Second Semester Examination
2017/2018 Academic Session

May/June 2018

EAH325 – Engineering Hydrology
(Hidrologi Kejuruteraan)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **FIFTEEN (15)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **LIMA BELAS (15)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper consists of **SIX (6)** questions. Answer **FIVE (5)** questions.

*[**Arahan** : Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

1. (a). In a catchment area, Station A was inoperative during a storm. Stations B, C and D, surrounding Station A were in operation during that storm and recorded 12.3, 14.8, and 11.9 cm of precipitation, respectively. Mean annual precipitations at the four stations A, B, C, and D are 1290, 1510, 1680, and 1375 mm, respectively. Estimate the missing precipitation of Station A.

Di satu kawasan tadahan air, Stesen A telah berhenti beroperasi semasa ribut. Stesen B, C, dan D yang berhampiran dengan Stesen A masih beroperasi semasa ribut tersebut dan telah masing-masing merekodkan 12.3, 14.8 dan 11.9 cm hujan. Purata hujan tahunan bagi keempat-empat stesen A, B, C, dan D adalah masing-masing 1290, 1510, 1680 dan 1375 mm. Anggarkan jumlah hujan yang hilang di Stesen A.

[4 marks/*markah*]

(b). Condensation of water vapour is mainly caused by adiabatic cooling of the moist air through lifting. With help of sketches, explain **THREE (3)** mechanisms of air lifting.

*Kondensasi wap air adalah disebabkan oleh penyejukan adiabatik udara yang lembab melalui angkatan. Dengan bantuan lakaran, terangkan **TIGA (3)** mekanisma angkatan udara.*

[6 marks/*markah*]

(c). In a catchment area, a landslide occurred somewhere near Station X in early 1985. **Table 1** shows the rainfall data for Station X and the average rainfall data from five neighboring stations. Based on the given data, check the consistency of the rainfall data at Station X and determine the corrected rainfall data.

Dalam satu kawasan tadahan hujan, satu tanah runtuh berlaku berdekatan Stesen X pada awal 1985. ***Jadual 1*** *menunjukkan data hujan bagi Stesen X dan purata hujan dari lima stesen berdekatan. Berdasarkan data yang diberikan, semak ketekalan data hujan bagi Stesen X dan tentukan data hujan dibetulkan.*

Table 1: **Rainfall data for Station X and average of five neighboring stations.**

Jadual 1: Data hujan bagi Stesen X dan purata lima stesen berhampiran.

Year/ *Tahun*	Station X / *Stesen X* (cm)	Average of Five Neighbouring Stations/ *Purata lima stesen berhampiran* (cm)
1994	17.1	14.2
1993	14.3	13.1
1992	17.5	14.7
1991	16	14.8
1990	19.1	16.2
1989	16.7	15.6
1988	19.4	15.1
1987	14.5	11.8
1986	16.1	12.9
1985	20	19.4
1984	13.9	15.7
1983	15.7	16.5
1982	14.1	15.6
1981	13	14.4
1980	10.1	11.2
1979	15.1	13.6
1978	14.2	16.4
1977	13.9	13.4
1976	13.1	14.3
1975	14	12.9

[10 marks/*markah*]

2. (a). At a meteorological station, air pressure is recorded as 100 kPa, air temperature as 20°C and the dew-point temperature as 16°C. Calculate the saturated and actual vapour pressure, relative humidity, and the specific humidity.

Di satu stesen meteorologi, tekanan udara direkodkan pada 100 kPa, suhu udara adalah 20°C dan suhu takat embun adalah 16°C. Kira tekanan wap tepu dan sebenar, kelembapan relatif dan kelembapan tentu.

[8 marks/*markah*]

(b). Evaporation recorded by pan differs from that of a lake due to several reasons. **Figure 1** shows a chart of monthly evaporation values in mm/d for a shallow lake, a deep lake and a Class A pan measured in the same region. Explain and match which data set (A, B or C) belongs to shallow lake, deep lake or evaporation pan.

