UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2005/2006
Peperiksaan Semester Pertama
Sidang Akademik 2005/2006

November 2005

EBS 238E/3 - Fluid Mechanics
EBS 238E/3 - Mekanik Bendalir

Time : 3 hours
Masa : 3 jam

Please check that this examination paper consists of FOURTEEN pages of printed material and TWO pages APPENDIX before you begin the examination.

This paper contains SEVEN questions. THREE questions in SECTION A and FOUR questions in SECTION B.

Answer FIVE questions. Answer TWO question from SECTION A, TWO question from SECTION B and ONE question from any sections. If a candidate answer more than five questions, only the first five answered will be examined and awarded marks.

Answer to any question must start on a new page.

All questions must be answered in English. However, TWO questions can be answered in Bahasa Malaysia.

Sila pastikan bahawa kertas peperiksaan ini mengandungi EMPAT BELAS muka surat beserta DUA muka surat (Lampiran) yang bercetak sebelum anda memulakan peperiksaan.

Kertas soalan ini mengandungi TUJUH soalan. TIGA soalan di BAHAGIAN A dan EMPAT soalan di BAHAGIAN B.

Jawab LIMA soalan. Jawab DUA soalan dari BAHAGIAN A, DUA soalan dari BAHAGIAN B dan SATU soalan dari mana-mana bahagian. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.

Jawab semua soalan dalam Bahasa Inggeris. Walau bagaimanapun, DUA soalan dibenarkan dijawab dalam Bahasa Malaysia.

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SECTION A

BAHAGIAN A

1. [a] Describe what is 'center of gravity (centroid)' and 'center of pressure'? Use figures where necessary.

(30 marks)

[b] Determine the resultant force and its location due to the water acting on the 1 m by 2 m rectangular area AB shown in Figure 1. (On the diagram distance OA is 1.22 m and AB is 2.0 m).

(Given: $\gamma_{water} = 9810\ N/m^3$)

(35 marks)

[c] Calculate the the resultant force and its location due to the water acting on the 1.25 by 2.0 m triangular area CD shown in Figure 1. The apex of the triangle is at C (On the diagram depth to point C is 1.0 m and the distance CD is 2.0 m).

(Given: $\gamma_{water} = 9810\ N/m^3$)

(35 marks)

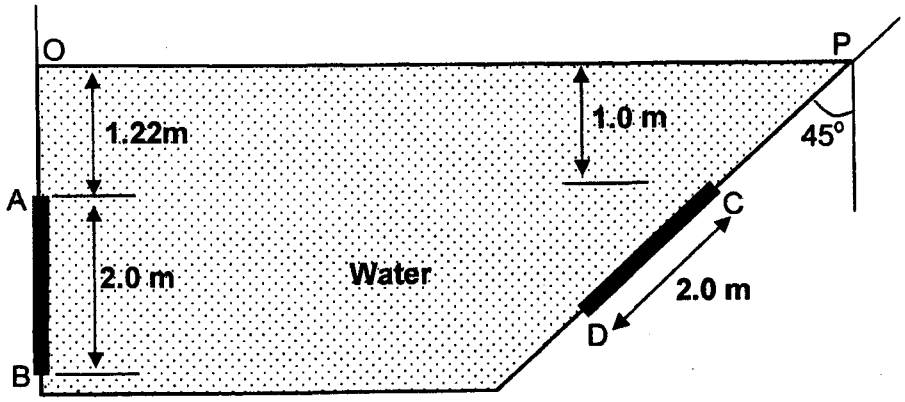


Figure 1

1. [a] *Terangkan apakah 'pusat graviti (centroid)' dan 'pusat tekanan'? Gunakan rajah di mana perlu.*

(30 markah)

[b] *Tentukan daya paduan dan kedudukannya disebabkan oleh air yang bertindak pada segiempat tepat (1 m x 2 m) kawasan AB yang ditunjukkan dalam Rajah 1. (Jarak OA ialah 1.22 dan AB ialah 2.0 m seperti yang ditunjukkan dalam Rajah 1).*

