National Exams December 2019

04-Bio-A7, Fluid Mechanics

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. Four (4) questions constitute a complete exam paper.
   The first four questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. All questions require calculation.

Problem 1.(25 points)

The differential energy equation for incompressible two dimensional through a "Darcy equation" porous medium is approximately

$$\rho c_p \frac{\sigma}{\mu}\frac{\partial p}{\partial x}\frac{\partial T}{\partial x} + \rho c_p \frac{\sigma}{\mu}\frac{\partial p}{\partial y}\frac{\partial T}{\partial y} + k\frac{\partial^2 T}{\partial y^2} = 0$$

Where σ is the permeability of the porous medium and p is the pressure and T is temperature, k is the conductivity, c_p is the specific heat and ρ is the density and μ is the dynamic viscosity. All other symbols have their usual meanings.

a) What are the appropriate dimensions of σ?
b) Non dimensionalize this equation using (L, U, ρ, To) as scaling constants and discuss any dimensionless parameters that arise.

Problem 2. (25 points)

Determine the gage pressure at point A in the below figure, in Pascal's. Is it higher or lower than $P_{atmosphere}$?(γ_{water}=9790 N/m^3, $\gamma_{mercury}$=133100 N/m^3)

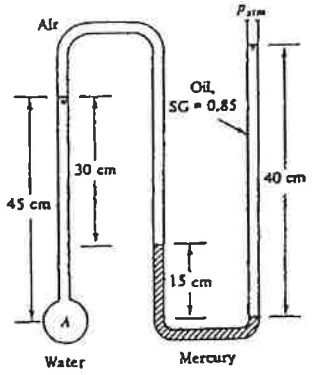

Figure for Question 2.

Problem 3. (25 points)

Two oil tanks are connected by two 9-m-long pipes, as shown in the below figure. Pipe 1 is 5 cm in diameter and is 6 m higher than pipe 2. It is found that the flow rate in pipe 2 is twice as large as the flow in pipe 1.

(a) What is the diameter of pipe 2?

(b) Are both pipe flows laminar?

(c) What is the flow rate in pipe 2 (m^3/s)?

Neglect minor losses.(ρ_{oil}=891 Kg/m^3, μ_{oil}=0.29 Kg/m.s)

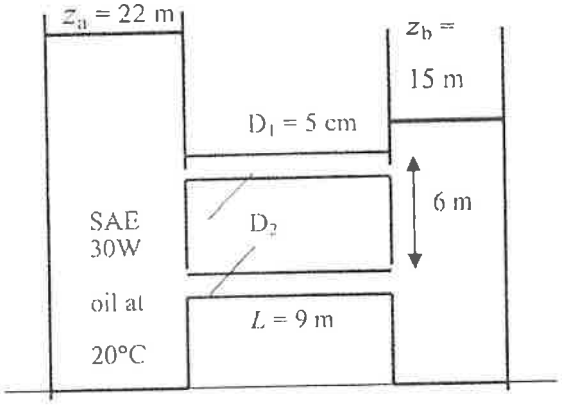

Figure for Question 3.

Problem 4. (25 points)

The parallel galvanized-iron pipe system(ε=0.15 mm) of below figure delivers water at 20°C(ρ=998 Kg/m^3, μ=0.001 Kg/m.s) with a total flow rate of 0.036 m^3/s. If the pump is wide open and not running, with a loss coefficient K = 1.5, determine (a) the flow rate in each pipe and (b) the overall pressure drop.

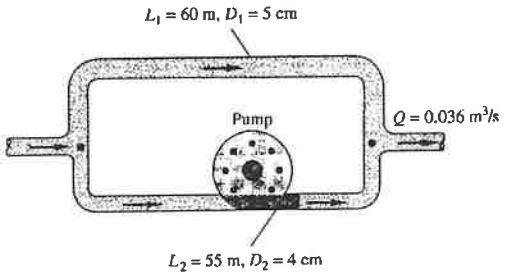

Figure for Question 4