TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering & Technology

DEPARTMENT OF MECHANICAL & AUTOMOTIVE ENGINEERING

UNIVERSITY EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMG 2301 FLUID MECHANICS II

SUPPLEMENTARY/SPECIAL EXAMINATION

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

INSTRUCTIONS TO CANDIDATES:

1. You should have **Answer Booklet** for this examination.
2. This paper contains **FIVE** questions. Answer **ANY THREE** questions.
3. All diagrams should be clearly drawn and labeled.
4. This paper consists of **SEVEN** printed pages.

Question 1

1. A pipe bends through 90° from its initial direction. The pipe reduces in diameter such that the velocity at point (2) is 1.5 times the velocity at point (1). The pipe is 200 mm diameter at point (1) and the static pressure is 100 kPa. The volume flow rate is 0.2 m^3/s. Assume there is no friction and the weight of the bend and water is negligible. Calculate the following.
   (a) The static pressure at (2).
   (b) The velocity at (2).
   (c) The horizontal and vertical forces on the bend F_H and F_V.
   (d) The total resultant force on the bend.

(20 marks)

Question 2

(a) Derive the expression for the loss of head at a sudden expansion and show that this may also be used to approximate to the loss through a sudden contraction. **(6 marks)**

(b) A 150 mm diameter pipe reduces in diameter abruptly to 100 mm diameter. If the pipe carries water at 30 L/s, calculate the pressure loss across the contraction and express this as a percentage of the loss to be expected if the flow was reversed. Take the coefficient of contraction as 0.6. **(7 marks)**

(c) A pipeline that transports oil at $40^{o}C$ at a rate of 3 m^3/s branches into two parallel pipes made of commercial steel that reconnect downstream. Pipe A is 500 m long and has a diameter of 30 cm while pipe B is 800 long and has a diameter of 45 cm. The minor losses are considered to be negligible. Calculate the flow rate through each of the parallel pipes. **(7 marks)**

Question 3

(a) Water main 0.6 m in diameter discharges 0.45 m^3/s. The surface of the pipe is rough and may be taken as having protuberances of effective height of 1.25 mm. Calculate the loss of head per unit length. Calculate also the loss of head per unit length in an 18 mm diameter pipe of the same material in which water at $15^{o}C$ is flowing at a velocity of 1.5 m/s. **(10 marks)**

(b) A thin oil having density of 800 kg/m^3 is pumped through a 300 mm pipeline 6.3 km long; the coefficient of viscosity of the oil is 0.01865 poises. The roughness of the inner surface of the pipe is such that the mean height of the roughness projections is 0.75 mm. The quantity of flow through the pipe is 0.22 m^3/s. Using the roughness coefficient curves, calculate the head lost in N/m^2 and the power required to drive the pump if the overall efficiency of the pump is 75%. **(10 marks)**

Question 4

(a) A steel circular pipeline of diameter 1.4 m has water flowing at a half-full. The pipeline is at gradient 1/250. Calculate the discharge from the pipe, Q? **(5 marks)**

(b) Water is to be transported in an open-channel whose surfaces are asphalt lined at a rate of 4 m^3/s in uniform flow. The bottom slope is 0.0015. Calculate the dimensions of the best cross-section if the shape of the channel is;

(i) Circular diameter *D*

(ii) Rectangular of bottom width *b*,

(iii) Trapezoidal of bottom *b*. **(15 marks)**

Question 5

(a) Show by dimensional analysis that the power *P* required to operate a test tunnel is given by

$$P = \rho L^3 V^3 f\left(\frac{\mu}{\rho L V}\right)$$

where ρ is the density and μ the coefficient of dynamic viscosity of the fluid *V* the linear velocity of the fluid relative to the tunnel and *L* the characteristic linear dimension of the tunnel. **(12 marks)**

(b) A water tunnel was constructed for visual observation of the flow past models. It operates with the water flowing at a velocity of 3 m/s in the working section and absorbs 3.75 kW. If it is to operate as a wind tunnel under dynamically similar conditions, determine (a) the corresponding speed of air in the working section, and (b) the power required. Assume that for water ρ = 1000 kg/m^3 and kinematic viscosity ν =1.14 × 10^{-6} m^2/s, for air ρ = 1.28 kg/m^3, ν = 14.8 × 10^{-6} m^2/s. **(8 marks)**

