UNAM
UNIVERSITY OF NAMIBIA

FACULTY	**AGRICULTURE, ENGINEERING, AND NATURAL SCIENCES**		
SCHOOL	**ENGINEERING AND THE BUILT ENVIRONMENT**		
DEPARTMENT	**CIVIL AND MINING ENGINEERING**		
SUBJECT	**HYDRAULICS & HYDRO-ENGINEERING**		
SUBJECT CODE	**TCVD3712**		
DATE	**NOVEMBER 2023**		
TIME ALLOWED	**3 HOURS**	**MARKS**	**100**

1ST OPPORTUNITY EXAMINATION

Examiner: Dr. Busari Afis

Internal Moderator: Dr. Katte Valentine

External Moderator: Prof. Akpofure Taigbenu (University of the Witwatersrand)

This question paper consists of **6** printed pages including this front page.

Instructions

1. Closed book examination.
2. Read the questions carefully.
3. The paper contains 6 questions. **Attempt any FOUR (4) questions** for full marks.
4. Some relevant equations, tables and charts have been provided.
5. Answers should be brief and to-the-point and where necessary be supplemented with neat sketches.
6. Marks for each question are indicated.
7. Any missing or 'wrong' data may be assumed suitably giving proper justification.
8. State all assumptions clearly.

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Q1

(a) List two (2) advantages and two (2) disadvantages of scale models *(4 marks)*

(b) The torque delivered by a water turbine depends on the discharge, Q, head, H, density, ρ, acceleration due to gravity, g, angular velocity, ω and efficiency, η. Show that the following equation is valid: *(11 marks)*

Hint: Choose H, ρ and ω as repeated variables

$$T = \rho g H^4 . f\left\{\omega\frac{H^3}{Q}, \eta\right\}$$

Q2

(a) The known outflow from a branch of a distribution system is 30 L/s. The pipe diameter is 150 mm, length 500 m and roughness coefficient estimated at 0.006 mm. Find the head loss in the pipe. Take coefficient of dynamic viscosity = 1.14×10^{-3} N s m^{-2}

(6 marks)

(b) Two reservoirs are connected by two pipelines in parallel. The difference in the elevation of the water surface between the upper and lower reservoir is constant at 150m. ***Pipeline 1*** has a diameter of 1.2m, while ***pipeline 2*** has a diameter of 0.9m. The pipelines are each 43km long with the friction factor, $f = 0.01$. Since the pipelines are long, assume that friction losses will dominate and that minor losses can be ignored. Calculate the discharge through each of the pipelines.

(9 marks)

Q3

(a) Water flows through a pipeline 0.4 m in diameter. The flow is laminar and the velocity at any radius r is given by $u = (0.6 - 15r^2)$ m s^{-1}. Calculate (i) the volume rate of flow, (ii) the mean velocity *(6 marks)*

(b) Glycerine of viscosity 0.9 N s m^{-2} and density 1260 kg m^{-3} is pumped along a horizontal pipe 6.5 m long of diameter, D = 0.01 m at a flow rate of Q = 1.8 litres min^{-1} . Determine the flow Reynolds number and verify whether the flow is laminar or turbulent. Calculate the pressure loss in the pipe due to frictional effects and calculate the maximum flow rate for laminar flow conditions to prevail. *(9 marks)*

Q4

Calculate the loss of head due to friction and the power required to maintain flow in a horizontal circular pipe of 40 mm diameter and 750 m long when water (coefficient of dynamic viscosity 1.14×10^{-3} N s m^{-2}) flows at a rate: (i) 4.0 litres min^{-1} ; (ii) 30 litres min^{-1} . Assume that for the pipe the absolute roughness is 0.00008 m.

(15 marks)

Q5

(a) A jet of water from a nozzle is deflected through an angle $\theta = 60°$ from its original direction by a curved vane which it enters tangentially (see **Fig. 5**) without shock with a mean velocity $\bar{v}_1$ of 30 m s^{-1} and leaves with a mean velocity $\bar{v}_2$ of 25 m s^{-1}. If the discharge A from the nozzle is 0.8 kg s^{-1}, calculate the magnitude and direction of the resultant force on the vane if the vane is stationary. ***(9 marks)***

(b) A trapezoidal channel has a bottom width of 5.0m and its sides slope at an angle of 45°. If the depth of flow is 2.0m, calculate the area of flow A, the wetted perimeter P, and the hydraulic radius R. If the discharge in the channel is $13.3m^3$ /s, calculate the Froude number.

(6 marks)

