Program: B. Sc. in ME
Semester: 5th (Winter)

Date: 15 December 2023
Time: 09:00 am – 12:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

Semester Final Examination
Course Number: ME 4511
Course Title: Fluid Mechanics II

Summer Semester : 2022 - 2023
Full Marks: 150
Time : 3.0 Hours

There are 06 (Six) questions. Answer **all** questions. The symbols have their usual meanings. Consider reasonable value for any missing data

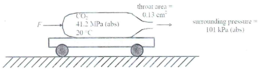
1. (a) Consider a turbulent flow in rough pipe of 300 mm diameter. At a point 25 mm from the pipe wall, the velocity gradient is 12.5 m/s and velocity of flow is 2 m/s. Find the average height of roughness. **(12.5+12.5) (CO2)**

   (b) For turbulent flow in a pipe of diameter 300 mm, find the shear velocity if the centerline velocity is 2 m/s and velocity at a point 100 mm from the center is 1.6 m/s.

2. (a) Define Prandtl Mixing Length Theory. Derive expression for Universal velocity distribution for Turbulent flow in in pipes. **(25) (CO3)**

   (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.

3. A CO_2 cartridge is used to propel a small rocket cart. Compressed CO_2, stored at a pressure of 41.2 MPa (abs) and a temperature of 20 °C, is expanded through a smoothly contoured converging nozzle with a throat area of 0.13 cm^2. **(25) (CO3)**
   Assume that the cartridge is well insulated and that the pressure surrounding the cartridge is 101 kPa (abs). For the given conditions,
   a) Calculate the pressure at the nozzle throat.
   b) Evaluate the mass flow rate of carbon dioxide through the nozzle.
   c) Determine the force, F, required to hold the cart stationary.
   d) Sketch the process on a T-s diagram.
   e) For what range of cartridge pressures will the flow through the nozzle be choked?
   f) Will the mass flow rate from the cartridge remain constant for the range of cartridge pressures you found in part (e)? Explain your answer.
   g) Write down (but do not solve) the differential equations describing how the pressure within the tank varies with time while the flow is choked.



4. Consider the flow of air through the converging-diverging nozzle shown in the figure below. The flow begins at stagnation conditions with P_o = 100 kPa (abs) and T_0 = 300 K. The nozzle exit-to-throat area ratio is A_E/A_T = 1.688 with a throat area of $A_T = 1 \times 10^{-4} m^2$. **(25) (CO3)**

a) Determine the back pressure at which the flow first becomes choked.
b) Determine the range of back pressures at which the flow at the exit is supersonic.
c) Determine the mass flow rate through the nozzle when the exit Mach number is 0.2.

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) (CO4)**

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

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.

6. A Ship is 300m long moves in seawater, whose density is 1030 kg/m³, A 1:100 model of this to be tested in a wind tunnel. The velocity of air in the wind tunnel around the model is 30m/s and the resistance of the model is 60N. Determine the velocity of ship in seawater and also the resistance of the ship in sea water. The density of air is given as 1.24 kg/m³. Take the Kinematic viscosity of seawater and air as 0.012 stokes and 0.018 stokes respectively. **(25) (CO3)**