APPENDIX

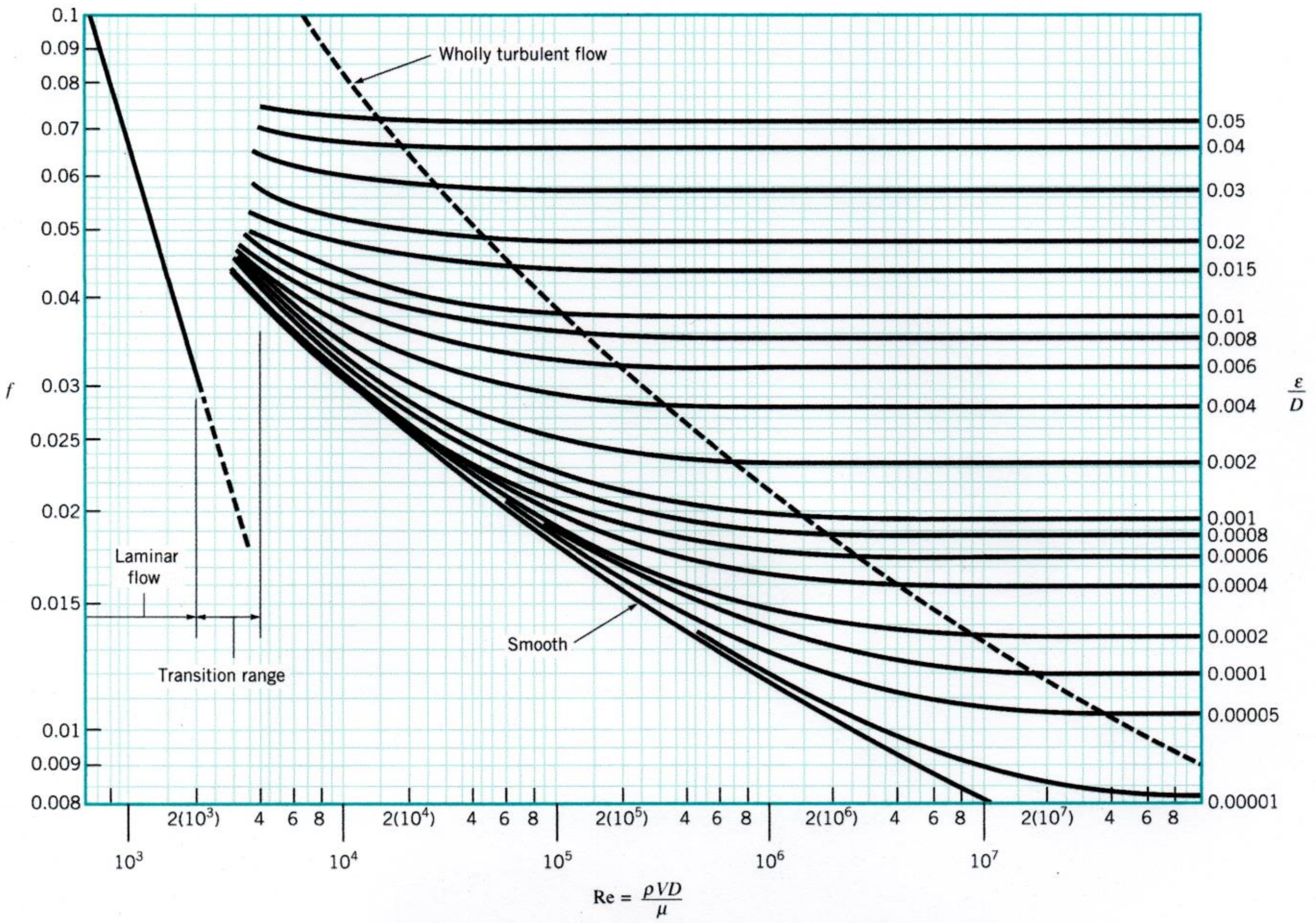

Figure 1: Moody chart – Variation of friction factor (f) with Reynolds number (Re) and pipe wall roughness (ε / D) for ducts of circular cross-section

Table 1: Equivalent sand-grain roughness (k_s) for various pipe materials* From Crowe and Elger (*2009*)

Boundary layer material	k_s, millimetres
Glass, plastic	smooth
Copper or brass tubing	0.0015
Wrought iron, steel	0.046
Asphalted cast iron	0.12
Galvanized iron	0.15
Cast iron	0.26
Concrete	0.3 to 3.0
Riveted steel	0.9 to 9.0
Rubber pipe (straight)	0.025

Table 2: Experimentally determined mean values of Manning coefficient *n* for water flow in open channels* From Chow (1959).

