UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 1996/97

April 1997

EMK 111 - Mekanik Bendalir I

Masa : [3 jam]

ARAHAN KEPADA CALON:

Sila pastikan bahawa kertas peperiksaan ini mengandungi **EMPAT BELAS** muka surat serta tiga lampiran dan **TUJUH** soalan yang bercetak sebelum anda memulakan peperiksaan ini.

Jawab **LIMA** soalan sahaja.

Sekurang-kurangnya satu (1) soalan mesti dijawab dalam bahasa Malaysia. Soalan-soalan lain boleh dijawab sama ada dalam bahasa Malaysia atau bahasa Inggeris.

Jawaban bagi setiap soalan hendaklah dimulakan pada muka surat yang baru.

Termasuk lampiran-lampiran:

1. Lampiran 1 - Physical properties of water and common liquids.
2. Lampiran 2 - Loss coefficient of pipe components and nozzle discharge coefficient.
3. Lampiran 3 - Moody diagram and degree of roughness of new pipes.

...2/-

S1. **[a]** **[i]** **Nyatakan Hukum Ketimbulan Archimedes.**

State Archimedes' Law of buoyancy.

(20 markah)

[ii] **Sebuah injap apung digunakan untuk mengawal aliran air masuk ke dalam sebuah tangki seperti pada Rajah S1[a]. Ia terikat pada sambungan AOB. Berat bagi penyambungan itu boleh diabaikan dan engsel membelok tanpa geseran di O. Panjang OA adalah 200 mm dan jarak di antara pusat bahan terapung dan engsel adalah 500 mm.**

Untuk memberhentikan aliran air sepenuhnya, injap itu perlu dipaksa pada kedudukan daya 10 N. Bila aliran air itu berhenti, sambungan AO adalah berkeadaan tegak.

Didapati juga, bila aliran air berhenti, permukaan bebas air di dalam tangki adalah 350 mm di bawah engsel. Tentukan berat bahan bulat yang terapung, jika bahan apung adalah 200 mm.

A float valve controls the inflow of water in a tank, as shown in Fig. Q1[a]. It is fixed to a link AOB. This link has negligible weight and it turns on a frictionless hinge at O. The length OA is 200 mm and the distance between the centre of the float and the hinge is 500 mm.

To stop the flow of water completely, the valve has to be forced on the seat with a force of 10 N. When the flow of water stops, the link AO is vertical.

It was also found that when the inflow of water stops, the free surface of the water in the tank is 350 mm below the hinge. Determine the weight of the spherical float, if the diameter of the float is 200 mm.

(40 markah)

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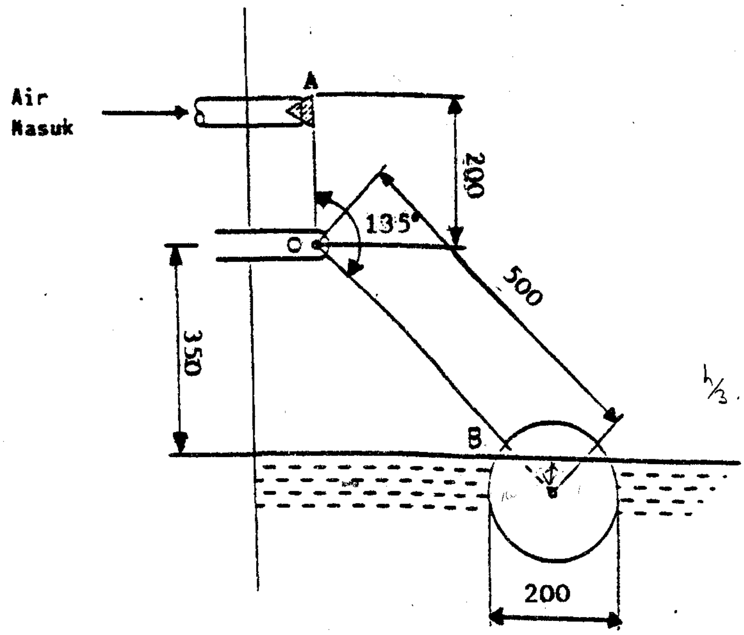

Rajah S1[a]
Figure Q1[a]

[b] **Tentukan ketinggian, h bagi cecair yang mempunyai graviti tentu 0.8 sehingga hujung pada papan sekat yang bersegiempat tepat, seperti ditunjukkan pada Rajah S1[b]. Kelebaran papan sekat adalah unit.**

Determine the height, h of the liquid of specific gravity 0.8, which will tip the rectangular flash board, shown in Fig. Q1[b]. The width of the flash board is unity.

