UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2011/2012

COURSE NAME	:	FLIGHT MECHANICS
COURSE CODE	:	BDU 20603
PROGRAMME	:	BACHELOR OF AERONAUTICAL ENGINEERING TECHNOLOGY WITH HONOURS
EXAMINATION DATE	:	JUNE 2012
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER FOUR (4) OUT OF FIVE (5) QUESTIONS.

THIS PAPER CONSISTS OF FIVE (5) PRINTED PAGES

Answer four (4) out of five (5) questions.

Q1 An airplane weighing 100,000 N is powered by a jet engine producing 20,000 N of thrust under sea level standard conditions. The wing area S is $25m^2$. The maximum lift coefficient $C_{Lmax} = 1.5$ and the polar drag coefficient C_D is given by $C_D = 0.016 + 0.064\ C_L^2$.:

Air properties at sea level and at an altitude 10 km are given respectively as below:

At sea level (SL) are :

Pressure $p_{SL} = 1.01325\ 10^5\ N/m^2$,

Temperature $T_{SL} = 288.15^0\ K$,

Air density $\rho_{SL} = 1.225\ kg/m^3$

Air viscosity $\mu_{SL} = 1.7894\ 10^{-5}\ \frac{kg}{s.\ m}$

At the altitude 10 km

Pressure ratio $\frac{p}{p_{SL}} = 0.26153$

Temperature $T = 223.252^0\ K$

Air density ratio $\frac{\rho}{\rho_{SL}} = 0.33756$

Viscosity ratio $\frac{\mu}{\mu_{SL}} = 0.81461$

Calculate :

(i) Stalling speed at sea level and at 10 km altitude,

(ii) $\left(\frac{C_D}{C_L}\right)_{min}$ and $\left(\frac{C_D}{C_L^{3/2}}\right)_{min}$

(iii) The aircraft speed at the minimum drag V_{md} and the aircraft speed at the minimum power required V_{mp} at sea level flight.

(iv) The minimum thrust required Tmin and the minimum power Pmin at sea level

(25 marks)

Q2 A piston-engine airplane has the following characteristics:

Aircraft weight $W = 11000\ N$,

Wing area reference $S = 11.9\ m^2$

Lift coefficient C_L as function angle of attack α : $C_L(\alpha) = 0.098\ (\alpha - \alpha_0)$

With the angle of attack at zero lift : $\alpha_0 = -3.8^0$

Drag coefficient C_D as function of lift coefficient is given as:

$C_D = 0.022 + 0.055\, C_L^2$

The maximum lift coefficient C_{Lmax} =1.4.
The aircraft engine BHP is 103 kW and propeller efficiency is 83 percent.

The atmospheric data at an altitude 3 km is given as :

Pressure ratio $\frac{p}{p_{SL}} = 0.69204$

Temperature $T = 268.659^0$ K

Air density $\frac{\rho}{\rho_{SL}} = 0.74225$

Viscosity $\frac{\mu}{\mu_{SL}} = 0.94656$

The atmospheric conditions at sea level (SL) are :

$p_{SL} = 1.01325\ 10^5$ N/m^2 , $T_{SL} = 288.15^0$ K , $\rho_{SL} = 1.225$ kg/m^3

$\mu_{SL} = 1.7894\ 10^{-5}\ \frac{kg}{s\,m}$

The aircraft flies in level flight and at an altitude of 3 km. Determine the following flight performance:of that aircraft in terms :

(i) Aircraft Stall speed V_{stall}
(ii) The maximum speed in level flight V_{max}
(iii) The minimum speed in level flight V_{min}
(iv) The aircraft speed at the minimum power required
(v) The angle of attack at that minimum power required.

(25 marks)

Q3 An airplane weighing 180000N has a wing area of 45 m^2 and drag polar given by $C_D = 0.017 + 0.05\, C_L^2$. The air properties at sea level and at altitude 10 km respectively are given as below:

- At sea level (SL) are :

  $p_{SL} = 1.01325\ 10^5$ N/m^2 , $T_{SL} = 288.15^0$ K , $\rho_{SL} = 1.225$ kg/m^3

  $\mu_{SL} = 1.7894\ 10^{-5}\ \frac{kg}{s\,m}$

- At an altitude 3 km is given as :

  Pressure ratio $\frac{p}{p_{SL}} = 0.69204$

  Temperature $T = 268.659^0$ K

  Air density $\frac{\rho}{\rho_{SL}} = 0.74225$

Viscosity $\frac{\mu}{\mu_{SL}} = 0.94656$

Determine :

(i). The thrust required and power required for a rate of climb of 2,000 m/min at a speed of 540 km/hour at 3 km altitude.

(ii) The rate of climb at 400 km/hour at sea level if the trust available is 45000 N.

(25 marks)

Q4 An propeller driven airplane having aircraft weight W = 88 290 N. The wing area S is 45 m^2. The drag polar is given by :$C_D = 0.022 + 0.05C_L^2$. Weight of fuel and oil = 15450 N, BSFC = 2.67 N/kW-hr. and propeller efficiency $\eta_p = 85\%$.
The air properties at sea level is given as follows:

$p_{SL} = 1.01325\ 10^5\ N/m^2$, $T_{SL} = 288.15^0\ K$, $\rho_{SL} = 1.225\ kg/m^3$

$\mu_{SL} = 1.7894\ 10^{-5}\ \frac{kg}{s\ m}$

Determine :

(i) The maximum range and endurance at sea level in a steady level flight at a constant angle of attack.

(ii) The velocity at the beginning and the end of flight

(iii) The power required at the beginning and the end of flight

(25 marks)

Q5 A jet airplane having a weight of 441 450 N and wing area of 110 m^2 has a tricycle type landing gear. The maximum lift coefficients C_{Lmax} with flaps is 2.7 and other data as given as follows :

The take-off speed $V_1 = 1.16\ Vs$
The transition speed $V_2 = 1.086\ V_1$
The lift coefficient C_L during ground run is 1.15
The drag polar with landing gear and flaps is $C_D = 0.044 + 0.05C_L^2$
Thrust variation during take-off can be approximated as :
$T = 128{,}500 - 0.0929\ V^2$, where V is the km/hour
The gravitational acceleration $g = 9.81\ m/s^2$

Aircraft Take-off takes place from a level and dry concrete runway (μ=0.02) and at the sea level.

Determine :

(i) The ground run distance S_1 and the required time for ground run t_1

(ii) The transition distance S_2 and the required time for the transition phase t_2

(iii) The climb distance to reach 15 m screen height and the required time taken for that purpose.

(25 marks)