UNIVERSITI SAINS MALAYSIA

First Semester Examination
2015/2016 Academic Session

December 2015 / January 2016

EAP313 – Wastewater Engineering
[*Kejuruteraan Air Sisa*]

Duration : 2 hours
[*Masa : 2 jam*]

Please check that this examination paper consists of **THIRTEEN (13)** pages of printed materials including **ONE (1)** appendix before you begin the examination.
[*Sila pastikan kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat bercetak termasuk **SATU (1)** lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions: This paper contains **FOUR (4)** questions. Answer **QUESTIONS 1** and **ANY OTHER 2 QUESTIONS.**
***[Arahan**: Kertas ini mengandungi **EMPAT (4)** soalan. Jawab **SOALAN 1** dan **MANA-MANA 2 SOALAN LAIN**.]*

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

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

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

In the event of any discrepancies, the English version shall be used.
[*Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.*]

PART A: Compulsary (40 marks)
BAHAGIAN A: Wajib (40 markah)

1. [a] Sketch a typical process flow diagrams of [i] primary and [ii] secondary treatments for domestic wastewater in Malaysia.

Lakar rajah kadaralir proses tipikal olahan [i] primer [ii] sekunder untuk air sisa domestik di Malaysia.

[7 marks*/markah*]

[b] There are **TWO (2**) effluent discharge standards in Malaysia. Differentiate between Standard A and Standard B.

*Terdapat **DUA (2)** standard pelepasan efluen di Malaysia. Bezakan antara Standard A dan Standard B.*

[5 marks*/markah*]

[c] There are many parameters need to be considered in the design of a primary sedimentation tank. With appropriate units and sketches, give **THREE (3)** of the most important parameters.

*Terdapat banyak parameter yang perlu dipertimbangkan dalam rekabentuk tangki enap primer. Dengan unit dan lakaran yang sesuai, berikan **TIGA (3)** daripada parameter yang terpenting.*

[6 marks*/markah*]

[d] A rectangular grit chamber is receiving a wastewater with peak flow at 1 minutes of 7500 m^3/day. If the length and width of the tank is 4.5 and 1.5 m respectively, calculate the Surface Loading Rate Rate and Weir Loading Rate of this tank.

Suatu kebuk kersik segiempat menerima air sisa dengan kadaralir puncak pada 1 minit, 7500 m^3/hari. Sekiranya panjang dan lebar tangki adalah masing-masing 4.5 m dan 1.5 m, kirakan nilai Kadar Beban Permukaan dan Kadar Beban Empang Limpah tangki ini.

[7 marks*/markah*]

[e] [i] Define the following terms used in wastewater engineering:

Takrifkan istilah-istilah berikut yang digunakan dalam bidang kejuruteraan air sisa:

- Dry weather flow rate (DWF)
  Kadar aliran cuaca kering

- Organic load (OL)
  Beban Organik

- Population equivalent (PE)
  Kesetaraan populasi

[6 marks/*markah*]

[ii] A wastewater treatment plan discharges its effluent with a flow rate of 3.0 m^3/s and BOD 40 mg/L into the river. The river has a the flow rate of 20 m^3/s and BOD 3.0 mg/L. Calculate the BOD of the river downstream from the effluent discharge point.

Suatu loji rawatan air sisa melepaskan efluen dengan kadar aliran 3.0 m^3/s *dan BOD 40 mg/L ke sungai. Sungai tersebut mempunyai kadar aliran 20* m^3/s *dan BOD 3.0 mg/L. Kira BOD di kawasan hilir dari takat pelepasan efluen.*

[4 marks/*markah*]

[f] All the sewage sludge produced at a treatment plant must be disposed of ultimately. Suggest **TWO (2)** techniques for the final disposal of wastewater sludge from a treatment plant.

Semua enapcemar air sisa yang dihasilkan di loji olahan mesti akhirnya dilupuskan. Cadangkan ***DUA (2)*** *teknik pelupusan akhir enapcemar air sisa dari suatu loji olahan.*

[5 marks/*markah*]

PART B: Answer 2 out of 3 questions (30 marks each)

BAHAGIAN B: Jawab 2 dari 3 soalan (30 markah setiap satu)

2. [a] A wastewater form a housing scheme with peak flow of 12500 m^3/d is mechanically course screened at the treatment plant. If the storage period of screenings is set to be 7 days, using data in Appendices, calculate the required surface area of the screenings tank. Take screen's opening 20 mm and tank's depth 2.5 meter.

