Problem Set 7: Supersonic Intakes

Problem 1: Design a CD intake for a mass flow rate of 50 kg/s at flight Mach number of 2.5 at 10 km altitude (pressure = 25 kPa and temperature of 250 K). Calculate the intake entry area and throat area.

Problem 2: For an engine face area (equal to compressor entry area) of 0.1 m^2 and compressor entry Mach number of 0.4, calculate the intake entry area, throat area and the mass flow rate of air entering the engine at sea level freestream total conditions of 101.325 kPa pressure and 300 K temperature. The design point Mach number of the engine is $M_\infty = 2.0$.

Problem 3: A CD intake designed for supersonic Mach $M_\infty = 1.5$ also chokes for a subsonic Mach number (M'). Find the value of M' (using web-based compressible calculator) and the ratio of mass flow rate at M' to that at M_∞. Also find the capture area and mass spillage if the same intake is operated at Mach 0.7 and Mach 1.2.

Problem 4: Calculate the total pressure ratio for a normal shock intake designed for freestream Mach 1.6. Also calculate the intake area ratio (entry to exit area ratio) and contraction ratio (exit to entry area ratio).

Problem 5: A 2D external compression intake has a 10 degree wedge. It is designed to operate at Mach 2.5 flight condition. It will have an oblique shock on the wedge and a normal shock at the cowl lip. Calculate the total pressure loss due to the two shock waves.

Problem 6: A mixed compression intake is to be designed for Mach 4 flight condition. The external part of the intake consists of two ramps of 10 degree and 20 degrees respectively. Calculate the cowl lip area and the length of the two ramps for a mass capture area of 1 m^2.