KOLEJ YAYASAN PELAJARAN JOHOR
FINAL EXAMINATION

COURSE NAME	:	**FLUID MECHANICS**
COURSE CODE	:	**DKM 2122**
EXAMINATION	:	**MEI 2017**
DURATION	:	**2 HOURS**

INSTRUCTION TO CANDIDATES

1. This examintaion paper consists **FIVE (5)** questions.
   Answer **FOUR (4)** questions only Answer Booklet.

2. Candidates are not allowed to bring any material to examination room except with the permission from the invigilator.

3. Please check to make sure that this examination pack consist of:
   i. Question Paper
   ii. Answer Booklet

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This examination paper consists of 8 printed pages including front page

QUESTION 1/ *SOALAN 1*

a. A tank contains 135 000 liters of a hydraulic fluid having a specific gravity of 0.9. Determine the fluid's specific weight, density and weight.
Sebuah tangki mengandungi 135 000 liter cecair hidraulik yang mempunyai graviti tentu 0.9. Tentukan berat tentu, ketumpatan dan berat bagi bendalir itu.

(7 marks/ *markah*)

b. In **figure 1** below, the moving plate is 0.7 m on a side (in contact with the oil) and the oil film is 4 mm thick. A 6 N force is required to move the plate at a velocity of 1 m/s. If the oil has specific gravity of 0.9, find the kinematic viscosity.
*Pada **rajah 1** di bawah, sebuah plat yang sedang bergerak mempunyai 0.5 m untuk setiap sisi (bersentuhan dengan mintak) dan ketebalan filem minyak sebanyak 6 mm. Daya sebanyak 9 N diperlukan untuk menggerakkan plat itu pada halaju 1.4 m/s. Jika graviti tentu minyak itu sebanyak 0.9, kirakan kelikatan kinematik bagi minyak itu.*

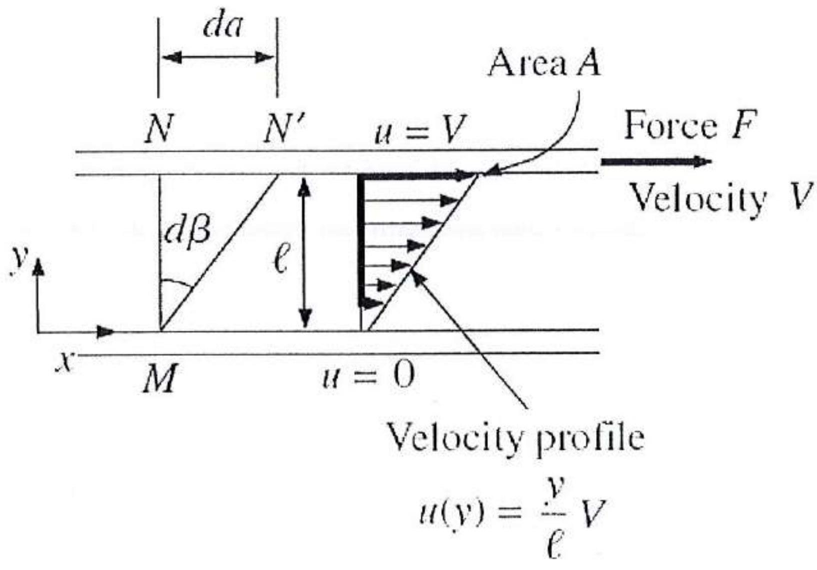


Figure 1/ *Rajah 1*

(8 marks/ *markah*)

[15 MARKS/ *15 MARKAH*]

QUESTION 2/ *SOALAN 2*

a. State Pascal's Law

Nyatakan Hukum Pascal

(3 marks/ *markah*)

b. What is the continuity equation, and what are its implications relative to fluid flow?

Apakah persamaan keterusan, dan apakah implikasinya terhadap aliran cecair?

(5 marks/ *markah*)

c. For the pressure booster of **figure 2** below, the following data are given:

Inlet oil pressure(p1)	= 2 Mpa
Air piston area (A1)	= 0.02 m^2
Oil piston area (A2)	= 0.0014 m^2
Load carrying capacity	= 246 732 N

Find the required load piston area, A3.

Penggalak tekanan pada ***rajah 2*** *di bawah mempunyai butiran data seperti berikut:*

Tekanan minyak masuk (p1)	*= 2 Mpa*
Luas omboh udara (A1)	*= 0.02 m^2*
Luas omboh minyak (A2)	*= 0.0014 m^2*
Beban yang mempunyai kapasiti	*= 246 732 N*

Kirakan luas omboh pada A3.