(40 markah)

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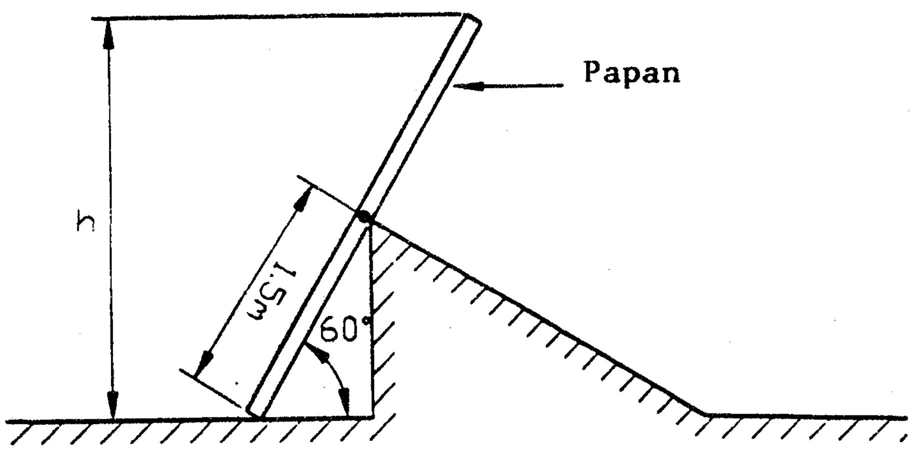


Rajah S1[b]
Figure Q1[b]

S2. [a] Takrifkan Rangkap Arus, ψ, dan upaya halaju, ϕ bagi aliran tak berputar dua dimensi.

Bagi aliran dua dimensi yang tak berputar, apakah syarat-syarat yang mesti dipatuhi?

Define the Stream Function, ψ, and the velocity potential, ϕ for a two dimensional irrotational flow.

If a two dimensional flow is irrotational, what conditions must it satisfy?

(30 markah)

...5/-

[b] **Bagi dua dimensi, aliran tak boleh mampat, komponen-komponen halaju, u dan v diberi sebagai:**

In a two dimensional, incompressible flow, the velocity components, u and v are given by:

$$u = \frac{y^3}{3} + 2x - x^2 y$$

$$v = xy^2 - 2y - \frac{x^3}{3}$$

[i] **Tunjukkan aliran mematuhi persamaan keselanjaran**

[ii] **Tunjukkan aliran tersebut adalah tak berputar**

[iii] **Dapatkan satu ungkapan untuk Rangkap Arus, ψ**

[i] *Show that the flow satisfies the continuity equation*

[ii] *Show that the flow is irrotational*

[iii] *Obtain an expression for the Stream Function, ψ*

(30 markah)

[c] **Dua tangki A dan B disambungkan dengan sebuah manometer tiub-U, tangki A mengandungi air dan tangki B mengandungi minyak dengan graviti tentu 0.8, seperti ditunjukkan pada Rajah S2[c]. Apakah perbezaan tekanan bagi kedua-dua tangki tersebut, $P_A - P_B$?**

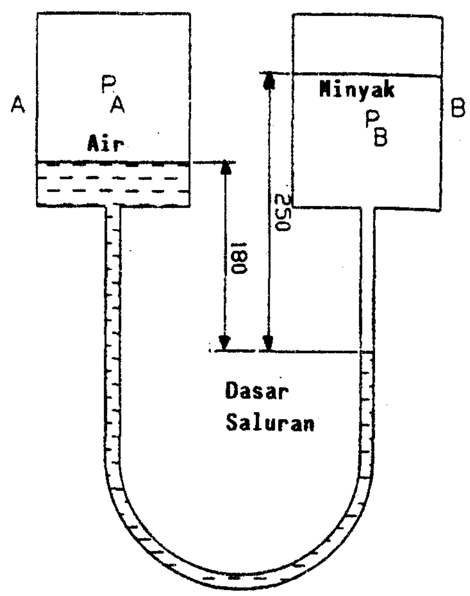
Jika P_B dinaikkan bagi membolehkan antara air/minyak di dalam tiub-U bergerak ke bawah sebanyak 20 mm, apakah nilai baru $P_A - P_B$?