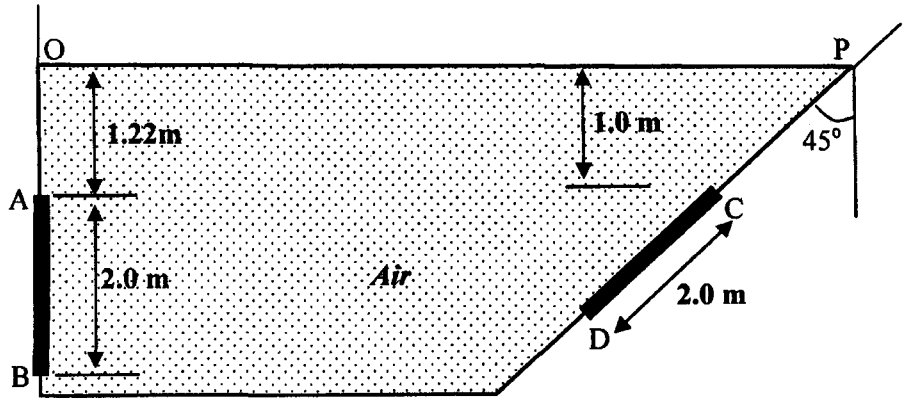
(Diberi: $\gamma_{air} = 9810\ N/m^3$)

(35 markah)

[c] *Tentukan daya paduan dan kedudukannya disebabkan oleh air yang bertindak pada segitiga (1.25 m x 2 m) kawasan CD yang ditunjukkan dalam Rajah 1. Puncak segitiga ialah pada C. (Pada Rajah 1 di bawah, kedalaman ke titik C ialah 1.0 m jarak CD ialah 2.0 m)*

(Diberi: $\gamma_{air} = 9810\ N/m^3$)

(35 markah)



Rajah 1

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2. [a] Explain the following fluid flow (with the aid of diagrams, where necessary):

(i) Steady uniform flow
(ii) Unsteady non-uniform flow
(iii) Compressible and incompressible flow
(iv) Streamline and stream tube

(30 marks)

[b] State four (4) limitations of Bernoulli equation.

(20 marks)

[c] A 5 meter long pipe is inclined at an angle of 15° with the horizontal. The smaller section of the pipe, which is at a lower level is of 80 mm diameter and the larger section of the pipe is of 240 mm diameter as shown in Figure 2. Determine the difference of pressures between the two section in N/m^2, if the pipe is uniformly tapering and the velocity of water at the smaller section is 1 m/s.

(50 marks)

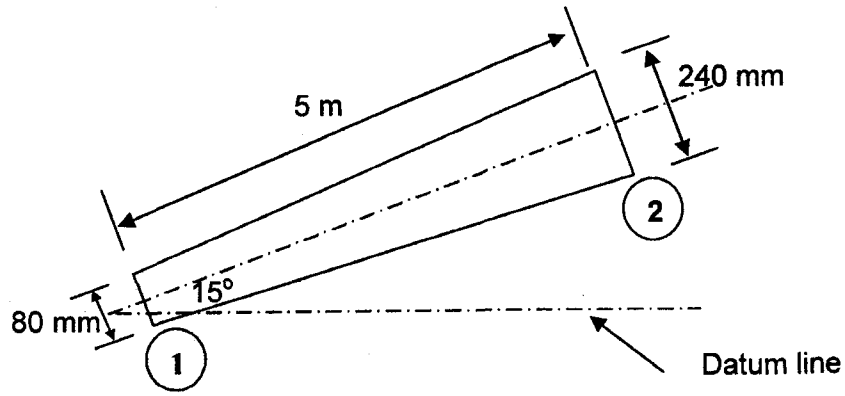

Figure 2

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2. [a] *Dengan bantuan rajah, terangkan keadaan aliran bendalir berikut:*

