Second Semester Examination
2018/2019 Academic Session

June 2019

EAH325 – *Engineering Hydrology (Hidrologi Kejuruteraan)*

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **SIXTEEN (16)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **ENAM BELAS (16)** 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 sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

1. (a). Water cycle plays an important role in the movement of water particles. With the aid of a sketch diagram, explain any **THREE (3)** processes involved in water cycle.

*Kitaran air memainkan peranan yang penting dalam pergerakan partikel air. Dengan bantuan gambar lakaran, terangkan mana-mana **TIGA (3)** proses dalam kitaran air.*

[6 marks/*markah*]

(b). Residence time is the average time of a water particle to pass through a phase. In an area, the volume of atmospheric water is 13900 km^3. The evapotranspiration from land and from ocean are 62000 km^3/year and 505000 km^3/year, respectively. Estimate the residence time of water particles in the atmosphere (in days).

Masa kediaman adalah masa purata zarah air untuk melalui satu fasa. Di satu kawasan, jumlah air atmosfera ialah 13900 km^3. Sejat transpirasi dari darat dan dari laut adalah masing–masing 62000 km^3/tahun dan 505000 km^3/tahun. Anggarkan masa kediaman partikel air di atmosfera (dalam hari).

[4 marks/*markah*]

(c). **Table 1** shows the annual average precipitation at Station A and the average annual rainfall of 5 surrounding stations from year 2006 to 2015. Station A was permanently removed at the end of 2010. Check the consistency of data of Station A. If data is found inconsistent, correct the inconsistent data.

Jadual 1 *menunjukkan purata hujan tahunan di Stesen A dan hujan tahunan purata 5 stesen sekelilingnya dari tahun 2006 hingga 2015. Stesen A telah diubah secara kekal pada akhir tahun 2010. Periksa konsistensi data bagi Stesen A. Jika data didapati tidak konsisten, betulkan data yang tidak konsisten tersebut.*

Table 1: Annual average precipitation of Station A and the surrounding stations/ *Jadual 1*: *Purata hujan tahunan bagi Stesen A dan stesen sekelilingnya.*

Year/ *Tahun*	Annual average precipitation of Station A (mm)/ *Purata hujan tahunan bagi Stesen A (mm)*	Annual average precipitation of 5 surrounding stations (mm)/ *Purata hujan tahunan bagi 5 stesen sekeliling (mm)*
2015	1430	1410
2014	1100	1260
2013	1170	1100
2012	1100	1230
2011	1200	1150
2010	1220	1430
2009	1280	1150
2008	750	950
2007	1120	1230
2006	1250	1350

[10 marks/*markah*]

2. (a). The amount of evaporation from a water surface can be estimated by using evaporimeter. Describe **THREE (3)** types of evaporimeters available.

Jumlah air yang tersejat dari permukaan air boleh dianggarkan menggunakan evaporimeter. Terangkan ***TIGA (3)*** *jenis evaporimeter yang ada.*

[6 marks/*markah*]

(b). A class A pan was set up adjacent to a lake. At the beginning of a certain week, the water level inside the pan was 212 mm. Later in that week, there was an event of 35 mm occurred and 30 mm of rain water was subsequently removed from the pan to keep the water level within the specified depth range. Calculate the pan evaporation and the lake evaporation if the depth of the water in the pan at the end of the week was 171 mm. Use a suitable pan coefficient **(Appendix)**.

Sebuah piring kelas A ditempatkan berdekatan sebuah tasik. Di awal minggu, paras air di dalam piring adalah 212 mm. Di pertengahan minggu, terdapat peristiwa hujan sebanyak 35 mm, dan 30 mm air hujan telah dikeluarkan daripada piring untuk memastikan paras air berada dalam julat kedalaman yang ditentukan. Kira pemeluapan bagi piring dan pemeluapan bagi tasik sekiranya kedalaman air di dalam piring pada hujung minggu adalah 171 mm. Gunakan pekali piring yang sesuai ***(Lampiran).***

[4 marks/*markah*]

(c). Estimate the potential evapotranspiration (PET) of an area from April to July for a sugarcane plantation. The area is at latitude of 20° N with mean monthly temperature as shown in **Table 2.** Blanney-Criddle formula may be applied for the estimation. Tables in the appendix may help.

