Name.....Student ID.....

# Prince of Songkla University
# Faculty of Engineering

**Exam: Mid-term Exam: Semester II** **Academic Year: 2009**
**Date: 26 December 2009** **Time: 09:00 – 12:00**
**Subject: 230-630 Advanced Transport Phenomena** **Room: S103**

- Only a lecture text book (Transport Phenomena, Bird) and lecture notes are allowed.
- All calculator models are allowed.
- Use of pencil is allowed.
- The exam paper have 2 parts, Part I: Momentum transport and Part II: Energy transport.
- The total page numbers are 8 pages, including first page.

ทุจริตในการสอบโทษขั้นต่ำคือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา

| Part | Problem No. | Points | Scores |
|---|---|---|---|
| I | 1 | 20 | |
| | 2 | 15 | |
| | 3 | 30 | |
| II | 4 | 20 | |
| | 5 | 15 | |
| | Total | 100 | |

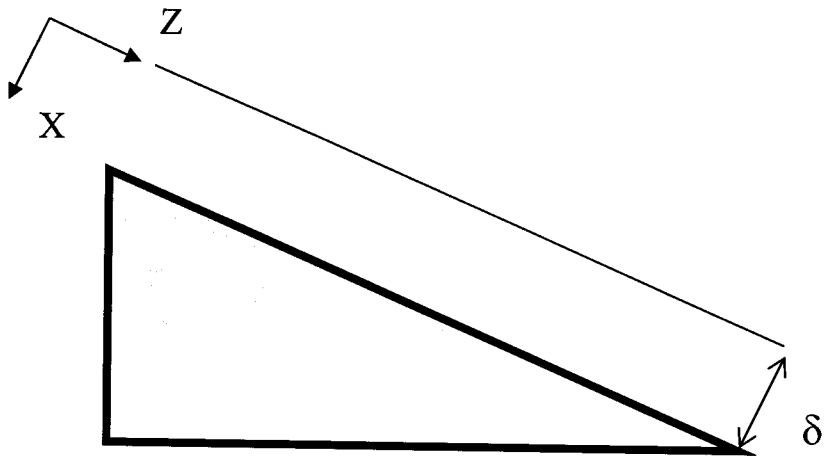
Exam prepared by
Chayanoot Sangwichien
Pakamas Chetpattananondh
17 December 2009

Name.....Student ID.....

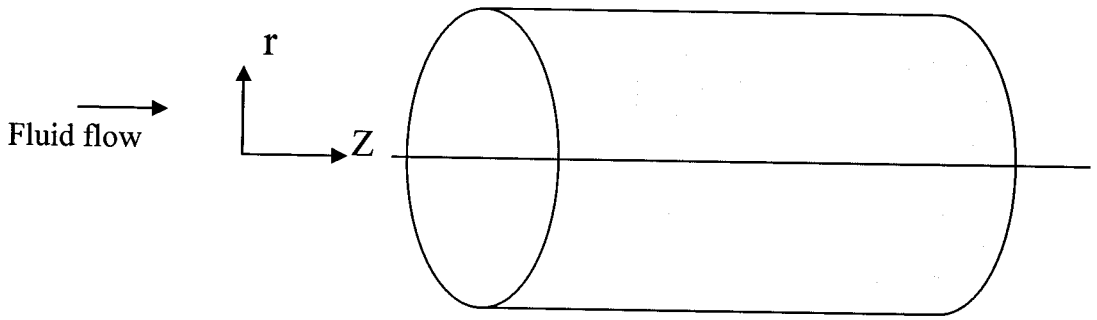
**Part I: Momentum Transport**

1. (20 points) Sketch the velocity profile and shear stress profile for each case.
   (Assume: steady state, laminar flow, incompressible fluid and Newtonian fluid)