(i) *aliran mantap seragam*

(ii) *aliran tidak mantap tidak seragam*

(iii) *aliran mampat dan tidak mampat*

(iv) *garis arus dan tiub arus*

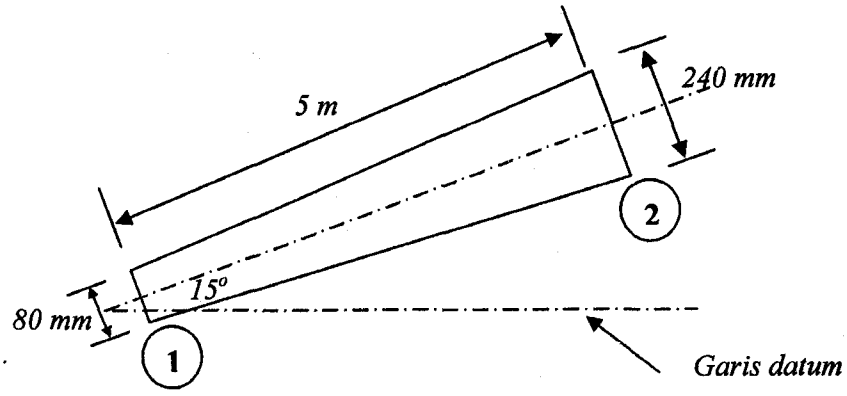
(30 markah)

[b] *Nyatakan empat (4) had-had persamaan Bernoulli.*

(20 markah)

[c] *Sebatang paip yang panjangnya 5 meter dicondongkan pada sudut 15° daripada aras ufuk. Bahagian kecil paip tersebut yang terletak pada aras bawah mempunyai diameter 80 mm manakala bahagian besar paip mempunyai diameter 240 mm, seperti yang ditunjukkan dalam Rajah 2. Dapatkan perbezaan tekanan antara kedua-dua bahagian tersebut dalam N/m^2, jika paip tirus secara seragam dan kelajuan air pada bahagian kecil ialah 1 m/s.*

(50 markah)



Rajah 2

3. [a] Starting with the Bernoulli and Continuity equations derive the following expression that can be used to measure flow rate with a venturi meter.

Note : Use common notation.

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2g\left(\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right)}{A_1^2 - A_2^3}}$$

(30 marks)

[b] Also, show that when the pressure difference is measured using manometer the following expression can be used.

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2gh\left(\frac{\rho_{man}}{\rho} - 1\right)}{A_1^2 - A_2^3}}$$

where : ρ_{man} = fluid density in the manometer

(30 marks)

[c] A venturi meter is used to measure the flow of water in a pipe of diameter 100 mm. The throat diameter of the venturi meter is 60 mm and it has a coefficient of discharge of 0.9. When a flow of 100 liters/s is flowing the attached manometer shows a head difference of 60 cm, what is the density of the manometric fluid of the manometer?

(40 marks)

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3. [a] *Dengan menggunakan persamaan Bernoulli dan persamaan Keselenjaran, terbitkan persamaan berikut yang boleh digunakan untuk mengukur kadar alir dengan menggunakan meter venture.*
Nota : Gunakan tatanda biasa.

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2g\left(\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right)}{A_1^2 - A_2^3}}$$

(30 markah)

[b] *Seterusnya, tunjukkan bahawa perbezaan tekanan meter venturi yang menggunakan manometer boleh menggunakan persamaan berikut:*

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2gh\left(\frac{\rho_{man}}{\rho} - 1\right)}{A_1^2 - A_2^3}}$$

di mana ρ_{man} = ketumpatan bendalir di dalam manometer

(30 markah)

[c] *Sebuah meter venturi digunakan untuk mengukur aliran air dalam sebuah paip yang mempunyai diameter 100 mm. Diameter kerongkongan meter venture tersebit ialah 60 mm dan mempunyai pekali luahan 0.9. Jika suatu aliran 100 liter/s mengalir, bacaan manometer menunjukkan perbezaan turus 60 cm, apakah ketumpatan bendalir dalam manometer tersebut?*

(40 markah)

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SECTION B

BAHAGIAN B

4. [a] Determine the most efficient section based on flow resistance for a trapezoidal channel. Assume equal side slope, that is, $m_1 = m_2$.

(60 marks)

[b] Describe briefly:

(i) Uniform flow in an open channel
(ii) Wetted perimeter
(iii) Hydraulic radius
(iv) The specific energy
(v) Critical depth

(40 marks)

4. [a] Dapatkan bahagian yang paling cekap berdasarkan aliran rintangan untuk sebuah saluran trapezoid. Anggap kecerunan sisi adalah sama, iaitu ,$m_1 = m_2$

(60 markah)

[b] Terangkan secara ringkas:

(i) Aliran seragam dalam sebuah saluran terbuka
(ii) Keliling basah
(iii) Jejari hidraulik
(iv) Tenaga tentu
(v) Kedalaman kritikal

(40 markah)

5. [a] Determine the flow distribution of water in parallel piping system shown below.