(7 marks/ *markah*)

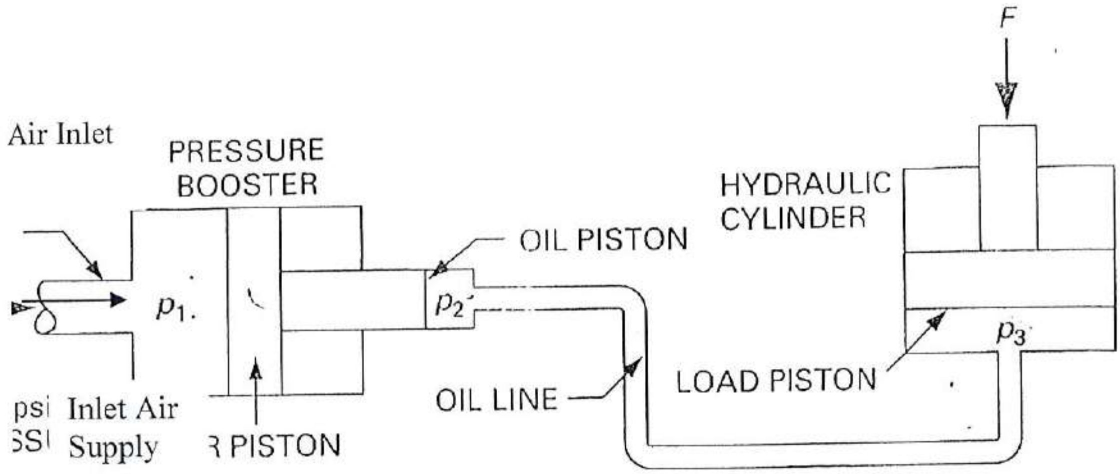


Figure 2/ *Rajah 2*

[15 MARKS/ *15 MARKAH*]

QUESTION 3/ *SOALAN 3*

a. What is the drag force.
Apakah itu daya seretan.

(3 marks/ *markah*)

b. A car travels with the speed of 90 km/h is having a drag coefficient as 0.26. If the area of cross section is 5 m^2, given the density of fluid is 1.2 kg/m^3, calculate the drag force.
Sebuah kereta bergerak dengan kelajuan 90 km / h mempunyai pekali seretan sebanyak 0.26. Jika luas keratan rentas sebanyak 5 m^2, *diberi ketumpatan bendalir ialah 1.2* kg/m^3, *kirakan daya seretannya?*

(3 marks/ *markah*)

c. What is the definition of pathline and streamline? How do pathlne and streamline indicate?
Apakah yang dimaksudkan dengan 'pathline' dan 'streamline'? Bagaimana 'pathlne' dan 'streamline' dikenalpasti?

(4.5 marks/ *markah*)

d. What is the definition of a streakline? How do streakline differ from streamlines?
Apakah yang dimaksudkan dengan 'streakline'? Bagaimana 'streakline' berbeza daripada 'streamline'?

(4.5 marks/ *markah*)

[15 MARKS/ *15 MARKAH*]

QUESTION 4/ *SOALAN 4*

a. Oil , with p= 900 kg/m³ and μ= 5.1366 x 10 $^{-3}$ kg/m.s, flows at 0.2 m³/s through 500m of 0.13 m diameter cast iron pipe. Determine

i. The head loss

(11 marks/ *markah*)

ii. The pressure drop if the pipe slopes down at 10 ° in the flow direction.

(4 marks/ *markah*)

Minyak dengan p= 900 kg/m³ dan μ= 5.1366 x 10 $^{-3}$ kg/m.s, *aliran pada 0.2 m³/s melalui 500 m dan paip daripada besi tuang berdiameter* 0.13 m. *Tentukan*

i. Kehilangan turus

ii. Penurunan tekanan jika kecerunan paip menurun pada 10 ° bagi aliran bendalir itu.

[15 MARKS/ *15 MARKAH*]

QUESTION 5/ *SOALAN 5*

a. Explain the meaning of Bernoulli's equation and how it effects the flow of a liquid in a hydraulic circuit.
Terangkan maksud persamaan Bernoulli dan bagaimana ia memberi kesan kepada aliran cecair di dalam litar hidraulik.

(3 marks/*markah*)

b. Defined what is the mechanical energy.
Berikan maksud apakah itu tenaga mekanikal.

(3 marks/ *markah*)

c. In a hydroelectric power plant, 100m^3/s of water flows from an elevation of 120 m to a turbine, where electric power is generated as shown in **figure 3**, the total irreversible head loss in the piping system from point 1 to point 2 (excluding the turbine unit) is determined to be 35 m. If the overall efficiency of the turbine- generated is 80 percent, estimate the elctric power output.

