Kafrelsheikh University
Faculty of Engineering
Mechanical Engineering Department
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Subject: Fluid Mechanics
Type: Final exam
Term: Second term
Time allowed: 3.0 hours
Full mark: 60
Year: 2nd year

This exam measures the ILOs A1, A2, B1.

Please, answer the following questions as much as you can. **Assume any missing data**

Question (1) [Marks = 50%]

(A) Derive the general form of the **continuity equation**.

(B) Drive the **Navier-Stokes Equations** of motion for incompressible fluid, steady and three-dimensional flows.

(C) **(i)** Starting from **NSE** for incompressible flow in **Cartesian coordinate**, drive for a Couette flow the following;

a) The velocity distribution in the clearance between the two parallel flat plates, if one of which is moving a velocity "U".

b) The flow rates per unit width "Q".

c) The shearing stress on the moving wall.

d) Draw the velocity distribution for U=0, U>0 in the same direction of the flow, and U >0 in the opposite direction of the flow and give a comment.

(ii) Oil flows between two parallel plates, one is at rest and the other moves with a constant velocity U. If the pressure is deceasing in the direction of the flow at a rate of 1.5 kg/m^2 per m. The dynamic viscosity is 0.005 kg.s/m^2, the spacing of the plates is 4 cm and volumetric flow rate Q per unit width is 4.15 liter/s per m. What is the velocity "U"?

Question (2) [Marks = 50%]

(A) At low velocities (laminar flow), the volume flow Q through a small-bore tube is a function only of the tube radius R, the fluid viscosity μ, and the pressure drop per unit tube length dp/dx. Using the pi theorem, find an appropriate dimensionless relationship.

(B) Oil (S=0.96, μ =9.8 poise) flows through a pipe of 1 m diameter at a rate of 5 m^3/s. If a geometrically similar pipe of 5 cm diameter carrying water (μ=0.01 poise). Calculate the discharge in the model.

(C) The capillary rise h of a liquid in a tube varies with tube diameter d, gravity g, fluid density ρ, surface tension σ, and the contact angle θ. (a) Find a dimensionless statement of this relation. (b) If h = 3 cm in a given experiment, what will h be in a similar case if the diameter and surface tension are half as much, the density is twice as much, and the contact angle is the same?

(D) A dam spillway is to be tested by using Froude scaling with a one-thirtieth-scale model. The model flow has an average velocity of 0.6 m/s and a volume flow of 0.05 m3/s. What will the velocity and flow of the prototype be? If the measured force on a certain part of the model is 1.5 N, what will the corresponding force on the prototype be?

All the best

Dr./ Fadl Essa