Air sisa dari suatu skim perumahan dengan kadaralir puncak 12500 m^3/hari disaring kasar secara mekanikal di loji olahan. Jika masa penstoran bahan saring adalah 7 hari, menggunakan data di Lampiran, kirakan luas permukaan tangki bahan saring yang diperlukan. Ambil saiz bukaan penyaring 20 mm dan tinggi tangki 2.5 m.

[9 marks/*markah*]

[b] Oil and grease should be removed prior to biological system at wastewater treatment plant. Using the data in **Table 1**:

*Minyak dan gris perlu disingkirkan sebelum sistem olahan biologi di loji olahan air sisa. Menggunakan data dalam **Jadual 1**:*

[i] Calculate the contributing Population Equivalent (PE).

Kirakan nilai Penduduk Setara (PE) yang menyumbang.

[6 marks/*markah*]

[ii] Calculate the volume of a suitable rectangular grease chamber to treat a wastewater with peak flow of 20000 m^3/day.

Kirakan isipadu kebuk gris segiempat yang sesuai untuk mengolah 20000 m^3/hari air sisa pada kadaralir puncak.

[4 marks/*markah*]

[iii] Calculate the expected amount of grease to be disposed at off-site disposal.

Kirakan jumlah gris yang dijangkakan untuk pelupusan luar tapak.

[3 marks/*markah*]

Table 1: Design parameters for grease chamber

Jadual 1: Parameter reka bentuk kebuk gris

Description	Unit	Design Criteria		
		PE ≤ 5,000*	5,000 < PE ≤10,000	PE > 10,000
Grease removal	-	Simple manual	Manual interceptor	Mechanical (conveyor)
Chamber type	-	Rectangular	Baffled tank	Aerated type
Minimum detention time (Q_{peak})	min	3	3	3
Grit and grease storage period before off-site disposal	day	30	7	7

* For PE less than 1,000, the grease chamber, grit chamber and sludge storage facility can be designed in accordance with the Imhoff tank principle.

[c] With the help of a sketch and the place of occurrence, describe 4 classes of settlement/sedimentation in wastewater sample.

Dengan bantuan lakaran dan lokasi terjadinya, terangkan 4 kelas enapan dalam sampel air sisa.

[8 marks/*markah*]

3. [a] Sketch the difference between an activated sludge process and the aerated lagoon in wastewater treatment.

Lakarkan perbezaan antara proses enap cemar teraktif dan lagun terudara dalam olahan air sisa..

[5 marks/*markah*]

[b] Determine the volume and retention time of a secondary sedimentation tank at peak flow 7500 m^3/d, MLSS = 3250 mg/L, Solids Loading Rate = 125 kg/m^2.day, and tank's depth= 2 m.

Tentukan isipadu dan masa tahanan tangki enap sekunder pada kadaralir puncak 7,500 m^3/hari, MLSS=3250 mg/L, Kadar Beban Pepejal = 125 kg/m^2.hari dan kedalaman=2 m.

[7 marks/*markah*]

[c] A waste stabilization pond is treating a wastewater from a hostel. If the organic load (BOD) is 1,260 kg/day, Surface Loading Rate is 300 kg/ha.day, vertical depth is 1.75 m, and BOD_5 is 250 mg/L, calculate the surface area and retention time of this pond. Ignore side slope.

Kolam penstabilan sisa sedang mengolah air sisa dari suatu asrama. Sekiranya beban organik (BOD) adalah 1260 kg/hari, Kadar Beban Permukaan 300 kg/ha.hari, kedalaman pugak 1.75 m dan BOD_5 250 mg/L, kirakan luas permukaan dan masa tahanan kolam. Abaikan cerun sisi.

[8 marks/*markah*]

[d] Sketch a typical process flow diagram for a Rotating Biological Contacter (RBC).
Lakar rajah proses kadaralir tipikal Penyentuh Biologi Berputar (RBC).

[5 marks/*markah*]

[e] Calculate suitable volume of a septic tank to treat a wastewater from a population of 20 people.

Kirakan isipadu tangki septik yang sesuai untuk mengolah air sisa dari 20 orang penduduk.

[5 marks/*markah*]

4. [a] Briefly discuss the differences between sewer and drinking water pipe.

Bincangkan secara ringkas perbezaan di antara pembetung dan paip air minum.

[5 marks/*markah*]

[b] What is the minimum slope required for a 60 cm diameter sewer to maintain an average velocity of flow equal to 0.9 m/s when the quantity of flow is 20% of the flowing full capacity?

Apakah cerun minimum yang diperlukan untuk pembetung 60 cm diameter untuk mengekalkan halaju purata aliran sama dengan 0.9 m/s apabila kuantiti aliran adalah 20% daripada pengaliran kapasiti?