*Dalam loji kuasa hidroelektrik, 100m^3 / s air mengalir dari ketinggian 120 m kepada turbin, di mana kuasa elektrik dihasilkan seperti yang ditunjukkan dalam **Rajah 3**, jumlah kehilangan keturusan yang tidak berbalik di dalam sistem perpaipan dari titik 1 ke titik 2 (tidak termasuk unit turbin) ditentukan sebanyak 35 m. Jika kecekapan keseluruhan turbine adalah 80 peratus, anggarkan elektrik kuasa output.*

(9 marks/ *markah*)

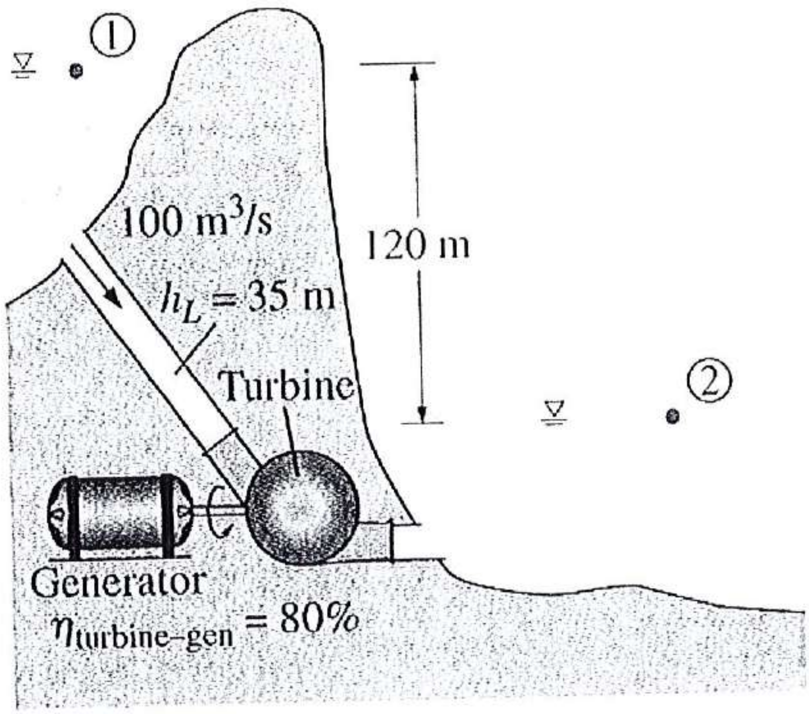


Figure 3/ *Rajah 3*

[15 MARKS/ *15 MARKAH*]

END OF QUESTION PAPER/ *KERTAS SOALAN TAMAT*

$Ma = \frac{V}{c} = \frac{Speed\ of\ flow}{speed\ of\ sound}$

$\rho = m / V$

$\gamma = \frac{W}{V}$

$\gamma = \rho\, a_g$

$SG = \rho_{substance} / \rho_{H2O}$

$SG = \frac{\gamma oil}{\gamma water}$

$c_p = c_v$

$Q = c_p\, m\, dT$

$W = F\, l$

$W = p\, A\, l$

$W = F_g\, h$

$W = (v_2^2 - v_1^2)\, m / 2$

$E_k = 1/2\, m\, v^2$

$EV = \frac{-\Delta p}{\Delta V / v}$

$\mu = \frac{\tau}{v/y} = \frac{F/A}{v/y}$

$v = \frac{\mu}{\rho}$

$\sigma_s = \frac{F}{2b}$

$W = \text{Force} \times \text{Distance} = F\,\Delta x = 2b\sigma_s\,\Delta x = \sigma_s\,\Delta A$

$P = \frac{F}{A}$

$p_A = p_G + p_{atm}$

$p = \rho g h$

$P_{total} = P_{atmosphere} + P_{fluid}$

$P_{total} = P_{atmosphere} + (\rho g h)$

$p = \frac{F}{A}$

$p = \frac{\gamma h A}{A} = \gamma h$

$pA = \gamma\, Ah$

$p = \gamma h = \rho g h$

$\gamma = \rho g$

$P_1 = P_2 \quad \rightarrow \quad \frac{F_1}{A_1} = \frac{F_2}{A_2} \quad \rightarrow \quad \frac{F_2}{F_1} = \frac{A_2}{A_1}$

$p_1 = p_2$

$F_R = (P_0 + \rho g y_C \sin\theta)A = (P_0 + \rho g h_C)A = P_C A = P_{avg} A$

$y_P = y_C + \frac{I_{xx,C}}{[y_C + P_0/(\rho g \sin\theta)]A}$

$y_P = y_C + \frac{I_{xx,C}}{y_C A}$

$F_B = F_{bottom} - F_{top} = \rho_f g(s + h)A - \rho_f g s A = \rho_f g h A = \rho_f g V$

$F_B = W \rightarrow \rho_f g V_{sub} = \rho_{avg,body} g V_{total} \rightarrow \frac{V_{sub}}{V_{total}} = \frac{\rho_{avg,body}}{\rho_f}$

$MB = \frac{1}{Vd}$

Reynolds No < 2300

2300 <Re. No < 4000

Reynolds No. > 4000

$Ma = \frac{V}{c} = \frac{\text{Speed of flow}}{\text{Speed of sound}}$

$c = \sqrt{kRT}$

$\frac{P}{\rho} + \frac{V^2}{2} + gz = \text{constant (along a streamline)}$

$\frac{P_1}{\rho} + \frac{V_1^2}{2} + gz_1 = \frac{P_2}{\rho} + \frac{V_2^2}{2} + gz_2$

