Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	AIRCRAFT AERODYNAMICS
COURSE CODE	:	BDX 31203
PROGRAMME CODE	:	BDX
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **FIVE (5)** QUESTIONS FROM SIX (6) QUESTIONS ONLY 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

Q1 Answer the following questions.

(a) State the 2 conservation laws inside a control volume.

(2 marks)

(b) Explain the body forces in the momentum equation of aerodynamics.

(2 marks)

(c) Describe the differences between centre of pressure and aerodynamics centre.

(3 marks)

(d) Explain the differences between induced drag and parasite drag.

(3 marks)

Q2 The aerodynamic boundary layer was first hypothesized by Ludwig Prandtl in a paper presented on August 12, 1904.

(a) State the 3 parameters which normally represent the boundary layer solutions.

(3 marks)

(b) Explain the differences between laminar and turbulent boundary layers.

(2 marks)

(c) Describe the formation of laminar separation bubble over aerofoil suction surface.

(3 marks)

(d) Explain the 2 factors affecting skin friction drag.

(2 marks)

Q3 A high-speed subsonic aeroplane with 10 m wingspan and a mean chord of 1.5 m is flying straight and level at an altitude of 5 km. The pitot tube at the wing leading edge measures the stagnation pressure as 70 kPa. The temperature lapse rate is 6.5 K/km, specific gas constant of air is 287 J/kgK and gravity acceleration is 9.81 m/s.

(a) Determine the outside air temperature (OAT) at the 5 km altitude if mean sea level temperature is 288.15 K.

(2 marks)

(b) Determine the aircraft's true airspeed (TAS) if mean sea level density and pressure is 1.225 kg/m^3 and 101325 Pa, respectively.

(3 marks)

(c) If the wing generating 80 kN of lift:

(i) Determine the wing lift coefficient.

(2 marks)

(ii) Determine how fast the aircraft must fly at 10 km altitude to produce the same amount of lift.

(3 marks)

Q4 Panel method is used in aerodynamics to analyse the flow around a streamlined body, at relatively low angle of attack and in a steady incompressible inviscid flow.

(a) For the case of steady flow past through an aerofoil:

(i) List the simplified Navier-Stokes equations.

(3 marks)

(ii) State irrotational condition which introduces the relation between the velocity components.

(1 marks)

(iii) Write the governing equation in term of potential function.

(1 marks)

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

(2 marks)

(c) Describe Hess-Smith panel method.

(3 marks)

Q5 Shockwaves occur when an object is moving beyond its critical Mach number.

(a) Describe the differences between oblique and normal shockwaves.

(4 marks)

(b) Explain the definition of critical Mach number.

(2 marks)

(c) Consider an aeroplane flying at a true airspeed of 250 m/s at 5 km altitude. Assuming the air is at standard conditions, the temperature lapse rate, specific heat ratio and mean sea level temperature is given as 6.5 K/km, 1.4 and 288.15 K, respectively. Calculate the aeroplane Mach number.

(4 marks)

Q6 Answer the following questions.

(a) Explain why the aeroplane will experience increasing drag during the turn.

(2 marks)

(b) An aeroplane glides with the engine off at an airspeed of 80 knots and is found to lose height at the rate of 10 m/s. Determine its lift to drag ratio.

(3 marks)

(c) Explain flight control basic requirements.

(3 marks)

(d) Explain the trimming of an aircraft.

(2 marks)

- END OF QUESTIONS -