Anggarkan keupayaan sejat transpirasi (PET) bagi satu kawasan bermula dari April ke Julai bagi kawasan ladang tebu. Kawasan tersebut berada pada latitut 20° U dengan purata suhu bulanan seperti dalam ***Jadual 2****. Formula Blanney-Criddle boleh digunakan bagi anggaran tersebut. Jadual di lampiran boleh membantu.*

Table 2: Mean temperature of the sugarcane plantation.
Jadual 2: Purata suhu bagi kawasan ladang tebu.

Month/*Bulan*	April	May	June	July
Mean Temperature/ *Purata Suhu* (°C)	15	18	20	24

[10 marks/*markah*]

3. (a). During a high flood, a river reach of 1.5 km apart has the following information.

Semasa banjir yang tinggi, jarak sungai sejauh 1.5 km mempunyai maklumat seperti berikut.

Upstream:/
Hulu:

Area of cross section/ *Keluasan keratan rentas*	$A_1 = 180\ m^2$
Wetted perimeter/ *Ukur lilit basah*	$P_1 = 50\ m$
Manning's roughness coefficient / *Pekali kekasaran Manning*	$n_1 = 0.03$
Reduced level of river water *Aras terlaras air sungai*	= 78.3 m

Downstream:/
Hilir:

Area of cross section *Keluasan keratan rentas*	$A_2 = 183\ m^2$
Wetted perimeter *Ukur lilit basah*	$P_2 = 51\ m$
Manning's roughness coefficient *Pekali kekasaran Manning*	$n_2 = 0.025$
Reduced level of river water *Aras terlaras air sungai*	= 78.0 m

Calculate the flood discharge. Neglect the losses.

Kira kadar alir banjir. Abaikan kehilangan.

[12 marks/*markah*]

(b). Area velocity method is most frequently used for discharge estimation in natural streams compared with slope area method. As a qualified engineer, with the aid of sketch diagram you should advise your client why you consider using area velocity method rather than slope area method.

Kaedah halaju luas paling kerap digunakan untuk penganggaran kadar aliran sungai berbanding dengan kaedah luas cerun. Sebagai jurutera yang berkelayakan, dengan bantuan gambarajah lakaran anda harus menasihati klien anda mengapa anda mempertimbangkan menggunakan kaedah halaju luas dan bukannya kaedah luas cerun.

[8 marks/*markah*]

4. (a). A tracer took 22 hr to travel from Well A to Well B which is 132 m apart. Map of the water table contour shows a difference of 0.8 m in the water table elevations. The aquifer is made up of mixed sand with porosity of 33% . Calculate the following:

Sejenis perunut mengambil 22 jam untuk perjalanan dari Telaga A ke Telaga B yang terletak sejauh 132 m. Peta kontur aras air menunjukkan perbezaan 0.8 m bagi ketinggian aras air. Akuifer tersebut terdiri daripada pasir bercampur dengan keliangan sebanyak 33%. Kirakan yang berikut:

(i). Coefficient of permeability,
Pekali kebolehtelapan,

(ii). Intrinsic permeability
Ketelapan intrinsik

(iii). Reynold's number, if mean particle size diameter of medium is 1 mm. Given that (μ = 0.0114 cm^2/s; 1.14 × 10^{-6} m^2/s)

Nombor Reynold jika saiz zarah sederhana adalah 1 mm. Diberi (μ = 0.0114 cm^2/s; 1.14 × 10^{-6} m^2/s)

[12 marks/*markah*]

(b). During a soil investigation at Bukit Merah, the following layers of soils are encountered as shown in **Table 3**. As a site engineer, calculate the equivalent coefficient of permeability both in vertical and horizontal directions.

*Semasa penyiasatan tanah di Bukit Merah, lapisan tanah berikut dijumpai seperti yang ditunjukkan dalam **Jadual 3**. Sebagai jurutera tapak, kirakan pekali kebolehtelapan yang setara sama ada dalam arah menegak dan melintang.*

[8 marks/*markah*]

Table 3: Coefficient of permeability for different soil layer
Jadual 3: Pekali kebolehtelapan untuk lapisan tanah yang berbeza

Layer / Lapisan	**A**	**B**	**C**	**D**	**E**
Layer thickness/ *Ketebalan lapisan (m)*	0.5	2.0	2.8	3.6	3.0
Coefficient of permeability / *Pekali kebolehtelapan* (m/day)	1.3	2.8	1.8	0.5	2.0

5. (a). There was a significant flooding in Sungai Pisang catchment due to three (3) hours of rainfall event. Determine the depth of flood runoff using rainfall hyetograph and 1 hr-UH provided by the consultant firm shown in **Table 4** and **Table 5**, respectively. The area of the Sungai Pisang catchment is 50 km^2.

