The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX 4240 Hydraulic Engineering I**
Academic Year	: 2019/20
Date	: 28th July 2020
Time	: 0930-1230hrs
Duration	**: 03 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **FIVE (05)** questions on **FOUR (04)** pages.
3. Answer **ALL FIVE (05)** questions.
4. Answer for each question should commence from a new page.
5. Necessary additional information is provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear hand writing.
8. Do not use Red colour pen.
9. Take,

   Density of water = 1000 kgm^{-3} Acceleration due to gravity = 9.81 ms^{-2}

   Kinematic viscosity of water = 1.12×10^{-06} m^2/s

Question 01

(a) Briefly explain the significance of Reynolds number in model studies.

(04 marks)

(b) Experiments are conducted to investigate the drag force on a bluff body in a wind tunnel. The drag force, F_D depends on its characteristic length, L, the relative velocity of flow past, V and the fluid properties, density, ρ and dynamic viscosity, μ. Derive the relationship among the variables in dimensionless form using Buckingham's Pi theorem.

(09 marks)

(c) The following wind tunnel test data from a 1:20 scale model of a bus are available:

Air speed, m/s	18.0	21.8	26.0	30.1	35.0	38.5	40.9	44.1	46.7	48.4
Drag force, N	3.10	4.41	6.09	7.97	10.7	12.9	14.7	16.9	18.9	20.3

The dimensions of the prototype (the bus) are; width, $w = 2.4$ m, and frontal area, $A = 8.0$ m^2. If the density and the kinematic viscosity of air are 1.20 kg/m^3 and 1.45 x 10^{-05} m^2/s, respectively,

(i) Demonstrate the variation of the aerodynamic drag coefficient, $C_D = F_D/\left(\frac{1}{2}\rho V^2 A\right)$ vs. Reynolds number, $Re = \rho V w/\mu$ using a graph.

(08 marks)

(ii) Estimate the minimum test speed in which C_D becomes constant.

(03 marks)

(iii) Estimate the aerodynamic drag force and power requirement for the prototype when speeding at 80 km/hr.

(06 marks)

Question 02

(a) What are "separation losses" in pipelines?

(03 marks)

(b) A pipeline connecting two reservoirs having a level difference of 12 m is 1240 m long, and rises to a height of 3 m above the upper reservoir level at a length 640 m from the entrance, before falling to the lower reservoir. The pipeline has a diameter of 150mm for the first 400 m and suddenly expands in to a 300 mm diameter section at an elevation of 1.5 m above the upper reservoir level. Assuming both the pipes to be smooth and with no entry or exit losses,

(i) Estimate the flow velocities in the smaller and the larger diameter pipes.

(11 marks)

(ii) Determine the flow rate through the system.

(03 marks)

(iii) Determine the gauge pressure at the summit point of the pipeline.

(03 marks)

Additional Information:

Friction head loss along a pipe, $h_f = f \frac{l}{d} \frac{v^2}{2g}$

Head loss at a sudden expansion of a pipe diameter, $h_{exp} = \frac{(v_1 - v_2)^2}{2g}$

Question 03

(a) With the aid of an appropriate sketch, show that for uniform flow, the shear stress on a channel bottom, τ_0 is related to the friction slope, i and hydraulic mean depth, m by the formula,

$\tau_0 = \rho g m i$

(07 marks)

(b) A rectangular channel 30.0 m wide, sloping at 1:1200 conveys 32.0 m^3/s of water at a depth of 1.63 m. Assuming the validity of Chezy's formula for this channel, determine the discharge in the channel when the depth of flow is 2.25 m.

(08 marks)

Additional Information:

Chezy's formula $\bar{v} = C\sqrt{mi}$

Chezy's coefficient, C is related to depth of flow, d and roughness of the channel, k by, $C = 5.75\sqrt{g}\log_{10}(13.2d/k)$

Question 04

A reservoir with a water level of 30 m above a datum supplies water to a junction box through a 300 mm diameter pipe, which is 1200 m long. From the junction box, three pipes each with a diameter 150 mm and a length 900 m feed into three reservoirs whose water levels are 20 m, 15 m and 10 m above the datum. Demonstrate how you can use the quantity balancing method to determine the quantity of water leaving/entering each reservoir. First assume a head of 26 m at the junction box and perform up to two iterations to determine the quantities. The friction factor, f for all the pipes is 0.015.

(20 marks)

Additional Information:

The head correction for quantity balancing method is given by,

$$\Delta h = \frac{2\sum Q}{\sum(Q/h_f)}$$

Question 05

(a) Briefly explain the importance of a draft tube for a turbine.

