \qquad v = u^{\frac{N}{J}} \qquad u = \frac{y}{y_o}$$

$$L = x_2 - x_1 = \frac{y_o}{S_o}\left\{(u_2 - u_1) - (F(u_2,N) - F(u_1,N)) + \left(y_c/y_o\right)^M \left(J/N\right)[F(v_2,J) - F(v_1,J)]\right\}$$

$$Q = \frac{1}{n} A R^{2/3} \sqrt{S_o} \qquad \frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1 + 8Fr_1^{\,2}}\right] \qquad Fr_2^{\,2} = \frac{q^2}{g y_2^{\,3}}$$

$$\frac{y_1}{y_2} = \frac{1}{2}\left[-1 + \sqrt{1 + 8Fr_2^{\,2}}\right] \qquad Fr_1^{\,2} = \frac{q^2}{g y_1^{\,3}} \qquad E_L = \frac{(y_2 - y_1)^3}{4 y_1 y_2}$$

$$P_L = \rho g Q E_L \qquad q = Q/B \qquad y_1 = \frac{Q}{b v_1} \qquad H_u = \left(\frac{N}{\sqrt{H}}\right) \qquad Q_u = \left(\frac{Q}{H}\right)$$

$$J = \frac{N}{(N-M+1)} \qquad v_1 = \left(\frac{2g(H_1 - H_o)}{2}\right)^{\frac{1}{2}} \qquad P_u = \left(\frac{P}{H^{\frac{3}{2}}}\right)$$