Bengal Engineering and Science University, Shibpur
Department of Aerospace Engineering and Applied Mechanics
BE (Aero) Part II 5th Semester Final Examination, November 2012

Aircraft Dynamics (AE 504)

Full Marks 70 **Time 3 Hrs**

Airplane Data and others pertaining are appended below
Graph-sheet will be supplied if you require
Answer any FIVE

1. a) Derive the general equation for endurance for an airplane.

   b) Estimate the maximum range at 30,000 ft for the Gulfstream IV. Also calculate the flight velocity required to obtain the range. The maximum usable fuel weight is 29,500 lb. The thrust specific fuel consumption of the Rolls-Royce Tay turbofan at 30,000 ft is 0.69 lb of fuel consumed per hour per pound of thrust.

2. a) Determine the conditions for achieving minimum turn radius and maximum turn rate.

   b) Determine the expression for maximum load factor for sustained level turn and constrained by maximum thrust available.

   c) Show that maximum of maximum load factor corresponds to the flying condition at $(L/D)_{max}$.

3. a) Determine the expression for V_∞ at maximum turn rate.

   b) Calculate the maximum turning rate and the corresponding values of load factor and velocity for a Gulfstream like airplane.

4. For the Gulfstream IV, calculate the total take off distance at sea level, assuming clearing a 35 ft obstacle. Assume the runway is dry concrete with coefficient of friction of 0.04. Assume $(C_L)_{max} = 1.86$.

5. a) Derive the expression for maximum climb angle and corresponding velocity for a jet-propelled aircraft.

   b) Consider a Gulfstream IV flying at 30,000 ft. Assume a total loss of engine thrust. Calculate (a) the minimum glide path angle, (b) the maximum range covered over the ground, and (c) the corresponding equilibrium glide velocity at 30,000 ft and at seas level.

6. Consider an airplane CJ-1. Calculate the (a) thrust required and L/D at 700 ft/s at sea level (b) minimum thrust and the velocity at which it occurs at sea level.

7. a) Show that time rate of change of energy height is equal to the specific excess power.

   b) Show that the time to climb will be a minimum when specific excess power is a maximum value.

   c) Consider an airplane flying at 620 mi/h at 35000 ft. Calculate its energy height.

   d) Consider an airplane in accelerated climb. At a given instant in this climb, the specific excess power is 120 ft/s, the instantaneous velocity is 500 ft/s, and the instantaneous rate of climb is 3000 ft/min. Calculate the instantaneous acceleration.

8. a) Show that minimum power is required when the airplane is flying such that $C_L^{3/2}/C_D$ is a maximum value.

   b) Show that the corresponding velocity is less than that for minimum thrust required.

Following Data may be used while answering the questions:

Density of air = **0.002377 slug/ft^3** at sea level

= **8.9068 X 10^{-4} slug/ft^3** at 30,000 ft.

Airplane Characteristics are given below:

Gulfstream IV:

Wing span = **75 ft** Wing area = **950 ft^2**

Normal gross weight = **73,000 lb**

Power plant: Two turbofan Rolls-Royce Tay 611-8 turbofans each one rated at a maximum thrust at sea level of **13,850-lb.**

Assume that the engine thrust (T) variation with velocity (V_∞) is given by:

$$T = 27700 - 21.28XV_\infty + 0.01117XV_\infty^2$$

Specific fuel consumption = **0.69** lb of fuel/(lb thrust)(h) at an altitude **30,000 ft.**

Parasite drag coefficient $C_{D,0}$ = **0.015** Oswald efficiency factor e = **0.9**

The height of the wing above the ground during the ground roll = **5.6 ft**

K_{uc} = **5.81 X 10^{-5}** for zero flap deflection and **3.16 X 10^{-5}** for maximum flap deflection.

Airplane CJ-1 (patterned after Cessna Citation 3):

Wing span = **53.3 ft**

Wing area = **318 ft^2**

Normal gross weight = **19815 lb**

Fuel capacity: **1119 gal** of kerosene

Power plant: Two turbofan engines of **3650-lb** thrust each at sea level.

Specific fuel consumption = **0.6 lb of fuel/(lb thrust)(h)**

Parasite drag coefficient $C_{D,0}$ = **0.02**

Oswald efficiency factor e = **0.81**