UNIVERSITI SAINS MALAYSIA

2nd. Semester Examination
2002/2003 Academic Session
Peperiksaan Semester Kedua
Sidang Akademik 2002/2003

February / March 2003

EAH 325E/3 – Engineering Hydrology *(Hidrologi Kejuruteraan)*

Time : 3 hour
Masa : 3 jam

Instruction to candidates:
Arahan Kepada Calon:

1. Ensure that this paper contains **TWELVE (12)** printed pages included appendix.
1. *Sila pastikan kertas peperiksaan ini mengandungi **DUA BELAS (12)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.*

2. This paper contains **SIX (6)** question. Answer **FIVE (5)** question only. Marks will be given to the **FIRST FIVE (5)** question put in order on the answer script and **NOT** the **BEST FIVE (5).**
2. *Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan sahaja. Markah hanya akan dikira bagi **LIMA (5)** jawapan **PERTAMA** yang dimasukkan di dalam buku mengikut susunan dan bukannya **LIMA (5)** jawapan terbaik.*

3. All questions carry the same mark.
3. *Semua soalan mempunyai markah yang sama.*

4. All questions **CAN BE** answered either in English or Bahasa Malaysia or combination of both languages.
4. *Semua soalan boleh dijawab dalam Bahasa Inggeris atau Bahasa Malaysia ataupun kombinasi kedua-dua bahasa.*

5. Write answered question number on the cover sheet of answer script.
5. *Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.*

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1. (a) What is a hydrologic cycle? Draw a schematic diagram of a hydrologic cycle and show the various components of the hydrologic cycle.

(8 marks)

(a) Apakah yang dimaksudkan dengan kitaran hidrolgogi? Dan tunjukkan kitaran hidrologi dan komponennya.

(8 markah)

(b) A catchment area of 140 km^2 received 120 cm of rainfall in a year. At the outlet of the catchment, flow in the stream draining the catchment was found to have an average rate of 2.0 m^3/s for 3 months, 3.0 m^3/s for 6 months and 5.0 m^3/s for 3 months.

i. What is the runoff coefficient (ratio between runoff and rainfall) of the catchment?

ii. If a forestation of the catchment reduces the runoff coefficient to 0.5, what is the increase in the abstraction from precipitation due to infiltration, evaporation and transpiration, for the same annual rainfall of 120 cm.

(6 marks)

(b) Kawasan tadahan seluas 140 km^2 menerima hujan 120 cm setahun. Air mengalir melalui alur keluar tadahan dengan kadar purata 2.0 m^3/s untuk 3 bulan, 3.0 m^3/s untuk 6 bulan dan 5.0 m^3/s untuk 3 bulan.

i. Tentukan pekali aliran terus (nisbah di antara aliran dan hujan) untuk tadahan.

ii. Sekiranya aktiviti pembalakan dalam kawasan tadahan mengurangkan pekali aliran terus kepada 0.5, tentukan peningkatan kehilangan hidrologik disebabkan penyusupan, pemeluwapan dan penyejatpeluhan, untuk hujan tahunan yang sama iaitu sebanyak 120 cm.

(6 markah)

(c) Analysis of data on maximum one-day rainfall depth at a location X indicated that a depth of 16 cm had a return period of 50 years. Determine the probability of a one-day rainfall depth equal to or greater than 16 cm occurring in location X.

i. Once in 10 successive years

ii. Two times in 10 successive years

iii. At least once in 10 successive years

(6 marks)

(c) Analisis data 1-hari kedalaman hujan pada lokasi X menunjukkan kedalaman 16 cm hujan mempunyai kala kembali 50 tahun. Tentukan kebarangkalian 1-hari kedalaman hujan bersamaan atau lebih tinggi (≥) dari 16 cm berlaku pada lokasi X:

i. Sekali dalam 10 tahun berturutan
ii. Dua kali dalam 10 tahun berturutan
iii. Sekurang-kurangnya sekali dalam 10 tahun berturutan

(6 markah)

2. (a) Define the following terms.

i. Cyclone,
ii. Extratropical cyclone,
iii. Anticyclone, and
iv. Convective precipitation

(5 marks)

(a) Bincangkan dengan ringkas perkara berikut:

i. Cyclone
ii. Extratropical cyclone
iii. Anticyclone
iv. Hujan Convective

(5 markah)

(b) For a drainage basin of 600 km^2, isohyetals drawn for a storm gave the following data :

Isohyetals (interval) (cm)	15–20	12–9	9–6	6–3	3–1
Inter-isohyetal area (km^2)	92	128	120	175	85

Estimate the average depth of the precipitation.