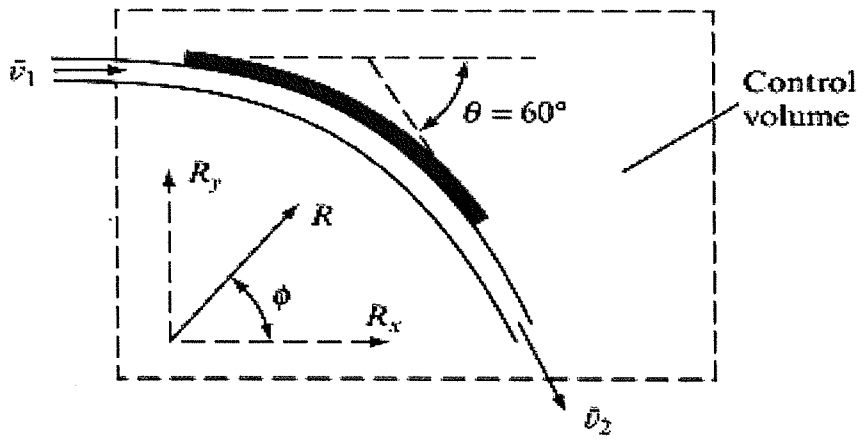
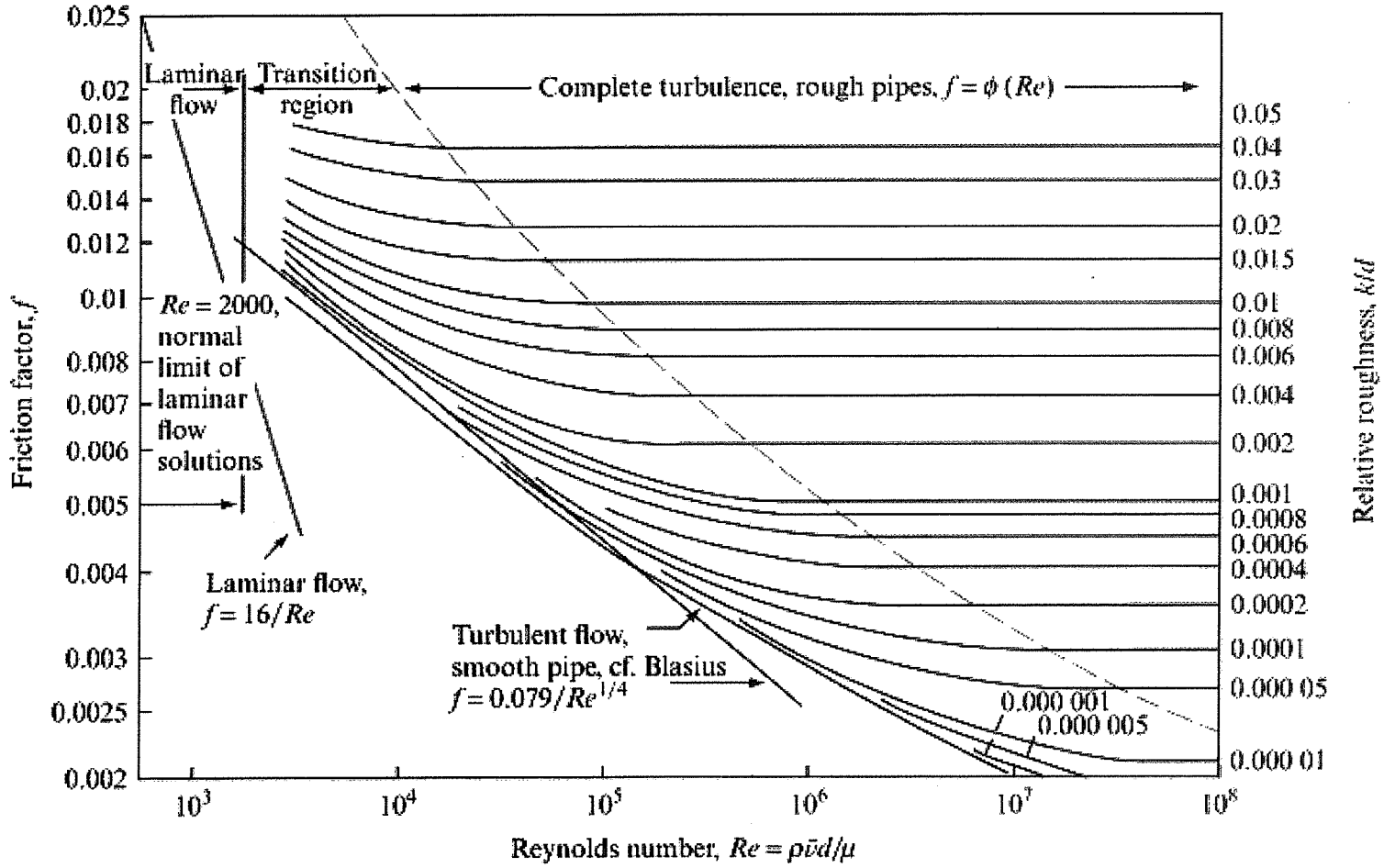


Fig. 5: A deflected water through a curved vane

Fundamental and Derived Units with Dimensions

Quantity	Symbol	Dimensions
Length	l	L
Mass	m	M
Time	t	T
Velocity	V	L/T
Acceleration	a	L/T^2
Angular velocity	Ω	T^{-1}
Force	F	F
Gravity	g	L/T^2
Flow rate	Q	L^3/T
Mass flux	$\dot{m}$	M/T
Pressure	p	M/LT^2
Stress	τ	M/LT^2
Density	ρ	M/L^3
Specific weight	γ	M/L^2T^2
Work	W	ML^2/T^2
Viscosity	μ	M/LT
Kinematic viscosity	ν	L^2/T
Power	$\dot{W}$	ML^2/T^3
Heat flux	$\dot{Q}$	ML^2/T^3
Surface tension	σ	M/T^2
Bulk modulus	B	M/LT^2


Laminar flow
Transition region
Complete turbulence, rough pipes, $f = \phi\,(Re)$
$Re = 2000$, normal limit of laminar flow solutions
Laminar flow, $f = 16/Re$
Turbulent flow, smooth pipe, cf. Blasius $f = 0.079/Re^{1/4}$
Friction factor, f
Reynolds number, $Re = \rho \bar{v} d/\mu$
Relative roughness, k/d
0.025
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.007
0.006
0.005
0.004
0.003
0.0025
0.002
10^3
10^4
10^5
10^6
10^7
10^8
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
0.000 05
0.000 01
0.000 001
0.000 005