UNIVERSITY OF JOHANNESBURG

PROGRAM	: NATIONAL DIPLOMA ENGINEERING: MECHANICAL
SUBJECT	: FLUID MECHANICS III
CODE	: IMF313
DATE	: SSA JUNE EXAMINATION 17 JULY 2019
DURATION	: (SESSION 1) 08:00 – 11:00 (3 HRS)
WEIGHT	: 60% OF FINAL MARK
TOTAL MARKS	: 100 MARKS

Examiner : MR VT. HASHE
Moderator : MR S. SIMELANE

INSTRUCTIONS:

1. PLEASE ANSWER ALL QUESTIONS NEATLY
2. SHOW ALL CALCULATIONS
3. ANSWERS WITHOUT UNITS WILL BE PENALIZED
4. NUMBER YOUR ANSWERS STRICTLY ACCORDING TO THE QUESTION

NUMBER OF PAGES **: 7 (Including cover page and 4 pages of annexures)**

QUESTION 1

Water at 1 atm and 20ºC is transported in a 150 m long circular concrete duct at a rate of 0.35 m^3/s. If the duct length is now doubled while the diameter remains constant at 300 mm and the total head loss is 20 m, determine the drop in the flow rate through the duct. Take the concrete rougness as 1.2 mm. Only use Moody chart.

[20]

QUESTION 2

A 600 m long and 1 m diameter pipe is fitted with a ball valve at the outlet and leads from large water plastic tank. The pipe discharges to the atmosphere and the piezometric head at the inlet end of the pipe is 23 m relative to the outlet level. The head loss through the open ball valve is 10 times the velocity head in the pipe, other minor losses amount to twice the velocity head. If the Darcy friction factor has to be taken as constant at 0.02, estimate the fluid velocity after 12 seconds.

[20]

QUESTION 3

A cylindrical tank 0.9 m diameter is emptied through a 50 mm diameter pipe 3.6 m long (both ends being sharp) for which the friction factor is 0.04. Find the time taken for the fluid level to fall from 2.4 to 1.2 m over the outlet.

[20]

QUESTION 4

A junior engineer is tasked to investigate what happens if a firehose diameter of 60 mm and hose ending nozzle of 20 mm is increased to the diameter of 80 mm and a nozzle of 25 mm. The supply water pressure is maintained at 700 kPa inside the pipe and investigations show that a fireman is currently experiencing a force of 1.6 kN. Do the necessary investigations and briefly report on your finding

[21]

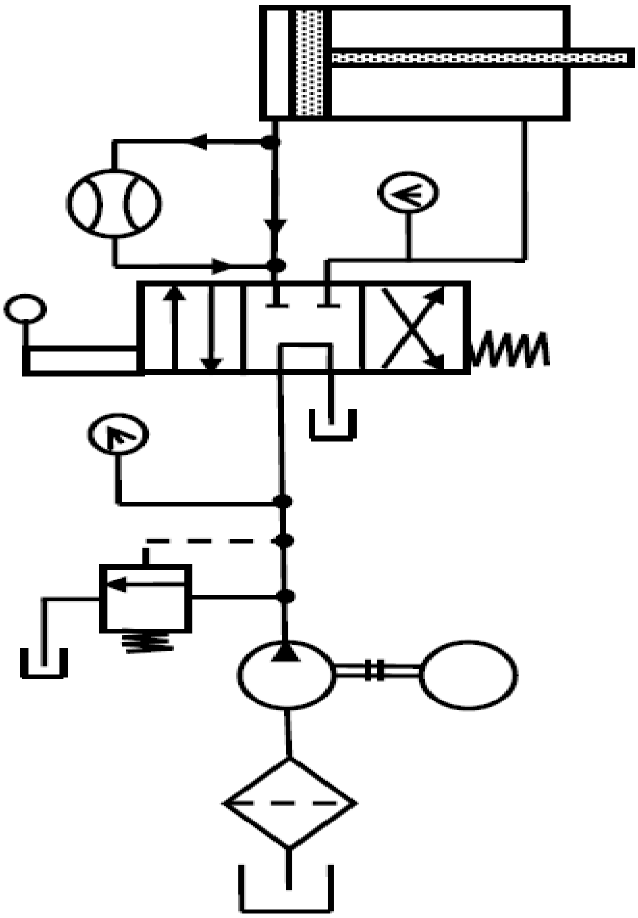
QUESTION 5

Figure 1 shows a circuit diagram for a particular application.