$\frac{P}{\rho g} + \frac{V^2}{2g} + z = H = \text{constant} \quad \text{(along a streamline)}$

$Z_1 + \frac{p1}{\gamma} + \frac{v1}{2g} + H_p - H_m - H_L = Z_2 + \frac{p2}{\gamma} + \frac{v2}{2g}$

$$\dot{m} = \rho V A_C = \rho \dot{V}$$

$$\dot{V} = VA$$

$$Q = AV$$

$$p = \gamma H$$

$$H_p = \frac{\text{Pump hydraulic power } (W)}{\gamma\left(\frac{N}{m^3}\right) x\, Q\left(\frac{m^3}{s}\right)}$$

Hydraulic power (W) = p (N/m²) x Q (m³/s)

$$\dot{m} = \rho V_{avg} A_c = \int_{A_c} \rho u(r)\, dA_c$$

$$V_{avg} = \frac{\int_{A_c} \rho u(r)\, dA_c}{\rho A_c} = \frac{\int_0^R \rho u(r) 2\pi r\, dr}{\rho \pi R^2} = \frac{2}{R^2}\int_0^R u(r) r\, dr$$

$$\text{Re} = \frac{\text{Inertial forces}}{\text{Viscous forces}} = \frac{V_{avg} D}{\nu} = \frac{\rho V_{avg} D}{\mu}$$

$$D_h = \frac{4A_c}{p}$$

$$\frac{\partial u(r, x)}{\partial x} = 0 \quad \rightarrow \quad u = u(r)$$

$$\frac{L_{h,\text{ laminar}}}{D} \cong 0.05\text{Re}$$

$$\frac{L_{h,\text{ turbulent}}}{D} = 1.359\text{Re}^{1/4}$$

$$\frac{L_{h,\text{ turbulent}}}{D} \approx 10$$

$$\frac{dP}{dx} = \frac{P_2 - P_1}{L}$$

Laminar flow: $\Delta P = P_1 - P_2 = \frac{8\mu L V_{avg}}{R^2} = \frac{32\mu L V_{avg}}{D^2}$

$$\Delta P_L = f\frac{L}{D}\frac{\rho V_{avg}^2}{2}$$

$$\rho V_{avg}^2/2$$

$$f = \frac{8\tau_w}{\rho V_{avg}^2}$$

$$f = \frac{64\mu}{\rho D V_{avg}} = \frac{64}{\text{Re}}$$

$$h_L = \frac{\Delta P_L}{\rho g} = f\frac{L}{D}\frac{V_{avg}^2}{2g}$$

$$\dot{W}_{\text{pump},L} = \dot{V}\Delta P_L = \dot{V}\rho g h_L = \dot{m} g h_L$$

$$V_{avg} = \frac{(P_1 - P_2)R^2}{8\mu L} = \frac{(P_1 - P_2)D^2}{32\mu L} = \frac{\Delta P\, D^2}{32\mu L}$$

$$\dot{V} = V_{avg} A_c = \frac{(P_1 - P_2)R^2}{8\mu L}\pi R^2 = \frac{(P_1 - P_2)\pi D^4}{128\mu L} = \frac{\Delta P\, \pi D^4}{128\mu L}$$

Pressure loss: $\Delta P_L = f\frac{L}{D}\frac{\rho V_{avg}^2}{2}$

Head loss: $h_L = \frac{\Delta P_L}{\rho g} = f\frac{L}{D}\frac{V_{avg}^2}{2g}$

$$\frac{P_1}{\rho g} + \alpha_1\frac{V_1^2}{2g} + z_1 + h_{\text{pump},u} = \frac{P_2}{\rho g} + \alpha_2\frac{V_2^2}{2g} + z_2 + h_{\text{turbine},e} + h_L$$

$$P_1 - P_2 = \rho(\alpha_2 V_2^2 - \alpha_1 V_1^2)/2 + \rho g[(z_2 - z_1) + h_{\text{turbine},e} - h_{\text{pump},u} + h_L]$$

$$W_x = W \sin\theta = \rho g V_{\text{element}} \sin\theta = \rho g(2\pi r\, dr\, dx) \sin\theta$$

$$(2\pi r\, dr\, P)_x - (2\pi r\, dr\, P)_{x+dx} + (2\pi r\, dx\, \tau)_r - (2\pi r\, dx\, \tau)_{r+dr} - \rho g(2\pi r\, dr\, dx)\sin\theta =$$

$$\frac{\mu}{r}\frac{d}{dr}\left(r\frac{du}{dr}\right) = \frac{dP}{dx} + \rho g \sin\theta$$

$$u(r) = -\frac{R^2}{4\mu}\left(\frac{dP}{dx} + \rho g \sin\theta\right)\left(1 - \frac{r^2}{R^2}\right)$$

$$V_{avg} = \frac{(\Delta P - \rho g L \sin\theta)D^2}{32\mu L}$$

$$\dot{V} = \frac{(\Delta P - \rho g L \sin\theta)\pi D^4}{128\mu L}$$

Horizontal pipe: $\dot{V} = \dfrac{\Delta P\, \pi D^4}{128\mu L}$

Inclined pipe: $\dot{V} = \dfrac{(\Delta P - \rho g L \sin\theta)\pi D^4}{128\mu L}$

