UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 6 Examination in Engineering: May 2026 (C-23)

Module Number: MN 6201 **Module Name: Application of CFD for Marine Design**

[Three Hours]

[Answer **all questions**, each question carries ten marks]

Q1 (a) What is Computational Fluid Dynamics (CFD)?

[02 Marks]

(b) How can Computational Fluid Dynamics (CFD) tools be applied to Marine Industry?

[02 Marks]

(c) What are the advantages of using Computational Fluid Dynamics (CFD) tools in marine design?

[02 Marks]

(d) How do numerical methods differ from analytical methods in problem solving?

[02 Marks]

(e) "Critical thinking skills are essential for applying CFD in industrial applications". Explain the statement.

[02 Marks]

Q2 (a) Explain governing equations that should be applied for the CFD analysis.

[02 Marks]

(b) Differential form of Momentum Equations for an incompressible 3-D flow can be written as:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\nu\frac{\partial^2 u}{\partial x^2}+\nu\frac{\partial^2 u}{\partial y^2}+\nu\frac{\partial^2 u}{\partial z^2}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\nu\frac{\partial^2 v}{\partial x^2}+\nu\frac{\partial^2 v}{\partial y^2}+\nu\frac{\partial^2 v}{\partial z^2}$$

$$\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}=-\frac{1}{\rho}\frac{\partial p}{\partial z}+\nu\frac{\partial^2 w}{\partial x^2}+\nu\frac{\partial^2 w}{\partial y^2}+\nu\frac{\partial^2 w}{\partial z^2}$$

Name the four terms of the above equations. Explain the physical meaning of each term.

Note: All symbols have their usual meanings.

[04 Marks]

(c) Simplify the above equations in Q2.(b) for steady, incompressible 2-D flow without considering the pressure terms.

[02 Marks]

(d) Convert the above equations in Q2.(b) for steady, incompressible 1-D flow in x-direction.

[02 Marks]

Q3 (a) Explain briefly Finite Volume approach used for discretization of governing partial differential equations.

[03 Marks]

(b) What is a computational domain in CFD analysis? Classify the different domain types.

[03 Marks]

(c) Explain selection of geometries for the domain types explained in Q3 (b) for realistic CFD results.

[02 Marks]

(d) Explain the different mesh types and their applications.

[02 Marks]

Q4 (a) Figure Q4 shows a fin whose base plate is at a constant temperatures of 200 °C and the end tip surface has 20 °C. For a constant thermal conductivity and uniform heat generation, a non-dimensionalized governing equation can be written down,

$$\frac{\partial}{\partial X}\left(\frac{\partial \Theta}{\partial X}\right) - \Psi^2\Theta = 0$$

Where $X = \frac{x}{L}$ and $\Theta = \frac{T - T_{tip}}{T_{base} - T_{tip}}$

Assuming $\Psi^2 = 3$ and discretizing the one dimensional domain using 5 cells of equal spacing resulting in 6 grid points, determine the following using the Finite Volume Method (FVM) for the cylindrical fin given in the figure.

i) The resulting set of algebraic equations to calculate the steady state temperature distribution.

ii) Coefficient matrix of the system of algebraic equations.

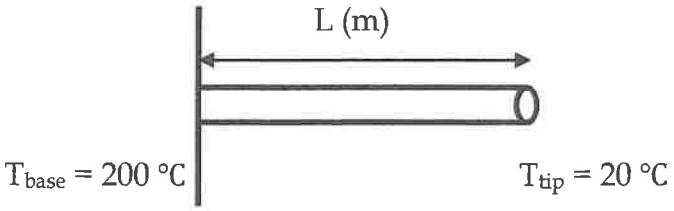


Figure Q4

[10 Marks]

Q5 Figure Q5 shows the Ahmed Body used for CFD analysis of turbulent flow patterns around a car. Analyze the flow around the body shown in the 2D domain. The flow is considered to be turbulent. Answer to the following questions;

i) Draw the streamline patterns around the Ahmed body.

ii) Compare the pressure at region A with region B.

iii) Is the turbulent kinetic energy at region A higher or lower than that at region B? Explain your answer.

iv) What are the inlet and outlet boundary conditions?

v) Propose a suitable mesh structure for the CFD analysis.

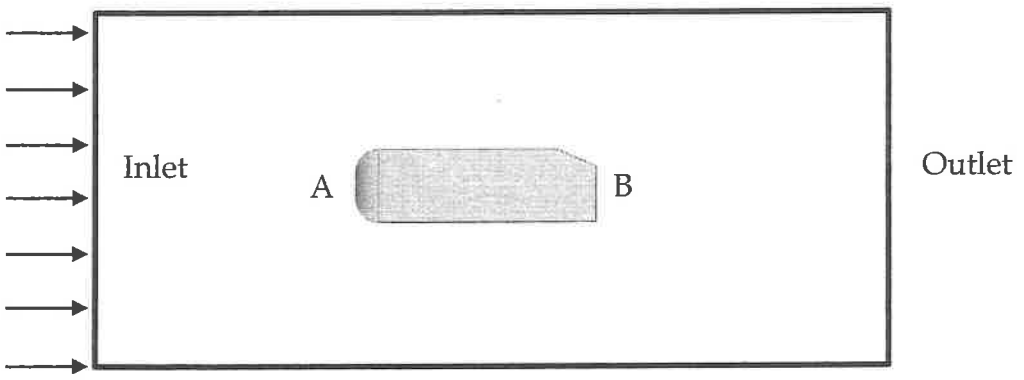


Figure Q5

[10 Marks]