Introduction to Aerospace Engineering and Design
Aircraft Performance

Professor Dava Newman

Problem Set #3 (19 Feb 04)
Due: 26 Feb 04

Each Problem is worth 20 points. Bonus Question for 5 points. Keep track of ALL units.

1. **Problem 4.2** Explain why it is important to know the amount and distribution of fuel and payload inside the aircraft before every flight.

2. **Problem 4.5** The stall speed of wide-body airliner was determined to be 133 kn (knots) at sea level with flaps down and wheels up. Find C_{Lmax} if the aircraft has a weight of 260 tons and a wing area of 361 m^2.

3. **Problem 4.10** An aircraft is in a steady level flight with a velocity of 225 kn. It initiates a level turn with a bank angle of 30º to reverse its course. Assuming that the aircraft maintains its velocity, how long does it take for the plane to reverse its course (i.e., change its direction by 180º)? What is turning radius of the aircraft?

4. **Problem 4.12** Some aircraft such as the F-22 Raptor feature thrust vectoring. By changing the nozzle configuration in flight, the direction of the thrust can be modified about the pitch axis or the yaw axis. Derive the 2-D equations of motion for an aircraft with pitch thrust vectoring.

5. **Problem 4.14** Estimate the range and endurance of a four-engine long-haul jet airliner based on the Airbus A340-300. Assume that the aircraft flies at a cruise speed of Mach 0.82 at an altitude of 35,000 ft and that it carries the maximum allowable payload. Use a density of 6.7 lb/gal for the jet fuel.

   The specifications of the aircraft are as follows:
   Operating empty weight = 129,900 kg
   Maximum take-off weight = 260,000 kg
   Maximum payload = 43,500 kg
   Fuel tank capacity = 141,500 l
   Wing area = 361.6 m^2
   Wing span = 60.3 m
   Parasite drag coefficient = 0.015
   Oswald efficiency factor = 0.81
   Engines: Four CFM-56-5C4, each with a maximum thrust of 151.1 kN
   Thrust specific fuel consumption: 0.567 h^{-1}

Hints: First determine the air density and temperature at an altitude of 35,000 ft from a Standard Atmosphere Table. To find the cruise speed, first calculate the speed of sound, then calculate velocity. The aspect ratio of the aircraft, fuel mass, and aircraft mass can then be calculated. Finally, calculate range and endurance using the coefficients of lift and drag.

Bonus Problem: (5 points). What new **information** did you use this week to **solve** a problem? Specifically state **what** the information was and **how** you gained the knowledge about the information, and **how** you solved the problem.