Penyejatan yang direkodkan oleh pan adalah berbeza daripada tasik disebabkan oleh beberapa sebab. ***Rajah 1*** *menunjukkan carta bagi penyejatan bulanan dalam mm/hari bagi tasik cetek, tasik dalam dan pan Kelas A yang diukur dalam kawasan yang sama. Terangkan dan suaikan set data (A, B, atau C) dengan tasik cetek, tasik dalam atau pan penyejatan.*

[4 marks/ *markah*]

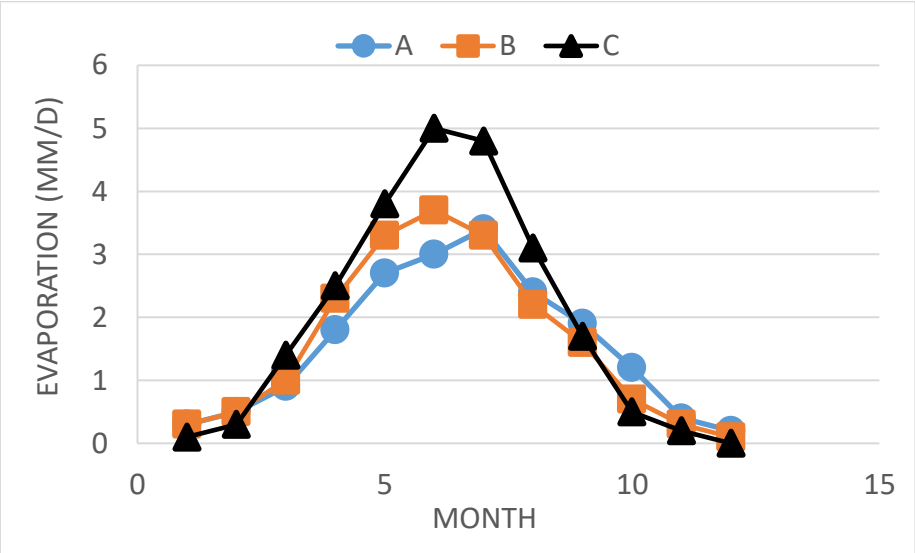

Figure 1: Evaporation level of deep lake, shallow lake and evaporation pan.

Rajah 1: Tahap penyejatan bagi tasik dalam, tasik cetek dan pan penyejatan

(c). Estimate the potential evapotranspiration (PET) of an area from January to March for rice crop. The area is at a latitude of 22°N with mean monthly temperature as shown in **Table 2.** You may apply Blanney-Criddle formula for the estimation.

Anggarkan keupayaan sejat transpirasi (PET) bagi satu kawasan bermula dari Januari ke Mac bagi tanaman padi. Kawasan tersebut berada pada latitud 22°N dengan purata suhu bulanan seperti dalam ***Jadual 2****. Anda boleh menggunakan formula Blanney-Criddle bagi anggaran tersebut.*

Table 2: Mean temperature of the area / ***Jadual 2: Purata suhu bagi kawasan tersebut.***

Month/*Bulan*	January	February	March
Mean Temperature/ *Purata Suhu (°C)*	12	16	24

[8 marks/*markah*]

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3. (a). With the aid of sketch diagram, discuss the following items:

Dengan bantuan gambarajah lakaran, bincangkan perkara dibawah:

(i). Cone of depression

Kon lekukan

(ii). Artesian aquifer and unconfined aquifer

Akuifer artes dan akuifer tak terkurung

[10 marks/*markah*]

(b). A 30 cm diameter well completely penetrates an unconfined aquifer of saturated depth of 40 m. After a long period of pumping at a steady rate of 1500 Lpm, the drawdown in the two observation wells 25 m and 75 m from the pumping well were found to be 3.5 m and 2.0 m respectively. Determine:

Sebuah telaga bergaris pusat 30 cm menembusi keseluruhan akuifer tak terkurung dengan kedalaman tepu 40 m. Selepas suatu jangka masa pengepaman yang panjang pada kadar 1500 Lpm, susutan aras di dalam dua telaga cerapan pada jarak 25 m dan 75 m dari telaga pam adalah masing- masing 3.5 m dan 2.0 m. Tentukan:

(i). The transmissivity of the aquifer

Kebolehpindahan akuifer

(ii). The drawdown at the pumping well

Susutan aras di telaga pengepaman

[10 marks/*markah*]

4. (a). Water level measurement is one of the most crucial factor in stream gauging. As a qualified engineer, point out factors to be considered while selecting site for water level measurement station. With the aid of sketch diagram, discuss suitable method for discharge measurement near hilly area.

