NATIONAL EXAM – December 2003

MEC-B7, AERODYNAMICS

3 HOUR DURATION

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer, a clear statement of any assumptions made.

2. This is an Open Book exam. Any non-communicating calculator is permitted, but you must indicate the type of calculator being used, i.e., write the name and model designation of the calculator on the first inside left hand sheet of the exam book.

3. Attempt all questions.

Marking Scheme

Question Number	Mark
1	10
2	20
3	40
4	15
5	15

Question 1

Sketch an aircraft and on this sketch show and label the following components: Ailerons, Rudder, Flaps, Winglets, and Elevator. Briefly explain the purpose of each of these components.

Question 2

Discuss:

(i) How aircraft fly?

(ii) The difference between skin friction drag, pressure drag and profile drag.

(iii) The difference between the critical Mach number and the drag divergence Mach number.

(iv) What is wave drag? When it occurs?

(v) What is induced drag and what does it depend on?

(vi) Why variable-pitch propellers are used.

(vii) Why by-pass is used with a turbojet engine.

(viii) Why turbofan engines are used instead of turboprop engines when the flight Mach number is high subsonic.

(ix) The meaning of the terms static and dynamic stability.

(x) Some of the methods used to achieve inherent lateral and directional stability in an aircraft.

Question 3

An aircraft has the following dimensions and characteristics:

Mass	12,500kg
Wing area	$70m^2$
Maximum thrust at sea level	70kN
Mean chord of wings	3.5m
In-flight drag coefficient,	$C_D = 0.03 + 0.04\ C_L^2$
Maximum C_L without high lift devices	1.5
Maximum C_L in landing configuration	2.4
Maximum C_L in take-off configuration	1.9
C_L during take-off run	0.2
C_L during landing run (spoilers are used)	-0.02
Thrust during approach to landing	0.001 of maximum thrust
Thrust during landing run (thrust reversers deployed)	-0.15
C_D during landing run	0.05
Wheel-runway rolling coefficient during takeoff	0.02
Wheel-runway rolling coefficient during landing	0.08
Landing speed	1.2 minimum speed
Take-off speed	1.2 minimum speed

For this aircraft determine the following:

(i) The maximum angle of climb at sea level and the velocity at which this occurs.
(ii) The maximum rate of climb at sea level.
(iii) The speed for maximum range at an altitude of 9500m.
(iv) The take-off distance to reach 15m at sea level.
(v) The landing distance from 15m at sea level.
(vi) The minimum glide angle at an altitude of 5000m and the speed at which it occurs.
(vii) The thrust required if the aircraft is descending at an angle of 5° to the horizontal and its velocity is 300km/hr. Assume an altitude of 5000m.
(viii) The maximum service ceiling (assume this occurs when R/C = 30m/min).

Question 4

An aircraft has the following characteristics:

Mass	10,000kg
Wing Area	$50m^2$
Maximum engine thrust	50kN
In-flight drag coefficient,	$C_D = 0.038 + 0.041\ C_L^2$
Maximum C_L without high lift devices	1.4
Maximum C_L with high lift devices	2.1

For this aircraft calculate:

(i) The maximum speed at which this aircraft can fly at an altitude of 5000m.
(ii) The minimum speed at which this aircraft can fly at an altitude of 5000m.
(iii) The minimum glide angle and the speed at which this occurs at this altitude.
(iv) The speed for maximum endurance at this altitude.

Question 5

An aircraft has the following characteristics:

Mass	10,000kg
Wing Area	$45m^2$
Maximum engine thrust	45kN
Maximum load factor	3.2
In-flight drag coefficient,	$C_D = 0.025 + 0.035\ C_L^2$
Maximum C_L	1.6

For this aircraft determine the following:

(i) The load factor that occurs if, when flying at 600 km/hr as sea level it encounters a vertical upward gust with a velocity of 20 m/s.
(ii) The minimum radius on which it can turn at sea level.