...6/-

Two tanks A and B are connected by a U-tube manometer, Tank A contains water and tank B contains oil of specific gravity 0.8, as shown in Figure Q2[c]. What is the difference in pressures of the two tanks, $P_A - P_B$?

If P_B *is increased so that the water/oil interface in the U-tube moves down by 20 mm, what is the new value of* $P_A - P_B$?

(40 markah)



Rajah S2[c]
Figure Q2[c]

S3. [a] Bendalir berketumpatan ρ dan berkelikatan μ mengalir pada halaju purata ν melalui sebuah paip bulat bergaris pusat dan pemalar geseran adalah f. Tunjukkan dengan menggunakan analisis dimensi sebagai:

Fluid of density ρ and viscosity μ flows at an average velocity ν through a circular pipe of diameter d and f is coefficient of friction. Show by dimensional analysis that:

...7/-

$$\tau_o = \rho v^2 f\left(\frac{\rho v d}{\mu}\right)$$

di mana τ_o adalah tegasan ricih pada dinding paip.

where τ_o is the shear stress at the pipe wall.

(50 markah)

[b] **Nyata dan takrifkan perbezaan jenis-jenis keserupaan.**

Kelakuan sebuah kapal-udara yang mempunyai 4 m garispusat dan 25 m panjang akan diselidiki pada laju 2.5 m/s. Sebuah model berskala 1/15 telah dibina. Kirakan kelajuan udara di dalam terowong angin di mana model sepatutnya diuji untuk penyelakuan keadaan yang sebenar.

State and define different kinds of similarity.

The behavior of an air-ship of 4 m diameter and 25 m length is to be investigated at a speed of 2.5 m/s. A 1/15 scale model is constructed. Calculate the air speed in the wind tunnel at which the model should be tested to simulate the actual conditions.

(50 markah)

S4. [a] [i] **Bagaimanakah nombor Reynolds boleh menolong dalam penerangan jenis aliran dalam mekanik bendalir.**

How is Reynolds' no. helpful in describing the type of flow in fluid mechanics?

(20 markah)

[ii] **Apakah geseran dan kehilangan-kehilangan yang kecil di dalam paip? Atas faktor apakah, faktor geseran bergantung bagi 'paip-licin'. Berikan beberapa contoh.**

...8/-

What are friction and minor losses in pipes? On what factors does friction factor depend for 'smooth pipes'. Give some examples.

(20 markah)

[b] **Air pada 20°C mengalir dari takungan A ke takungan B melalui sebuah paip berbesi tuang yang panjangnya 20 m dan bergarispusat D = 45 mm pada kadar aliran 0.002 m^3/s yang ditunjukkan pada Rajah S4[b]. Sistem ini mengandungi sebuah jalan masuk berpinggir tajam dan enam siku berulir teratur 90°.**

Tentukan:

[i] halaju aliran
[ii] Nombor Reynolds
[iii] faktor geseran
[iv] kehilangan-kehilangan geseran
[v] kehilangan-kehilangan yang kecil

Water at 20°C is to flow from a reservoir A to reservoir B through a cast iron pipe of length 20 m and diameter D = 45 mm at a flow rate of 0.002 m^3/s as shown in Figure Q4[b]. The system contains a sharp edged entrance and six regular threaded 90° elbows.