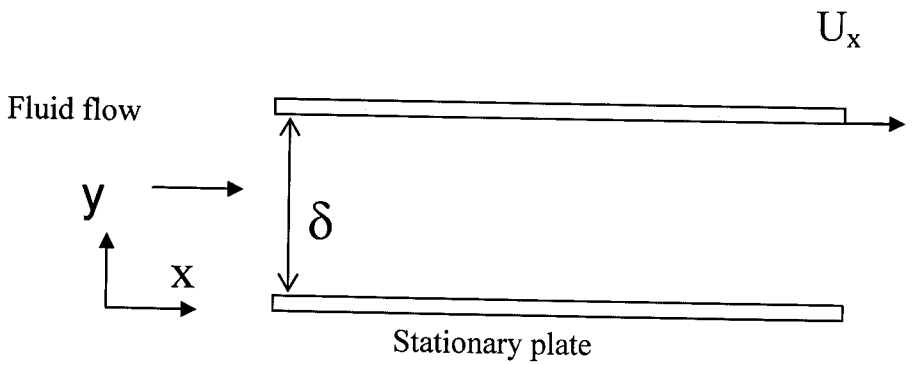
Case 1: Flow of a falling film




Case 2: Flow in pipe

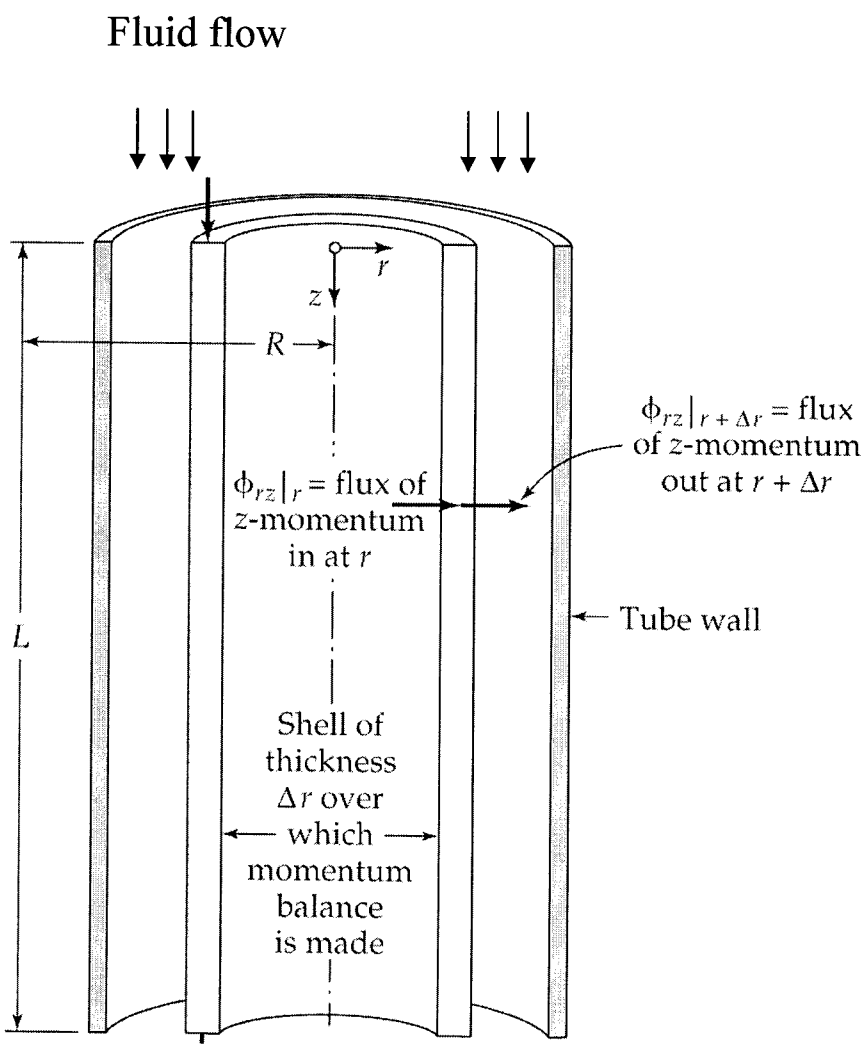



Case 3: Flow between parallel plates



Name.....Student ID.....

Case 4: Flow through an annulus



Name.....Student ID.....

