SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

SEMESTER I EXAMINATION 2016-2017

– Transport Pheonomena

November 2016 TIME ALLOWED: 2 HOURS

INSTRUCTIONS TO CANDIDATES

1. This examination paper contains **8** questions.
2. Answer all questions. The marks for each question are indicated at the beginning of each question.
3. This **IS NOT an OPEN BOOK** exam.
4. Candidates may use calculators. However, they should write down systematically the steps in the workings.
5. Some formulas that might help.
   For laminar pipe flow, $u_{avg} = -\frac{1}{8\mu}\frac{\Delta p}{\Delta x}R^2$,$\Delta p$ is the pressure loss due to viscous effects, R is the radius of pipe
   For pipe flow, $h_f = f\frac{L}{d}\frac{v^2}{2g}$, f is the friction factor
   The acceleration of gravity $g = 10\text{m}\cdot\text{s}^{-2}$

Problem 1. (10 marks)
Determine the difference in pressure between the inside and outside of a soap film bubble at 20°C, if the diameter of the bubble is 5 mm. (The coefficient of surface tension σ=0.025 N/m.)

Problem 2. (14 marks)
Gate AB in figure below is semicircular, hinged at B, and held by a horizontal force P at A. What force P is required for equilibrium?

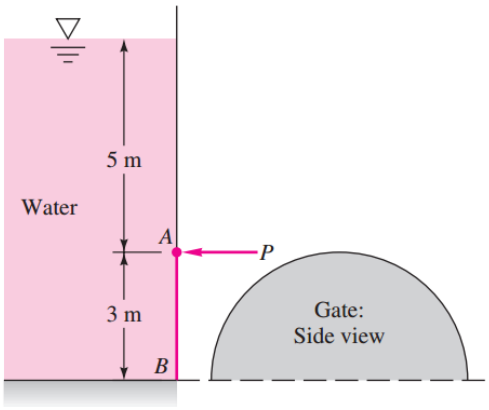

Figure 1: Problem 2

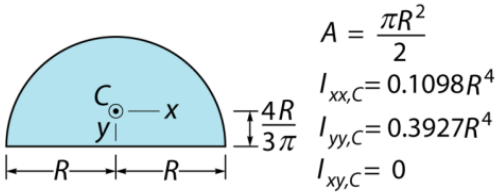

Figure 2: Centroidal coordinates and moments of area for a semicircle

Problem 3. (14 marks)
Assume some 2-dimensional flow field satisfy

$$u = x + t$$
$$v = y + t$$

and let $x = a, y = b$ when $t = 0$, find the Lagrangian velocity expression.

Problem 4. (10 marks)
Show mass conservation of incompressible flow is

$$\nabla \cdot \mathbf{u} = 0$$

Problem 5. (12 marks)
Below is a picture which describes the siphon phenomenon: the water is siphoned from a large tank through a constant diameter hose. Assume water to be inviscid, incompressible and flow to be steady. (The acceleration of gravity $g = 10\,\mathrm{m} \cdot \mathrm{s}^{-2}$.) Please determine:

(a) velocity of water leaving (3) as a free jet

(b) water pressure in tube at (2)

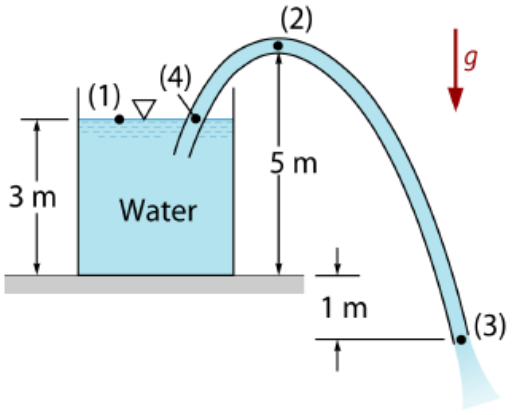

Figure 3: Problem 5

Problem 6. (14 marks)
In flow past a flat plate, the boundary layer thickness δ varies with distance x, freestream velocity U, viscosity μ, and density ρ. Find the dimensionless parameters for this problem.

Problem 7. (10 marks)
Write out the three components of $\frac{D\mathbf{u}}{Dt} = -\frac{1}{\rho}\nabla p + \nu\nabla^2\mathbf{u}$ in x-y-z Cartesian coordinates.b) Set u =(u(y), 0, 0), and simplified the x- and y-momentum equations.

Problem 8. (16 marks)
The tankpipe system of Fig.xxx is to deliver at least $11\text{m}^3/\text{h}$ of water at 20°C to the reservoir. What is the maximum roughness height allowable for the pipe? ($\rho = 1000\text{kg/m}^3$, $\mu = 0.001\text{kg/(m}\cdot\text{s)}$ and $g = 10\text{m}\cdot\text{s}^{-2}$)
hint:$h_f = f\frac{L}{d}\frac{v^2}{2g}$, f is the friction factor

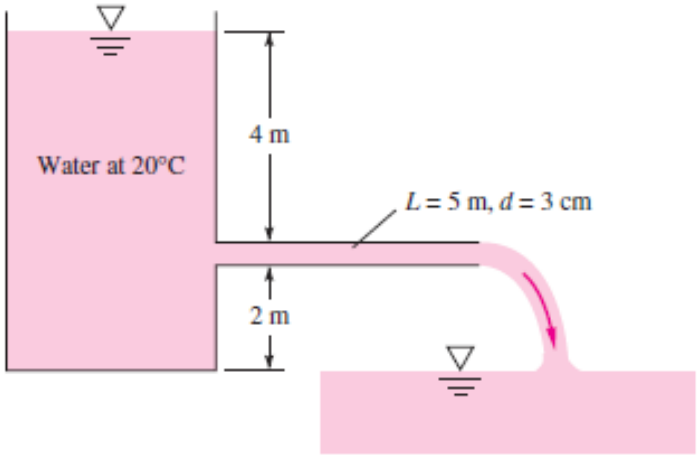

Figure 4: Problem 8