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Cerapan aras air adalah salah satu faktor penting dalam pengukuran aliran. Sebagai seorang jurutera yang bertauliah, nyatakan faktor yang perlu dipertimbangkan bagi memilih tapak untuk stesen cerapan aras air. Dengan bantuan gambarajah lakaran, bincangkan kaedah yang bersesuaian bagi pengukuran aliran di kawasan berbukit.

[10 marks/*markah*]

(b). The data pertaining to a stream-gauging operation at a gauging site, R are given in **Table 3**. The rating equation of the current meter is v = 0.51 Ns + 0.03 m/s. Calculate the discharge in the stream R.

*Data yang berkaitan dengan operasi mengukur aliran di tapak pengukuran, R diberikan dalam **Jadual 3**. Persamaan penilaian bagi meter arus adalah v = 0.51 Ns + 0.03 m/s. Kirakan aliran di dalam sungai R.*

Table 3: Data collected at site R / ***Jadual 3: Data terkumpul bagi tapak R***

Distance from edge (m)	0	1.0	3.0	5.0	7.0	9.0	11.0	12.0
Depth (m)	0	1.1	2.0	2.5	2.0	1.7	1.0	0
Revolutions of a current meter kept at 0.6 depth	0	39	58	112	90	45	30	0
Duration of observation (s)	0	100	100	150	100	100	100	0

[10 marks/*markah*]

5. Widespread flood in Bandar Baharu has resulted into disruption to the daily activities and businesses of the city dweller. The plan for flood mitigation requires a unit hydrograph to estimate direct runoff volume generated from the design effective rainfall event for a particular average recurrence interval. The streamflow at the gauging station from Bandar Baharu river with catchment area 27,216 ha generated by 1 hr duration of constant rainfall provided by the Drainage and Irrigation Department is given in **Table 4**. Estimate the 1-hr UH and 2-hr UH using streamflow given in **Table 4**. Use the superposition method to determine 2-hr unit hydrograph. Use a constant base flow of 20 m^3/s in the computation.

Kejadian banjir yang berlaku di Bandar Baharu menyebabkan gangguan di dalam menjalankan aktiviti harian dan perniagaan kepada penduduk bandar tersebut. Perancangan tebatan banjir memerlukan kepada unit hidrograf untuk menganggarkan isipadu air larian terus yang dijanakan oleh peristiwa hujan rekabentuk dengan purata sela ulangan yang tertentu. Aliran sungai di stesen cerapan sungai Bandar Baharu dengan keluasan tadahan 27,216 ha yang dijanakan oleh hujan yang malar dengan tempoh 1 jam diperolehi dari Jabatan Pengairan dan Saliran diberikan dalam ***Jadual 4****. Anggarkan 1-jam UH dan 2-jam UH menggunakan data aliran sungai di dalam* ***Jadual 4****. Gunakan kaedah superposisi untuk menentukan 2-jam unit hidrograf. Gunakan aliran dasar yang malar 20 m^3/s di dalam pengiraan.*

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Table 4 Streamflow Hidrograf
Jadual 4 Hidrograf Aliran Sungai

Ordinate (hr) *Ordinat (j)*	Streamflow/ *Aliran Sungai* (m^3/s)
0	20
1	150
2	370
3	620
4	820
5	670
6	620
7	370
8	220
9	120
10	20

[20 marks/*markah*]

6. (a). Briefly describe factors which can affect the volume and peak flow of flood runoff.
Terangkan secara ringkas faktor yang boleh mempengaruhi isipadu dan puncak aliran banjir.

[4 marks/*markah*]

(b). Majlis Perbandaran Seberang Perai plans to construct a road in northern part of the region. The design of the platform of the road requires some analysis on the flood probability and magnitude. The mean and variance of the 80 years of annual streamflow recorded in the locality are 120 m^3/s and 30 m^6/s^2, respectively. Assuming the data is log-normally distributed, determine the following:

Majlis Perbandaran Seberang Perai merancang untuk membina jalan di bahagian Seberang Perai Utara. Rekabentuk pelantar jalan tersebut memerlukan analisis kebarangkalian dan magnitud banjir. Purata dan varians untuk 80 tahun rekod kadaralir tahunan adalah masing-masing, 120 m^3/s dan 30 m^6/s^2. Dengan anggapan data menunjukkan taburan log-normal, tentukan perkara berikut:

(i). the return period for a streamflow discharge ≥ 150 m^3/s

kala ulangan untuk kadaralir sungai ≥ 150 m^3/s

(ii). the magnitude of 50 year return period flood

magnitud kadaralir dengan 50 tahun kala ulangan

(iii). the magnitude of an average annual streamflow discharge with 200 year return period.

magnitud purata tahunan kadaralir sungai dengan 200 tahun kala ulangan.

