First Semester Examination
2019/2020 Academic Session

December 2019 / January 2020

EAH221 – *Fluid Mechanics for Civil Engineers (Mekanik Bendalir untuk Jurutera Awam)*

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **FIFTEEN (15)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **LIMA BELAS (15)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions : This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.

[***Arahan*** *: Kertas ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan*.]

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

(1). (a). A micromanometer is used to measure the pressure in Pipe A as shown in **Figure 1**. The ratio of area of the reservoir to the area of the manometer pipe limb is 50:1. The manometer pipe is inclined at an angle of 30°. Determine the pressure in the pipe.

*Satu mikromanometer di gunakan untuk mengukur tekanan dalam Paip A seperti dalam **Rajah 1**. Nisbah luas kawasan takungan kepada paip manometer ialah 50:1. Paip manometer dicondong pada sudut 30°. Tentukan tekanan dalam paip.*

[8 marks/*markah*]

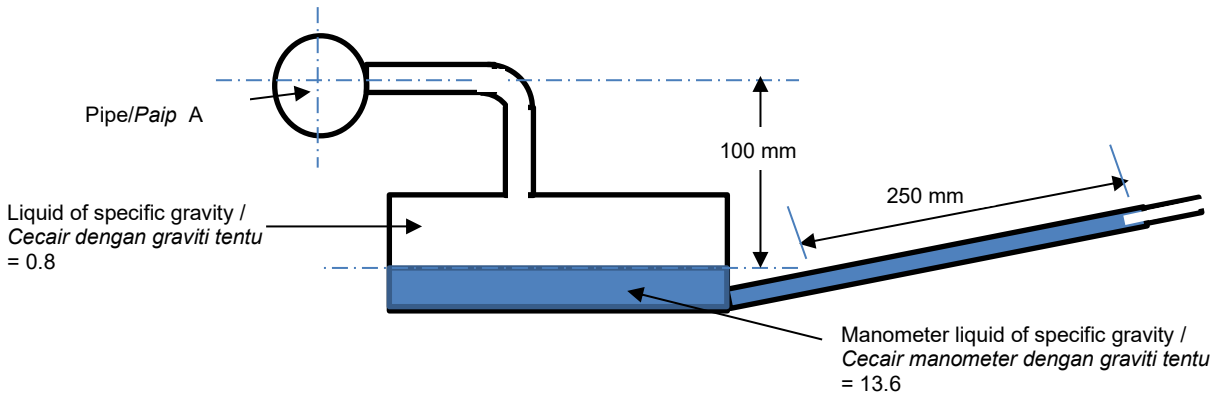


Figure 1/*Rajah 1*

(b). A circular plate of 5.0 m diameter has a circular hole of 1.5 m diameter with its centre 1.25 m above the centre of the plate as shown in **Figure 2.** The plate is immersed in water at an angle of 30° to the horizontal and with the top edge 2 m below the free surface.

*Satu plat bulat dengan garispusat 5.0 m mempunyai satu lubang bulat bergarispusat 1.5 m dengan pusatnya 1.25 m di atas pusat plat seperti dalam **Rajah 2**. Plat tersebut direndam dalam air pada sudut 30° mendatar dan bahagian atasnya ialah 2 m di bawah permukaan air bebas.*

(i). Determine the total force due to pressure on the plate
Tentukan jumlah daya disebabkan tekanan atas plat

(ii). Calculate the depth of centre of pressure
Kira kedalaman pusat tekanan

Given that Moment of inertia of circles $I_G = \frac{\pi(Diameter^4)}{64}$

Diberi momen inertia bulatan $I_G = \frac{\pi(Garispusat^4)}{64}$

[12 marks/*markah*]

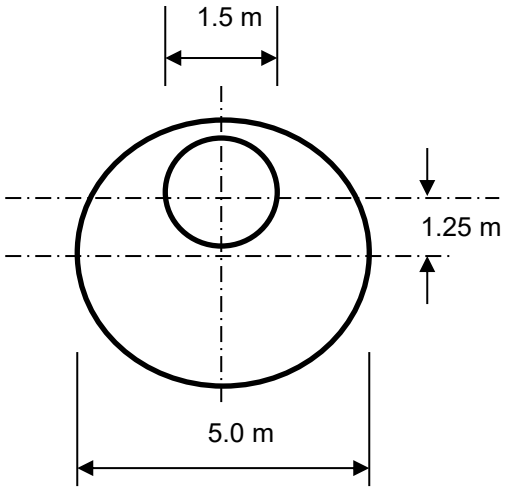


Figure 2/*Rajah 2*

(2). (a). A tank contains water for a height of 0.75 m and oil of specific gravity of 0.8 above the water for a height of 1.5 m as shown in **Figure 3**. Calculate the force due to pressure per meter length of the tank.

