ASE 376K Homework # 4

1. A jet aircraft moves with a velocity of 200 m/s where the air temperature is 20°C and the pressure is 101 kPa. The inlet and exit areas of the turbojet engine of the aircraft are 1 m^2 and 0.6 m^2, respectively. It is known that the exit jet nozzle velocity is 1522 m/s (from lab calculation) if the exhaust gases expand to 101 kPa at a temperature of 1,000°C. The mass flow rates of the inlet and exhaust flow are 240 kg/s and 252 kg/s, respectively. As a thermal engineer, your task is to (a) determine if the temperature of the exhaust gases is too high for the turbine blades as they exit from the combustion chamber. (b) Determine the amount of combustion energy necessary to provide the thrust. The maximum tolerable temperature of the blades is 3,000 K. It is known that the pressure ratio of the multi-stage compressor is 8 to 1.
Assumptions and simplifications:

- neglect all losses and inefficiencies. All processes are isentropic.
- Neglect all kinetic energy components except at the inlet and the nozzle.
- Air and fuel mixture behaves as an ideal gas and has the same thermal properties as the air.
- All shaft work produced by the turbine are used to drive the compressor.
- Air (& mixture) has a constant C_P=1 kJ/kg.K, and γ=1.4

2. For problem 1, calculate the overall efficiency of the engine and compare with the Brayton Cycle efficiency.

3. An engine is flying at M=0.85 at an altitude of 27000ft. The maximum temperature that the turbine can handle is 2800K. The compressor pressure ratio, PR = 35. Make assumptions for any other variables you need. Using the equations derived in Lecture 14-15, compute the thrust of the engine for efficiency values of 1, 0.9 and 0.8 (i.e., set all the η values and rc to the same for each calculation)
What is the loss in thrust because of the inefficiencies? Report the answer in the form of this table.

$\eta_n = \eta_t = \eta_c = \eta_b = \eta_d$ = rc	Specifc Thrust (k-Ns/kg)
1	
0.9	
0.8	

Writing a short computer code for this problem might be the best way to solve this problem, since you have to repeat the calculation three times.