Q_{in} = 600 L/min

Pipe	*L* (m)	*D* (mm)	*f*	Σ *K*
1	30	50	0.020	3
2	40	75	0.025	5
3	60	60	0.022	1

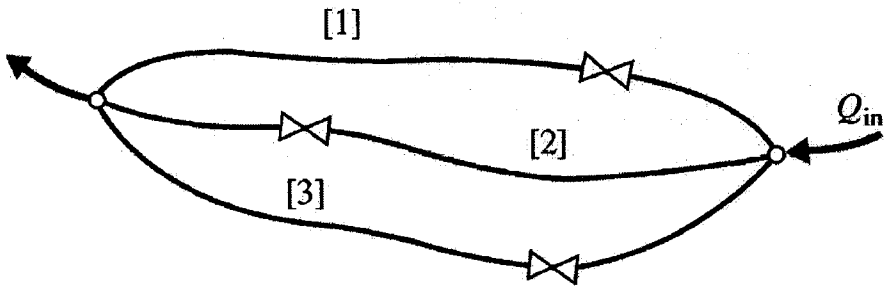

Figure 3

(60 marks)

[b] If for a piping system the value Q represents the volumetric flow rate, Δh_{A-B} represents the head loss between initial point A and the final point B, select the proper combination of the following relationships for

(i) Series Piping
(ii) Parallel Piping
(iii) Branch Piping

(40 marks)

(a) $0 = Q_1 + Q_2 + Q_3$

(b) $\Delta h_{A-B} = \Delta h_1 + \Delta h_2 + \Delta h_3$

(c) $Q = Q_1 + Q_2 + Q_3$

(d) $z_1 + \Delta h_1 = z_2 + \Delta h_2 = z_3 + \Delta h_3$

(e) $Q_1 = Q_2 = Q_3$

(f) $\Delta h_{A-B} = \Delta h_1 = \Delta h_2 = \Delta h_3$

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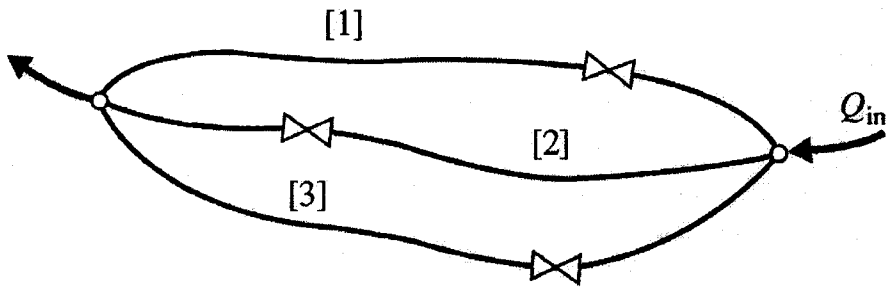
5. [a] *Dapatkan taburan aliran air dalam sistem perpaipan selari yang berikut:*

Q_{in} = 600 L/min

Pipe	*L (m)*	*D (mm)*	*f*	*ΣK*
1	*30*	*50*	*0.020*	*3*
2	*40*	*75*	*0.025*	*5*
3	*60*	*60*	*0.022*	*1*



Rajah 3

(60 markah)

[b] *Jika Q mewakili kadar alir isipadu, Δh_{A-B} mewakili kehilangan turus antara titik permulaan A dan titik akhir B bagi suatu sistem perpaipan, pilih kombinasi hubungan yang sesuai untuk menerangkan perkara berikut:*

(i) Perpaipan Bersiri

(ii) Perpaipan Selari

(iii) Perpaipan Cabang

(40 markah)