*Sebuah tangki mengandungi air dengan ketinggian 0.75 m dan minyak dengan graviti tentu 0.8 di atas air pada ketinggian 1.5 m seperti dalam **Rajah 3.** Kirakan daya kerana tekanan untuk setiap meter panjang tangki.*

[8 marks/*markah*]

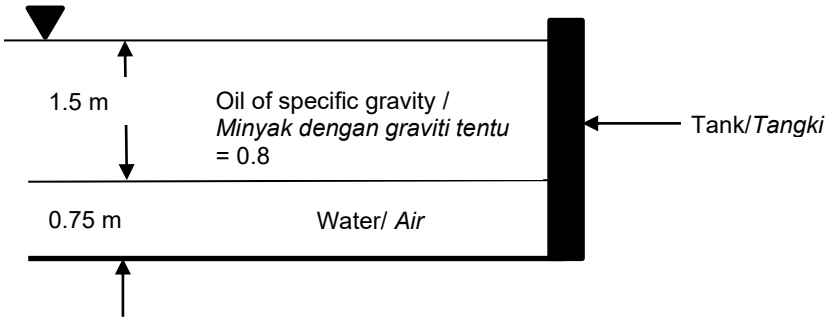


Figure 3/*Rajah 3*

(b). A block of wood of dimensions 150 mm x 150 mm in section and specific gravity of 0.75 is required to float in water. Calculate the maximum length of the block of wood so that it may float vertically in water.

Satu blok kayu dengan dimensi keratan rentas 150 mm x 150 mm dan graviti tentu 0.75 perlu terapung dalam air. Kirakan panjang maksima blok kayu tersebut untuk ia terapung secara menegak dalam air.

[12 marks/*markah*]

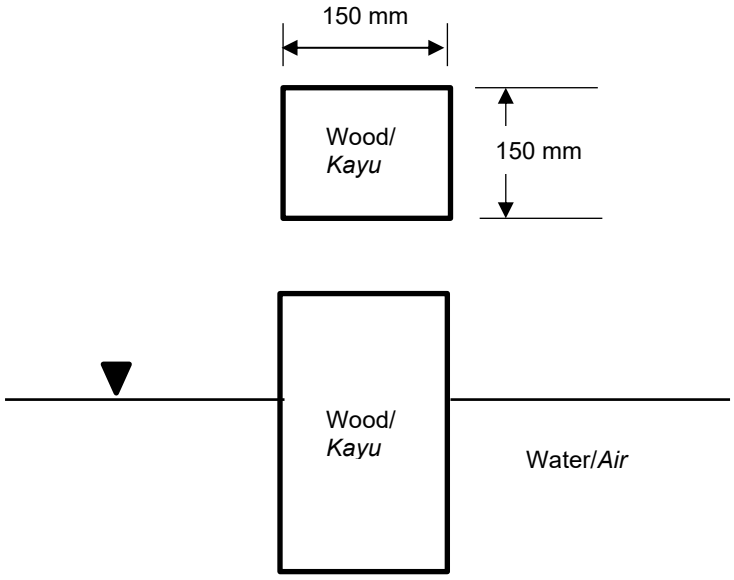


Figure 4/*Rajah 4*

(3). (a). As shown in **Figure 5**, describe the relationship between the potential energy of water (its level) and its kinetic energy (the speed at which it gushes out of the nozzle). What is the requirement for fire engine to fight the blaze?

