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# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2018/2019

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| COURSE NAME | : | FLIGHT MECHANICS |
| COURSE CODE | : | BDU20603 |
| PROGRAMME | : | 2BDC |
| EXAMINATION DATE | : | JUNE / JULY 2019 |
| DURATION | : | 3 HOURS |
| INSTRUCTION | : | PART A: ANSWER **ALL** QUESTIONS<br>PART B: ANSWER **ONE(1)** QUESTION **ONLY**. |

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



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PART – A : ANSWER **ALL** QUESTIONS

**Q1** Given an airplane having data as follow:

- Aircraft weight $W = 80000\ N$
- Wing area reference $S = 24\ m^2$
- Drag polar coefficients $C_D$ : $C_D = 0.02 + 0.06\ C_L^2$
- The maximum lift coefficients $C_{Lmax} = 1.6$
- Engine Thrust $T = 160000\ N$

The atmospheric data gives the air density at sea level $\rho = \rho_{S.L} = 1.225 \frac{kg}{m^3}$ and at at altitude $h = 10000\ m$ $\rho = \rho_{10000} = 0.413 \frac{kg}{m^3}$ .

Calculate :

(a) Stalling speeds at sea level and at *10 km* altitude.

(5 marks)

(b) Obtain the drag to lift ratio in the form $(C_D / C_L)_{min}$ and $(C_D / C_L^{3/2})_{min}$

(10 marks)

(c) The required minimum thrust $T_{rmin}$, the required minimum power $P_{rmin}$, the aircraft flight speed at minimum drag $U_{md}$ and at the minimum power $U_{mp}$ if the aircraft flies at sea level

15 marks)

**Q2** Two commercial airplanes both use a jet engine. The first aircraft called as aircraft A and the second aircraft has code name aircraft B. Both aircraft has the same aircraft weight $W = 80000\ N$ and the engine thrust $T = 160000\ N$. Their differences are in term of drag polar and wing area S as given below:

Aircraft A :
- Wing area reference $S = 24\ m^2$
- Drag polar coefficients $C_D$ :
  $C_D = 0.02 + 0.06\ C_L^2$

Aircraft B:
Wing area reference $S = 30\ m^2$
Drag polar coefficient $C_D$
$C_D = 0.016 + 0.054\ C_L^2$

The buyer want to buy one of them based on three criteria (1) the aircraft which give a higher maximum speed , (2) the aircraft has a lower minimum power required, (3) the aircraft which provide a high rate of climb.
As consultant , you had been asked to provide data to allow the buyer make a decision in selecting the aircraft. The air density at the seal level is, $\rho = \rho_{S.L} = 1.225 \frac{kg}{m^3}$ . For both aircraft make calculation for :

(a) The aircraft's maximum flight speed .


(15 marks)

(b) The maximum rate of climb

(15 marks)

(c) The minimum power required

(15 marks)

**PART – B : ANSWER ONE QUESTION ONLY**

**Q3.** (a) Shows that for propeller driven aircraft starts from the relation thrust $T$ equal to drag $D$ will give that the maximum velocity for given Brake Horse Power $P$ can be solved by the following equation.

$$A_1 U^4 - B_1 U + C = 0$$

Where :

$$A_1 = \frac{1}{2000}\rho S C_{D0}$$

$$B_1 = P_{req} = P_{av}$$

$$C_1 = \frac{K}{500}\left(\frac{W^2}{\rho S}\right)$$

$P_a$ is given in kilowatt power

$\rho$ : air density

$S$ : wing area reference

$C_{D0}$: the zero lift drag coefficient

$K$ : the induced drag factor

$P_{av}$ : power available

W : aircraft weight

(15 marks)

(b) Given a light aircraft Piper 172 powered by an engine with the Brake Horse Power $[BHP] = 140\ kW$. The other aircraft data as given below:

Aircraft weight $W = 11000\ N$

Wing Area reference $S = 16\ m^2$

Drag polar coefficient $C_D = 0.012 + 0.05\ C_L^2$

Propeller efficiency $\eta = 0.9$

If the aircraft flies at sea level in which the air density $\rho = 1.225\ kg/m^3$, determine the maximum velocity for this airplane.

(10 marks)

**Q4.** A sailplane has the following characteristics :



Drag coefficient $C_D = 0.02 + 0.025\ C_L^2$

The slope of wing lift coefficient $C_{L\alpha w} = 0.093$,
The wing zero lift angle of attack $\alpha_{0Lw} = -4^0$,
The wing incidence angle $i_w = 0^0$,
The wing aerodynamics center a.c. location $= 0.24\ c$,
Horizontal tail area $S_t = S / 7$,
The distance between wing aerodynamics center to tail aerodynamic center $l_t = 4\ c$,
The gradient of down wash angle of attack $d\varepsilon/d\alpha = 0.4$,
The gradient of horizontal tail lift coefficient $C_{L\alpha t} = 0.05$ and
The efficiency factor $\eta = 0.9$.
The wing Area denoted as $S$ and the mean aerodynamic chord $c$.

Neglect the contribution of fuselage.

(a) Find the aircraft center of gravity c.g. location for which the equilibrium is reached with zero lift on the tail at the lift coefficient corresponding to the best guiding angle. (12 marks)

(b) Calculate the tail setting angle. ( 8 marks)

(c) Is the sailplane stable? (5 marks)

**- END OF QUESTION -**