# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2012/2013

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| COURSE NAME | : | COMPUTATIONAL FLUID DYNAMICS |
| COURSE CODE | : | BDE 4043/ BDE 40403 |
| PROGRAMME | : | BDD |
| EXAMINATION DATE | : | JUNE 2013 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | ANSWER **FOUR (4)** QUESTIONS ONLY |

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

**Q1** (a) Explain briefly the following terms of boundary conditions:

(i) Axis;

(ii) Periodic;

(iii) Pressure outlet;

(iv) Symmetry; and

(v) Wall

(10 marks)

(b) A CFD code is used to solve a two-dimensional ($x$ and $y$) incompressible, laminar flow of a gasoline through a rectangular channel in which there is large circular settling chamber (**Figure 1(b)**). The fluid is Newtonian. Flow enters from the left and exists to the right as shown. Top-bottom symmetry is assumed. Inlet velocity $V$ is known, and outlet pressure $P_{out}$ is also known.

(i) List the variables (unknowns) in the problem.

(ii) Outline the corresponding equations to be solved by the computer.

(iii) Specify the boundary conditions that should be applied to your computational domain and sketch your computational domain with the appropriate boundary conditions that you have specified.

(15 marks)

**Q2** Derive the three-dimensional (3-D) energy equation using an infinitesimal small fluid element of side lengths $dx$, $dy$ and $dz$.

(25 marks)

**Q3** (a) Explain briefly **TWO** advantages and **TWO** disadvantages of using an implicit and explicit method respectively.

(10 marks)

(b) At a given station in the flow along a pipe, the variation of the flow velocity, $u$, is given by the expression

$$u = 1600(1 - e^{-x/L})$$

where the $L$ is a characteristic length, 1 cm. The units of $u$ are m/s. The viscosity of the air is $1.8 \times 10^{-5}$ kg/m.s. Assume the grid points is equally spaced in the $x$-direction from the pipe inlet, with $\Delta x = 0.1$ cm, calculate the shear stress $\tau_w$ at the wall from the pipe inlet where $x = 0$ cm until $x = 0.2$ cm using

(i) a first order one-sided difference;
(ii) the second order one-sided difference; and
(iii) *exact*; and
(iv) compare these calculated finite-difference results in (i) and (ii) with exact value in (iii) and comment on your answer.

(15 marks)

**Q4** (a) Simple partial differential equations (PDEs) can be classified into three types: elliptic, parabolic and hyperbolic types. Classify the Partial Differential Equations by using Cramer's rule.

(10 marks)

(b) Describe each type of PDE and their traditional solution methods in details.

(15 marks)

**Q5** (a) Give reasons why turbulent flows are more difficult to simulate than laminar flows.

(2 marks)

(b) The numerical methods used in turbulent flow simulations can be grouped into three categories. Explain each category, making use of sketch (es) as appropriate, and also describe the relative strengths and weaknesses of each category.

(6 marks)

(c) Write the term Reynolds averaging in mathematical form.

(2 marks)

(d) Applying Reynolds averaging to the Navier-Stokes equations, derive the Reynolds- Averaged Navier-Stokes equations, and explain the difference from the Navier-Stokes equations.

(15 marks)

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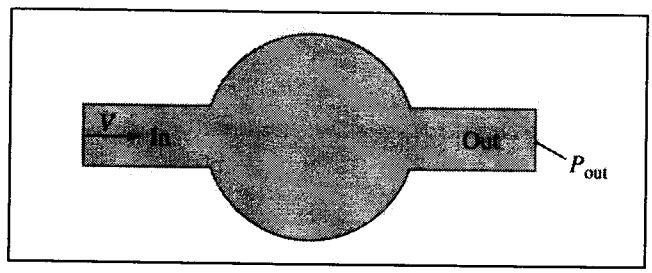


**FIGURE Q 1(b)**

**- END OF QUESTIONS -**