[15 marks/*markah*]

[c] The increase in the cell size and cell mass during the development of an organism is termed as growth. Sketch a cell growth curve to help describe the dynamics of the bacterial growth.

Peningkatan saiz sel dan jisim sel semasa pembentukan organisma dipanggil sebagai pertumbuhan. Lakarkan suatu graf pertumbuhan sel untuk membantu menerangkan sifat dinamik pertumbuhan bakteria.

[10 marks/*markah*]

APPENDICES / *LAMPIRAN*

Peak Factor = $4.7\ p^{-0.11}$ (p in thousand)
Faktor Puncak = $4.7\ p^{-0.11}$ (p dalam ribu)

Retention time=Volume/discharge

Masa tahanan = Isipadu /kadaralir

Population Equivalent = $\frac{\text{Organic load from premises}}{\text{Organic load from 1 person}}$
Penduduk Setara = $\frac{\textit{Beban Organik Premis}}{\textit{Beban Organik 1 orang}}$

Manning: $Q=(1/n)\ (A)\ (R)^{2/3}\ (s)^{1/2}$

$V=(1/n)\ (R)^{2/3}\ (s)^{1/2}$

$R=A/P$

Width of screen = $\frac{\text{(width of blade + opening)}}{\text{opening}}$ $\frac{\text{(Discharge)}}{\text{(velocity) (depth of wastewater)}}$
Lebar saring = $\frac{\textit{(Lebar bilah + saiz bukaan)}}{\textit{Saiz bukaan}}$ $\frac{\textit{(Kadaralir)}}{\textit{(Halaju) (Kedalaman air sisa)}}$

Pumping cycle = $\frac{\text{Actual volume}}{\text{Dry Weather Flow}} + \frac{\text{Actual volume}}{\text{(Pumping rate-Dry Weather Flow)}}$
Sela pengepaman = $\frac{\textit{Isipadu sebenar}}{\textit{Kadaralir Cuaca Kering}} + \frac{\textit{Isipadu sebenar}}{\textit{(Kadar pam-Kadaralir Cuaca Kering)}}$

Surface Overflow Rate = $\frac{\text{Discharge}}{\text{Surface Area}}$
Kadar Beban Permukaan = $\frac{\textit{Kadaralir}}{\textit{Luas Permukaan}}$

Solids Loading Rate = $\frac{\text{(Discharge) (Mixed Liquor)}}{\text{Surface Area}}$
Kadar Beban Pepejal = $\frac{\textit{(Kadaralir) (Likur Tercampur)}}{\textit{Luas Permukaan}}$

Weir Loading Rate = $\frac{\text{Discharge}}{\text{Length of weir}}$
Kadar Beban Empang Limpah = $\frac{\textit{Kadaralir}}{\textit{Panjang Empang Limpah}}$

Volume of pyramid = (1/3) (base area) (height)
Isipadu Piramid = *(1/3) (luas dasar) (tinggi)*

Organic Load = (Discharge) (BOD)
Beban Organik = *(Kadaralir) (BOD)*

Keluasan Tangki enap primer = $\frac{\text{(Kadaralir + Kadaralir Pusing Balik) (Likur Tercampur)}}{\text{Fluks}}$

Fluks Pepejal = $\frac{\text{Halaju enapan}}{\text{(1/Kepekatan Pepejal) - (1/Kepekatan Pepejal Terenap)}}$

Kinetik BOD $BOD_t=Lo(1-10^{-k1t})$

$k_T=k_{20}(1.047)^{(T-20)}$

$L_T=L_{20}[1+0.02(T-20)]$

Thomas: $(t/BOD)^{1/3} = (kL_o)^{-1/3} + (k^{2/3}/6L_o^{1/3})\ t$

Beban Organik = (Kadaralir) (BOD)

Beban Organik Isipadu = $\frac{\text{(Kadaralir) (BOD)}}{\text{Isipadu}}$

Makanan: Microorganism = $\frac{\text{(Kadaralir) (BOD)}}{\text{(Isipadu) (Likur Tercampur)}}$

Beban Organik Kawasan = $\frac{\text{(Kadaralir) (BOD)}}{\text{Luas Permukaan}}$

Keperluan Oksigen = $\frac{Q \times BOD_5}{BOD_5/BOD_L}$ - 1.42 Px

Pertambahan Likur Tercampur = $\frac{y}{1+kd\theta c}$ (Kadaralir)(BOD)

