EAS 4300 Homework 8:
Turbofan Engine

Due Thursday, April 21st at the beginning of class

1. (50 points) You are to specify the bypass ratio of a turbofan engine for a comercial aircraft that is to cruise at a Mach number of 0.8. The exhaust from two streams are not internally mixed and both streams are ideally expanded. The design altitude is 10,000 m. The fuel has a heat of combustion of 43,000 kJ/kg, and a stoichiometric fuel-to-air ratio of 0.06. Assume the gamma is constant at 1.4 throughout the fan, 1.4 in the core up to the entrance of the burner, and 1.35 for the rest of the core (burner, turbine, and core nozzle). Assume the gas constant is fixed at R = 287 J/kgK. The maximum temperature at the inlet of the turbine is 1500 K. The compressor pressure ratio is 24, and the fan pressure ratio is 2.0. Plot I, TSFC, η_o, η_p, η_{th} vs. bypass ratio. Is there an optimum bypass ratio that maximizes the overall efficiency? Use the following efficiencies:

   $\eta_d = 0.94$
   $\eta_c = 0.87$
   $\eta_f = 0.92$
   $\eta_b = 0.98$
   $r_b = 0.97$
   $\eta_t = 0.85$
   $\eta_{cn} = 0.97$
   $\eta_{fn} = 0.98$

2. (50 points) Use the model developed in problem 1 to further optimize r_c and r_f at the optimum bypass ratio determined in problem 1. Do this using a single table where these values are varied across the following ranges:

   $1.5 < r_f <$ **2.2**
   $20 < r_c < 28$

   Make a table with 900 rows. Vary r_f over the range using the "repeat pattern" across 30 rows. Vary r_c over the range using the "apply pattern" across 30 rows. From this table solution, you can make an x-y-z plot, with $\eta_o(r_c,\ r_f)$. For the conditions and efficiencies listed in problem 1, determine if a different combination of r_c and r_f (other than 24 and 2) result in a further increase in the overall efficiency.