UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2016/2017 Academic Session

June 2017

EAH325 – Engineering Hydrology
[*Hidrologi Kejuruteraan*]

Duration : 3 hours
[*Masa : 3 jam*]

Please check that this examination paper consists of **THIRTEEN (13)** pages of printed material including appendices before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** 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.*]

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] **Figure 1** shows a catchment area with three rain gauges inside and two rain gauges outside its borders. The annual rainfall of these stations is as shown in **Table 1**. Calculate the mean precipitation of this area by using the Thiessen polygon method.

Rajah 1 *menunjukkan satu kawasan tadahan air yang mempunyai tiga tolok hujan di dalam dan dua tolok hujan di luar sempadannya. Taburan hujan tahunan bagi stesen tersebut adalah seperti dalam* ***Jadual 1****. Kirakan purata taburan hujan kawasan ini dengan menggunakan kaedah poligon Thiessen.*

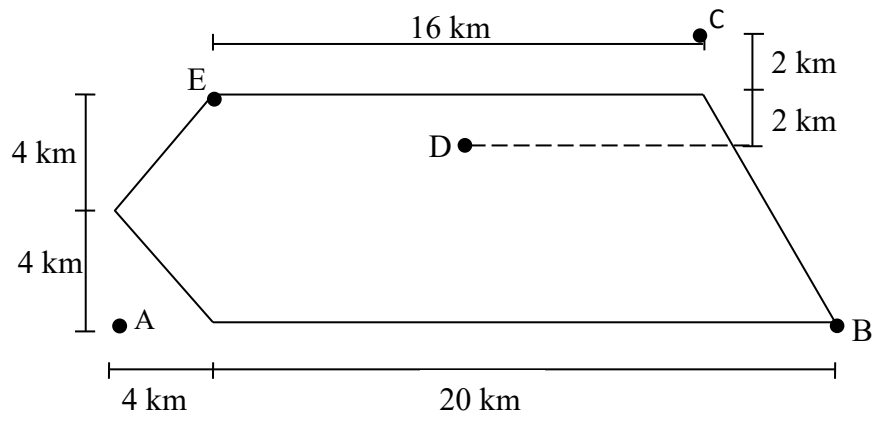

Figure 1: Catchment area/*Rajah 1: Kawasan tadahan air*

Table 1: Annual rainfall for stations A to E

Jadual 1: Hujan tahunan bagi stesen A sehingga E

Station/ *Stesen*	Annual Rainfall/ *Hujan tahunan* (mm)
A	120
B	95
C	60
D	65
E	70

[14 marks/*markah*]

[b] Define these terms:
Beri takrifan kepada yang berikut:

[i] Warm front
Perenggan panas

[ii] Tropical cyclone
Puting beliung tropika

[iii] Air mass
Jisim udara

[6 marks/*markah*]

2. [a] A Class A Pan was installed adjacent to a lake. At the beginning of a week, the water level inside the pan was 201 mm. Within that week, there was a rainfall of 43 mm, and 20 mm of water was 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 189 mm. Use a suitable pan coefficient as shown in **APPENDIX (Table 1A).**

Sebuah Dulang Kelas A ditempatkan bersebelahan sebuah tasik. Pada permulaan minggu, paras air di dalam piring adalah 201 mm. Dalam minggu tersebut, terdapat hujan sebanyak 43 mm dan 20 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 189 mm. Gunakan pekali piring yang sesuai seperti yang ditunjukkan dalam ***LAMPIRAN (Jadual 1A).***

[4 marks/*markah*]

[b] In March, a reservoir with average surface spread of 4.5 km^2 has water surface temperature of 20°C and relative humidity of 30%. Wind velocity measured at 2.0 m above the ground at a nearby observatory is 21 km/h. Calculate the average evaporation loss from the reservoir in mm/day, and the total depth and volume of evaporation loss for March.

Pada bulan Mac, sebuah takungan dengan purata bukaan permukaan 4.5 km^2, mempunyai suhu air permukaan 20°C dan kelembapan relatif sebanyak 30 %. Kelajuan angin pada 2.0 m di atas paras tanah pada balai cerap yang berdekatan diukur pada kelajuan 21 km/j. Kira purata kehilangan penyejatan daripada takungan tersebut dalam mm/hari, dan jumlah kedalaman serta kehilangan penyejatan untuk bulan Mac.

[10 marks/*markah*]

[c] Describe **THREE (3)** factors that will affect evaporation process.