Determine:

[i] velocity of flow
[ii] Reynolds' no.
[iii] friction factor
[iv] friction losses
[v] minor losses

(60 markah)

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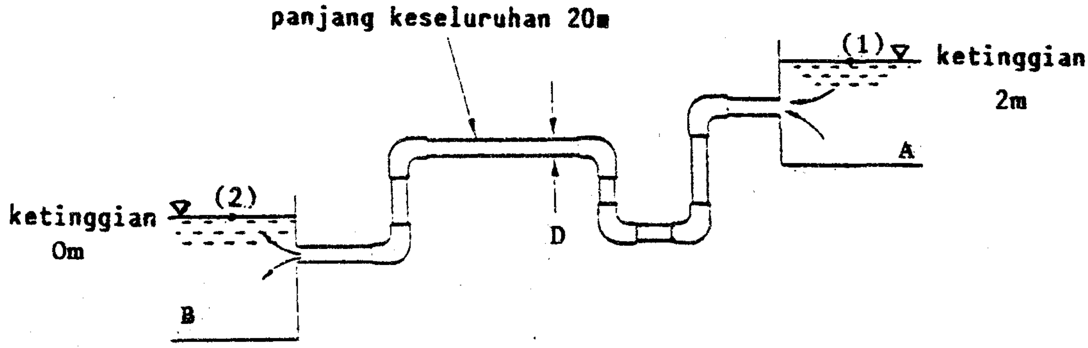


Rajah S4[b]
Figure Q4[b]

S5. [a] [i] Dari persamaan Bernoulli tunjukkan perhubungan di antara statik, dinamik dan jumlah tekanan. Bagaimanakah ianya diukur?

From Bernoulli's equation derive the relationship between static, dynamic and total pressure. How are they measured?

(20 markah)

[ii] Lakarkan susuk halaju bagi aliran lamina dan gelora di dalam paip. Nyatakan perhubungan antara halaju purata dan maksimum dalam aliran lamina.

Sketch velocity profile for laminar and turbulent flow in pipe. State the relationship between average and maximum velocity in laminar flow.

(20 markah)

[b] Ethyl-alkohol mengalir melalui sebuah paip bergarispusat 60 mm di sebuah kilang penapis. Susutan tekanan yang merentasi meter muncung bagi mengukur kadar aliran adalah 4 kPa. Garispusat muncung adalah 36 mm. Re = 1 x 10^5. Kirakan luahan yang sebenar.

...10/-

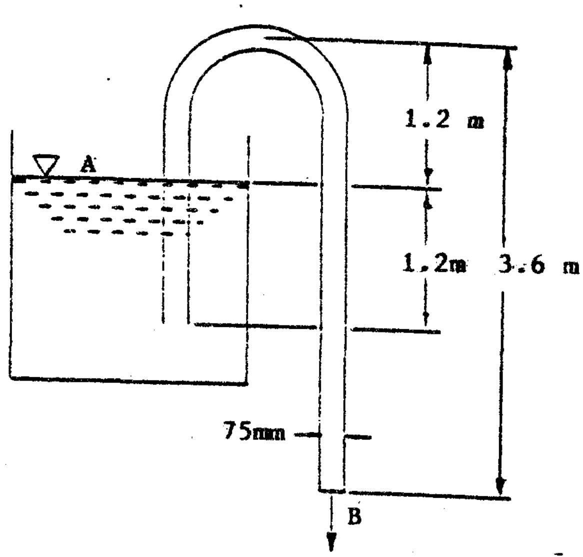
Ethyl alcohol flows through a pipe of diameter 60 mm in a refinery. The pressure drop across the nozzle meter to measure flow rate is 4 kPa. The diameter of the nozzle is 36 mm. Re = 1 x 10^5. Calculate actual discharge.

(30 markah)

[c] **Sebuah sifon air mempunyai garispusat dalaman yang tetap 7.5 cm diaturkan seperti pada Rajah S5[c]. Jika kehilangan geseran di antara A dan B adalah 0.6 $v^2/2g$ di mana v adalah aliran halaju di dalam sifon, tentukan kadar aliran.**

A water syphon having a constant inside diameter of 7.5 cm is arranged as shown in Figure Q5[c]. If friction loss between A and B is 0.6 $v^2/2g$ where v is velocity of flow in syphon, determine flow rate.

(30 markah)



Rajah S5[c]
Figure Q5[c]

S6. [a] [i] **Atas faktor-faktor apakah daya angkat dan seretan bagi sebuah jasad bergantung? Namakan satu/dua cara untuk mengurangkan seretan bagi sebuah jasad.**

On what factors does lift and drag of a body depend? Name one/two methods to reduce the drag of a body.