Nisbah enap cemar kembali $R=\frac{\text{Kadaralir kembali}}{\text{Kadaralir}}$

$X_a=X_R(1/1+R)$

Keperluan Oksigen = aLr + bSa
a = Pekali penyingkiran BOD

Lr = BOD tersingkir
b = pekali endagenous enap cemar

Sa = Jisim Likur Tercampur

Kadar Bekalan Oksigen = $\frac{\text{Oksigen Diperlu}}{\text{BOD tersingkir}}$

Umur = $\frac{\text{(Isipadu) (Likur Tercampur)}}{\text{E.C. (Kadaralir Disingkir)(Likur Tercampur Pusing Balik) + (Kadaralir Efluen)(Pepejal Terampai Efluen)}}$

$1/\theta = yu - k_d$

$\theta_c = \frac{V.MLSS}{Q_w.SS}$

Indeks Isipadu Enap cemar (SVI) = (Isipadu MLSS mengenap dalam 30 minit)/MLSS

Tangki Septik, C=225P

Pond design:

$L_e/L_i = 1/(1+k_1t)$

$A = Q/Dk_1 [L_i/L_e-1]$

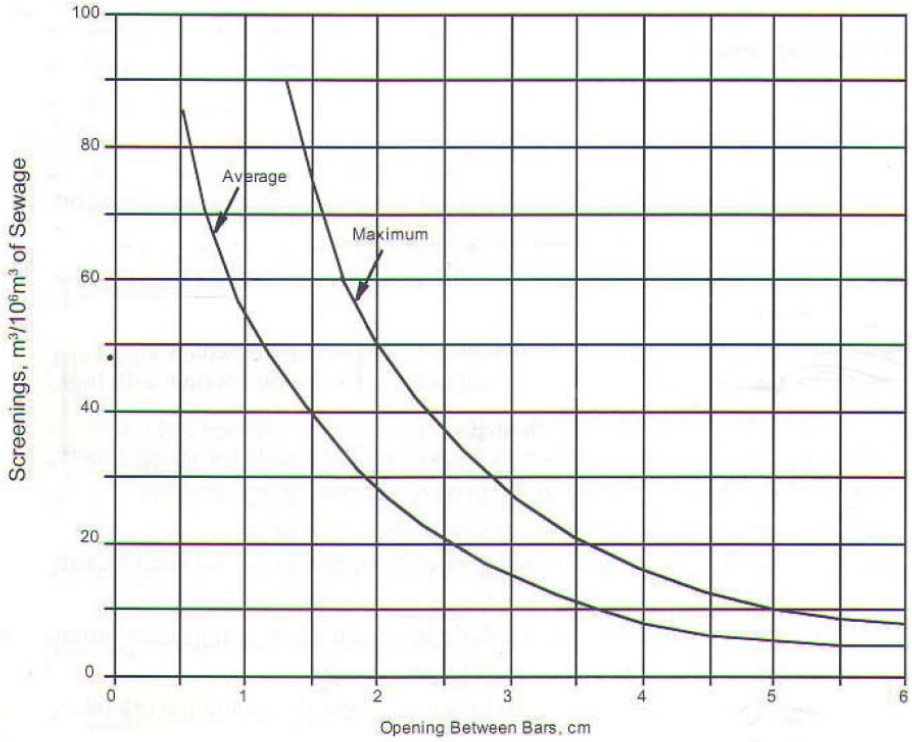
$k_T = 0.30 (1.085)^{T-20}$

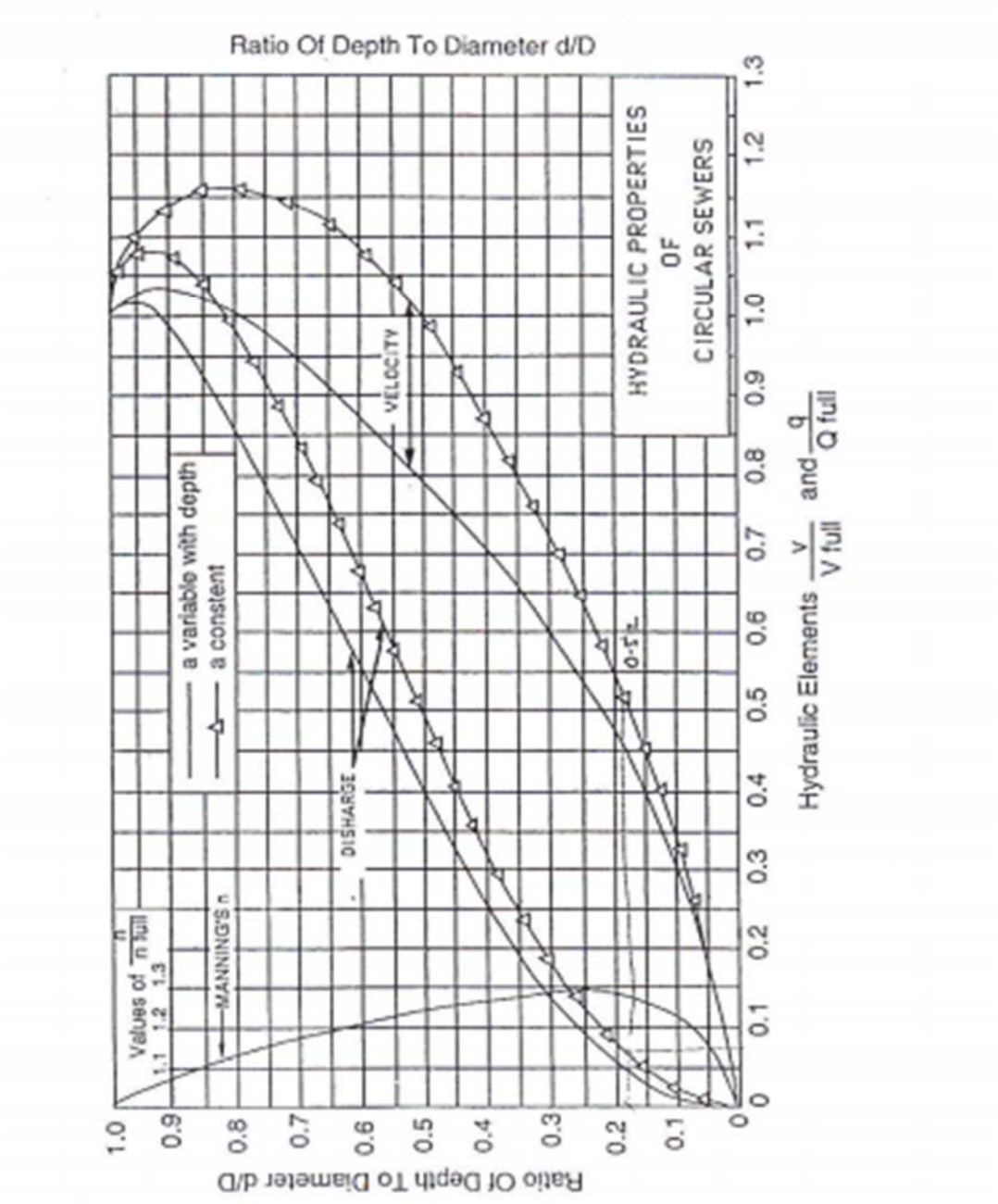
Organic Loading = L_iQ/A
Beban Organik = L_iQ/A

Maximum Organic Loading = $7.5 (1.054)^T$
Beban Organik Maksimum = $7.5 (1.054)^T$

Table B.1 Recommended Population Equivalent Factors

Type of Premise/Establishment	Population Equivalent (recommended)
Residential	5 per house
Commercial (includes offices, shopping complex, entertainment/ recreational centres, restaurants, cafeteria, theaters)	3 per 100 m^2 gross area
