Aircraft Mechanics II

(Course Code: AE 305/305M/717)

Department of Aerospace Engineering
Indian Institute of Technology Bombay

Instructor:
Shashi
Ranjan
Kumar

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Tutorial : 2

TA: Prajakta Surve

1. Consider an airplane patterned after the Fairchild Republic A-10, a twin-jet attack aircraft. The airplane has the following characteristics: wing area = 47 m^2 , aspect ratio = 6.5, Oswald efficiency factor = 0.87, weight = 103,047 N, and parasite drag coefficient = 0.032. The airplane is equipped with two jet engines with 40,298 N of static thrusts *each* at sea level.

   (a) Calculate and plot the power-required curve at sea level.

   (b) Calculate the maximum velocity at sea level.

   (c) Calculate and plot the power-required curve at 5 km altitude.

   (d) Calculate the maximum velocity at 5 km altitude. (Assume the engine thrust varies directly with freestream density.)

2. The following data apply to a $\frac{1}{25}$ scale wind tunnel model of a transport airplane. The full-scale mass of the aircraft is 22,680 kg. Assume that the aerodynamic data can be applied at full-scale. For level unaccelerated flight at $V = 123$ m/s of the full-scale aircraft, under the assumption that propulsion effects can be ignored, find the limits on tail angle i_t, and CG position h imposed by the conditions $C_{m_0} > 0$ and $C_{m_\alpha} < 0$.

   Geometric Data: Wing area, $S = 0.139$ m^2, Wing mean aerodynamic chord, $\bar{c} = 15.61$ cm, $\bar{l}_t = 38.84$ cm, Tail area $S_t = 0.0342$ m^2

   Aerodynamic Data : $a_{wb} = 0.077/\text{deg}$, $a_t = 0.064/\text{deg}$, $\epsilon_0 = 0.72°$, $\frac{\partial \epsilon}{\partial \alpha} = 0.30$, $C_{m_{acwb}} = -0.018$, $h_{n_{wb}} = 0.25$, $\rho = 1.225\text{kg/m}^3$

3. A model of a wing-body shape is mounted in a wind tunnel having flow conditions in the test section equal to standard sea-level properties with a velocity of 100 m/s. The wing area and chord are 2 m^2 and 0.5 m, respectively. The moment about the center of gravity when the lift is zero is found to be -15 N $\cdot$ m. When the model is pitched to another angle of attack, the lift and moment about the center of gravity are measured to be 4125 N and 22.45 N $\cdot$ m, respectively. Calculate the value of the moment coefficient about the aerodynamic center and the location of the aerodynamic center.

4. Assume that a horizontal tail with no elevator is added to the wing body model in above problem. The distance from the airplane's center of gravity to the tail's aerodynamic center is 1 m. The area of the tail is 0.45 m^2, and the tail-setting angle is 1.5°. The lift slope of the tail is 0.1 per degree. From experimental measurement, $\epsilon_0 = 0$ and $\frac{\partial \epsilon}{\partial \alpha} = 0.4$.

(a) If the absolute angle of attack of the model is 5° and the lift at this angle of attack is 4624 N, calculate the moment about the center of gravity.

(b) Does this model have longitudinal stability and balance?

(c) Calculate the neutral point and static margin for h = 0.3.

5. Assume that an elevator is added to the horizontal tail of the configuration given in Problem 4. The elevator control effectiveness is 0.04. Calculate the elevator deflection angle necessary to trim the configuration at an angle of attack of 8°.