Uphill flow: $\theta > 0$ and $\sin\theta > 0$

Downhill flow: $\theta < 0$ and $\sin\theta < 0$

$$\frac{1}{\sqrt{f}} = -2.0\log\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{\text{Re}\sqrt{f}}\right)$$

$$\frac{1}{\sqrt{f}} \cong -1.8\log\left[\frac{6.9}{\text{Re}} + \left(\frac{\varepsilon/D}{3.7}\right)^{1.11}\right]$$

$$h_L = 1.07\frac{\dot{V}^2 L}{gD^5}\left\{\ln\left[\frac{\varepsilon}{3.7D} + 4.62\left(\frac{\nu D}{\dot{V}}\right)^{0.9}\right]\right\}^{-2} \qquad \begin{array}{l}10^{-6} < \varepsilon/D < 10^{-2}\\ 3000 < \text{Re} < 3\times 10^8\end{array}$$

$$\dot{V} = -0.965\left(\frac{gD^5 h_L}{L}\right)^{0.5}\ln\left[\frac{\varepsilon}{3.7D} + \left(\frac{3.17\nu^2 L}{gD^3 h_L}\right)^{0.5}\right] \qquad \text{Re} > 2000$$

$$D = 0.66\left[\varepsilon^{1.25}\left(\frac{L\dot{V}^2}{gh_L}\right)^{4.75} + \nu\dot{V}^{9.4}\left(\frac{L}{gh_L}\right)^{5.2}\right]^{0.04} \qquad \begin{array}{l}10^{-6} < \varepsilon/D < 10^{-2}\\ 5000 < \text{Re} < 3\times 10^8\end{array}$$

$$K_L = \frac{h_L}{V^2/(2g)}$$

$$h_L = \Delta P_L/\rho g$$

$$K_L = \Delta P_L/(\rho V^2/2)$$

$$h_L = K_L\frac{V^2}{2g}$$

$$h_L = K_L\frac{V^2}{2g} = f\frac{L_{\text{equiv}}}{D}\frac{V^2}{2g} \;\rightarrow\; L_{\text{equiv}} = \frac{D}{f}K_L$$

$$h_{L,\text{total}} = h_{L,\text{major}} + h_{L,\text{minor}} = \sum_i f_i\frac{L_i}{D_i}\frac{V_i^2}{2g} + \sum_j K_{L,j}\frac{V_j^2}{2g}$$

$$h_{L,\text{total}} = \left(f\frac{L}{D} + \sum K_L\right)\frac{V^2}{2g}$$

$$K_L = \alpha\left(1 - \frac{A_{\text{small}}}{A_{\text{large}}}\right)^2$$

$$h_{L,1} = h_{L,2} \quad\rightarrow\quad f_1\frac{L_1}{D_1}\frac{V_1^2}{2g} = f_2\frac{L_2}{D_2}\frac{V_2^2}{2g}$$

$$\frac{V_1}{V_2} = \left(\frac{f_2}{f_1}\frac{L_2}{L_1}\frac{D_1}{D_2}\right)^{1/2} \quad\text{and}\quad \frac{\dot{V}_1}{\dot{V}_2} = \frac{A_{c,1}V_1}{A_{c,2}V_2} = \frac{D_1^2}{D_2^2}\left(\frac{f_2}{f_1}\frac{L_2}{L_1}\frac{D_1}{D_2}\right)^{1/2}$$

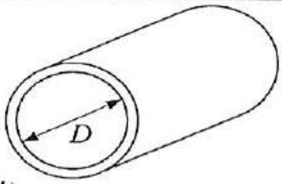
$$\frac{P_1}{\rho g} + \alpha_1\frac{V_1^2}{2g} + z_1 + h_{\text{pump},u} = \frac{P_2}{\rho g} + \alpha_2\frac{V_2^2}{2g} + z_2 + h_{\text{turbine},e} + h_L$$

$$h_{\text{pump},u} = (z_2 - z_1) + h_L$$

$$\dot{W}_{\text{pump, shaft}} = \frac{\rho\dot{V}gh_{\text{pump},u}}{\eta_{\text{pump}}}$$

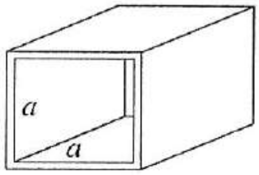
$$\dot{W}_{\text{elect}} = \frac{\rho\dot{V}gh_{\text{pump},u}}{\eta_{\text{pump-motor}}}$$

