UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

EAH 325/3 – 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 appendices 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 contains **SIX (6)** questions. Answer **FIVE (5)** questions.
[***Arahan*** *: Kertas ini mengandungi* ***ENAM (6)*** *soalan. Jawab* ***LIMA (5)*** *soalan.*

You may answer the question either in Bahasa Malaysia or English.
[*Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris*].

All questions **MUST BE** answered on a new page.
[*Semua soalan* ***MESTILAH*** *dijawab pada muka surat baru*].

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) Describe the characteristics of rainfall and the conditions for the formation of rainfall/precipitation.

[6 marks]

(b) Using the data given in Table 1, check the rainfall data at gauge A for consistency using the record at gauges W, X, Y and Z, which have consistent records. Gauge A was temporarily relocated in January 1983 and will be returned to its original location in January 1987. Adjust the record (at gauge A) for the period from 1983 to 1986 inclusive.

Table 1

Year	Annual Rainfall at Gauge (×10 cm)				
	W	X	Y	Z	A
1977	42	38	40	46	34
1978	54	48	54	58	48
1979	58	56	54	58	50
1980	50	46	46	52	44
1981	38	44	34	46	32
1982	42	40	36	44	40
1983	46	40	44	50	48
1984	34	32	36	40	40
1985	36	32	36	40	44
1986	44	38	40	50	50

[14 marks]

2. (a) Discuss three main factors which affect the infiltration process.

[6 marks]

(b) A catchment is covered with fair condition grass over 40% of the area and 60% residential (1/4-acre lots). Its 50% area is of soil group B and 50% area is of soil group C. In a rainstorm it receives 15 cm of total rainfall. Assume antecedent moisture condition number II. Determine the amount of infiltration.

[8 marks]

(c) Determine the phi-index (ϕ-index) for a rainfall hyetograph shown in Table 2 which generates direct runoff of 11.5 cm.

Table 2: Rainfall Hyetograph

Time (hr)	Intensity (cm/hr)
0 – 2	1.3
2 – 4	3.6
4 – 6	2.8

[6 marks]

3. (a) Discuss comparatively the following terms:-

(i) Confined and Unconfined Aquifer

(ii) Darcy's law and Dupuit's assumption

[5 marks]

(b) Two observation wells are 150 meters apart, with difference in water surface elevation being 1.75 meters. A tracer dye is injected into the well that has the higher water level, and a mean travel time of 6.25 days is measured. Find the hydraulic conductivity in m/day.

[5 marks]

(c) Using Penman's method, determine the daily PET for the following area:-

Bukit Kayu Hitam	: June
Latitude	: 10^0 N
Average temperature	: 20^0C
Crop cover	: Green Crops (r = 0.15)
Cloud cover, n/N	: 0.43
Wind speed	: 2.35 m/s
Relative humidity	: 82%
Stefan-Boltzman constant	: 2.01 x 10^{-9} mm/day
Constants	: b = 0.52
Psychrometric constant	: 0.49 mmHg/^{o}C

$$H_n = H_a(1-r)\left(a + b\frac{n}{N}\right) - \sigma T_a^4\left(0.56 - 0.092\sqrt{e_a}\right)\left(0.10 + 0.90\left(\frac{n}{N}\right)\right)$$

$$E_a = 0.35(e_w - e_a)(0.5 + 0.15U_2)$$

[10 marks]

4. (a) Describe four (4) methods for direct determination of streamflow discharge.

[6 marks]

(b) Describe three (3) methods for estimating the mean velocity along a vertical depth of a river using a current meter.

[4 marks]

(c) The data in Table 3 obtained in a streamflow gauging observation. A current meter with a calibration equation v = (0.32N + 0.032) m/s where, N is the revolution per second and v is the velocity, was used to measure the velocity at 0.6 depth. Using the mid-section method, calculate the discharge in the stream.

Table 3

Distance from right bank (m)	0	2	4	6	9	12	15	18	20	22	23	24
Depth (m)	0	0.50	1.10	1.95	2.25	1.85	1.75	1.65	1.50	1.25	0.75	0
Number of revolutions (N)	0	80	83	131	139	121	114	109	92	85	70	0
Time (s)	0	180	120	120	120	120	120	120	120	120	150	0

[10 marks]

5. (a) Describe the stream flow component.

[2 marks]

(b) Describe any three (3) methods for base flow separation.

[3 marks]

(c) Describe the principle of Superposition for determination of Direct Runoff Hydrograph (DRH).

[4 marks]

(d) The triangular 6-hr unit hydrograph (UH) of a catchment has a peak discharge of 100 m^3/s, time to peak 24 hr and time base 72 hr.