(a) $0 = Q_1 + Q_2 + Q_3$

(b) $\Delta h_{A-B} = \Delta h_1 + \Delta h_2 + \Delta h_3$

(c) $Q = Q_1 + Q_2 + Q_3$

(d) $z_1 + \Delta h_1 = z_2 + \Delta h_2 = z_3 + \Delta h_3$

(e) $Q_1 = Q_2 = Q_3$

(f) $\Delta h_{A-B} = \Delta h_1 = \Delta h_2 = \Delta h_3$

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6. [a] Estimate the flow rate to be expected through the plastic siphon shown in Figure 4, if the diameter is 8 cm

(60 marks)

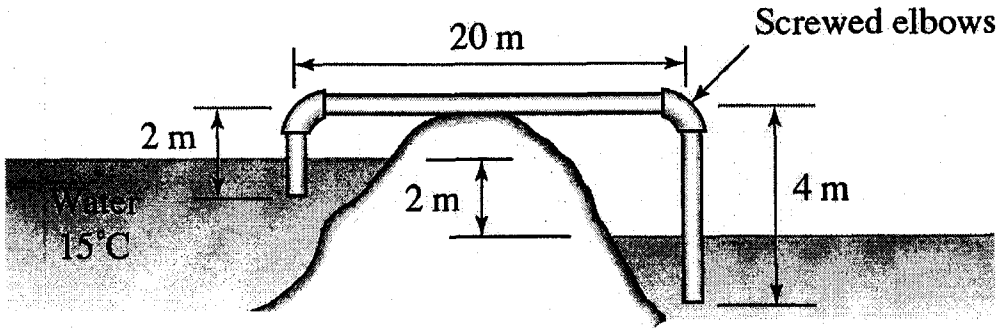

Figure 4

Given : K_{elbow} = 0.64

$K_{entrance}$ = 0.50

K_{exit} = 0.46

[b] Indicate the correct statement:

In a turbulent flow in a pipe, the head loss

A. varies with the velocity squared
B. is directly proportional to the flow rate
C. decreases with increase with the Reynolds number
D. is directly proportional to the length of the pipe

(40 marks)

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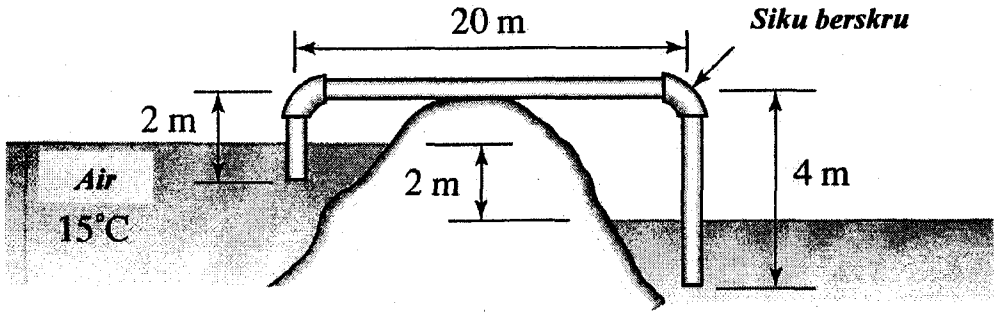
6. [a] *Anggarkan kadar alir yang dijangkakan bagi sebuah sifon plastik, seperti yang ditunjukkan dalam Rajah 4, jika diameter paip ialah 8 cm.*

(60 markah)



Rajah 4

Diberi : $K_{siku} = 0.64$

$K_{masuk} = 0.50$

$K_{keluar} = 0.46$

[b] *Pilih kenyataan yang tepat:*

Dalam aliran gelora suatu paip, kehilangan turus

A. berubah dengan kuasa dua kelajuan

B. berkadar terus dengan kadar alir

C. berkurang dengan bertambahnya nombor Reynolds

D. berkadar terus dengan panjang paip

(40 markah)

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7. [a] A centrifugal water pump rotates at 800 rpm. The impeller has uniform blade widths b_1 = 25 mm, and radii r_1 = 40 mm, r_2 = 125 mm. The blade angles are $\beta_1 = 45°$, $\beta_2 = 30°$. Assuming no angular momentum of fluid at the blade entrance, determine the ideal flow rate, pressure head rise across the impeller, and the theoretical torque and power requirements.