*Merujuk **Rajah 5**, huraikan hubungan antara tenaga potensi (paras air) dan tenaga kinetik (kelajuan ketika ia keluar dari muncung). Apakah keperluan Bomba untuk melawan kebakaran?*

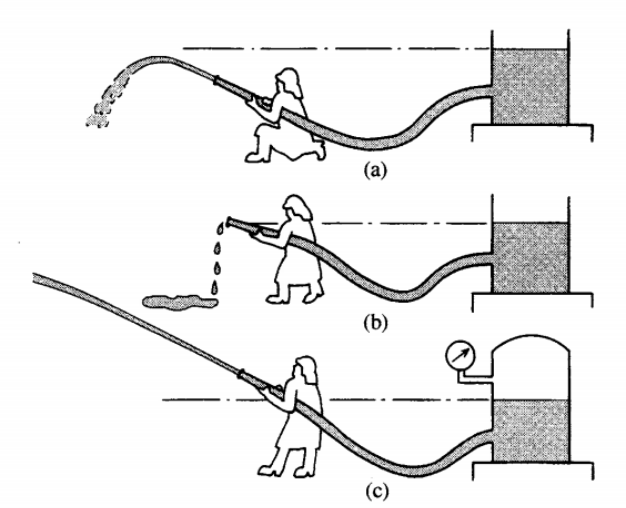


Figure 5: Conservation of Fluid Energy
Rajah 5: Keabadian Tenaga Bendalir

[4 marks/*markah*]

(b). A jet of water with flow rate Q and diameter *d* strikes the stationary plate at angle θ as shown in **Figure 6**. If θ = 60°, d = 25 mm and Q = 120 L/s, determine Q_1, Q_2 and F.

*Jet air dengan kadar aliran Q dan diameter d menghentam plat pegun pada sudut θ seperti yang ditunjukkan dalam **Rajah 6**. Jika θ = 60 °, d = 25 mm dan Q =120 L/ s, tentukan Q_1, Q_2 dan F.*

(i). Calculate the force on this stationary plate and its stationary direction.

Kirakan daya pada plat pegun ini dan arah pegunnya.

(ii). Calculate the force on a moving plate of 30% of the jet velocity (in x-direction to the right)

Kirakan daya pada plat bergerak 30% daripada halaju jet (pada arah kanan x)

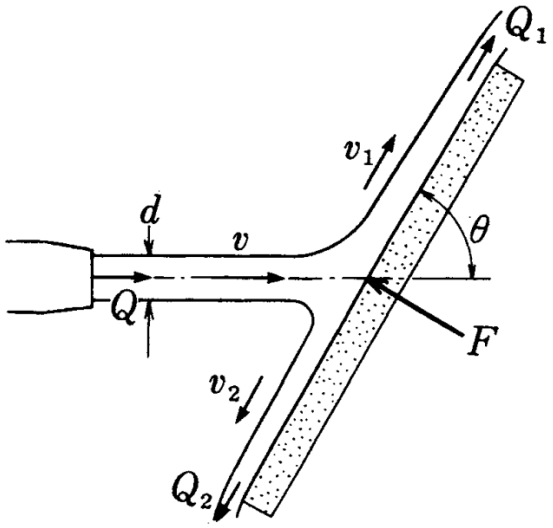


Figure 6: Water jet hits a stationary plate
Rajah 6: Hentaman jet air ke atas plat pegun

[16 marks/*markah*]

(4). (a). By using Bernoulli equation, prove that the V_B is equal to square root of 2gH ($V_B = \sqrt{2gH}$) as shown in **Figure 7**. Please state all your assumptions.

*Dengan menggunakan persamaan Bernoulli, buktikan bahawa V_B adalah sama dengan punca kuasa dua 2gH ($V_B = \sqrt{2gH}$) seperti dalam **Rajah 7**. Sila nyatakan semua andaian anda.*

[4 marks/*markah*]

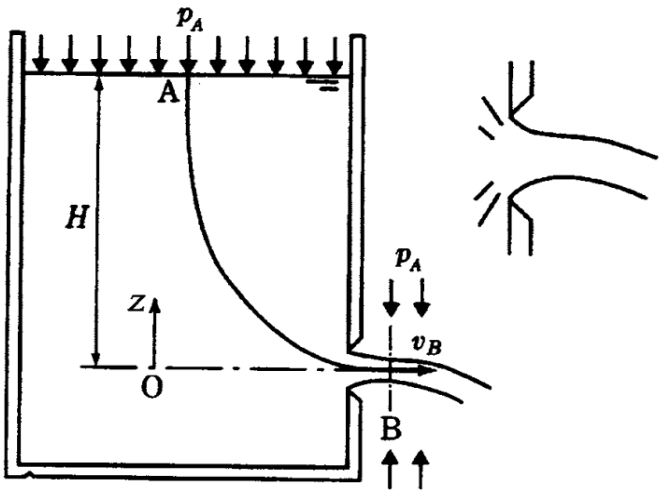


Figure 7: Torricelli's theorem of flow through a small hole

Rajah 7: Teori Torricelli bagi aliran melalui lubang halus

(b). Determine the time needed for the water surface in the tank to drop from H_1 = 300 cm to H_2 = 50 cm as shown in **Figure 8.** (Hint: The outflow velocity is not linear to the depth; however, average velocity represents the mean value.)

