ASE 376K Homework # 3

Use the equations at the bottom of this question and any other you need to write a computer program to perform a Ramjet Analysis to plot **<u>TSFC and Isp</u>** as a function of different parameters – you can use Excel, Matlab, Python or any other programming language of your choice. <u>Label the axis and Label the plots.</u> Explain briefly what you see in the plots.

1. Plot TSFC and Isp vs M, from 1.5 to 4.5 in steps of 0.25
   - Set all efficiencies and loss factors to 1.
   - Incoming static temperature = 220K.
   - T04 (Tmax) = 3400K
   - Perfectly expanded nozzle, so pa=pe
   - Heat of combustion, Qr = 45 MJ/kg
   - Cp = 1005 J/kg/K, R = 287 J/kg/K, g = 1.4

2. Plot TSFC and Isp vs T_{04} (i.e., maximum allowable temperature at the exit of the combustor), vary from 1000K to 4000K in steps of 200K.
   - Set all efficiencies and loss factors to 1.
   - Incoming static temperature = 220K.
   - Perfectly expanded nozzle, so pa=pe
   - Heat of combustion, Qr = 45 MJ/kg
   - Cp = 1005 J/kg/K, R = 287 J/kg/K, g = 1.4
   - incoming Mach number of 3

3. Plot TSFC and Isp vs r_d, and h_b individually by varying them one at a time from 0.6 to 1 (in steps of 0.1). Hold the other efficiencies/loss factors at 1. For example, if you are looking at the effect of r_d, make all other at 1 and vary r_d from 0.6 to 1.
   - incoming Mach number of 3.
   - perfectly expanded nozzle, so pa=pe
   - T04 (Tmax) $<$ 3400K
   - Incoming static temperature, 220K
   - Heat of combustion, Qr = 45 MJ/kg
   - Cp = 1005 J/kg/K, R = 287 J/kg/K, g = 1.4

$$\frac{\mathcal{T}}{\dot{m}_a} = (1 + f)\sqrt{\frac{2\gamma R T_{04}(m - 1)}{(\gamma - 1)m}} - \mathrm{M}\sqrt{\gamma R T_a} + \frac{p_e A_e}{\dot{m}_a}\left(1 - \frac{p_a}{p_e}\right),$$

in which

$$m = \left(1 + \frac{\gamma - 1}{2}\mathrm{M}^2\right)\left(r_d r_c r_n \frac{p_a}{p_e}\right)^{(\gamma-1)/\gamma}.$$

$$f = \frac{(T_{04}/T_{0a}) - 1}{(\eta_b Q_R/c_p T_{0a}) - (T_{04}/T_{0a})},$$