Circular tube:



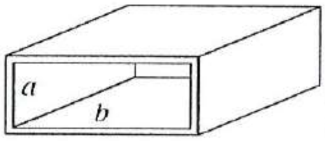
$$D_h = \frac{4(\pi D^2/4)}{\pi D} = D$$

Square duct:



$$D_h = \frac{4a^2}{4a} = a$$

Rectangular duct:



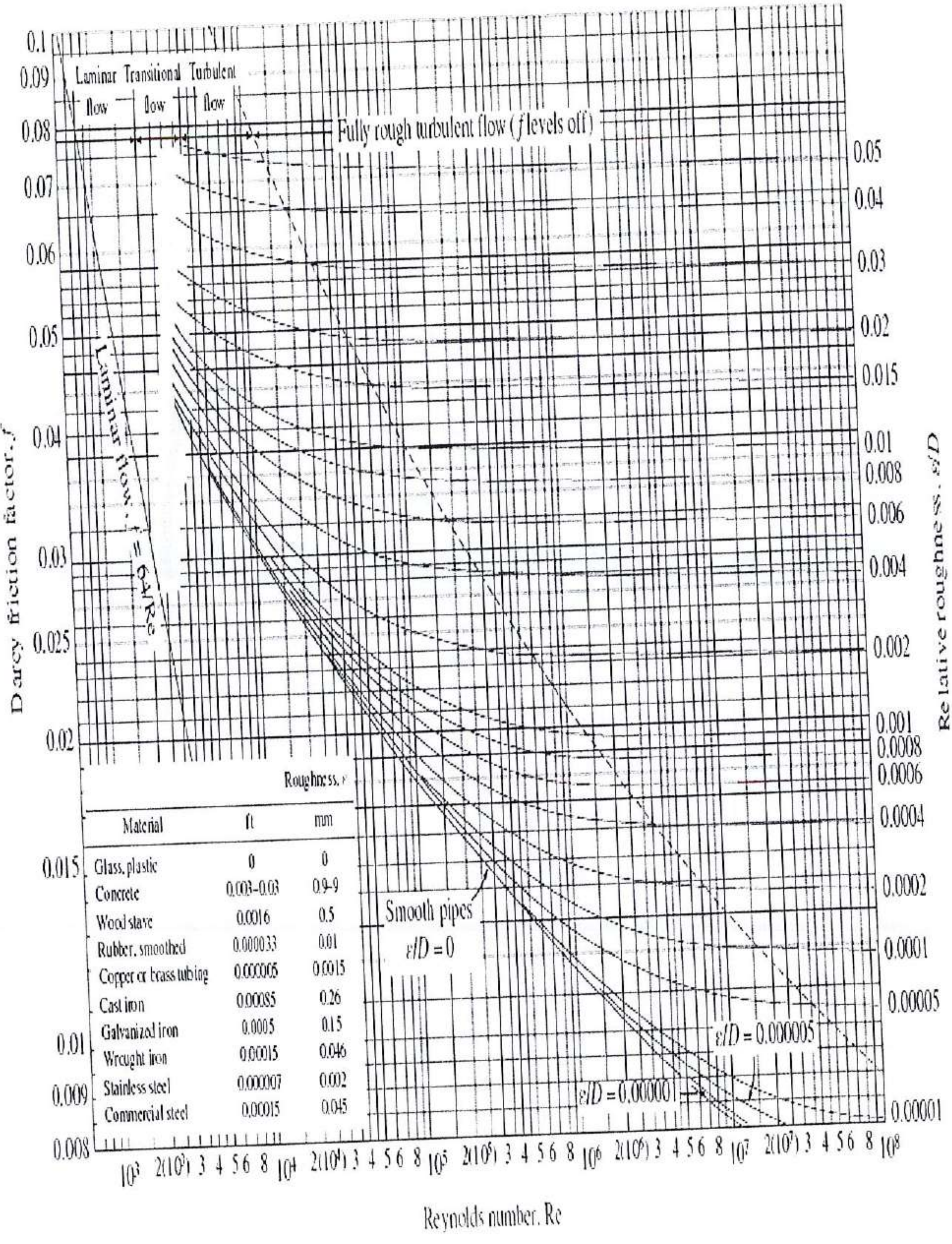
$$D_h = \frac{4ab}{2(a+b)} = \frac{2ab}{a+b}$$

Relative Roughness, ε/D	Friction Factor, f
0.0*	0.0119
0.00001	0.0119
0.0001	0.0134
0.0005	0.0172
0.001	0.0199
0.005	0.0305
0.01	0.0380
0.05	0.0716

* Smooth surface. All values are for Re = 10^6 and are calculated from the Colebrook equation.