(a) Redraw the circuit and identify the main components (8)

(b) State the type of circuit and (1)

(c) Explain how this circuit functions. (10)



[19]

End

FORMULAS AND ADDITIONAL DATA

$$\mathrm{Re} = \frac{VD}{\nu}$$

$$V = \frac{\dot{V}}{A_c}$$

$$h_L = f\frac{L}{D}\frac{V^2}{2g}$$

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

$F = \dot{m}v$

TABLE A–9

Properties of air at 1 atm pressure

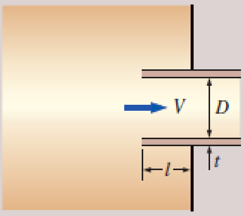
Temp. T, °C	Density ρ, kg/m^3	Specific Heat c_p J/kg·K	Thermal Conductivity k, W/m·K	Thermal Diffusivity α, m^2/s	Dynamic Viscosity μ, kg/m·s	Kinematic Viscosity ν, m^2/s	Prandtl Number Pr
−150	2.866	983	0.01171	4.158×10^{-6}	8.636×10^{-6}	3.013×10^{-6}	0.7246
−100	2.038	966	0.01582	8.036×10^{-6}	1.189×10^{-6}	5.837×10^{-6}	0.7263
−50	1.582	999	0.01979	1.252×10^{-5}	1.474×10^{-5}	9.319×10^{-6}	0.7440
−40	1.514	1002	0.02057	1.356×10^{-5}	1.527×10^{-5}	1.008×10^{-5}	0.7436
−30	1.451	1004	0.02134	1.465×10^{-5}	1.579×10^{-5}	1.087×10^{-5}	0.7425
−20	1.394	1005	0.02211	1.578×10^{-5}	1.630×10^{-5}	1.169×10^{-5}	0.7408
−10	1.341	1006	0.02288	1.696×10^{-5}	1.680×10^{-5}	1.252×10^{-5}	0.7387
0	1.292	1006	0.02364	1.818×10^{-5}	1.729×10^{-5}	1.338×10^{-5}	0.7362
5	1.269	1006	0.02401	1.880×10^{-5}	1.754×10^{-5}	1.382×10^{-5}	0.7350
10	1.246	1006	0.02439	1.944×10^{-5}	1.778×10^{-5}	1.426×10^{-5}	0.7336
15	1.225	1007	0.02476	2.009×10^{-5}	1.802×10^{-5}	1.470×10^{-5}	0.7323
20	1.204	1007	0.02514	2.074×10^{-5}	1.825×10^{-5}	1.516×10^{-5}	0.7309
25	1.184	1007	0.02551	2.141×10^{-5}	1.849×10^{-5}	1.562×10^{-5}	0.7296
30	1.164	1007	0.02588	2.208×10^{-5}	1.872×10^{-5}	1.608×10^{-5}	0.7282
35	1.145	1007	0.02625	2.277×10^{-5}	1.895×10^{-5}	1.655×10^{-5}	0.7268
40	1.127	1007	0.02662	2.346×10^{-5}	1.918×10^{-5}	1.702×10^{-5}	0.7255
45	1.109	1007	0.02699	2.416×10^{-5}	1.941×10^{-5}	1.750×10^{-5}	0.7241
50	1.092	1007	0.02735	2.487×10^{-5}	1.963×10^{-5}	1.798×10^{-5}	0.7228
60	1.059	1007	0.02808	2.632×10^{-5}	2.008×10^{-5}	1.896×10^{-5}	0.7202
70	1.028	1007	0.02881	2.780×10^{-5}	2.052×10^{-5}	1.995×10^{-5}	0.7177

TABLE 8–4

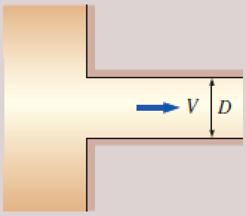
Loss coefficients K_L of various pipe components for turbulent flow (for use in the relation $h_L = K_L V^2/(2g)$, where V is the average velocity in the pipe that contains the component)*

