AE4451
Seitzman
Summer 2025

Problem Set #C: Engine Component Analysis

- Homework solutions should be neat and logically presented, see format requirements at http://seitzman.gatech.edu/classes/ae4451/homeworkformat.html.
- If appropriate, include **a sketch** of the flow/system, and indicate clearly your choice of **control surface**.
- Always indicate any **assumptions** you make. If you use any results or equations from the class notes or text in your solutions, please note and **reference** them (but you better be sure they are applicable to the problem at hand).
- Try to **solve** the problem **algebraically** first. If possible, only use numbers/values in the final steps of each solution.

1. Turbofan Inlet Sizing

You have been tasked with the preliminary sizing design of the engine inlet for a turbofan engine. You have been given two flight conditions and the required air mass flow rate through the engine at each flight condition. Moreover, your design should be such that the Mach number at the front plane of the engine inlet does not exceed a value of 0.710 at either flight condition, but the inlet area should be as small as possible.

Flight Condition	Flight speed (m/s)	Ambient p (atm)	Ambient T (C)	Air Mass Flowrate (kg/s)
High Alt. Cruise	248	0.2038	-52.5	578
MaxTake-off Power	77.2	0.9641	16.8	1351

Determine:

a) the corrected mass flow rate at each of these flight conditions
b) your design values for the proper front plane cross-sectional area and diameter
c) the front plane Mach number at each flight condition

2. Turbofan Core Nozzle Sizing

You have been asked with the preliminary design of the core nozzle of a turbofan engine with separate core and bypass nozzles. It has been decided to use a *converging* geometry for the core nozzle. The nozzle will be operating at an altitude where the ambient conditions are 219 K and 25.8 kPa, while the conditions of the gas entering the core nozzle are:

- stagnation properties = 250.0 kPa, 896.3 K
- molecular weight (also called molar mass) = 28.7
- mass flow rate = 57.8 kg/s

Assuming the flow in the core nozzle is reversible and adiabatic and the gas has a specific heat ratio of 1.333, determine:

a) the cross-sectional area and diameter at the exit of the core nozzle
b) the pressure at the exit plane of the core nozzle

3. LPC Compressor Stage Analysis

The 1st stage of the axial LPC for a turbofan engine is designed to operate with a flow coefficient of 0.557, a loading coefficient of 0.341, a mean rotor radius of 0.341 m and a stage efficiency of 91.27% at the following conditions:

- inflow stagnation properties = 274.1 K, 33.6 kPa
- inlet axial air velocity = 139 m/s and swirl angle = 38.8°
- inlet mass flow rate = 56.8 kg/s

Determine:

a) the rotational speed (in rpm) of the stage's rotor and the power (in kW) required to turn the rotor
b) the stagnation temperature and stagnation pressure exiting the stage
c) the swirl angle of the flow leaving the rotor in the reference frame of the engine (not the rotor's reference frame)