SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

SEMESTER I EXAMINATION 2016-2017

– Transport Pheonomena

November 2016 TIME ALLOWED: 2 HOURS

<u>INSTRUCTIONS TO CANDIDATES</u>

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 $g = 10\mathrm{m}\cdot\mathrm{s}^{-2}$

Problem 1. (10 marks)

Two clean and parallel glass plates, separated by a gap of $b = 1.470$ mm, are dipped in water. If coefficient of surface tension σ=0.0735 N/m , determine how high the water will rise. (Assume the density of water $\rho_w = 1 \times 10^3\,\mathrm{kg} \cdot \mathrm{m}^{-3}$,the acceleration of gravity $g = 10\,\mathrm{m} \cdot \mathrm{s}^{-2}$.)

Problem 2. (14 marks)

The uniform beam in figure below, of size L by h by b and with specific weight γ_b, floats exactly on its diagonal when a heavy uniform sphere is tied to the left corner, as shown. Show that this can happen only (a) when $\gamma_b = \gamma/3$ and (b) when the sphere has size

$$D = \left[\frac{Lhb}{\pi(\mathrm{SG}-1)}\right]^{1/3}.$$

Hint: The specific weight (γ) is the weight per unit volume of a material. The specific gravity (SG) is defined as $\mathrm{SG} = \gamma_{\mathrm{sphere}}/\gamma$. The buoyancy of the beam, being a perfect triangle of displaced water, acts at $L/3$ from the left corner.

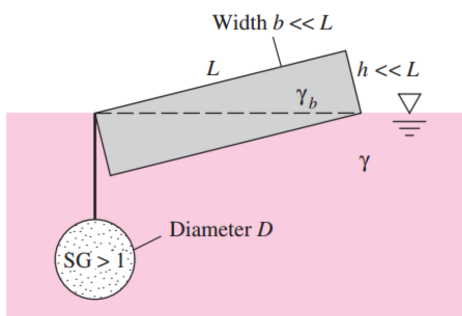

Figure 1: Problem 2

Problem 3. (14 marks)

Assume some 2-dimensional flow field satisfy

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

determine the streamline and pathline that is through point $(-1, -1)$,when $t = 0$.

Problem 4. (10 marks)
Assume some flow in a tube is steady.the cross-section area,density,and velocity is $A(x), \rho(x), u(x)$ respectively,deduct the mass conservation equation.

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 $g = 10\,\mathrm{m \cdot s^{-2}}$.) Please determine:

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

(b) water pressure in tube at (4)

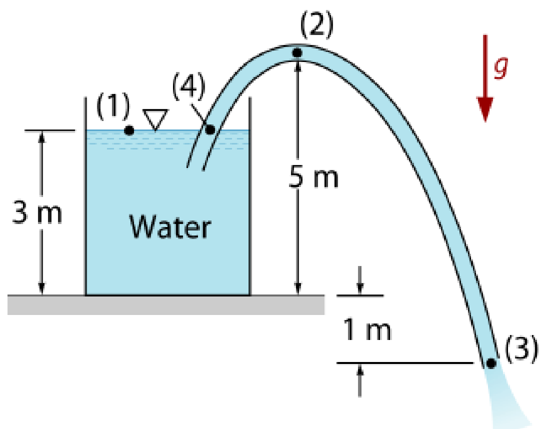

Figure 2: Problem 5

Problem 6. (12 marks)
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 $\mathrm{d}p/\mathrm{d}x$. Please find an appropriate dimensionless relationship.

Problem 7. (14 marks)

Planar Couette flow is generated by placing a viscous fluid between two infinite parallel plates and moving one plate (say, the upper one) at a velocity U with respect to the other one. The plates are a distance h apart. Two immiscible viscous liquids are placed between the plates as shown in the diagram. The lower fluid layer has thickness d. Solve for the velocity distributions in the two fluids. The viscosity of fluid 1 and fluid 2 is μ_1 and μ_2 respectively. (for incompressible planar Couette flow,the mass conservation is $\nabla \cdot \mathbf{u} = 0$,and the momentum conservation is $\nabla^2 \mathbf{u} = 0$)

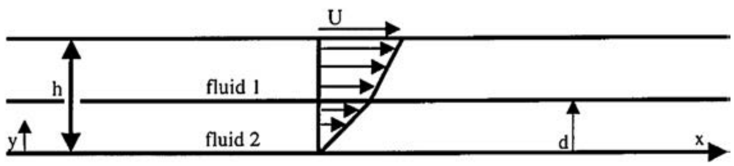

Figure 3: Problem 7

Problem 8. (14 marks)

An oil with $\rho = 900\text{kg/m}^3$ and $\nu = 0.0002\text{m}^2/\text{s}$ flows upward through an inclined pipe as shown in Fig.xxx. The pressure and elevation are known at sections 1 and 2, 10 m apart. Assuming steady laminar flow, (a) compute head loss h_f between 1 and 2, and compute (b) V, (c) Re. Is the flow really laminar?(hint:$u_{avg} = -\frac{1}{8\mu}\frac{\rho g h_f}{\Delta l}R^2$)(The acceleration of gravity $g = 10\text{m} \cdot \text{s}^{-2}$)

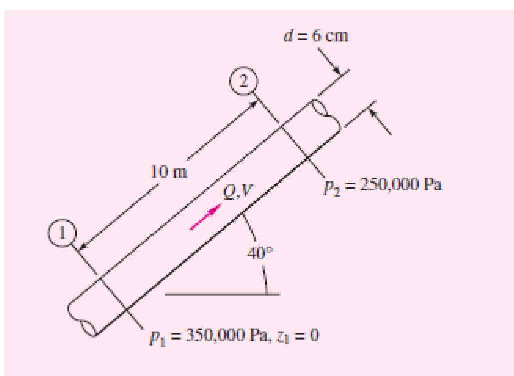

Figure 4: Problem 8