Equivalent roughness values for new commercial pipes*

Material	Roughness, ε ft	Roughness, ε mm
Glass, plastic	0 (smooth)	
Concrete	0.003–0.03	0.9–9
Wood stave	0.0016	0.5
Rubber, smoothed	0.000033	0.01
Copper or brass tubing	0.000005	0.0015
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Wrought iron	0.00015	0.046
Stainless steel	0.000007	0.002
Commercial steel	0.00015	0.045



Material	Roughness, ε (ft)	Roughness, ε (mm)
Glass, plastic	0	0
Concrete	0.003–0.03	0.9–9
Wood stave	0.0016	0.5
Rubber, smoothed	0.000033	0.01
Copper or brass tubing	0.000005	0.0015
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
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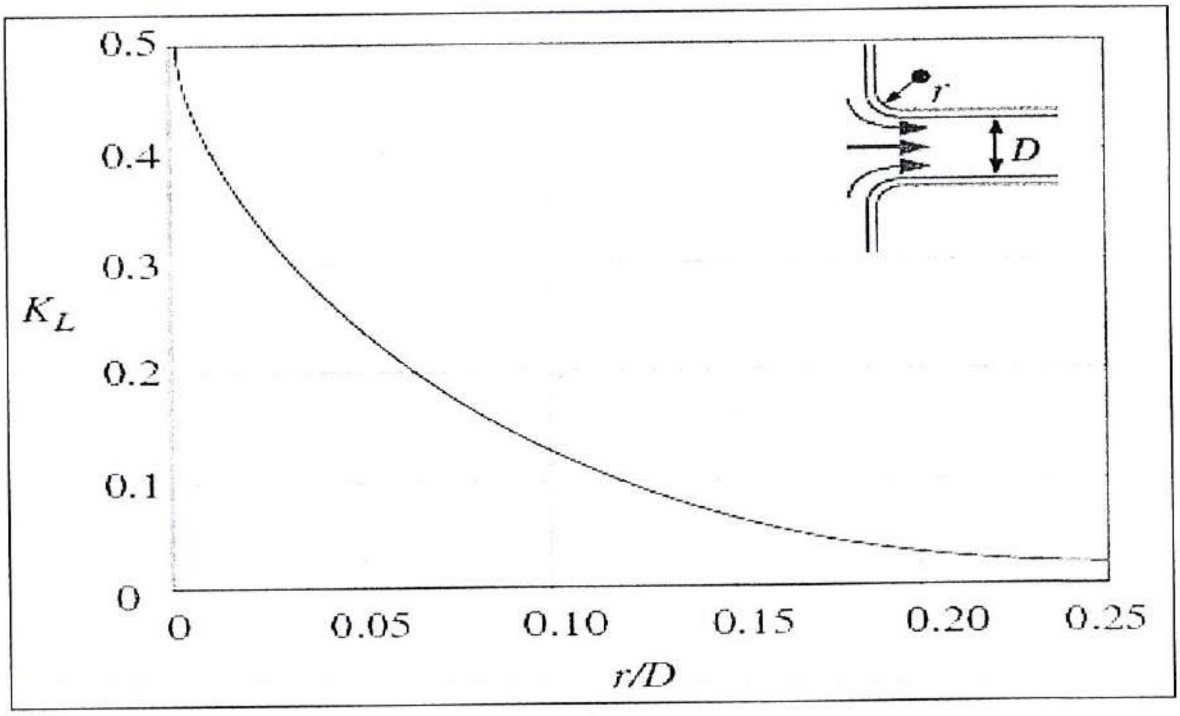
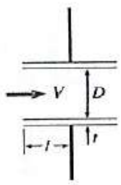


TABLE 14–3

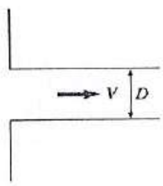
Loss coefficients K_L of various pipe components for turbulent flow (for use in the relation $h_L = K_L V^2/(2g)$, where V is the average velocity in the pipe that contains the component)*

Pipe Inlet

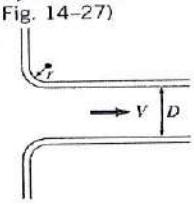
Reentrant: $K_L = 0.80$
($t \ll D$ and $l \approx 0.1D$)



Sharp-edged: $K_L = 0.50$

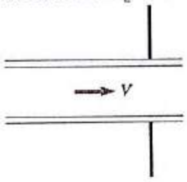


Well-rounded ($r/D > 0.2$): $K_L = 0.03$
Slightly rounded ($r/D = 0.1$): $K_L = 0.12$
(see Fig. 14–27)