Kebanjiran yang signifikan telah berlaku di tadahan Sungai Pisang disebabkan tiga (3) jam peristiwa hujan. Tentukan kedalaman aliran banjir menggunakan hietograf hujan dan 1 jam-UH yang dibekalkan oleh firma perunding di ***Jadual 4*** *dan* ***Jadual 5****. Keluasan kawasan tadahan Sungai Pisang adalah 50 km^2.*

[12 marks/*markah*]

Table 4: Effective Rainfall Hyetograph
Jadual 4 :Hietograf Hujan Efektif

Time (hr) *Masa (jam)*	Effective Rainfall (mm) *Hujan Efektif (mm)*
0 - 1	80
1 - 2	140
2- 3	70

Table 5:1-hr UH
Jadual 5:1-jam UH

Ordinate (hr) *Ordinat (jam)*	1-hr UH (m^3/s/cm)
0	0
1	25
2	65
3	115
4	155
5	125
6	115
7	65
8	35
9	15
10	0

(b). The study and proposal for flood mitigation project in Sungai Pisang catchment needs for the application of 2-hr UH. Determine 2-hr UH for Sungai Pisang catchment using 1-hr UH given in **Table 5**. Use superposition method for the derivation of 2-hr UH.

*Kajian dan cadangan untuk projek tebatan banjir di tadahan Sungai Pisang memerlukan applikasi 2-jam UH. Tentukan 2-jam UH menggunakan 1-jam UH yang diberikan di dalam **Jadual 5**. Gunakan kaedah superposisi untuk menerbitkan 2-jam UH.*

[8 marks/*markah*]

6. (a). Discuss **FOUR (4)** factors which can affect the flood risk in a catchment area in term of frequency and magnitude.

*Bincangkan **EMPAT (4)** faktor yang boleh mempengaruhi risiko banjir di kawasan tadahan dari segi frequensi dan magnitud.*

[8 marks/*markah*]

(b). Majlis Perbandaran Kota Setar plans to construct a bridge in northern part of the city. The design of the platform of the bridge requires some analysis on the flood probability and magnitude. The mean and variance of the 80 years of annual streamflow record in the locality are 125 m^3/s and 60 m^6/s^2, respectively. Assuming the data is normally distributed, determine the following:

Majlis Perbandaran Kota Setar merancang untuk membina jambatan di bahagian utara Bandar tersebut. Rekabentuk pelantar jambatan tersebut memerlukan analisis kebarangkalian dan magnitud banjir. Purata dan varians untuk 80 tahun rekod kadaralir tahunan adalah masing-masing, 125 m^3/s dan 60 m^6/s^2. Dengan anggapan data menunjukan taburan normal, tentukan perkara berikut:

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(i). The probability of average annual streamflow discharge ≥ 100 m^3/s

Kebarangkalian purata tahunan kadaralir ≥ 100 m^3/s

(ii). The probability of average annual streamflow discharge ≤ 150 m^3/s

Kebarangkalian purata tahunan kadaralir ≤ 150 m^3/s

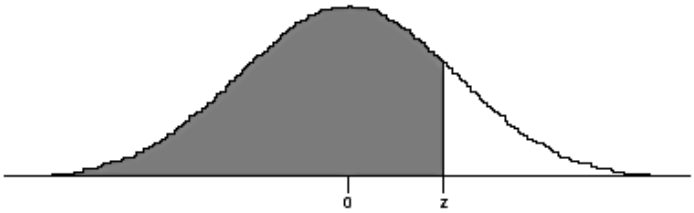
(iii). The magnitude of average annual streamflow discharge with 200 year return period.

Magnitud purata tahunan kadaralir dengan 200 tahun kala ulangan.

[12 marks/*markah*]

APPENDIX/ LAMPIRAN

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

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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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Types of pan	Average value	Range
Class A Pan	0.70	0.60-0.80
Colorado Sunken Pan	0.78	0.75-0.86
USGS Floating Pan	0.80	0.70-0.82

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

$$E_T = 2.54\ K\ F$$

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

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

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

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

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

$$K_u = \frac{1}{n} A_u R_u^{2/3}$$

$$S_2 = \frac{S_1 L + \Re(h_{vu} - h_{vd})}{L}$$

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

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

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

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

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

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

$$h_{vu} = \frac{\alpha_u (Q_1 / A_u)^2}{2g}$$

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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	

...16/-

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

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