(20 markah)

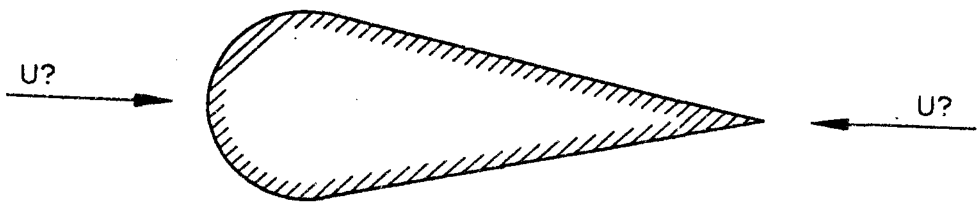
[ii] **Anggapan bahawa 'objek-objek tajam boleh melintas melalui udara lebih baik daripada objek tumpul'. Berdasarkan anggapan ini, seretan pada objek yang ditunjukkan pada Rajah S6[a] seharusnya kurang bila angin bertiup dari kanan ke kiri dari angin bertiup, dari kiri ke kanan.**

Eksperimen menunjukkan keadaan sebaliknya adalah benar. Terangkan.

It is often assumed that 'sharp objects can cut through the air better than blunt ones'. Based on this assumption, the drag on the object shown in Figure Q6[a] should be less when air blows from right to left than when it blows from left to right.

Experiments show that the opposite is true. Explain.

(20 markah)



Rajah S6[a]
Figure Q6[a]

[b] **Pendapat bahawa kuasa P diperlukan bagi mengatasi seretan aerodinamik pada kenderaan yang bergerak berkadar dengan halaju v sebagai $P \alpha v^n$. Apakah nilai terhampir bagi pemalar n?.**

Berapa banyakkah kuasa manusia diperlukan untuk mengayuh sebuah basikal dari 20 km/jam kepada 30 km/jam dengan menganggap luasan depan adalah 0.35 m^2 dan pekali seretan adalah 0.88.

It is suggested that the power P needed to overcome aerodynamic drag on a vehicle travelling at velocity v varis as $P\alpha v^n$. What is the approximate value of the constant n?.

How much man power is required to pedal a bicycle from 20 km/hr to 30 km/hr assuming frontal area is 0.35 m^2 and drag coefficient of 0.88.

(30 markah)

[c] **Sebuah pesawat udara berkuasakan manusia mempunyai data berikut:**

- **laju penerbangan 15 km/jam**
- **saiz sayap**
  - **perentas = 2.5 m**
  - **rentang = 32 m**
- **berat (termasuk juruterbang) = 95 kg**
- **pekali seretan = 0.046**

Tentukan pekali daya angkat dan kuasa yang diperlukan oleh juruterbang.

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A human powered aircraft has the following data:

- *flight speed 15 km/hr*
- *wing size*
  - *chord = 2.5 m*
  - *span = 32 m*
- *weight (including pilot) = 95 kg*
- *drag coefficient = 0.046*

Determine lift coefficient and power required by the pilot.

(30 markah)

S7. [a] Terangkan struktur dan ketebalan lapisan sempadan bagi satu aliran ke atas kawasan plat rata bagi aliran lamina dan gelora.

Explain the boundary layer structure and thickness for a flow over a long flat plate region of laminar and turbulent flow.

(40 markah)

[b] Sebuah model hidrofoil bergerak dalam 'keadaan melayang' (contoh: badannya tidak bersentuh air dan hanya disokong dengan kerajangnya) dengan halaju 1.5 m/s. Anggapkan hidrofoil sebagai plat rata dengan panjangnya 100 mm dan lebarnya bersamaan 250 mm. Tentukan:

[i] nombor Reynolds
[ii] ketebalan (δ) dan tebal anjakan (δ^*) lapisan sempadan
[iii] seretan
[iv] bandingkan seretan bagi sebuah kerajang yang sama bergerak di udara

Anggapkan ketumpatan bersamaan 1.2 kg/m^3.

