1. (50 points) A non-afterburning turbojet is being designed for operation at an altitude of 15 km and a Mach number of 1.8. The maximum stagnation temperature at the inlet of the turbine is 1500 K. The fuel is a jet fuel having a LHV of 43124 kJ/kg and f_{st} is 0.06. The following efficiencies apply at this Mach number:

$\eta_d = 0.9$	$\eta_b = 0.98$	$\eta_t = 0.92$
$\eta_c = 0.9$	$r_b = 0.97$	$\eta_n = 0.98$

Use a gamma value of 1.4 up to the burner, and a value of 1.3 for the rest of the engine. Assume R is 0.287 kJ/kgK throughout the engine. Plot the specific thrust, TSFC, η_{th}, η_p, and η_o as a function of r_c, the total pressure ratio across the compressor. Is there an optimum r_c that minimizes TSFC? Is there an optimum r_c that maximizes specific thrust? Consider a range of r_c from 2 to 60. Assume the exhaust is ideally expanded. Also plot the nozzle area ratio as a function of r_c.

$kJ := 10^3 \cdot J$

$nd := 0.9 \quad nt := 0.92 \quad alt := 15\ km \quad hc := 43124\ \frac{kJ}{kg} \quad R := 0.287\ \frac{kJ}{kg \cdot K}$

$nc := 0.9 \quad nn := 0.98 \quad M_{flt} := 1.8 \quad fst := 0.06 \quad cp_{in} := 1004.5 \cdot \frac{J}{kg \cdot K}$

$nb := 0.98 \quad rb := 0.97 \quad T_{04} := 1500\ K \quad \gamma_{in} := 1.4 \quad \gamma_b := 1.3$

$$cp_b := \frac{\gamma_b}{\gamma_b - 1} \cdot R = 1.244\ \frac{kJ}{kg \cdot K}$$

Outside Engine

$P_a := 18750\ Pa = 2.719\ psi \quad T_a := 216.65\ K \quad U := M_{flt} \cdot \sqrt{\gamma_{in} \cdot R \cdot T_a} = 1188\ mph$

$$T_{0a} := T_a \cdot \left(1 + \frac{\gamma_{in} - 1}{2} \cdot M_{flt}^2\right) = 357.039\ K \qquad P_{0a} := P_a \cdot \left(1 + \frac{\gamma_{in} - 1}{2} \cdot M_{flt}^2\right)^{\frac{\gamma_{in}}{\gamma_{in} - 1}} = 15.625\ psi$$

Inlet/Diffuser

$$T_{02} := T_{0a} \qquad T_{02a} := nd \cdot (T_{02} - T_a) + T_a \qquad P_{02} := P_a \cdot \left(\frac{T_{02a}}{T_a}\right)^{\frac{\gamma_{in}}{\gamma_{in} - 1}} \qquad \gamma = 0.577$$

Compressor

Note: Mathcad usually starts vector indices at 0

$rc := 2, 3..60 \qquad P_{03}(z) := z \cdot P_{02}$ define a FUNCTION rather than a vector

$$T_{03a}(z) := T_{02} \cdot \left(\frac{P_{03}(z)}{P_{02}}\right)^{\frac{\gamma_{in} - 1}{\gamma_{in}}} \qquad T_{03}(z) := \frac{T_{03a}(z) - T_{02}}{nc} + T_{02} \qquad w_{c\_in}(z) := cp_{in} \cdot (T_{03}(z) - T_{02})$$

Combuster

$$fb(z) := \frac{T_{04} - T_{03}(z)}{\frac{nb \cdot hc}{cp_b} - T_{04}} \qquad fb(2) = 0.033$$

T_{03s} (

Combu

fb (

$fb(2) = 0.033$ I assume your loop wants to return to4(z)

```
fb=(t04-t03)/(((nb*hc)/cp)-to4)
for i=1:length(fb)
    if fb(i)>fs
        fb(i)=fs
        t04(i)=1/(1+fb(i))*(((nb*hc)/cp)+to3)
    end
end
```

My fb is (similar to the first line of code)

$$fb(rc) := \frac{T_{04} - T_{03}(rc)}{\left(\frac{nb \cdot hc}{cp_b}\right) - T_{04}}$$

$$T_{04}(z) := \text{if}\left(fb(z) > fst, \frac{1}{1+fst} \cdot \left(\frac{nb \cdot hc}{cp_b} + T_{03}(z)\right), \frac{1}{1+fb(z)} \cdot \left(\frac{nb \cdot hc}{cp_b} + T_{03}(z)\right)\right)$$