(04 marks)

(b) Show that an expression for the specific speed, N_s of a turbine in terms of its speed N, output power P, and head H is given by,

$$N_s = \frac{N\sqrt{P}}{H^{5/4}}$$

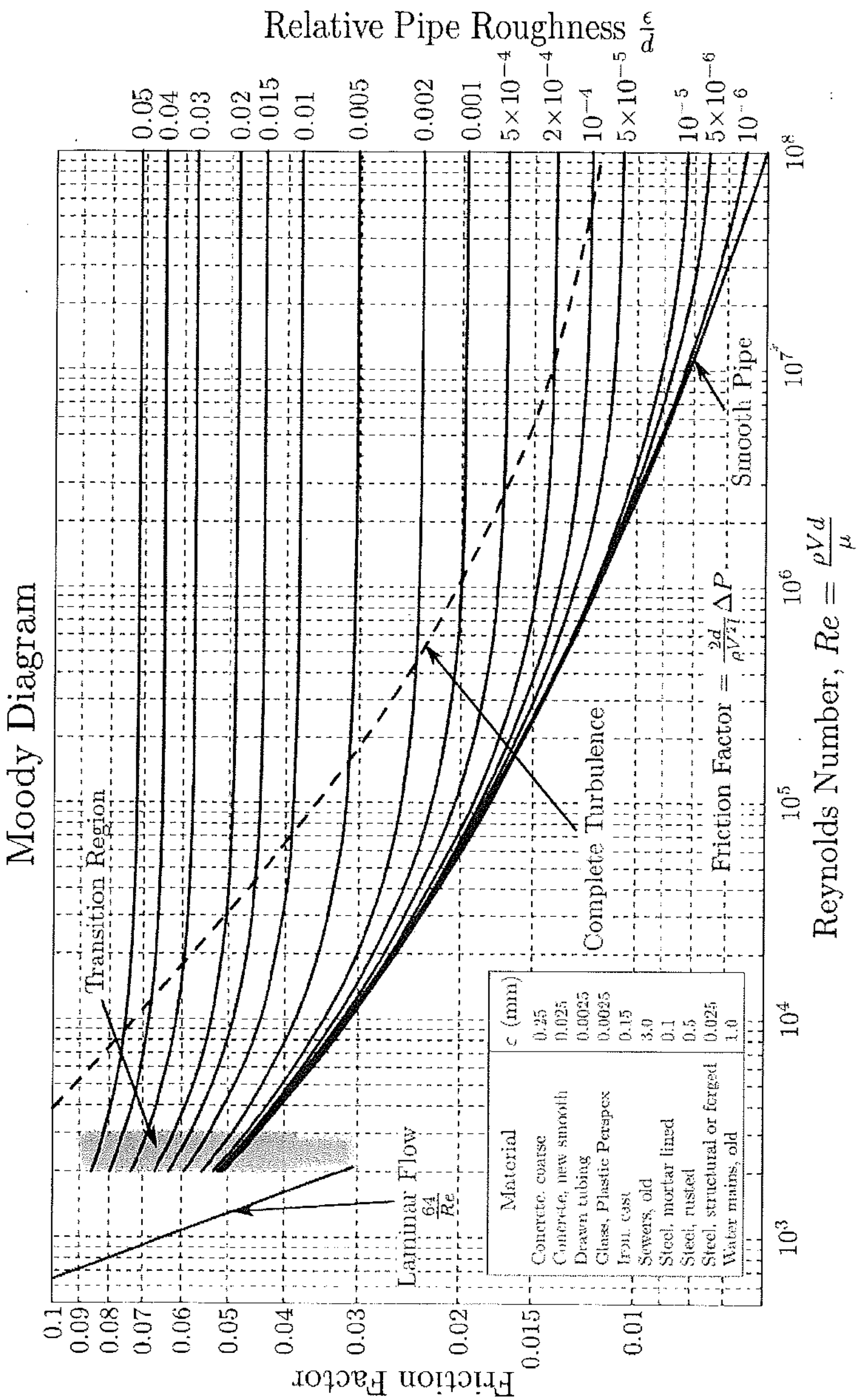
(06 marks)

(c) A vertical-shaft Francis water turbine rotates at 375 rpm under a net head of 27.5 m. The runner has a diameter of 0.75 m at inlet, a flow area of 0.20 m^2, and a blade angle of 75 degrees. The guide-vane angle at inlet is 15 degrees (aligned in the direction of absolute velocity). Calculate the overall efficiency of the turbine assuming a mechanical efficiency of 97%.

(05 marks)

Additional information:

The hydraulic efficiency of a turbine is given by, $\eta_h = \frac{u_1 v_{w1}}{gH}$ x 100%



Moody's diagram