Wall material	n
A. Artificially lined channels	
Glass	0.010
Brass	0.011
Steel, smooth	0.012
Steel, painted	0.013
Steel, riveted	0.015
Cast iron	0.013
Concrete, finished	0.012
Concrete, unfinished	0.014
Wood, planed	0.012
Wood, unplanned	0.013
Clay tile	0.014
Brickwork	0.015
Asphalt	0.016
Corrugated metal	0.022
Rubble masonry	0.025
B. Excavated earth channels	
Clean	0.022
Gravelly	0.025
Weedy	0.030
Stonny, cobbles	0.035
C. Natural channels	
Clean and straight	0.030
Sluggish with deep pools	0.040
Major rivers	0.035
Mountain streams	0.050
D. Floodplains	
Pasture farmland	0.035
Light bush	0.050
Heavy bush	0.075
Trees	0.150

Table 3: List of Dimensions Associated with Common Physical Quantities From Crowe and Elger (*2009*).

		Dimensions	
Physical Quantity	**Symbol**	***FLT* System**	***MLT* System**
Acceleration	dV/dt	LT^{-2}	LT^{-2}
Angle	θ	$F^{0}L^{0}T^{0}$	$M^{0}L^{0}T^{0}$
Angular acceleration	$\dot{\omega}$	T^{-2}	T^{-2}
Angular velocity	ω, Ω	T^{-1}	T^{-1}
Area	A	L^{2}	L^{2}
Density	ρ	$FL^{-4}T^{2}$	ML^{-3}
Energy	E	FL	$ML^{2}T^{-2}$
Force	F	F	MLT^{-2}
Frequency	v	T^{-1}	T^{-1}
Heat	Q	FL	$ML^{2}T^{-2}$
Length	L	L	L
Mass	M	$FL^{-1}T^{2}$	M
Mass flow	$\dot{m}$	$FL^{-1}T$	MT^{-1}
Modulus of elasticity		FL^{-2}	$ML^{-1}T^{-2}$
Moment of a force		FL	$ML^{2}T^{-2}$
Moment of inertia (area)		L^{4}	L^{4}
Moment of inertia (mass)		FLT^{2}	ML^{2}
Momentum	M	FL	$ML^{2}T^{-2}$
Power	P	FLT^{-1}	$ML^{2}T^{-3}$
Pressure	p	FL^{-2}	$ML^{-1}T^{-2}$
Specific heat	c_{p}, c_{v}	$L^{2}T^{-2}\Theta^{-1}$	$L^{2}T^{-2}\Theta^{-1}$
Specific weight	γ	FL^{-3}	$ML^{-2}T^{-2}$
Speed of sound	a	LT^{-1}	LT^{-1}
Strain	ϵ	$F^{0}L^{0}T^{0}$	$F^{0}L^{0}T^{0}$
Strain rate	$\dot{\varepsilon}$	T^{-1}	T^{-1}
Stress	σ, τ	FL^{-2}	$ML^{-1}T^{-2}$
Surface tension	Υ	FT^{-1}	MT^{-2}
Temperature	T	Θ	Θ
Time	T	T	T

Thermal conductivity	k	$FLT^{-1}\Theta^{-1}$	$MLT^{-3}\Theta^{-1}$
Thermal expansion coefficient	β	Θ^{-1}	Θ^{-1}
Torque	T	FL	$ML^{2}T^{-2}$
Velocity	V	LT^{-1}	LT^{-1}
Viscosity (dynamic)	μ	$FL^{-2}T$	$ML^{-1}T^{-1}$
Viscosity (kinematic)	ν	$L^{2}T^{-1}$	$L^{2}T^{-1}$
Volume	Q	L^{3}	L^{3}
Volume flow	$\dot{Q}$	$L^{3}\mathrm{T}^{-1}$	$L^{3}\mathrm{T}^{-1}$
Work	W	FL	$ML^{2}T^{-2}$