UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: September 2023

Module Number: ME 6201 **Module Name: Advanced Fluid Mechanics**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

Useful equations with usual notations are given in page number 05

Drag Coefficient (C_D) vs **Reynolds Number (Re)** plot for spherical particles is given in page number 05

Q1 a) Write brief notes on the following,

i) Laminar and Turbulent Flows

ii) Compressible and Incompressible Flows

[2.0 Marks]

b) Briefly describe **three** methods of preventing the separation of the boundary layer.

[3.0 Marks]

c) Describe the effect of streamlining body shapes on pressure drag and skin friction drag.

[2.0 Marks]

d) A barge with a rectangular bottom surface 35m long and 10m wide is traveling down a river at a velocity of 0.6 m/s. If the boundary layer flow changes from laminar to turbulent at a Reynolds Number 5×10^5, considering the density of water = 998 kgm^{-3}, and kinematic viscosity$(v) = 1 \times 10^{-6}\ m^2/s$ find the following,

Note: State any assumptions made

i) The distance from the leading edge up to which the boundary layer is laminar.

[2.0 Marks]

ii) The total drag force.

[2.0 Marks]

iii) The power required to overcome the boundary friction.

[1.0 Mark]

Q2 a) Particulate systems are utilized in different process requirements. Use of **granular beds** in **gas cleaning** is one of such applications.

(i) Draw a schematic diagram with essential components to demonstrate a particular gas cleaning process using a granular bed [1.5 Marks]

(ii) "**Filtration** and **adsorption** are the fundamental mechanisms caused to facilitate gas cleaning". Briefly explain this statement [2.5 Marks]

(iii) Briefly explain two advantages of **adsorption** taken place through the granular bed in gas cleaning [1.5 Marks]

b) A granular bed consists of spherical alumina particles of average diameter of 3 mm. The drag force per single particle is 6 μN at a flow velocity of 4 mm/s inside a liquid dye of specific gravity of 1.2.

(i) Determine the flow region of this system according to the **C_D vs Re** plot [3.0 Marks]

(ii) Calculate the kinematic viscosity of the dye [1.5 Marks]

(iii) List out the assumptions you made in the above two steps; Q2 b(i) and b(ii) [2.0 Marks]

Q3 a) Write brief notes on the following.

i) Deformed Layer

ii) Chemically Reacted Layer

iii) Physisorbed Layer

iv) Chemisorbed Layer

[4.0 Marks]

b) Describe the effect on the coefficient of friction due to the adhesion of polymers with rough surfaces when the normal load increases.

[2.0 Marks]

c) Briefly describe the influence of temperature rise during frictional heating on the behaviour of a tribological system.

[2.0 Marks]

.......Q3 is continued to page 3

Q3 is continued from page 3…….

d) Describe the applications of tribology on the following with examples

i) Automotive Tribology

ii) Tribology in Manufacturing

[4.0 Marks]

Q4 a) Briefly explain the term "**Fluidization**" in terms of the initial conditions and the required external factors

[1.5 Marks]

b) Draw a schematic diagram of a typical **fluidized bed reactor** with essential components.

[2.0 Marks]

c) Discuss the process of Fluidization when the **gas flow rate** is gradually increased.

[3.5 Marks]

d) A fluidized slurry travels through the exit stream of a fluidized bed with a mass flux of **M**. The exit stream is a circular pipe with a diameter of **D** and the average velocity of the slurry is $\bar{u}$.

(i) Prove that the maximum shear stress of the exit stream is given by

$\dfrac{4.\rho\,\bar{u}^2}{Re}$, where, ρ is the density of the slurry and Re is the Reynolds Number of flow.

[3.0 Marks]

(ii) Show that $\bar{u} = \dfrac{M}{\rho}$ [1.0 Mark]

(iii) State the assumptions you made in the above steps; Q4 d(i) and d(ii)

[1.0 Mark]

Q5 a) Define the following terms as applicable for a **liquid, gas two phase flow** and state expressions for each using standard notations

(i) Static Dryness

(ii) Sip Ratio

(iii) Void Fraction

(iv) Volumetric Dryness

[4.0 Marks]

b) (i) Starting from the standard notations, prove that $\alpha = \frac{\rho_x}{\rho_g} q$ and $\beta = \frac{\rho_x}{\rho_g} x$

where,

α	Void Fraction
β	Volumetric Dryness
ρ_x	Mean Density of Two Phases (liquid and gas)
ρ_g	Density of Gas Phase
q	Static Dryness
x	Mass Quality