(i) Determine the area of the catchment represented by the unit hydrograph.

[3 marks]

(ii) Calculate the Direct Runoff Hydrograph (DRH) due to a rainfall excess of 2 cm during first 6 hr and 4 cm during the second 6 hr interval. The base flow is assumed 25 m^3/s constant throughout.

[8 marks]

6. (a) At a particular river gauging station, the base 10 logarithms of the annual peak flow series have a mean of 1.81, and a standard deviation of 0.78. The historical data are in m^3/s. It is desired to build a temporary bridge over this river so that the probability that the bridge will fail in any of the five (5) years is 0.1. Compute the design return period and magnitude of the design flood.

[8 marks]

(b) Hydrologic data at a certain catchment were recorded and frequency analysis of annual flood series at a river gauging station for the period 1950-2000 gave 100-year return period flood magnitude 500 m^3/s and 10-yr return period flood of 300 m^3/s. Analysis was performed assuming that the historical flood series follows Gumbel's distribution.

(i) Compute the mean annual flood and the variance of the annual flood series.

(ii) Determine the probability of having a flood equal to or greater than 550 m^3/s next year.

(iii) Estimate the magnitude of 50-year return period flood.

(iv) Determine the probability of the mean flood being equalled or exceeded during the next 3 years.

[12 marks]

$$X_T = \mu + K_T\sigma$$

$$K_T = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[\ln\left(\frac{T}{T-1}\right)\right]\right\}$$

1. (a) *Terangkan dengan ringkas ciri hujan dan keadaan untuk kejadian hujan.*

[6 markah]

(c) *Dengan mengunakan data yang diberikan dalam Jadual 1, semak konsistensi data hujan pada tolok A mengunakan data hujan tolok W, X, Y dan Z, yang mempunyai data hujan yang konsisten. Kedudukan Tolok A diubah pada Januari 1983 dan akan dikembalikan ke kedudukan asal pada Januari 1987. Laraskan rekod (pada tolok A) untuk tempoh dari 1983 sehingga 1986.*

Jadual 1

Tahun	*Hujan Tahunan Tolok (×10 cm)*				
	W	*X*	*Y*	*Z*	*A*
1977	*42*	*38*	*40*	*46*	*34*
1978	*54*	*48*	*54*	*58*	*48*
1979	*58*	*56*	*54*	*58*	*50*
1980	*50*	*46*	*46*	*52*	*44*
1981	*38*	*44*	*34*	*46*	*32*
1982	*42*	*40*	*36*	*44*	*40*
1983	*46*	*40*	*44*	*50*	*48*
1984	*34*	*32*	*36*	*40*	*40*
1985	*36*	*32*	*36*	*40*	*44*
1986	*44*	*38*	*40*	*50*	*50*

[14 markah]

2. (a) *Bincangkan dengan ringkas tiga faktor utama yang mempengaruhi proses penyusupan.*

[6 markah]

(b) *Suatu kawasan tadahan mempunyai keadaan litupan rumput sederhana 40% dari kawasan dan 60% kawasan perumahan. Seluas 50% dari kawasan terdiri dari jenis kumpulan tanah B dan 50% dari kawasan terdiri dari jenis kumpulan tanah C. Untuk suatu kejadian ribut kawasan tersebut menerima 15 cm jumlah hujan. Anggap keadaan lembapan lampau nombor II. Tentukan jumlah penyusupan yang dihasilkan oleh ribut tersebut.*

[8 markah]

(c) Tentukan indek phi-index (ϕ-index) untuk hyetograph hujan di dalam Jadual 2 yang menjanakan airlarian langsung sebanyak 11.5 cm.

Jadual 2 Hyetograf Hujan

Masa (jam)	*Keamatan (cm/jam)*
0 - 2	1.3
2 – 4	3.6
4 - 6	2.8

[6 markah]

3. (a) Terangkan dan bandingkan perkara berikut:-

(i) Akuifer terkurung dan tak terkurung

(ii) Hukum Darcy dan Anggapan Dupuit

[5 markah]

(b) Jarak dua telaga pemerhatian adalah 150 meter dengan perbezaan aras air 1.75 meters. Surihan pewarna disuntik kedalam satu telaga yang mempunyai aras air yang lebih tinggi, dan sukatan masa kembara purata adalah 6.25 hari. Tentukan konduktiviti hidraulik dalam m/hari.