...14/-

A model hydrofoil is moving in a 'flying condition' (i.e. with its hull out of water and solely supported by its foils) with a velocity of 1.5 m/s. Treating hydrofoil as flat plate with length 100 mm and width equal to 250 mm. Determine:

[i] *Reynolds' no.*

[ii] *boundary layer thickness (δ) and displacement thickness (δ^*)*

[iii] *drag*

[iv] *compare the drag for a similar foil moving in air*

Assume that the density is equal to 1.2 kg/m^3.

(60 markah)

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LAMPIRAN 1

TABLE B.2 Physical Properties of Water (SI Units)[a]

Temperature (°C)	Density, ρ (kg/m³)	Specific Weight[b], γ (kN/m³)	Dynamic Viscosity, μ (N·s/m²)	Kinematic Viscosity, ν (m²/s)	Surface Tension[c], σ (N/m)	Vapor Pressure, p_v [N/m² (abs)]	Speed of Sound[d], c (m/s)
0	999.9	9.806	1.787 E − 3	1.787 E − 6	7.56 E − 2	6.105 E + 2	1403
5	1000.0	9.807	1.519 E − 3	1.519 E − 6	7.49 E − 2	8.722 E + 2	1427
10	999.7	9.804	1.307 E − 3	1.307 E − 6	7.42 E − 2	1.228 E + 3	1447
20	998.2	9.789	1.002 E − 3	1.004 E − 6	7.28 E − 2	2.338 E + 3	1481
30	995.7	9.765	7.975 E − 4	8.009 E − 7	7.12 E − 2	4.243 E + 3	1507
40	992.2	9.731	6.529 E − 4	6.580 E − 7	6.96 E − 2	7.376 E + 3	1526
50	988.1	9.690	5.468 E − 4	5.534 E − 7	6.79 E − 2	1.233 E + 4	1541
60	983.2	9.642	4.665 E − 4	4.745 E − 7	6.62 E − 2	1.992 E + 4	1552
70	977.8	9.589	4.042 E − 4	4.134 E − 7	6.44 E − 2	3.116 E + 4	1555
80	971.8	9.530	3.547 E − 4	3.650 E − 7	6.26 E − 2	4.734 E + 4	1555
90	965.3	9.467	3.147 E − 4	3.260 E − 7	6.08 E − 2	7.010 E + 4	1550
100	958.4	9.399	2.818 E − 4	2.940 E − 7	5.89 E − 2	1.013 E + 5	1543

[a] Based on data from *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988.
[b] Density and specific weight are related through the equation $\gamma = \rho g$. For this table, $g = 9.807\ m/s^2$.
[c] In contact with air.
[d] From R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

TABLE 1.6 Approximate Physical Properties of Some Common Liquids (SI Units)

Liquid	Temperature (°C)	Density, ρ (kg/m³)	Specific Weight, γ (kN/m³)	Dynamic Viscosity, μ (N·s/m²)	Kinematic Viscosity, ν (m²/s)	Surface Tension,[a] σ (N/m)	Vapor Pressure, p_v [N/m² (abs)]	Bulk Modulus,[b] E_v (N/m²)
Carbon tetrachloride	20	1,590	15.6	9.58 E − 4	6.03 E − 7	2.69 E − 2	1.3 E + 4	1.31 E + 9
Ethyl alcohol	20	789	7.74	1.19 E − 3	1.51 E − 6	2.28 E − 2	5.9 E + 3	1.06 E + 9
Gasoline[c]	15.6	680	6.67	3.1 E − 4	4.6 E − 7	2.2 E − 2	5.5 E + 4	1.3 E + 9
Glycerin	20	1,260	12.4	1.50 E + 0	1.19 E − 3	6.33 E − 2	1.4 E − 2	4.52 E + 9
Mercury	20	13,600	133	1.57 E − 3	1.15 E − 7	4.66 E − 1	1.6 E − 1	2.85 E + 10
SAE 30 oil[c]	15.6	912	8.95	3.8 E − 1	4.2 E − 4	3.6 E − 2	—	1.5 E + 9
Seawater	15.6	1,030	10.1	1.20 E − 3	1.17 E − 6	7.34 E − 2	1.77 E + 3	2.34 E + 9
Water	15.6	999	9.80	1.12 E − 3	1.12 E − 6	7.34 E − 2	1.77 E + 3	2.15 E + 9

[a] In contact with air.
[b] Isentropic bulk modulus calculated from speed of sound.
[c] Typical values. Properties of petroleum products vary.