[16 marks/*markah*]

APPENDIX/*LAMPIRAN*

Table A1: Monthly daytime hours percentages P_h (hours) in north latitude

North Lat.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	8.50	7.66	8.49	8.21	8.50	8.22	8.50	8.49	8.21	8.50	8.22	8.50
10	8.13	7.47	8.45	8.37	8.81	8.60	8.86	8.71	8.25	8.34	7.91	8.10
15	7.94	7.36	8.43	8.44	8.98	8.80	9.05	8.83	8.28	8.26	7.75	7.88
20	7.74	7.25	8.41	8.52	9.15	9.00	9.25	8.96	8.30	8.18	7.58	7.66
25	7.53	7.14	8.39	8.61	9.33	9.23	9.45	9.09	8.32	8.09	7.40	7.42
30	7.30	7.03	8.38	8.72	9.53	9.49	9.67	9.22	8.33	7.99	7.19	7.15
35	7.05	6.88	8.35	8.83	9.76	9.77	9.93	9.37	8.36	7.87	6.97	6.86
40	6.76	6.72	8.33	8.95	10.02	10.08	10.22	9.54	8.39	7.75	6.72	6.52

Table A2: Values of *K* for selected crops		
Crop.	Value of K	Range of monthly values
Rice	1.10	0.85-1.30
Wheat	0.65	0.50-0.75
Maize	0.65	0.50-0.80
Sugarcane	0.90	0.75-1.00
Cotton	0.65	0.50-0.90
Potatoes	0.70	0.65-0.75
Natural vegetation		
Very dense	1.30	
Dense	1.20	
Medium	1.00	
Light	0.80	

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Formulas:

$$e_w = 4.584 \exp\left(\frac{17.27t}{237.3+t}\right)$$

$$q_v = 0.622 \frac{e_a}{p} \qquad \frac{e_a}{e_w}$$

$$u_9 = u_h \left(\frac{h_1}{h}\right)^{1/7}$$

$$E_L = K_M (e_w - e_a)\left(1+\frac{u_9}{16}\right)$$

$$E_a = 0.35\left(1+\frac{u_2}{160}\right)(e_w - e_a)$$

$$P_x = \frac{N_x}{M}\left[\frac{P_1}{N_1}+\frac{P_2}{N_2}+...+..\frac{P_m}{N_m}\right]$$

$$P_x = \frac{1}{M}\left[P_1 + P_2 + ... + ... P_m\right]$$

$$\text{PET} = \frac{AH_n + E_a\gamma}{A+\gamma}$$

$$P_{r,n} = {}^n C_r P^r q^{n-r}$$

$$= \frac{n!}{(n-r)!r!} P^r q^{n-r}$$

$$F = \sum P_h \bar{T}_f / 100$$

$$E_T = 2.54\ K\ F$$

$$P_{cx} = P_x \frac{S_1}{S_2}$$

…14/

Normal Distribution Table

Normal Deviate z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-4.0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
-3.9	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
-3.8	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
-3.7	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
-3.6	.0002	.0002	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
-3.5	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002	.0002
-3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
-3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
-3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
-3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
-3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
-2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
-2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
-2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
-2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
-2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
-2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
-2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
-2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
-2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
-2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
-1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
-1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
-1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
-1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
-1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
-1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
-1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
-1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
-1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
-1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
-.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
-.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
-.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
-.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
-.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
-.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
-.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483

…15/-

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3365	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4938	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990
3.1	0.4990	0.4991	0.4991	0.4991	0.4992	0.4992	0.4992	0.4992	0.4993	0.4993
3.2	0.4993	0.4993	0.4994	0.4994	0.4994	0.4994	0.4994	0.4995	0.4995	0.4995
3.3	0.4995	0.4995	0.4995	0.4996	0.4996	0.4996	0.4996	0.4996	0.4996	0.4997
3.4	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4997	0.4998

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