*Tentukan masa yang diperlukan agar permukaan air di dalam tangki akan susut dari H_1 = 300 sm hingga H_2 = 50 sm seperti yang ditunjukkan dalam **Rajah 8.** (Petunjuk: Halaju aliran keluar tidak lelurus dengan kedalaman; Walau bagaimanapun, halaju purata mewakili nilai purata.)*

[6 marks/*markah*]

...8/-

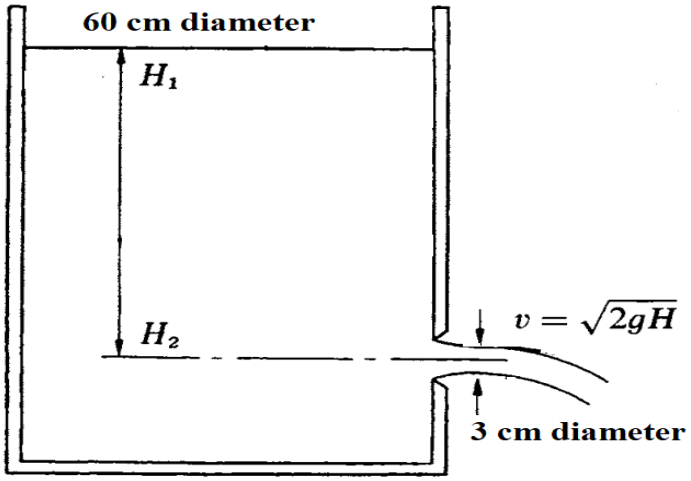


Figure 8: Water surface drop due to a small hole

Rajah 8: Susutan aras permukaan air disebabkan oleh lubang halus

(c). A sluice gate is used to control the water flow rate as shown in **Figure 9**. The gate is 10 meter wide. Calculate the flow rate under the sluice gate and the force on the gate. Please state all your assumptions.

*Pintu sluis digunakan untuk mengawal kadar aliran air seperti yang ditunjukkan dalam **Rajah 9**. Pintu tersebut adalah 10 meter lebar. Hitung kadar aliran di bawah pintu sluis dan daya terhadap pintu tersebut. Sila nyatakan semua andaian anda.*

[10 marks/*markah*]

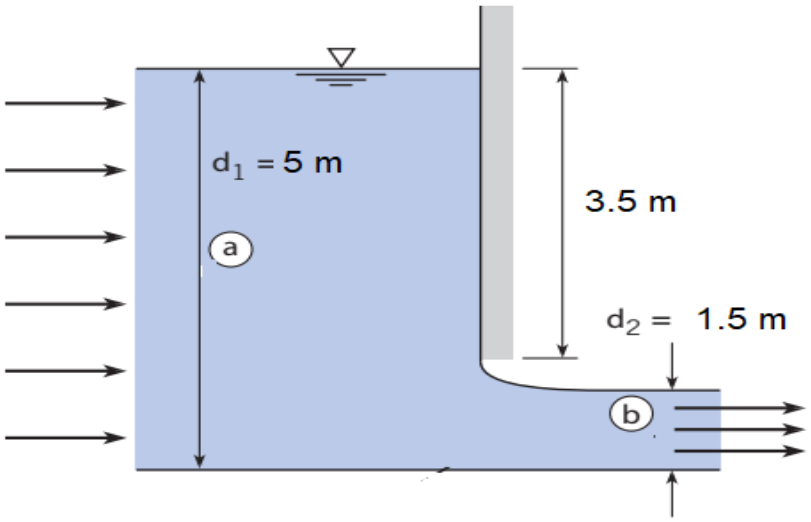
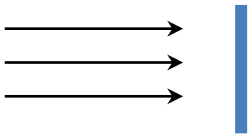


Figure 9: Flow through sluice gate
Rajah 9: Aliran melalui pintu sluis

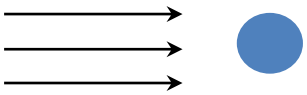
(5). (a). The flow around blunt and streamlined bodies will affect pressure drag and friction drag and ultimately produce different types of wakes. Using a diagram in **Figure 10 (i) to (iv)**, distinguish and sketch the resulting pressure drag, friction drag and the resulting wake on each of the following shape:

*Aliran di sekeliling badan yang tumpul dan badan garis arus akan menjejaskan daya tekanan seretan dan daya seret geseran yang akhirnya menghasilkan pelbagai jenis keracak. Menggunakan rajah dalam **Rajah 10 (i) ke (iv)**, bezakan dan lakarkan daya tekanan seretan, daya seret geseran dan keracak yang terhasil bagi setiap bentuk berikut:*

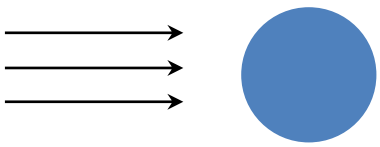
(i).



(ii).



(iii).



(iv).

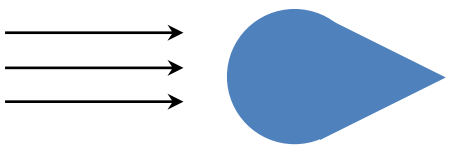


Figure 10 / *Rajah 10*

[8 marks/*markah*]

(b). Body of any shape will experience forces and moments when immersed in a fluid stream. Consider a square pile 50 cm x 50 cm that is driven into a river bed with exposed stump pile to the flow of 1.2 m. It is given that the velocity of the flow is 2.5 m/s with the temperature of 15° C. Determine the drag force and the bending moment at the bottom of the stump.

Semua bentuk jasad akan mengalami daya dan momen apabila ditenggelamkan dalam aliran bendalir. Pertimbangkan satu cerucuk segi empat tepat 50 sm x 50 sm yang akan dibenamkan ke dasar sungai dengan panjang tunggul cerucuk yang terdedah kepada aliran ialah 1.2 m. Diberi halaju aliran sungai adalah 2.5 m/s dengan suhu 15 °C. Tentukan daya seret dan momen lentur di bahagian tunggul cerucuk.

[8 marks/*markah*]

(c). A pipe of 30 m long with diameter of the pipe 25 mm is to be laid across a river. The temperature of the river is 15° C. The flow of the river is 3.5 m/s. Determine the drag force exerted on the pipe by the river flow.

Sebatang paip 30 m panjang dengan diameter 25 mm merentasi sebatang sungai. Suhu sungai ialah 15° C. Halaju aliran sungai ialah 3.5 m/s. Tentukan daya seret yang dikenakan terhadap paip oleh aliran sungai tersebut.

[4 marks/*markah*]

(6). (a). Flow measurement refers to the ability to measure velocity, volume flowrate or mass flow rate of any liquid or gas. Explain the difference between variable-head meters and variable-area meters. With the aid of a diagram, explain the mechanism for these meters:

Pengukuran aliran merujuk kepada keupayaan untuk mengukur halaju, kadar aliran isipadu atau kadar aliran jisim sebarang cecair atau gas. Terangkan perbezaan antara meter berubah tekanan dan meter berubah luas. Dengan bantuan gambar rajah, terangkan mekanisma meter ini:

(i). Orifice flowmeter
Meter aliran orifis

(ii). Magnetic flowmeter
Meter aliran magnetik

[4 marks/*markah*]

(b). Flow in an open channel can be determined using overflow weir. By applying contuinity and energy equations, prove that flowrate for a broad-crested weir can be determined using the following equation:

Aliran di saluran terbuka boleh ditentukan dengan menggunakan empang limpah. Dengan menggunakan persamaan keselanjaran dan tenaga, buktikan bahawa kadar alir untuk empang limpah puncak lebar boleh ditentukan menggunakan persamaan berikut:

$$Q_{ideal} = b\sqrt{g}\left(\frac{2}{3}\right)^{\frac{3}{2}}\left(H + \frac{V_1^2}{2g}\right)^{\frac{3}{2}}$$

where,
dimana,

Q = Discharge */ kadar alir*
B = Length of the weir */ panjang empang limpah*
H = Head over the weir / *Tekanan di atas empang limpah*
V = Velocity / *halaju*

[10 marks/*markah*]

(c). An alternative of measuring flow is by using a sharp-crested weir. A rectangular sharp-crested weir is to be constructed in a testing flume. The minimum head to be measured is 50 mm and the maximum head on the weir should not exceed one-third of its length. The minimum and maximum discharge in the channel is 55 *L/s* and 1260 *L/s* respectively. Determine the suitable length of the weir.