(5 marks)

(b) Isohyet hujan untuk kawasan tadahan seluas 600 km^2 diberikan seperti berikut

Isohyetals (interval) (cm)	*15–20*	*12–9*	*9–6*	*6–3*	*3–1*
Luas Inter-isohyetal (km^2)	*92*	*128*	*120*	*175*	*85*

Anggarkan purata hujan untuk kawasan tadahan tersebut.

(5 markah)

(c) Describe a procedure for checking and correcting inconsistency in rainfall data records.

(5 marks)

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(c) Terangkan kaedah untuk menyemak dan pembetulan rekod hujan yang tidak konsisten.

(5 markah)

(d) A catchment area has seven raingauge stations. In a year the annual rainfall recorded by the gauges are as follows.

Station	P	Q	R	S	T	U	V
Rainfall (cm)	130.0	142.1	118.2	108.5	165.2	102.1	146.9

For a 4% error in the estimate of the mean rainfall, calculate the minimum number of additional stations required to be established in the catchment.

(5 marks)

(d) Jumlah hujan tahunan untuk setahun pada suatu kawasan tadahan yang diukur dari tujuh (7) stesen tolok hujan adalah seperti berikut:

Stesen	*P*	*Q*	*R*	*S*	*T*	*U*	*V*
Hujan (cm)	*130.0*	*142.1*	*118.2*	*108.5*	*165.2*	*102.1*	*146.9*

Tentukan jumlah minima stesen tolok hujan tambahan yang perlu disediakan di dalam kawasan tadahan untuk mencapai 4% ralat dalam anggaran purata hujan,

(5 markah)

3. (a) Distinguish between:

i. Aquifer and aquitard
ii. Unconfined aquifer and leaky aquifer
iii. Influent and effluent stream
iv. Water table and piezometric surface
v. Specific capacity of a well and specific yield of an aquifer

(10 marks)

(a) Bezakan perkara berikut:

i. Akuifer dan akuitard
ii. Akuifer bebas dan akuifer bocor
iii. Sungai influen dan sungai kumbahan
iv. Paras air bumi dan paras piezometrik
v. Simpanan tentu dan hasil tentu akuifer

(10 markah)

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(b) A 30-cm well penetrating a confined aquifer is pumped at a rate of 1200 liters/min. The drawdown at an observation well at a radial distance of 30 m is as follows:

Time from start (min)	1.0	2.5	5	10	20	50	100	200	500	1000
Drawdown (m)	0.2	0.5	0.8	1.2	1.8	2.5	3.0	3.7	4.4	5.0

Calculate the aquifer transmissibility and storage coefficient.

(10 marks)

(b) Telaga dengan garis pusat 30 cm yang menusuk akuifer terkurung di pam dengan kadar 1200 liter/min. Surutan pada telaga pemerhatian dengan jarak radial 30m diberikan seperti berikut.

Masa (min)	*1.0*	*2.5*	*5*	*10*	*20*	*50*	*100*	*200*	*500*	*1000*
Surutan (m)	*0.2*	*0.5*	*0.8*	*1.2*	*1.8*	*2.5*	*3.0*	*3.7*	*4.4*	*5.0*

Tentukan nilai pekali keterusan (T) dan pekali kebolehsimpanan (S).

(10 markah)

4. (a) Give a brief description for the following terms:

i. S-Curve
ii. Superposition method
iii. Unit Hydrograf

(5 marks)

(a) Jelaskan perkara berikut:

i. Lengkung S
ii. Kaedah superposisi
iii. Unit Hidrograf

(5 markah)

(b) Streamflow hydrograf generated from rainfall event occurring on 100 hectare catchment is given in Table 1.0. The baseflow for the river is estimated at 2.5 m^3/s. Compute the following:

i. Direct runoff hydrograf
ii. Effective rainfall
iii. Unit hydrograph for the catchment

(15 marks)

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Table 1.0

Time (hour)	Streamflow Discharge (m^3/s)
0	2.5
0.15	9.5
0.30	11.5
0.45	18.5
1.00	29.5
1.15	40.5
1.30	48.5
1.45	55.5
2.00	50.5
2.15	41.5
2.30	33.5
2.45	28.5
3.00	19.5
3.15	13.5
3.30	9.5
3.45	5.5
4.00	2.5

