For each problem below assume the following

- Constant specific heat
- Air enters and leaves the compressor or turbine stage in the axial direction with no change in velocity and no change in mean radius
- Air always enters and leaves the blades at the blade angles (i.e., the velocity relative to the blade is in the direction of the tangent to the blade at the leading/trailing edge of blades)

**Problem 1.** Air, at 101 kPa and 288K enters an axial-flow compressor stage (that has a rpm of 7,000) at an absolute speed of 170 m/s. Air enters and leaves the stage in the axial direction. At the entry to the stage, the tip and hub diameters are 70 cm and 50 cm respectively. Air is turned 18 degrees as it passes through the rotor.

a. Construct the velocity diagrams at the mean blade diameter for this stage. Show all angles and blade shape schematics clearly.
b. Calculate the work and power developed by this stage based on mean diameter conditions.
c. Calculate the pressure and temperature at the exit of rotor (state 1.5) and exit of stator (state 2).
d. Calculate the overall percent change in specific volume through the stage.

**Problem 2.** Sketch a component layout diagram for a turbojet, a turbofan, a turboprop, and a gas turbine for power generation. Why did turbojets give way to turbofans for air travel.

**Problem 3.** Air, at a total temperature of 1400 K and a total pressure of 2230 kPa, enters the nozzle row of a turbine stage in the axial direction at the rate of 36.4 kg/s. Other known data are:

- Turbine rotor speed 14,000 rpm
- Mean blade diameter 48.3 cm
- \( V_{a3.5} \) (axial velocity at nozzle exit) 170.0 m/s
- \( \alpha_{3.5} \) (alpha at nozzle exit) +72.0°
- \( \alpha_{4} \) (alpha at turbine rotor exit) 0.0°

a. Construct the velocity diagrams at the mean blade diameter for this stage
b. Calculate the work and power developed by this stage based on mean diameter conditions
c. Calculate the pressure and temperature at the entry of nozzle (state 3), exit of nozzle (state 3.5, also same as entry to rotor) and exit of the entire stage (state4).