16.50 Spring 2001
Problem Set #9
Assigned: 4/11/01
Due Date: 4/18/01

This problem addresses the design of the first stage of a high-pressure compressor for a high-bypass turbofan engine.

We begin with the overall design of the compression system, which is to be done for the sea-level-static or takeoff condition. The engine is to have a bypass ratio of 10 with a turbine temperature ratio $\theta t=6$. For this part assume ideal compression and expansion.

a) Find the overall compression temperature ratio for maximum power.
b) Find the fan temperature ratio (again for maximum power). These two values set the temperature ratio of the core compressor.

Now lets assume the core compressor has 10 stages, all with the same blade speed at mean radius (400 m/s) and stagnation temperature rise, so that the first stage must produce a temperature rise of just 1/10 the total. This sets its design requirement for this first stage

Assume zero swirl at entrance to the first rotor, zero swirl at the stator exit, constant axial velocity at half the blade speed, and a solidity σ of 2.0, then

c) Draw the velocity triangles at mid radius for the first stage. (How would they differ for the remaining nine stages?)
d) Find the pressure ratio of the first stage, first for ideal compression, then for an efficiency of 0.9.
e) Find the diffusion factors for the rotor and stator.

f) Assume the mass flow of the compressor is 40 kg/s and the hub/tip ratio of the first stage rotor is 0.5, and find the required tip diameter of the first stage rotor. Assume the axial velocity is constant through the compressor.

g) Finally, assuming the overall efficiency of the compressor is 0.85, find the hub/tip ratio of the last stage of compression if its mean radius is the same as that of the first stage. Then make a sketch of the core compressor flow path.