Homework 4. Due Tuesday April 15 @ 10:00 am. Write up Problem 3!

Problem 1. Consider an ideal air-standard cycle for a gas-turbine, jet propulsion unit. The pressure and temperature entering the compressor are 100 kPa, 290K. The pressure ratio across the compressor is 14 to 1, and the turbine inlet temperature is 1500K. When the air leaves the turbine, it enters the nozzle and expands to 100 kPa. Determine the pressure at the nozzle inlet and the velocity of the air leaving the nozzle. (Answer: \( V_{\text{exit}} = 969 \text{ m/s} \))

Problem 2. Repeat Problem 1 but assume that the isentropic compressor efficiency is 87%, the isentropic turbine efficiency is 89%, and the isentropic nozzle efficiency is 96%. (Answer: \( V_{\text{exit}} = 965 \text{ m/s} \))

Problem 3. The gas turbine cycle shown below is to be used as an automotive engine. In the first turbine the gas expands to pressure \( P_5 \), just low enough for this turbine to drive the compressor. The gas is then expanded through a second turbine connected to the drive wheels. The data for this engine are shown in the figure. Consider the working fluid to be air throughout the entire cycle. The compressor efficiency is 82%, both turbines have efficiencies of 87% and the regenerator efficiency is 70%. Also assume that friction causes pressure drop in the burner and on both sides of the regenerator. In each case the pressure drop is estimated to be 2% of the inlet pressure to that component of the system. Determine: (a) the intermediate pressure \( P_5 \); (b) the net work output of the engine per kilogram of air, and the mass flow rate through the engine; and (c) the air temperature entering the burner \( T_3 \), and the thermal efficiency of the engine. (Answer: \( \eta_{\text{th}} = 68.7\% \))