Alternatif bagi mengukur kadar alir adalah dengan menggunakan empang limpah puncak. Empang limpah segi empat tepat puncak tajam perlu dibina dalam salur pengujian. Turus tekanan minimum yang diukur adalah 50 mm dan turus tekanan maksimum di atas puncak tidak boleh melebihi satu pertiga daripada panjangnya. Diberi kadar alir minimum dan maksimum dalam saluran itu masing-masing adalah 55 L/s dan 1260 L/s. Tentukan panjang yang sesuai bagi empang limpah.

[6 marks/*markah*]

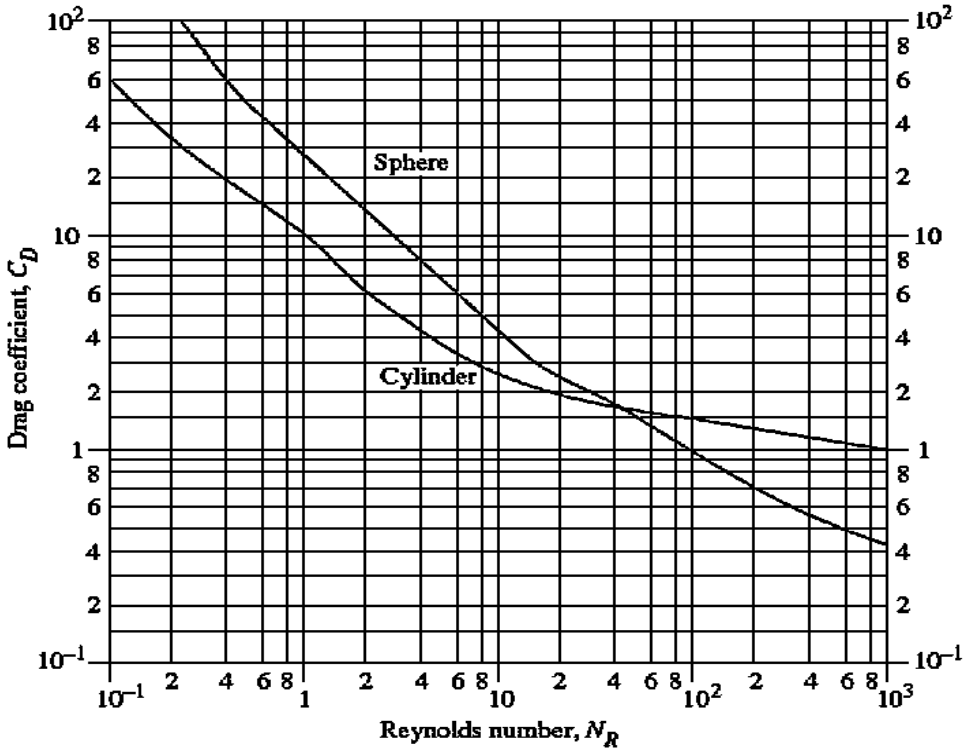
APPENDIX/ *LAMPIRAN*

Table 1 – Properties of Water

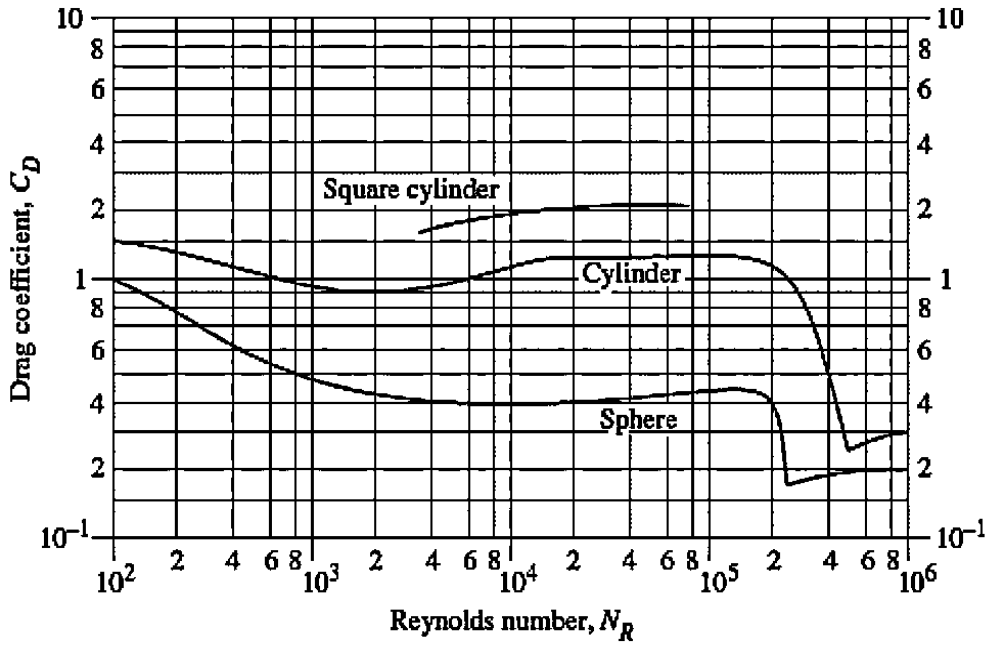
TABLE A.1 SI units [101 kPa (abs)]

