PRINCE OF SONGKLA UNIVERSITY
FACULTY OF ENGINEERING

Midterm Examination : Semester II (#1)	Academic Year	:	2002
Date : 22 December 2002	Time	:	13.30-16.30
Subject : 230-630 Advanced Transport Phenomena I	Room	:	R 300

- ข้อสอบมี 5 ข้อ ต้องทำทุกข้อ คะแนนเต็ม 80 คะแนน
- ควรใช้เวลาทำข้อสอบโดยเฉลี่ย 2 นาที/คะแนน
- อนุญาตให้นำหนังสือ เอกสาร เครื่องคำนวณ และอุปกรณ์อื่น ๆ เข้าห้องสอบได้

สุธรรม สุขมณี
ผู้ออกข้อสอบ
15 ธันวาคม 2545

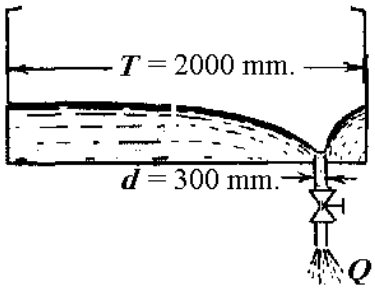
1) The viscosity of acetylene (C_2H_2) is measured as 10.11 μPa.s at 1 atm and 25 °C. Estimate the viscosity at 123.2 atm and 191 °C. (10 points)

2) Derive an expression for the steady laminar velocity distribution of the Ostwald-de-Waele (power-law) fluid of constant density ρ flowing in a very long horizontal tube of length L and radius R with the pressure drop of $(P_0 - P_L) = \Delta P$. In making the derivation, one must first get rid of the absolute value sign. Because in tube flow dv_z/dr is everywhere negative the power law for this problem becomes:

$$\tau_{rz} = -m\left|\frac{dv_z}{dr}\right|^{n-1}\frac{dv_z}{dr} = m\left|-\frac{dv_z}{dr}\right|^{n-1}\left(-\frac{dv_z}{dr}\right) = m\left(-\frac{dv_z}{dr}\right)^n$$

(20 points)

3) A glycerin storage tank 2000 mm in diameter is to be built with a draw-off line 300 mm in diameter, 500 mm from the sidewall of the tank and extending vertically upward 200 mm from the tank bottom. (See Figure below) It is known from experience that as glycerin is withdrawn from the tank a vortex will form, and, as the liquid level drops, this vortex will ultimately reach the draw-off pipe, allowing air to be sucked into the glycerin. This is to be avoided.



It is proposed to predict the minimum liquid level at which this entrainment can be avoided, at a draw-off rate of 150 m^3/h, by model study in a smaller tank. For convenience, water at 30 °C (the density is 996.4 kg/m^3 and the viscosity is 0.8 mPa.s) is used for the fluid in this model study.

Determine the proper tank dimensions and operating conditions for the model if the density of the glycerin is 1245 kg/m^3 and its viscosity is 44 mPa.s. It may be assumed that, in either the full-size tank or the model, vortex shape is dependent only upon the amount of liquid in the tank and the draw-off rate, that is, the vortex establishes itself very rapidly.

(15 points)

4) An finite body of liquid with constant ρ and μ is bounded between two large parallel plates of area A, which are everywhere seperated by a very small distance b. Initially, the liquid and the solid surfaces are at rest; but at time $t = 0$ the lower plate is set in motion in the positive x-direction with a velocity of V. Find the velocity as a function of y and t (an unfinished integral form of the function is acceptable). There is no pressure gradient or gravity force in the x-direction, and the flow is assumed to be laminar. (15 points)

5) Water is flowing through a long, straight, level run of smooth 154.1-mm i.d. pipe, at a temperature of 20 °C (the density is 1000 kg/m^3 and the viscosity is 0.001 Pa.s). The pressure gradient along the length of the pipe is 4.5 Pa/m.

   5.1 Determine the wall shear stress τ_o in Pa (Newton per square meter).

   5.2 Assuming the flow to be turbulent, determine the radial distances from the pipe wall and the ratio of $\mu^{(t)}/\mu$ at the laminar sublayer-buffer zone interface and the buffer zone-fully developed turbulent flow interface.

(20 points)