Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	AIRCRAFT AERODYNAMICS
COURSE CODE	:	BDX 31203
PROGRAMME CODE	:	BDX
EXAMINATION DATE	:	JULY/AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **FIVE (5)** QUESTIONS **ONLY.** 2. THIS FINAL EXAMINATION IS CONDUCTED VIA **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

Q1 (a) Sketch an airfoil showing the definitions of lift, drag, moments, angle of attack, and relative wind.

(3 marks)

(b) Explain the importance of using a reference point at 1/4 chord from the airfoil leading edge in aerodynamics analysis.

(3 marks)

(c) Discuss the idea that has been extended for solving flow problem by using a vortex model to produce a velocity difference between upper and lower surface of an aerodynamic body.

(4 marks)

Q2 (a) Describe body forces which are considered in the derivation of momentum equation in aerodynamics.

(3 marks)

(b) Describe surface forces which are considered in the derivation of momentum equation in aerodynamics.

(3 marks)

(c) The velocity components for a certain incompressible, steady flow field are $u = x^2 + y^2 + z^2$ and $v = xy + yz + z$. Determine the form of the z component, w required to satisfy the continuity equation.

(4 marks)

Q3 (a) Explain the parameters which normally represent the boundary layer solutions.

(3 marks)

(b) The aerodynamic boundary layer was first hypothesized by Ludwig Prandtl in a paper presented on August 12, 1904 at the third International Congress of Mathematicians in Heidelberg, Germany. Describe the main idea of the paper.

(3 marks)

(c) Total mass flow in boundary layer is given by $\dot{m}_{tot} = \int_0^\infty \rho u \, dy$, where ρ is the density of fluids, and u is the local velocity. Determine the displacement thickness, δ^*. State your assumption.

(4 marks)

Q4 (a) Panel method takes into account that physical flow phenomena is that around a streamlined body, at relatively low angle of attack and low Mach Number. For the case of steady flow past through an airfoil:

(i) List the simplified Navier-Stokes equations.
(ii) State irrotational condition which introduces the relation between the velocity components.
(iii) Write the governing equation in term of potential function.

(3 marks)

(b) Explain the mathematical impact of irrotational condition on the solution of steady incompressible inviscid flow problems.

(3 marks)

(c) Describe Hess-Smith panel method.

(4 marks)

Q5 (a) The compressibility can be expresed as $\tau = -\frac{1}{v}\frac{dv}{dp}$ where v is the volume of a fluid element, and p is the pressure exerted on the sides of the element. However, the expressions $\tau_T = -\frac{1}{v}\left(\frac{dv}{dp}\right)_T$ and $\tau_S = -\frac{1}{v}\left(\frac{dv}{dp}\right)_S$ are more precise. Discuss these statements.

(3 marks)

(b) Discuss supersonic flow in relation to shock waves.

(3 marks)

(c) An aircraft has a 3 m diameter propeller. Calculate the thrust, if the engine is being tested on the ground before take-off and the velocity of the slipstream is 80 knots.

(4 marks)

Q6 (a) By sketching a lift curve, show that the angle of attack, α, can be expressed in term of lift coefficient and the slope of the curve for both symmetric and cambered airfoil.

(4 marks)

(b) Explain flight control basic requirements.

(3 marks)

(c) Explain the trimming of an aircraft.

(3 marks)

- END OF QUESTIONS -