*Terangkan **TIGA (3)** faktor yang akan mempengaruhi proses pemeluapan.*

[6 marks/*markah*]

3. [a] During high flood, a river reach of 1.5 km has the following information. Calculate flood discharge. Assume there are no other losses.

Sewaktu banjir besar, capaian sungai sejauh 1.5 km mempunyai maklumat seperti berikut. Kira kadar alir banjir. Abaikan kehilangan lain.

Upstream:

Hulu:

Area of cross section/ *Luas keratan rentas*	$A_1 = 180\ m^2$
Wetted perimeter/ *Parameter basah*	$P_1 = 50\ m$

Manning's roughness coefficient/
pekali kekasaran Manning $n_1 = 0.03$

Reduced level of water/
Tahap pengurangan air = 78.3 m

Downstream:

Hilir:

Area of cross section/
Luas keratan rentas $A_1 = 183\ m^2$

Wetted perimeter/
Parameter basah $P_1 = 51$ m

Manning's roughness coefficient/
pekali kekasaran Manning $n_1 = 0.025$

Reduced level of water/
Tahap pengurangan air = 78.0 m

[14 marks/*markah*]

[b] At a certain point in an unconfined aquifer of 3 km^2 area, the water table was at an elevation of 102.00 m. Due to a natural recharge in a wet season, its level rose to 103.20 m. A volume of 1.5 Mm^3 of water was then pumped out of the aquifer causing the water table to reach a level of 101.20 m. Assuming the water table in the entire aquifer to respond in the similar way, estimate:

Paras air bumi di dalam akuifer tidak terkurung dengan keluasan 3 km^2 pada satu titik tertentu adalah 102.00 m. Paras air tersebut meningkat kepada 103.20 m disebabkan oleh imbuhan semula jadi semasa musim lembap. Isipadu air sebanyak 1.5 Mm^3 dipam keluar daripada akuifer menyebabkan perubahan paras air bumi kepada 101.20 m. Anggapkan paras air bumi di dalam akuifer tersebut mempunyai tindak balas yang sama, tentukan:

[i] The specific yield of the aquifer
hasil tentu akuifer

[ii] The volume of recharge during the wet season.
isipadu imbuhan semasa musim lembap.

[6 marks/*markah*]

4. [a] The rating curve of a current meter used for measuring velocity in a small river is given as V = 0.62N + 0.032 m/s, where N is the resolutions/s. Velocity is measured at the mid of the sections. Calculate the discharge of the river from the following data.

Keluk kedudukan bagi meter arus yang digunakan untuk mengukur halaju dalam sungai kecil diberikan sebagai V = 0.62N + 0.032 m/s, di mana N adalah resolusi/s. Halaju diukur pada pertengahan bahagian. Kira kadar alir sungai daripada data berikut.

Table 2 : River information and velocity measurement
Jadual 2 : Maklumat sungai dan ukuran halaju

Distance from bank (m)/ *Jarak dari tebing (m)*	0	2	5	8	12	15	18	21	23	24
Depth (m)/ *Kedalaman (m)*	0	0.6	1.2	1.8	2.4	1.9	1.4	1.1	0.5	0
N at 0.6d/ *N pada 0.6d*	0	60	90	120	150	140	100	80	50	0
Time (s)/ *Masa(s)*	0	150	140	140	160	140	140	140	140	0

[12 marks/*markah*]

[b] With the aid of sketch diagram, discuss about following items:
Dengan bantuan gambarajah lakaran, bincangkan mengenai perkara berikut:

[i] Aquifer and aquitard
Akuifer dan akuitad

[ii] Influent and effluent stream
Sungai influen dan efluen

[iii] Artesian aquifer and unconfined aquifer
Artesian akuifer dan akuifer tidak terkurung

[8 marks/*markah*]

5. Last year there was a widespread flood in Bandar Perpaduan due to six (6) hour of continuous rainfall event which has resulted into disruption to the activities and businesses of the city dweller. The effective rainfall at two (2) hour interval for six (6) hour is given in **Table 3**. The plan for flood mitigation requires an estimation of direct runoff volume generated from the design effective rainfall event with 100 year average recurrence interval given in **Table 3**. The 1 hr-UH for the area provided by the consultant firm is given in **Table 4**. Estimate the peak discharge and volume of direct runoff using the information given in **Table 3** and **Table 4**. Use the superposition method to determine the unit hydrograph and direct runoff hydrograph.