[5 markah]

(c) *Dengan mengunakan kaedah Penman, tentukan PET harian bagi kawasan berikut:*

Bukit Kayu Hitam	*: June*
Latitut	*: 10^0 N*
Suhu purata	*: 20^0C*
Litupan tumbuhan	*: Green Crops (r = 0.15)*
Linkungan Awan, n/N	*: 0.43*
Kelajuan angin, U_2	*: 2.35 m/s*
Kelembapan Relatif	*: 82%*
Angkatap Stefan-Boltzman	*: 2.01 x 10^{-9} mm/day*
Angkatap	*: b = 0.52*
Angkatap Psychrometric	*: 0.49 mmHg/^{o}C*

$$H_n = H_a(1-r)\left(a + b\frac{n}{N}\right) - \sigma T_a^4\left(0.56 - 0.092\sqrt{e_a}\right)\left(0.10 + 0.90\left(\frac{n}{N}\right)\right)$$

$$E_a = 0.35(e_w - e_a)(0.5 + 0.15U_2)$$

[10 markah]

4. (a) *Terangkan dengan ringkas empat (4) kaedah untuk pengukuran lansung aliran sungai.*

[5 markah]

(b) *Terangkan tiga (3) kaedah untuk anggaran purata halaju aliran di sepanjang kedalaman pugak untuk suatu sungai menggunakan jangka arus.*

[5 markah]

(c) *Data cerapan pengukuran aliran sungai diberikan dalam Jadual 3. Jangka arus dengan persamaan tentukur v = (0.32N + 0.032) m/s di mana N adalah revolusi per saat dan v adalah halaju, yang digunakan untuk mengukur kelajuan pada kedalaman 0.6. Dengan menggunakan kaedah pertengahan bahagian, hitung kadaralir di sungai tersebut.*

Jadual 3

Jarak dari Tebing (m)	*0*	*2*	*4*	*6*	*9*	*12*	*15*	*18*	*20*	*22*	*23*	*24*
Kedalaman (m)	*0*	*0.50*	*1.10*	*1.95*	*2.25*	*1.85*	*1.75*	*1.65*	*1.50*	*1.25*	*0.75*	*0*
Jumlah Revolusi (N)	*0*	*80*	*83*	*131*	*139*	*121*	*114*	*109*	*92*	*85*	*70*	*0*
Masa (detik)	*0*	*180*	*120*	*120*	*120*	*120*	*120*	*120*	*120*	*120*	*150*	*0*

[10 markah]

5. *(a) Terangkan dengan ringkas komponen aliran sungai.*

[2 markah]

(b) Terangkan dengan ringkas tiga (3) kaedah pemisahan aliran dasar.

[3 markah]

(c) Terangkan prinsip superposisi untuk hitungan hidrograf airlarian langsung.

[4 markah]

(d) 6-jam unit hidrograf dari suatu tadahan adalah dalam bentuk segitiga dengan puncak 100 m^3/s, masa ke puncak 24 jam dan masa dasar 72 jam.

(i) Tentukan luas tadahan untuk unit hidrograf tersebut.

[3 markah]

(ii) Hitung hidrograf aliran lansung yang dijanakan oleh hujan efektif 2 cm selama 6 jam pertama dan 4 cm selama 6 jam kedua. Aliran dasar diandaikan 25 m^3/s malar secara berterusan.

[8 markah]

6. *(a)* *Pada stesen pengukur sungai tertentu, menggunakan logaritma bes 10 daripada siri aliran puncak tahunan menghasilkan purata 1.81 dan sisihan piawai 0.78. Data lampau yang digunakan adalah dalam unit m^3/s. Hal ini dikehendaki untuk membina jambatan sementara diatas sungai dengan kebarangkalian bahawa jambatan akan gagal dalam salah satu daripada lima (5) tahun adalah 0.1. Hitung rekabentuk kala kembali dan magnitud rekabentuk banjir.*

[8 markah]

(b) *Data hidrologik pada suatu tadahan tertentu dicatat dan analisis frekuensi urutan banjir tahunan pada suatu stesen pengukur sungai untuk tempoh 1950-2000 menghasilkan 100-tahun kala kembali dengan magnitud banjir 500 m^3/s dan 10-tahun kala kembali dengan magnitud banjir 300 m^3/s. Analisis dilakukan dengan anggapan bahawa sejarah urutan banjir mengikuti taburan Gumbel.*

(i) *Tentukan purata Banjir tahunan dan sisihan piawai urutan banjir tahunan.*

(ii) *Tentukan kebarangkalian berlaku banjir sama atau lebih besar dari 550 m^3/s tahun hadapan.*

(iii) *Hitung magnitud banjir dengan 50-tahun kala kembali.*

(iv) *Tentukan kebarangkalian purata banjir akan sama atau melebihi, sepanjang 3 tahun hadapan.*