(b) Hidrograf kadaralir sungai yang dihasilkan oleh suatu peristiwa hujan daripada kawasan tadahan seluas 100 hektar diberikan dalam Jadual 1.0. Dianggarkan aliran dasar untuk sungai tersebut ialah 2.5 m^3/s. Tentukan perkara berikut:

i. Hidrograf air larian langsung
ii. Hujan efektif
iii. Unit hidrograf kawasan tadahan

(15 markah)

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Jadual 1.0

Masa (jam)	*Kadar Sungai (m^3/s)*
0	*2.5*
0.15	*9.5*
0.30	*11.5*
0.45	*18.5*
1.00	*29.5*
1.15	*40.5*
1.30	*48.5*
1.45	*55.5*
2.00	*50.5*
2.15	*41.5*
2.30	*33.5*
2.45	*28.5*
3.00	*19.5*
3.15	*13.5*
3.30	*9.5*
3.45	*5.5*
4.00	*2.5*

5. (a) Give **THREE (3)** factors which can contribute to the increase in peak flow discharge of direct runoff hydrograph.

(5 marks)

*(a) Berikan **TIGA (3)** faktor yang boleh menyumbang pada peningkatan puncak kadaralir hidrograf air larian langsung.*

(5 markah)

(b) Catchment area covered with woods and with fair hydrologic condition over an area of 500 hectare will be developed with land use changes as given in Table 2..0 Compute the increase in direct runoff due to the changes in land use for a total rainfall depth of 15 cm. The catchment area consists of hydrologic soil group C and assumes average antecedent condition for both before and after land use changes.

(15 marks)

Table 2.0

Land use	Area (%)
Paved parking lots.	15
Streets and roads with paved curbs and storm sewers.	20
Residential districts with 65% average impervious area.	15
Residential districts with 30% average impervious area.	50

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(b) Kawasan hutan (woods) seluas 500 hektar yang mempunyai keadaan hidrologik yang sederhana (fair hydrologic condition) akan dibangunkan dengan butiran perubahan guna tanah yang diberikan dalam Jadual 2.0. Tentukan pertambahan air larian disebabkan perubahan guna tanah tersebut untuk peristiwa hujan sedalam 15 cm. Kawasan tadahan terdiri dari tanah kumpulan C dan anggapkan keadaan lembapan lampau purata (average antecedent condition) untuk kedua-dua keadaan guna tanah tersebut.

(15 markah)

Jadual 2.0

Guna Tanah	*Keluasan (%)*
Lot tempat letak kereta berturap.	*15*
Jalan berturap dengan bahu jalan dan pembentung air larian ribut.	*20*
Kawasan perumahan (residential) dengan 65% tak telap air.	*15*
Kawasan perumahan (residential) dengan 30% tak telap air	*50*

6. The record of average annual discharge for a streamflow gauging station is given in Table 3.0. Assuming the data is normally distributed, determine the following:

i. The probability of average annual streamflow discharge $\geq 150\ m^3/s$
ii. The probability of average annual streamflow discharge $\leq 75\ m^3/s$
iii. The magnitude of average annual streamflow discharge with 100 year return period.

(20 marks)

Table 3.0

Year	Average Discharge (m^3/s)	Year	Average Discharge (m^3/s)
2000	43.56	1990	73.88
1999	89.45	1989	62.87
1998	53.67	1988	63.22
1997	74.32	1987	55.43
1996	55.87	1986	72.54
1995	92.61	1985	40.65
1994	67.92	1984	55.24
1993	73.88	1983	85.98
1992	49.65	1982	79.32
1991	78.92	1981	61.13

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Rekod purata kadaralir tahunan untuk satu stesen pengukuran kadaralir sungai ditunjukkan pada Jadual 3.0. Menggunakan taburan normal tentukan perkara berikut:

i. kebarangkalian purata kadaralir tahunan $\geq 150\ m^3/s$
ii. kebarangkalian purata kadaralir tahunan $\leq 75\ m^3/s$
iii. magnitud kadaralir dengan purata ulangan 100 tahun

(20 markah)

Jadual 3.0

Tahun	*Purata Kadaralir* (m^3/s)	*Tahun*	*Purata Kadaralir* (m^3/s)
2000	*43.56*	*1990*	*73.88*
1999	*89.45*	*1989*	*62.87*
1998	*53.67*	*1988*	*63.22*
1997	*74.32*	*1987*	*55.43*
1996	*55.87*	*1986*	*72.54*
1995	*92.61*	*1985*	*40.65*
1994	*67.92*	*1984*	*55.24*
1993	*73.88*	*1983*	*85.98*
1992	*49.65*	*1982*	*79.32*
1991	*78.92*	*1981*	*61.13*