Schools/Educational Institutions: – Day schools/institutions – Fully residential – Partial residential	 0.2 per student 1 per student 0.2 per student for non residential student and 1 per student for residential student
Hospitals	4 per bed
Hotels (with dining and laundry facilities)	4 per room
Factories (excluding process water)	0.3 per staff
Market (wet type)	3 per stall
Petrol Kiosks/Service Stations	18 per service bay
Bus Terminal	4 per bus bay
Taxi Terminal	4 per taxi bay
Mosque	0.5 per person
Church/Temple	0.2 per person
Stadium	0.2 per person
Swimming Pool/Sports Complex	0.5 per person
Public Toilet	16 per wc
Type of Premise/Establishment	Population Equivalent (recommended)
Airport	0.2 per passenger 0.3 per employee
Laundry	10 per machine
Prison	1 per person
Golf Course	20 per hole


100
80
60
40
20
0
Average
Maximum
Screenings, m³/10⁶m³ of Sewage
0
1
2
3
4
5
6
Opening Between Bars, cm


Ratio Of Depth To Diameter d/D
HYDRAULIC PROPERTIES OF CIRCULAR SEWERS
VELOCITY
DISCHARGE
a variable with depth
a constent
MANNING'S n
Values of n/n full
1.1 1.2 1.3
Hydraulic Elements v/V full and q/Q full
Ratio Of Depth To Diameter d/D
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3
1.0 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0

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