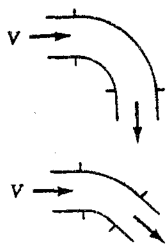
(B) SOME PROPERTIES OF AIR AT ATMOSPHERIC PRESSURE

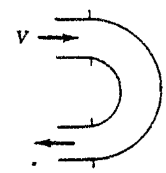
Temperature °C (°F)	Density ρ kg/m³	Kinematic Viscosity ν m²/s	Dynamic Viscosity μ Pa s
− 17.8 (0)	1.382	1.171 × 10⁻⁵	1.57 × 10⁻⁵
− 6.7 (20)	1.326	1.263	1.68
+ 4.4 (40)	1.274	1.356	1.73
15.6 (60)	1.222	1.468	1.79
20.0 (68)	1.202	1.486	1.80
26.7 (80)	1.176	1.570	1.84
37.8 (100)	1.135	1.672	1.90
48.9 (120)	1.109	1.756 × 10⁻⁵	1.95 × 10⁻⁵

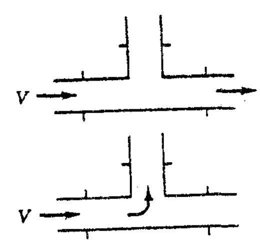
LAMPIRAN 2

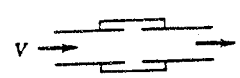
TABLE 8.3 Loss Coefficients for Pipe Components $\left(h_L = K_L \frac{V^2}{2g}\right)$

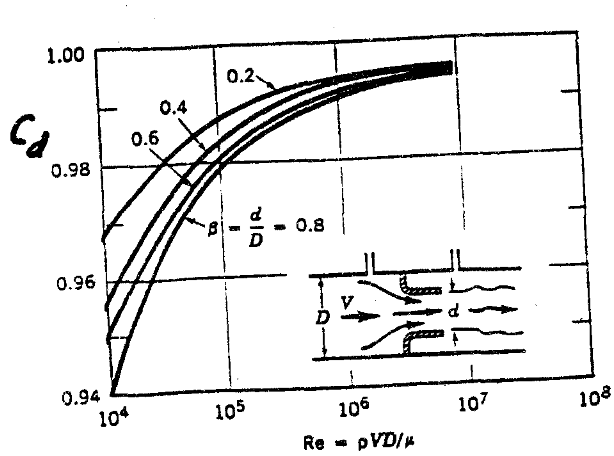
Component	K_L
a. Elbows	
Regular 90°, flanged	0.3
Regular 90°, threaded	1.5
Long radius 90°, flanged	0.2
Long radius 90°, threaded	0.7
Long radius 45°, flanged	0.2
Regular 45°, threaded	0.4
b. 180° return bends	
180° return bend, flanged	0.2
180° return bend, threaded	1.5
c. Tees	
Line flow, flanged	0.2
Line flow, threaded	0.9
Branch flow, flanged	1.0
Branch flow, threaded	2.0
d. Union, threaded	0.08
e. Valves	
Globe, fully open	10
Angle, fully open	2
Gate, fully open	0.15
Gate, ¼ closed	0.26
Gate, ½ closed	2.1
Gate, ¾ closed	17
Swing check, forward flow	2
Swing check, backward flow	∞
Ball valve, fully open	0.05
Ball valve, ⅓ closed	5.5
Ball valve, ⅔ closed	210











Nozzle meter discharge coefficient (Ref. 24).

