Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	FLIGHT MECHANICS
COURSE CODE	:	BDU 20603
PROGRAMME CODE	:	BDC
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS IN **PART A** AND **ONE (1)** QUESTION **ONLY** IN **PART B**. 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 **FIVE (5)** PAGES

PART A: ANSWER **ALL** QUESTIONS

Q1 (a) Compare the differences between turbojet engine and turboprop engine. State also two names of the aircraft for each engine type.

(5 marks)

(b) As a design engineer, you are requested to choose the best propeller size for a new twin-engine aircraft. The diameter of the available propellers are 3, 4 and 5 m. Determine the thrust for every propeller,

(i) If the engine is being tested on the ground before take-off and the velocity of the slipstream is 80 knot.

(6 marks)

(ii) If the new aircraft flying at 160 knots with height 5000 ft and the velocity of the slipstream relative to the aircraft is know 180 knots.

(7 marks)

(iii) Based on the results in **Q1 (b) (i) and (ii),** which propeller size is the best for your new aircraft. Explain your answer.

(2 marks)

Q2 A high-speed subsonic aeroplane with 10 m wingspan and a mean chord of 1.5 m is flying at an altitude of 5 km. The pitot tube at the wing leading edge measures the stagnation pressure as 70 kPa.

(a) Determine the outside air temperature (OAT) at the 5 km altitude.

(4 marks)

(b) Determine the aircraft's true airspeed (TAS).

(6 marks)

(c) The aeroplane wing has the following characteristics:

Span efficiency factor: 0.9
Profile drag coefficient: 0.0045
Zero-lift angle of attack: -2°
Lift curve slope: 0.12
Angle of Attack: 5°

If the aircraft's indicated airspeed (IAS) at mean sea level and 5 km altitude is the same, compare the lift force, drag force and lift-to-drag ratio produced at mean sea level and 5 km altitude.

(10 marks)

Q3 An aeroplane glides with the engine off at an airspeed of 80 knots, and is found to lose height at the rate of 1500 ft/min.

(a) Determine the glide angle (assume no wind condition).

(6 marks)

(b) Find the value of the lift to drag ratio for this aeroplane during gliding.

(4 marks)

(c) If the aeroplane weight is 5000 N, drag polar is $0.01 + 0.02C_L^2$ and wing area is 10 m^2, assuming glide angle is very small, examine whether 80 knots airspeed can produce the maximum glide range at sea level and no wind condition.

(10 marks)

PART B: ANSWER **ONE** QUESTION ONLY

Q4 Two commercial twin jet engine aeroplanes, namely Aircraft A and Aircraft B, have the same empty weight $W = 80$ kN and use identical jet engines that can provide thrust $T = 8$ kN per engine. Their differences are in term of drag polar and wing area are as follow:

		Aircraft A	Aircraft B
Reference wing area, S (m^2)	:	20	30
Drag polar coefficient	:	$C_D = 0.02 + 0.06\, C_L^2$	$C_D = 0.016 + 0.054\, C_L^2$

A buyer wants to buy one of them based on three criteria; (1) high maximum speed, (2) low minimum power required and (3) high flight speed at maximum climb angle.

(a) As a consultant, which aircraft will you advise the buyer to buy? Support your advice by providing data based on the required criteria.

(24 marks)

(b) Assume the buyer choose Aircraft A.

(i) If during a climb, the engine is producing 20 kN thrust per engine; determine the climb gradient if one engine inoperative during the climb.

(6 marks)

(ii) Calculate the maximum range the aircraft can glide from 10 km altitude if both engines inoperative.

(10 marks)

Q5 A jet airplane having a weight of 441450 N and wing area of 110 m^2 has a tricycle type landing gear. Its C_{Lmax} with flaps is 2.7 and other data are given as follows:

The take-off speed $V_1 = 1.16\ V_S$
The transition speed $V_2 = 1.086\ V_1$
The lift coefficient C_{Lg} during ground run is 1.15
The drag polar with landing gear and flaps is $C_{Dg} = 0.044 + 0.05 C_{Lg}^2$
Thrust variation during take-off, $T = 128{,}500 - 0.0929\ V^2$
where, V is in the km/hour unit and gravitational acceleration g is 9.81 m/s^2

If an airport has a 900 m dry concrete runway (μ=0.02),

(a) Evaluate whether the runway length is sufficient for this aircraft to take-off.
(24 marks)

(b) Determine the total time and distance required to reach 15 m screen height.
(16 marks)

– END OF QUESTIONS –

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List of Equations

1 m/s = 1.94 knots

Density ratio, $\frac{T}{T_0} = \left(1 - \frac{\lambda}{T_0}h\right)$

Pressure ratio, $\frac{p}{p_0} = \left(1 - \frac{\lambda}{T_0}h\right)^{5.256}$

Density ratio, $\frac{\rho}{\rho_0} = \left(1 - \frac{\lambda}{T_0}h\right)^{4.256}$

Temperature Lapse Rate in Troposphere, λ = 6.5°C/ 1000 m

Propeller Thrust, $T = \frac{1}{2}\rho_o A(V_e + V_i)(V_e - V_i)$

Stall speed, $V_s = \sqrt{\frac{2W}{\rho S C_{Lmax}}}$

Lift Curve, $C_L = C_{L\alpha}(\alpha - \alpha_0)$

Total drag, $D = D_0 + D_i$

Drag polar, $C_D = C_{D0} + KC_L^2$

Induced Drag, $C_{Di} = \frac{C_L^2}{\pi e A_r}$

Power available, $P_{ave} = \eta BHP$

Power required, $P_{req} = DV = \sqrt{\frac{2W^3}{\rho S}}\left(\frac{C_D}{C_L^{3/2}}\right)$

Climb angle, $\sin\gamma = \frac{V_C}{V}$

Glide Range = Height x (L/D)

Rate of Turn, ROT = TAS/R

Rate 1 turn = 180° turn/ minute

Distance for ground run phase: $S = \frac{W}{2gB}\ln\left(\frac{A}{A - BV_1^2}\right)$

Distance for transition phase: $S = \frac{W}{2g}\left(\frac{V_2^2 - V_1^2}{T - D}\right)$

Distance for climb phase: $S = \frac{Screen\ height}{\tan\gamma}$