Pipe Inlet

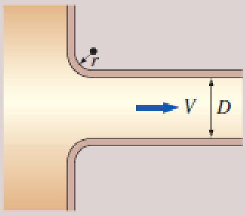
Reentrant: $K_L = 0.80$
($t \ll D$ and $l \approx 0.1D$)



Sharp-edged: $K_L = 0.50$

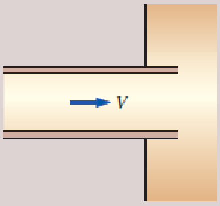


Well-rounded ($r/D > 0.2$): $K_L = 0.03$
Slightly rounded ($r/D = 0.1$): $K_L = 0.12$
(see Fig. 8–39)

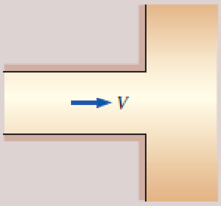


Pipe Exit

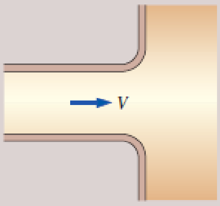
Reentrant: $K_L = \alpha$



Sharp-edged: $K_L = \alpha$



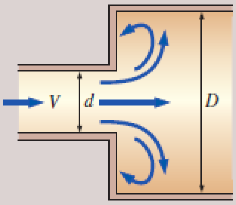
Rounded: $K_L = \alpha$



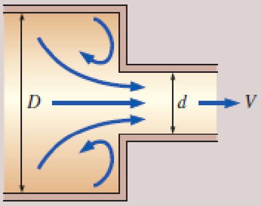
Note: The kinetic energy correction factor is $\alpha = 2$ for fully developed laminar flow, and $\alpha \approx 1.05$ for fully developed turbulent flow.

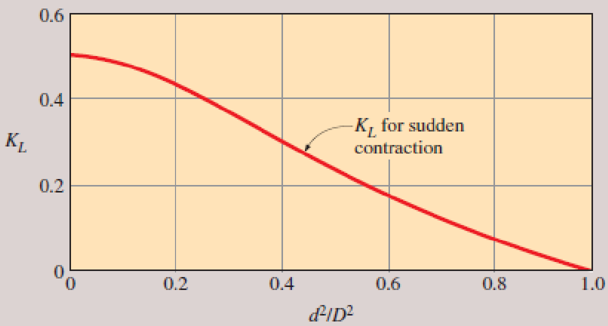
Sudden Expansion and Contraction (based on the velocity in the smaller-diameter pipe)

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



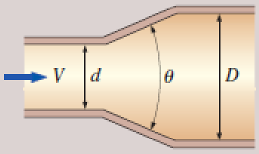
Sudden contraction: See chart.