(60 marks)

[b] What type of pump is shown Figure 5? How does it operate?

(40 marks)

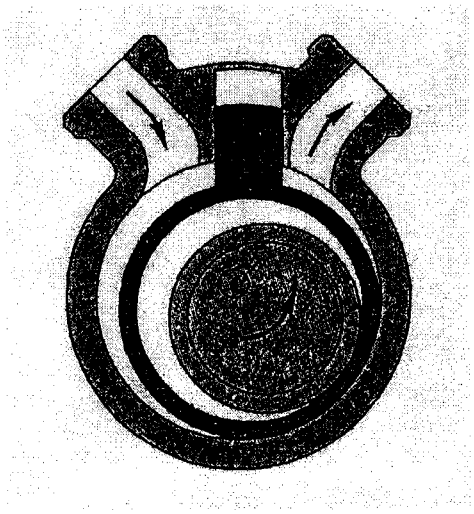

Figure 5

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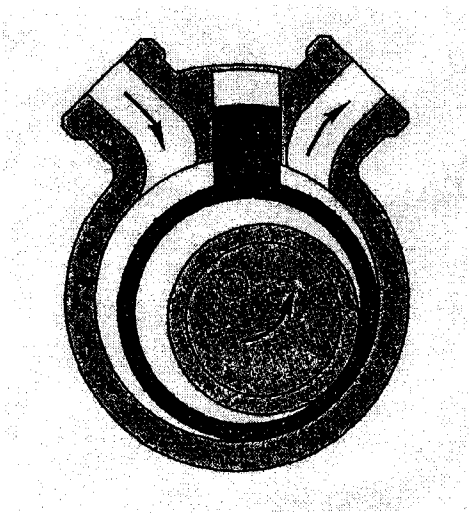
7. [a] *Sebuah pam empar air berputar pada 800 putaran seminit. Pendesak mempunyai bilah yang lebarnya berukuran* $b_1 = 25$ *mm, dan jejari* $r_1 = 40$ *mm,* $r_2 = 125$ *mm. Sudut bilah ialah* $\beta_1 = 45^o$, $\beta_2 = 30^o$. *Dengan mengabaikan momentum sudut bendalir pada jalan masuk, dapatkan kadar alir unggul, kenaikan turus tekanan pendesak, kilas teori dan kuasa yang diperlukan.*

(60 markah)

[b] *Apakah jenis pam yang ditunjukkan dalam Rajah 5? Bagaimana ia beroperasi?*

(40 markah)



