 CHEN 511

Transport Phenomena

Chemical Engineering

Faculty of Engineering and Architecture

American University of Beirut

Monday, 4th February 2013

This exam paper has 4 questions

Answer all questions

You have two hours to complete this exam

GOOD LUCK

Q1. Heavy oil with a kinematic viscosity of 3.45 x 10-4 m2/s is at rest in a long vertical tube with a radius of 0.70 cm. The fluid is suddenly allowed to flow from the bottom of the tube by virtue of gravity. After what time will the velocity at the tube center be within 10% of its final value? (10 marks)

What is the result if water at 68oC is used (kinematic viscosity = 1.0037 x 10-6 m2/s.

Use the Fig below to help you with solving the problem.



Q2. A fluid with a constant density and viscosity is contained between two parallel plates. The distance between the plates is b. Initially the fluid and the solids are at rest. Then at time, t=0, the solid surface is set in motion in the positive x direction with velocity vo.

State the initial and boundary conditions for this problem and then find the velocity, vx as a function y and t. (50 marks)

Q3. An incompressible fluid flows steadily through a stationary vertical pipe of R=12.5 cm. No pressure is applied to the fluid of viscosity μ=0.002 N s/m2 (free fall conditions). The flow is fully developed and described by Navier-Stokes equation.

Determine the maximum velocity vmax, and stress applied to the pipe τ. (30 marks)

Additional information:

Gravitational acceleration, *gz* = 10 m/s2

Fluid density, *ρ* = 1000 kg/m3

Q4. Water flows in a straight square duct of constant cross-section area. The flow is stable and one-dimensional. Someone claims that he expects the water to slow down along the duct because of friction. Use the equation of continuity to determine if this prediction is correct.

(10 marks)

END OF EXAM