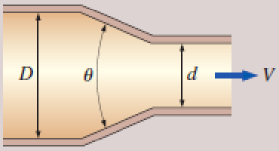


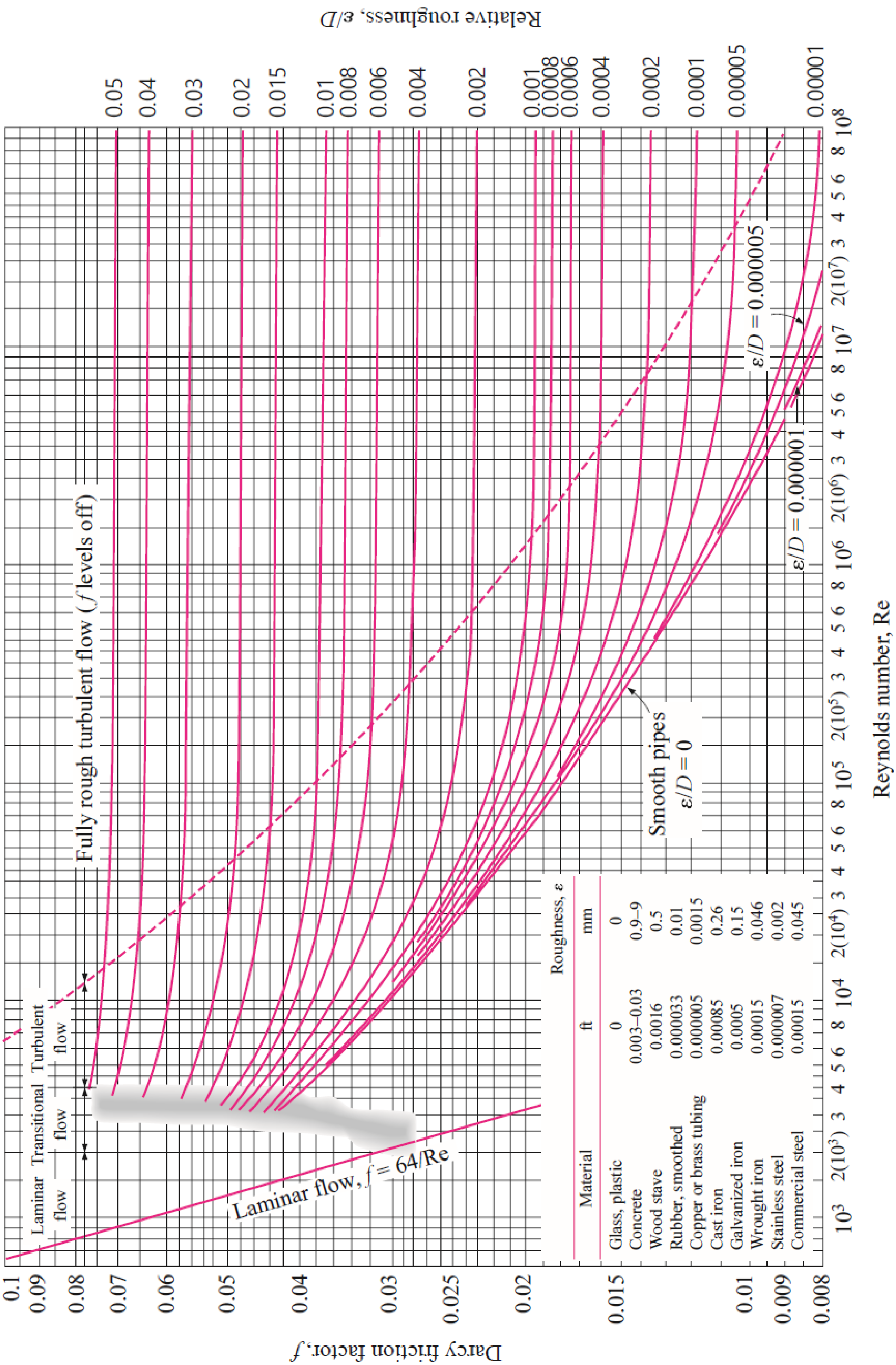
Gradual Expansion and Contraction (based on the velocity in the smaller-diameter pipe)

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 $\theta = 60°$




Relative roughness, ε/D
Darcy friction factor, f
Reynolds number, Re
Fully rough turbulent flow (f levels off)
Laminar flow
Transitional flow
Turbulent flow
Laminar flow, f = 64/Re
Smooth pipes ε/D = 0
ε/D = 0.000005
ε/D = 0.000001
Roughness, ε
Material | ft | 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
Wrought iron | 0.00015 | 0.046
Stainless steel | 0.000007 | 0.002
Commercial steel | 0.00015 | 0.045
0.05 0.04 0.03 0.02 0.015 0.01 0.008 0.006 0.004 0.002 0.001 0.0008 0.0006 0.0004 0.0002 0.0001 0.00005 0.00001
0.1 0.09 0.08 0.07 0.06 0.05 0.04 0.03 0.025 0.02 0.015 0.01 0.009 0.008
10³ 2(10³) 3 4 5 6 8 10⁴ 2(10⁴) 3 4 5 6 8 10⁵ 2(10⁵) 3 4 5 6 8 10⁶ 2(10⁶) 3 4 5 6 8 10⁷ 2(10⁷) 3 4 5 6 8 10⁸