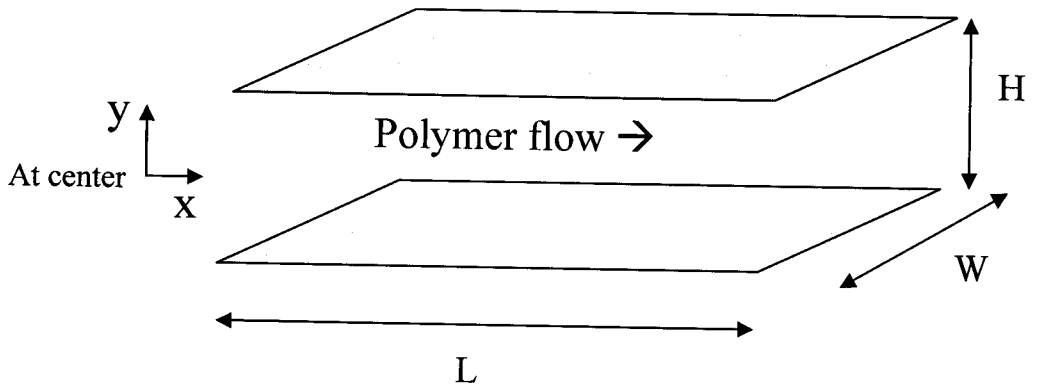
2. (15 points) An oil is flowing down a vertical wall as a film 1.7 mm thick. The oil density is 820 kg/m3 and the viscosity is 0.20 Pa.S. Calculate the average velocity.

Name.....Student ID.....

3. (30 points) For a Non-newtonian fluid which obeys a power law, derive an equation of velocity profile and momentum flux profile for flowing of polymer across the slit. The pressure at x = 0 is $P_0$ and at x = L is $P_L$ while $\frac{dv_x}{dy} = 0$ at y = 0.

(Assume: Steady state, laminar flow, incompressible fluid, 1-D flow, and no edge effect)

Given: $\tau_{yx} = -m\left(\frac{dv_x}{dy}\right)^n$ "Power Law Model"



Name.....Student ID.....

(- This page is intentionally blanked for Problem 3.-)

Name.....Student ID.....

## Part II: Energy Transport

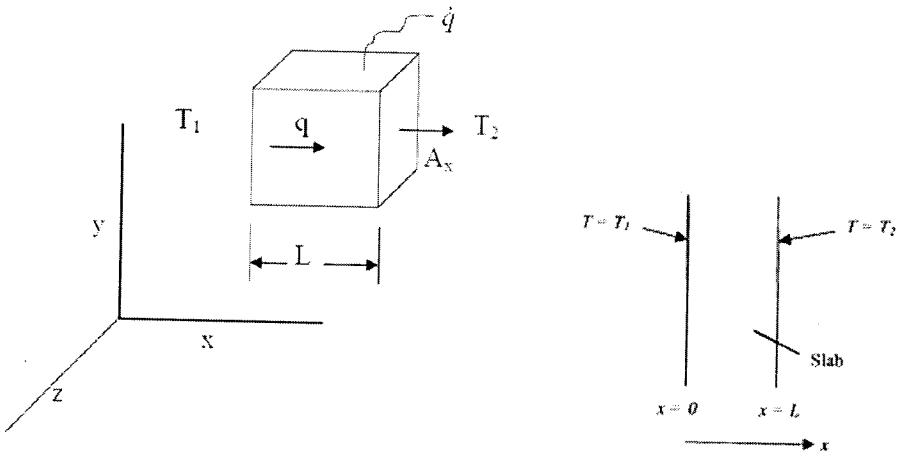
4. Predict the thermal conductivity of ethylene at 580 K and 100 atm by the following methods:

(a) Use Fig. 9.2-1. Obtain the necessary critical properties from Appendix E. The experimental value $k = 16.83 \times 10^{-3}$ W/m.K at 1.013 bar and 0°C. (5 points)

(b) Use the Eucken formula to get the thermal conductivity at 580 K and low pressure. Then apply a pressure correction by using Fig. 9.2-1. Heat capacity is 1.3 kJ/kg.K (15 points)

Name.....Student ID.....

5. (15 points)




Consider the system shown above. The top, bottom, front and back of the cube are insulated, so that heat can be conducted through the cube only in the x direction. At $x = 0$, $T = T_1$ and at $x = L$, $T = T_2$. Derive the temperature profile equation describing the temperature T as a function of x.

Note: Chain rule

$$\frac{d}{dx}\left(a\frac{dT}{dx}\right)=0$$

$$\frac{d^2T}{dx^2}+\left(\frac{1}{a}\frac{da}{dx}\right)\frac{dT}{dx}=0$$