[12 markah]

$$X_T = \mu + K_T\sigma$$

$$K_T = -\frac{\sqrt{6}}{\pi}\left\{0.5772 + \ln\left[\ln\left(\frac{T}{T-1}\right)\right]\right\}$$

Appendix 1

Lampiran 1

Table 1: Saturation vapor pressure of water		
Temperature (^{o}C)	Saturation vapor pressure e_w (mm of Hg)	A (mm/^{o}C)
0	4.58	0.30
5.0	6.54	0.45
7.5	7.78	0.54
10.0	9.21	0.60
12.5	10.87	0.71
15.0	12.79	0.80
17.5	15.00	0.95
20.0	17.54	1.05
22.5	20.44	1.24
25.0	23.76	1.40
27.5	27.54	1.61
30.0	31.82	1.85
32.5	36.68	2.07
35.0	42.81	2.35
37.5	48.36	2.62
40.0	55.32	2.95
45.0	71.20	3.66

Appendix 2

Lampiran 2

Table 2: Mean monthly solar radiation at top of atmosphere, H_a (in mm of evaporated water/day)

North Lat.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
10	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
20	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
30	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.9
40	6.0	8.3	11.0	13.9	15.9	16.7	16.3	14.8	12.2	9.3	6.7	5.4
50	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3.0

Appendix 3

Lampiran 3

Soil Conservation Service Runoff Curve Numbers (Urban Areas)

Cover description		Curve numbers for hydrologic soil group –			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved: open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

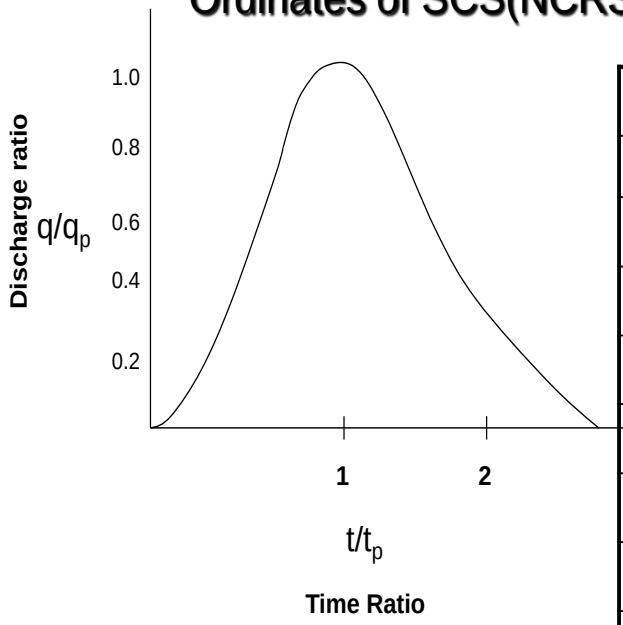
[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's ae assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Appendix 4

Lampiran 4

NRCS Synthetic Unit Hydrograph
Ordinates of SCS(NCRS) dimensionless UH

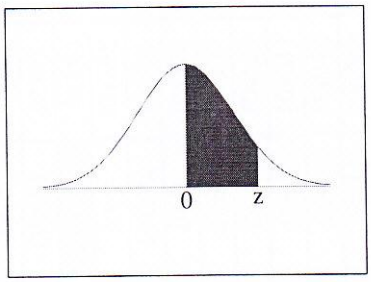


t/t_p	q/q_p	t/t_p	q/q_p	t/t_p	q/q_p
0	0	1.1	0.98	2.8	0.98
0.1	0.015	1.2	0.92	3.0	0.075
0.2	0.075	1.3	0.84	3.5	0.036
0.3	0.16	1.4	0.75	4.0	0.018
0.4	0.28	1.5	0.66	4.5	0.009
0.5	0.43	1.6	0.56	5.0	0.004
0.6	0.60	1.8	0.42		
0.7	0.77	2.0	0.32		
0.8	0.89	2.2	0.24		
0.9	0.97	2.4	0.18		
1.0	1.00	2.6	0.13		

Appendix 5

Lampiran 5

Standard Normal Distribution Table



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990
3.1	.4990	.4991	.4991	.4991	.4992	.4992	.4992	.4992	.4993	.4993
3.2	.4993	.4993	.4994	.4994	.4994	.4994	.4994	.4995	.4995	.4995
3.3	.4995	.4995	.4995	.4996	.4996	.4996	.4996	.4996	.4996	.4997
3.4	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4997	.4998
3.5	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998	.4998

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