Pada tahun lepas kejadian banjir telah berlaku di Bandar Perpaduan disebabkan peristiwa hujan yang berterusan selama enam (6) jam telah menyebabkan banjir dan mengakibatkan gangguan di dalam menjalankan aktiviti dan perniagaan kepada penduduk Bandar tersebut. Hujan efektif dengan sela masa dua (2) jam untuk enam (6) jam diberikan di dalam ***Jadual 3****. Perancangan tebatan banjir memerlukan kepada maklumat isipadu air larian terus yang dijanakan oleh peristiwa hujan rekabentuk dengan purata sela ulangan 100 tahun yang diberikan di dalam* ***Jadual 3****. Syarikat perunding telah menyediakan 1-jam UH untuk kawasan tersebut dan diberikan di dalam* ***Jadual 4****. Anggarkan puncak aliran dan isipada air larian terus menggunakan maklumat yang diberikan di dalam* ***Jadual 3*** *dan* ***Jadual 4****. Gunakan kaedah superposisi untuk menentukan unit hidrograf dan hidrograf aliran terus.*

[20 marks/*markah*]

Table 3: Effective Rainfall/*Jadual 3: Hujan Efektif*

Time (hr) *Masa (jam)*	Effective Rainfall (mm) *Hujan Efektif (mm)*
0 - 2	150
2 - 4	180
4 - 6	130

Table 4: 1-hr UH/*Jadual 2: 1-jam UH*

Ordinate (hr) *Ordinat (j)*	1-hr UH *($m^3/s/cm$)*
0	0
1	30
2	70
3	120
4	160
5	130
6	120
7	70
8	40
9	20
10	0

6. [a] Describe factors which can affect the volume and peak flow of flood runoff.

Terangkan faktor yang boleh mempengaruhi isipadu dan puncak aliran banjir.

[4 marks/*markah*]

[b] Kota Bharu Municipal Council plans to construct a road in northern part of the city. The design of the platform of the road requires some analysis on the flood probability and magnitude. The mean and standard deviation of the 60 years of annual streamflow record in the locality are 175 m^3/s and 25 m^3/s, respectively. Assuming the data is normally distributed, determine the following:

Majlis Perbandaran Kota Bharu merancang untuk membina jalan di bahagian utara bandar tersebut. Rekabentuk pelantar jalan tersebut memerlukan analisis kebarangkalian dan magnitud banjir. Purata dan sisihan piawai untuk 60 tahun rekod kadaralir tahunan adalah masing-masing, 175 m^3/s dan 25 m^3/s. Dengan anggapan data menunjukan taburan normal, tentukan perkara berikut:

[i] the probability of average annual streamflow discharge ≤ 250 m^3/s

kebarangkalian purata tahunan kadaralir ≤ 250 m^3/s

[ii] the magnitude of average annual streamflow discharge with 200 year return period.

magnitud purata tahunan kadaralir dengan 200 tahun kala ulangan.

[10 marks/*markah*]

[c] The magnitude of a flood with return period of 50 years, occurring in a particular 9 year period (n) is represented by x**.** Determine the probability of the following:

Magnitud banjir dengan kala ulangan 50 tahun, berlaku dalam tempoh 9 tahun (n) diwakili oleh x. Tentukan kebarangkalian kejadian berikut:

[i] $P(X \leq x)_n$

[ii] $P(X \geq x)_n$

[6 marks/*markah*]

APPENDIX/*LAMPIRAN*

Table 1A: Evaporation Pan Coefficient/
Jadual 1A*: *Pekali Dulang Pemeluapan

Types of pan/ *Jenis Dulang*	Average value/ *Nilai Purata*	Range/ *Julat*
Class A Pan/ *Dulang Kelas A*	0.70	0.60-0.80
Colorado Sunken Pan/ *Dulang Tenggelam Colorado*	0.78	0.75-0.86
USGS Floating Pan/ *Dulang Terapung USGS*	0.80	0.70-0.82

Formulas/*Formula:*

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

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

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

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

$$f_p = f_c + (f_0 - f_c)e^{-K_h t}$$

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

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

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

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

$$K_d = \frac{1}{n} A_d R_d^{2/3}$$

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

$$h_{vd} = \frac{\alpha_d \left(Q_1 / A_d\right)^2}{2g}$$

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

$$Q_2 = K S_2^{1/2}$$

$$K = \sqrt{K_u . K_d}$$

Normal Distribution Table/
Jadual Taburan Normal

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

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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