Rajah 5

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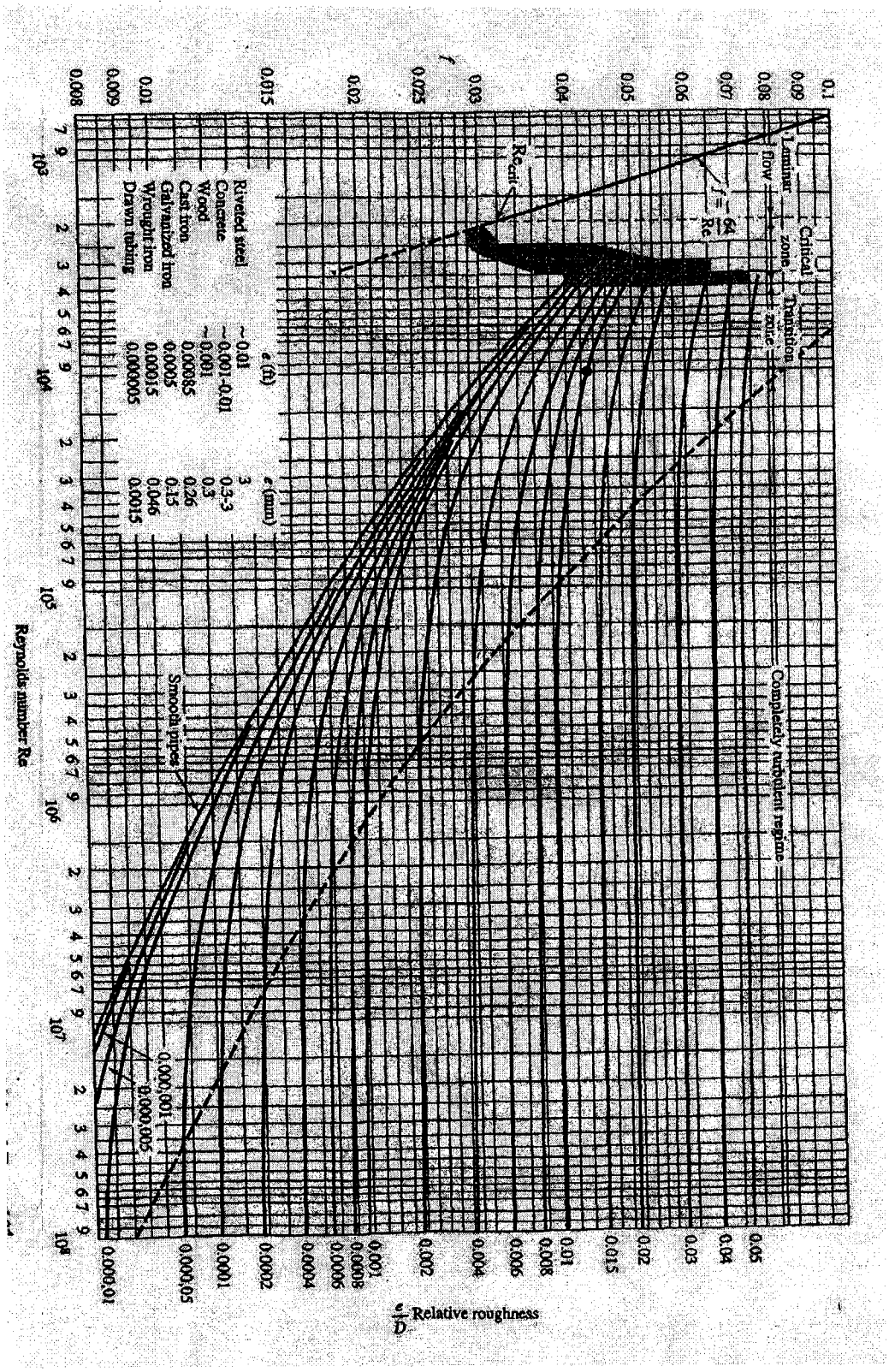
APPENDIX 1

LAMPIRAN 1



Moody diagram (Note: if e/D = 0.006 and Re =10^4, the dot locates f = 0.043)

APPENDIX 2

LAMPIRAN 2

Properties of Common Liquids at Atmospheric Pressure and Approximately 60 to 70°F (16 to 21°C)

	Specific weight γ		*Density* ρ		*Surface tension*[a] σ		*Vapor pressure* p_v	
Liquid	lb/ft^3	N/m^3	slugs/ft^3	kg/m^3	lb/ft	N/m	psia	kPa
Alcohol, ethyl	49.3	7 744	1.53	789	0.0015	0.022	—	—
Benzene	56.2	8 828	1.75	902	0.0020	0.029	1.50	10.3
Carbon tetrachloride	99.5	15 629	3.09	1 593	0.0018	0.026	12.50	86.2
Gasoline	42.4	6 660	1.32	680	—	—	—	—
Glycerin	78.6	12 346	2.44	1 258	0.0043	0.063	2×10^{-6}	1.4×10^{-5}
Kerosene	50.5	7 933	1.57	809	0.0017	0.025	—	—
Mercury	845.5	132 800	26.29	13 550	0.032	0.467	2.31×10^{-5}	1.59×10
SAE 10 oil	57.4	9 016	1.78	917	0.0025	0.036	—	—
SAE 30 oil	57.4	9 016	1.78	917	0.0024	0.035	—	—
Turpentine	54.3	8 529	1.69	871	0.0018	0.026	7.7×10^{-3}	5.31×10^{-2}
Water	62.4	9 810	1.94	1000	0.0050	0.073	0.34	2.34

[a]In contact with air.

Properties of Common Liquids at Atmospheric Pressure and Approximately 16^0 to 21^{0}C

Sifat-Sifat Bendalir Biasa padaTekanan Atmosfera dan Suhu anggaram 16^0 to 21^{0}C