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Curve Numbers for Urban Land Uses[a]

COVER DESCRIPTION		CURVE NUMBERS FOR HYDROLOGIC SOIL GROUP			
COVER TYPE AND HYDROLOGIC CONDITION	AVERAGE % IMPERVIOUS AREA[b]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[c]					
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, roof, driveways, etc. (excluding right-of-way)[d]		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)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1–2-in. 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:					
$\frac{1}{8}$ acre or less (town houses)	65	77	85	90	92
$\frac{1}{4}$ acre	38	61	75	83	87
$\frac{1}{3}$ acre	30	57	72	81	86
$\frac{1}{2}$ 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)		77	86	91	94
Idle lands (*CN*s are determined using cover types similar to those in Table 5.8).					

Source: Reproduced from U.S. Department of Agriculture,-SCS (1986).
[a]Average runoff condition, Antecendent Moisture Condition (AMC) II, and Ia = 0.2*S*'.
[b]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.
[c]*CN*s shown are equivalent to those of pasture. Composite *CN*s may be computed for other combinations of open space cover type.
[d]In some warmer climates, a curve number of 95 may be used.

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Runoff Curve Numbers for Hydrologic Soil-Cover Complexes
(Antecedent Moisture Condition II)

COVER			HYDROLOGIC SOIL GROUP			
LAND USE	TREATMENT OR PRACTICE	HYDROLOGIC CONDITION	A	B	C	D
Fallow	Straight row	—	77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and terraced	Poor	66	74	80	82
	Contoured and terraced	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded	Straight row	Poor	66	77	85	89
legumes[a]	Straight row	Good	58	72	81	85
or	Contoured	Poor	64	75	83	85
rotation	Contoured	Good	55	69	78	83
meadow	Contoured and terraced	Poor	63	73	80	83
	Contoured and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		—	59	74	82	86
Roads (dirt)[b]		—	72	82	87	89
(hard surface)[b]		—	74	84	90	92

Source: U.S. Department of Agriculature *National Engineering Handbook*, Soil Conservation Service U.S. Department of Agriculture Section 4, Chapter 9, Hydrologic Soil Cover Complexes, 1972. Washington, DC.
[a]Close drilled or broadcast.
[b]Including right-of-way.

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Normal Distribution Function Table

$$F(z) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-\frac{t^2}{2}} dt$$

z	.0	.0100	.0200	.0300	.0400	.0500	.0600	.0700	.0800	.0900
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.10	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5733
.20	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.30	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.40	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.50	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.60	.7257	.7291	.7324	.7356	.7389	.7422	.7454	.7486	.7517	.7549
.70	.7580	.7611	.7642	.7673	.7703	.7734	.7764	.7793	.7823	.7852
.80	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.90	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.00	.8413	.8437	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.10	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8830
1.20	.8849	.8869	.8888	.8906	.8925	.8943	.8962	.8980	.8997	.9015
1.30	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.40	.9192	.9207	.9222	.9236	.9251	.9265	.9278	.9292	.9306	.9319

continued

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z	.0	.0100	.0200	.0300	.0400	.0500	.0600	.0700	.0800	.0900
1.50	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.60	.9452	.9463	.9474	.9484	.9795	.9505	.9515	.9525	.9535	.9545
1.70	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.80	.9641	.9648	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.90	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.00	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.10	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.20	.9861	.9864	.9868	.9871	.9874	.9878	.9881	.9884	.9887	.9890
2.30	.9893	.9895	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.40	.9918	.9920	.9922	.9924	.9926	.9928	.9930	.9932	.9934	.9936
2.50	.9938	.9940	.9941	.9943	.9944	.9946	.9949	.9948	.9951	.9952
2.60	.9953	.9955	.9956	.9957	.9958	.9960	.9961	.9962	.9963	.9964
2.70	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.80	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.90	.9981	.9982	.9982	.9983	.9983	.9984	.9985	.9985	.9985	.9986
3.00	.9986	.9987	.9987	.9988	.9988	.9988	.9989	.9989	.9990	.9990
3.10	.9990	.9991	.9991	.9991	.9991	.9992	.9992	.9992	.9993	.9993
3.20	.9993	.9993	.9993	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.30	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9996
3.40	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997