Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	ANALYTICAL APPROACH IN FLUID DYNAMICS
COURSE CODE	:	BWA 33103
PROGRAMME CODE	:	BWA
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

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PART A

Q1 **Figure Q1.1** and **Figure Q1.2** illustrate the formation of the velocity boundary layer and the thermal boundary layer when a fluid at a specific temperature, flows over a surface at a different temperature.

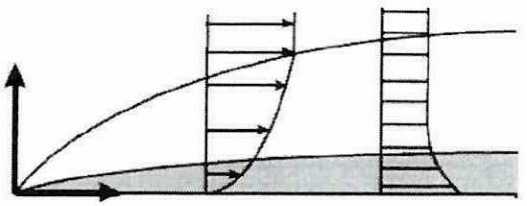

Figure Q1.1

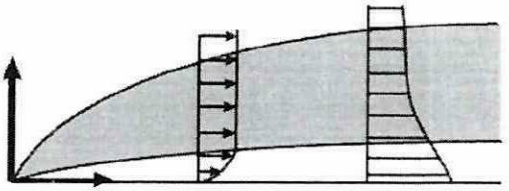

Figure Q1.2

(a) Complete the label of the axis x, axis y; the velocity-related components i.e. the velocity boundary-layer thickness δ_v, the freestream velocity U_∞ and the no-slip velocity condition U_0; and the thermal-related components i.e. the thermal boundary-layer thickness δ_T, the ambient temperature T_∞ and the wall temperature T_w.

(7 marks)

(b) Please indicate the suitable range of the Prandtl number, Pr including the relation between δ_v and δ_T for each range of Pr.

(3 marks)

Q2 Consider the quadratic equation as follows:

$$(1-\varepsilon)x^2+2x-1=0.$$

Use a regular perturbation method and find the first three terms of the equation.

(10 marks)

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Q3 (a) Write a Taylor series for:

(i) function $f(x)$ at $x=a$ up to n-terms.

(3 marks)

(ii) function $f(x,y)$ at $(x,y)=(a,b)$ up to the third derivative terms.

(7 marks)

(b) Consider the algebraic equation

$$x^2-\varepsilon x+1=0.$$

(i) Find the analytical solution of this quadratic equation.

(2 marks)

(ii) If $\varepsilon \ll 1$, find the solution of Equation (1) using the Taylor series.

(6 marks)

(iii) Compare the solution obtained in **Q3b(ii)** using the binomial approach.

(7 marks)

Q4 Consider the following nonlinear ordinary differential equation,

$$\frac{d^3\theta}{dx^3}+\theta\frac{d^2\theta}{dx^2}=0,$$

subject to boundary conditions $\theta(0)=0$, $\theta'(0)=0$ and $\theta(\infty)=1$.

Construct the series of solution using homotopy perturbation method up to the third term.

(10 marks)

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Q5 Consider the nonlinear ordinary differential equation as follows:

$$\frac{dy(x)}{dx} + y^2(x) + 1 = 0,$$

subject to $y = 0$ at $x = 0$.

Apply the Adomian decomposition method to construct the solution up to the third term.

(8 marks)

Q6 Consider the dimensional equation given by:

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{\kappa}{\rho C_p}\frac{\partial^2 T}{\partial y^2}.$$

(4)

Find the non-dimensional form of the equation by using the following non-dimensional parameters,

$$X = \frac{x}{a},\ Y = \frac{y}{a}Gr^{\frac{1}{4}},\ \theta = \frac{T - T_\infty}{T_s - T_\infty},\ U = \frac{a}{\nu}Gr^{-\frac{1}{2}}u,\ V = \frac{a}{\nu}Gr^{-\frac{1}{4}}v,\ \rho = \frac{\mu}{\nu} \text{ and } \Pr = \frac{\mu C_p}{\kappa}.$$

(17 marks)

- END OF QUESTIONS -

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