[4.0 Marks]

(ii) Further derive that the slip ratio ; $S = \frac{(1-\alpha)}{(1-\beta)} \cdot \frac{\beta}{\alpha}$

[2.0 Marks]

c) Briefly explain the importance of **Pour Point** and **Flash Point** in the selection of a lubricant for a particular lubrication purpose

[2.0 Marks]

Table Q1 Q2 . Useful equations with usual notations

Drag force acting on a particle (F_D)	$F_D = \dfrac{C_D\, u^2\, \rho . A_p}{2}$
Drag Coefficient for laminar flow	$= \dfrac{1.328}{\sqrt{Re_L}}$
Drag Coefficient for turbulent flow	$= \dfrac{0.072}{\sqrt[5]{Re_L}}$ (for $5 \times 10^5 < Re_L < 10^7$)
	$= \dfrac{0.455}{(\log_{10} Re_L)^{2.58}}$ (for $10^7 < Re_L < 10^9$)
Drag Coefficient for combined flow	$= \dfrac{0.455}{(\log_{10} Re_L)^{2.58}} - \dfrac{1700}{Re_L}$ (for $10^7 < Re_L < 10^9$)

Drag Coefficient Variation with Particle Reynolds Number

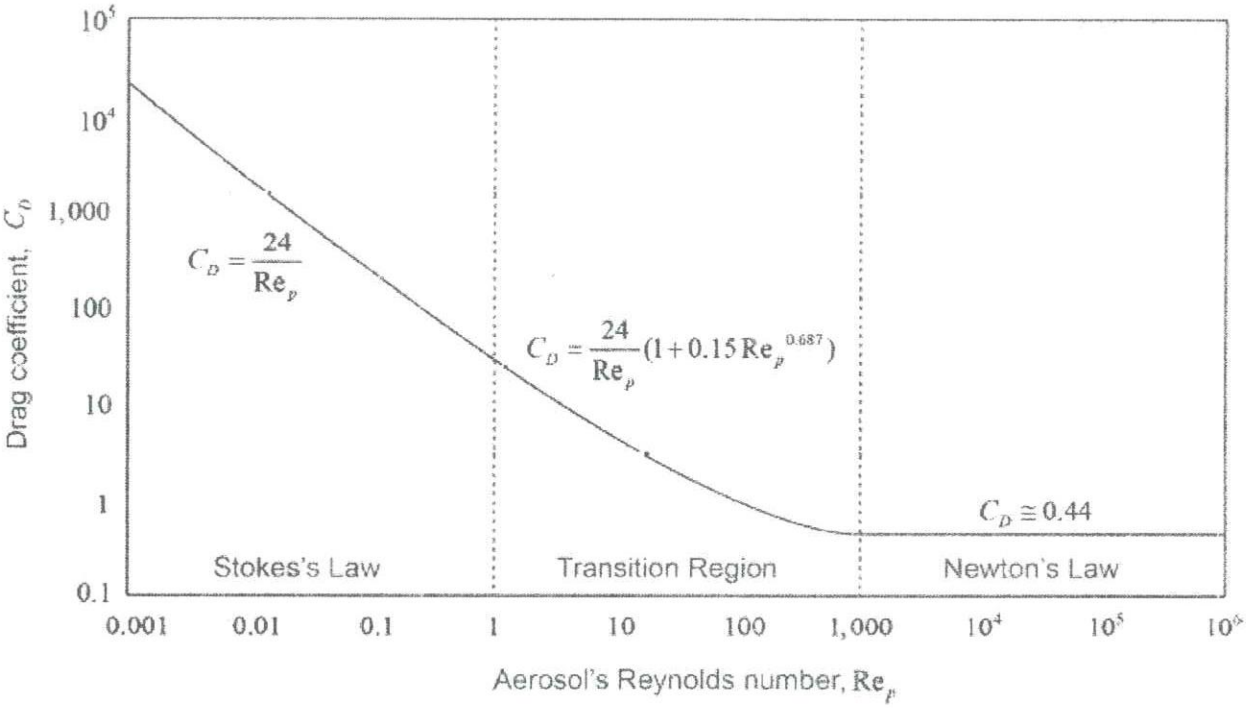

Figure Q2. Plot of C_D vs Re_p for spherical particles