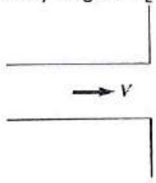


Pipe Exit

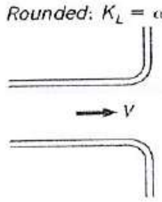
Reentrant: $K_L = \alpha$



Sharp-edged: $K_L = \alpha$



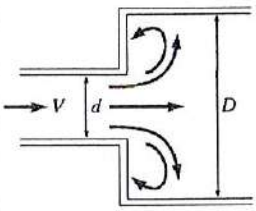
Rounded: $K_L = \alpha$

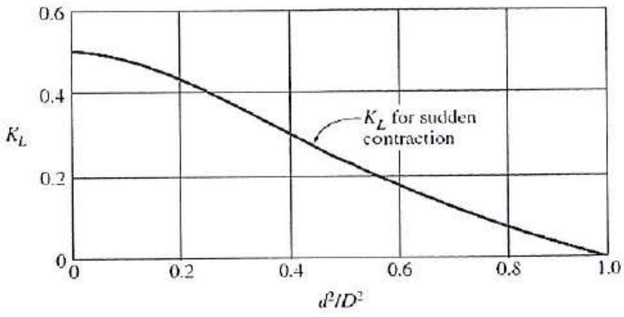


Note: The kinetic energy correction factor is $\alpha = 2$ for fully developed laminar flow, and $\alpha \approx 1.05$ for fully developed turbulent flow.

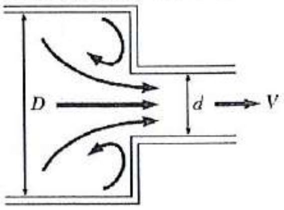
Sudden Expansion and Contraction (based on the velocity in the smaller-diameter pipe)

Sudden expansion: $K_L = \alpha\left(1 - \dfrac{d^2}{D^2}\right)^2$





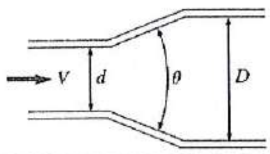
Sudden contraction: See chart.



Gradual Expansion and Contraction (based on the velocity in the smaller-diameter pipe)

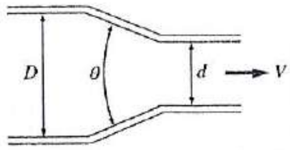
Expansion (for $\theta = 20°$):

$K_L = 0.30$ for $d/D = 0.2$
$K_L = 0.25$ for $d/D = 0.4$
$K_L = 0.15$ for $d/D = 0.6$
$K_L = 0.10$ for $d/D = 0.8$



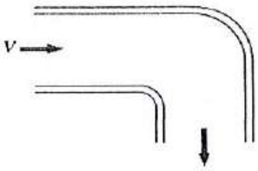
Contraction:

$K_L = 0.02$ for $\theta = 30°$
$K_L = 0.04$ for $\theta = 45°$
$K_L = 0.07$ for $\theta = 60°$

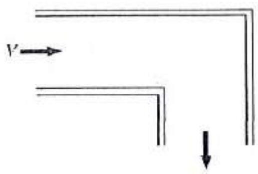


Bends and Branches

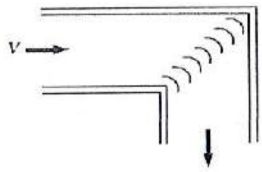
90° smooth bend:
Flanged: $K_L = 0.3$
Threaded: $K_L = 0.9$



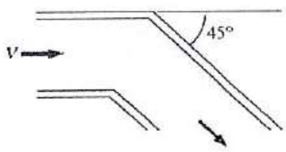
90° miter bend (without vanes): $K_L = 1.1$



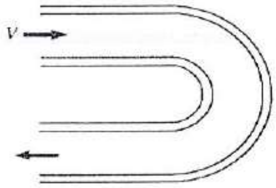
90° miter bend (with vanes): $K_L = 0.2$



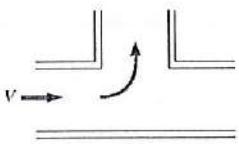
45° threaded elbow: $K_L = 0.4$



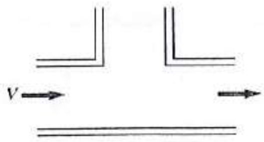
180° return bend:
Flanged: $K_L = 0.2$
Threaded: $K_L = 1.5$



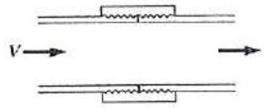
Tee (branch flow):
Flanged: $K_L = 1.0$
Threaded: $K_L = 2.0$



Tee (line flow):
Flanged: $K_L = 0.2$
Threaded: $K_L = 0.9$



Threaded union: $K_L = 0.08$



Valves

Globe valve, fully open: $K_L = 10$
Angle valve, fully open: $K_L = 5$
Ball valve, fully open: $K_L = 0.05$
Swing check valve: $K_L = 2$

Gate valve, fully open: $K_L = 0.2$
$\frac{1}{4}$ closed: $K_L = 0.3$
$\frac{1}{2}$ closed: $K_L = 2.1$
$\frac{3}{4}$ closed: $K_L = 17$

* These are representative values for loss coefficients. Actual values strongly depend on the design and manufacture of the components and may differ from th given values considerably (especially for valves). Actual manufacturer's data should be used in the final design.