(17)

Name of the Program: B. Sc. in Mechanical Engineering
Semester: 8th (Summer)

Date: 08 May, 2023

Time: 10:00 am – 01:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: MCE 4811
Course Title: Fluid Mechanics II

Summer Semester : 2021 - 2022
Full Marks: 150
Time : 3.0 Hours

There are **06 (Six)** questions. Answer **all** questions (choose option from question 1 and 5). The symbols have their usual meanings.

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1. A smooth pipe of diameter 300 mm and length 600 m carries water at the rate of 0.4 m^3/s. Determine the head loss due to friction, wall shear stress, centerline velocity and thickness of laminar sub-layer. Take kinematic viscosity of water as 0.018 stokes. (CO6) **(25)**

OR A rough pipe of diameter 300 mm and length 600 m carries water at the rate of 0.4 m^3/s. The wall roughness is 0.015 mm. Determine the co-efficient of friction, wall shear stress, centerline velocity and velocity at a distance of 100 mm from the pipe wall. Take kinematic viscosity of water as 0.018 stokes. (CO6) **(25)**

2. (a) Define Prandtl Mixing Length Theory. Derive expression for Universal velocity distribution for Turbulent flow in in pipes. (CO6) **(25)**

(b) Consider a case of a flow through parallel plates, one stationary and other moving at velocity U. Write the governing equation for such flow and derive dimensionless form of the equation. (CO6)

3. **Part 1:** A student team is to design a human-powered submarine for a design competition. The overall length of the prototype submarine is 2.24 m, and the designers hope that it can travel fully submerged through water at 0.56 m/s. The water is freshwater (a lake) at T = 15 ^{0}C. The design team builds a one-eighth scale model to test in their university's wind tunnel as shown in Fig. 1. A shield surrounds the drag balance strut so that the aerodynamic drag of the strut itself does not influence the measured drag. The air in the wind tunnel is at 25 ^{0}C and at atmospheric pressure. At what air speed do they need to run the wind tunnel in order to achieve similarity? **(25)**

Part 2: The students measure the aerodynamic drag on their model submarine in the wind tunnel. They are careful to run the wind tunnel at conditions that ensure similarity with the prototype submarine. Their measured drag force is 2.3 N. Estimate the drag force on the prototype submarine at the conditions given in part 1.

Part 3: Some students want to visualize flow over a spinning baseball. Their fluids laboratory has a nice water tunnel into which they can inject multicolored dye streaklines, so they decide to test a spinning baseball in the water tunnel as shown in Fig. 2. Similarity requires that they match both the Reynolds number and the Strouhal number $\left(St = \frac{fL}{V}\right)$ between their model test and the actual baseball that moves through the air at 80 mph and spins at 300 rpm. Both the air and the water are at 20 ^{0}C. At what speed should they run the water in the water tunnel, and at what rpm should they spin their baseball? (CO4)

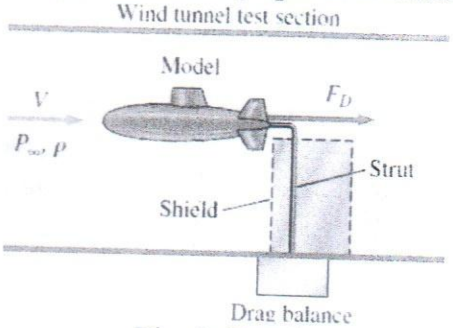

Fig. 1: Part 1

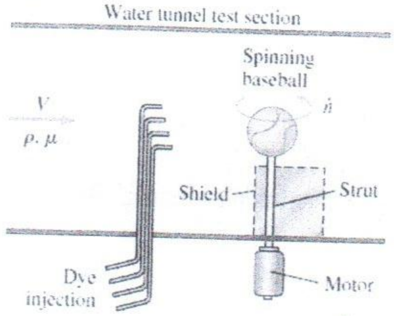

Fig. 2: Part 3

4. A combustion chamber consists of tubular combustors of 15-cm diameter as shown in Figure 3. Fuel with a heating value of 42,000 kJ/kg is injected into the air and is burned with an air–fuel mass ratio of 40. Approximating combustion as a heat transfer process to air, determine the temperature, pressure, velocity, and Mach number at the exit of the combustion chamber. (CO2) **(25)**

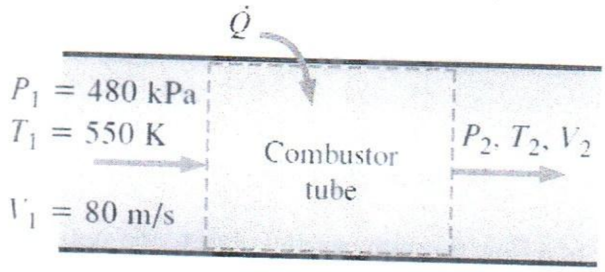

Fig. 3

5. Consider a flat plate placed parallel to a uniform stream of air at a velocity of U and at standard atmospheric conditions. The velocity distribution in the boundary layer along the length of the plate can be modeled by the following equation: **(25)**

$$u(y) = U\left\{1 - \left(\frac{y}{\delta}\right)^2\right\}$$

where:

u(y) is the velocity at a distance y from the plate surface

y is the distance from the plate surface

δ is the boundary layer thickness.

Find the displacement thickness, momentum thickness, and energy thickness. (CO5)

OR Derive equations of the displacement thickness, momentum thickness, and energy thickness for the flow over a flat plate. (CO5)

6. Derive an expression for Force, Torque and Power for Conical bearing with necessary assumptions and sketch. (CO6) **(15)**

A conical bearing is used to support a shaft rotating at a speed of 2000 rpm. The diameter of the large end of the bearing is 60 mm and the diameter of the small end is 40 mm. The length of the bearing is 100 mm and the annular space between the shaft and the bearing is filled with an oil having viscosity 0.01 Ns/m^2. Find the torque and Power required to rotate the shaft. (10)

If the working fluid is 30% heavier than the above, find the torque and power. (CO6)