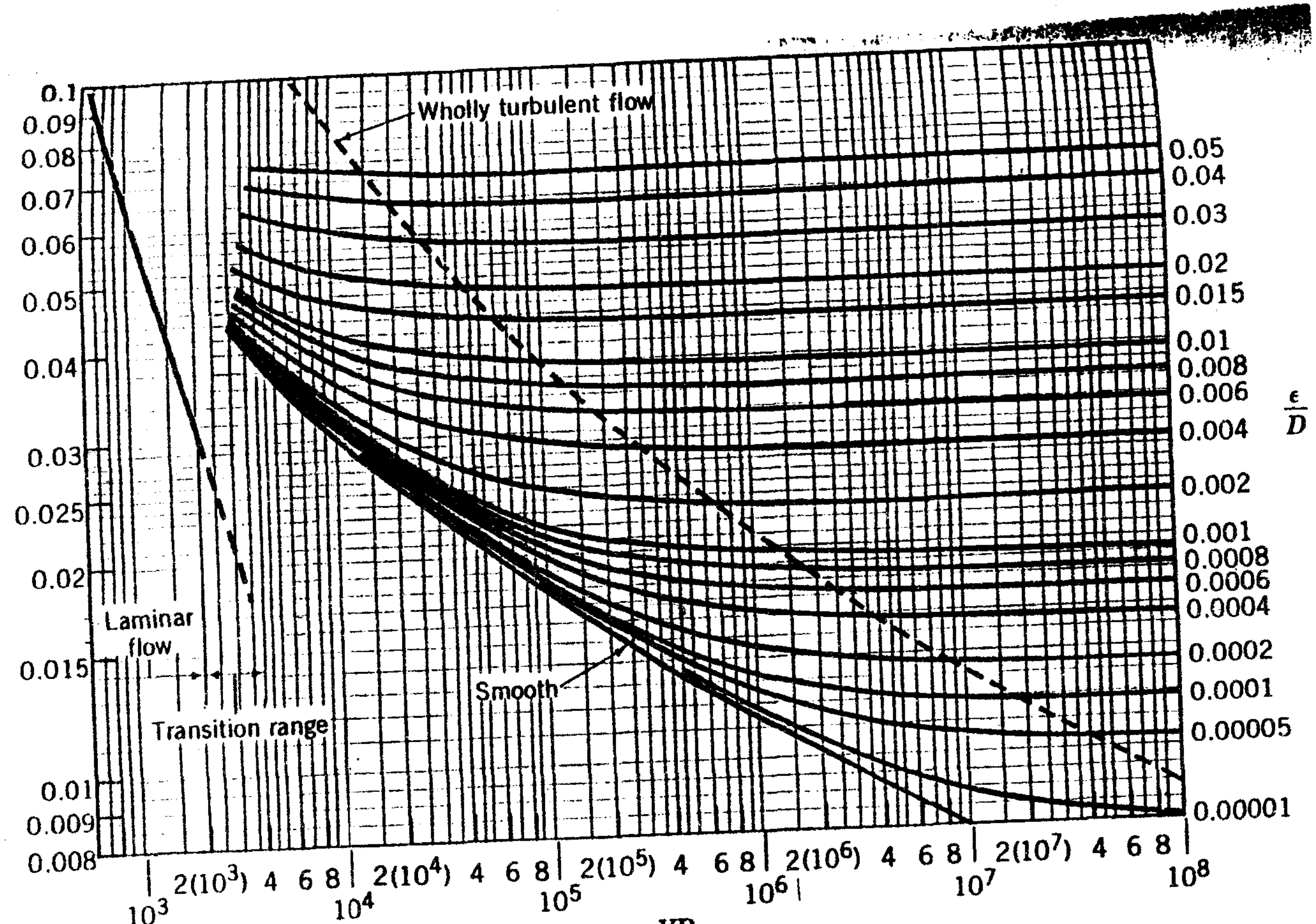


FIGURE 8.23 Friction factor as a function of Reynolds number and relative roughness for round pipes—the Moody chart (Data from Ref. 7 with permission).

TABLE 8.2 Equivalent Roughness for New Pipes [from Moody (Ref. 7) and Colebrook (Ref. 8)].

Pipe	Equivalent Roughness, ε: Feet	Equivalent Roughness, ε: Millimeters
Riveted steel	0.003–0.03	0.9–9.0
Concrete	0.001–0.01	0.3–3.0
Wood stave	0.0006–0.003	0.18–0.9
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Commercial steel or wrought iron	0.00015	0.045
Drawn tubing	0.000005	0.0015
Plastic, glass	0.0 (smooth)	0.0 (smooth)