Temperature (°C)	Specific Weight γ (kN/m^3)	Density ρ (kg/m^3)	Dynamic Viscosity η (Pa·s)	Kinematic Viscosity ν (m^2/s)
0	9.81	1000	1.75×10^{-3}	1.75×10^{-6}
5	9.81	1000	1.52×10^{-3}	1.52×10^{-6}
10	9.81	1000	1.30×10^{-3}	1.30×10^{-6}
15	9.81	1000	1.15×10^{-3}	1.15×10^{-6}
20	9.79	998	1.02×10^{-3}	1.02×10^{-6}
25	9.78	997	8.91×10^{-4}	8.94×10^{-7}
30	9.77	996	8.00×10^{-4}	8.03×10^{-7}
35	9.75	994	7.18×10^{-4}	7.22×10^{-7}
40	9.73	992	6.51×10^{-4}	6.56×10^{-7}
45	9.71	990	5.94×10^{-4}	6.00×10^{-7}
50	9.69	988	5.41×10^{-4}	5.48×10^{-7}
55	9.67	986	4.98×10^{-4}	5.05×10^{-7}
60	9.65	984	4.60×10^{-4}	4.67×10^{-7}
65	9.62	981	4.31×10^{-4}	4.39×10^{-7}
70	9.59	978	4.02×10^{-4}	4.11×10^{-7}
75	9.56	975	3.73×10^{-4}	3.83×10^{-7}
80	9.53	971	3.50×10^{-4}	3.60×10^{-7}
85	9.50	968	3.30×10^{-4}	3.41×10^{-7}
90	9.47	965	3.11×10^{-4}	3.22×10^{-7}
95	9.44	962	2.92×10^{-4}	3.04×10^{-7}
100	9.40	958	2.82×10^{-4}	2.94×10^{-7}

...14/-



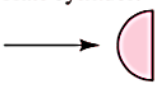
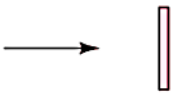
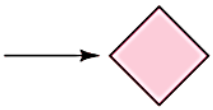
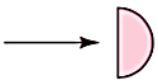
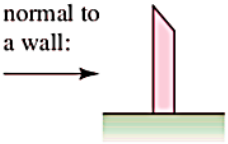
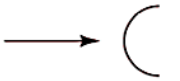
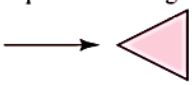
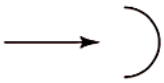
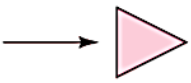
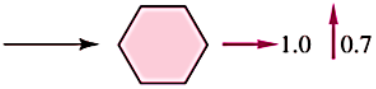
(a) C_D vs. N_R for lower values of N_R



(b) C_D vs. N_R for higher values of N_R

Drag coefficients for spheres and cylinders

...15/-

Shape	C_D based on frontal area	Shape	C_D based on frontal area	Shape	C_D based on frontal area
Square cylinder:		Half cylinder:		Plate:	
	2.1		1.2		2.0
	1.6		1.7	Thin plate normal to a wall:	
Half tube:		Equilateral triangle:			1.4
	1.2		1.6	Hexagon:	
	2.3		2.0		1.0 0.7

Drag coefficients for spheres and cylinders ($Re \geq 10^4$)

Moment/*Momen*

$$M = \frac{FL}{2}$$

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