MAE 112 PROPULSION

MIDTERM EXAM

October 26, 2022

Do all parts of the three problems in eighty minutes. Open books and notes are allowed. Calculators without communication capability are allowed. Cellphones, tablets, and laptops should not be available.

1(a) 15 points. Establish the equations which can be employed for the calculation of the equilibrium composition and final temperature when normal decane $C_{10}H_{22}$ burns adiabatically at a constant pressure of ten atmospheres. The mixture is lean with 100% excess air in terms of moles. The air and the fuel in gaseous form enter at a temperature of 700°R. Consider the products to be CO_2, CO, H_2O, H_2, O_2, and N_2 only. Write all the required equations with known quantities and parameters substituted into the equation. Identify the unknowns but do not solve the equations.

(b) 10 points. In an ideal case where no CO or H_2 occurs in the products, what would be the mole fractions for CO_2 and H_2O in the products?

(c) 5 points. Which of the two temperatures from (1a) and (1b) do you expect to be larger? Why?

2. Consider a nozzle with stagnation pressure and stagnation temperature of twenty-five atmospheres and 2000K. The value of $\gamma = 1.25$ and the value of $c_p = .30$ Btu/1bm °R. The throat area is $0.01m^2$. The flow is perfectly expanded to the ambient pressure of one atmosphere. Calculate the following quantities: (a) 10 points - the exhaust velocity;, (b)10- points - the mass flow; and (c) 10 points - the thrust coefficient.

3. Consider a Kantrowitz-Donaldson diffuser designed for a flight Mach number of $2^{1/2} = 1.41$. The entrance area equals 0.5 square feet and the ambient air temperature and pressure are 550°R and 0.5 atmospheres. The flow is isentropic everywhere except across the normal shockwave. Determine:

(a) 15 points - the minimum cross-sectional area of the throat such that a normal shock may be stabilized at the entrance,

(b) 10 points -the maximum mass flow, and

(c) 15 points - the maximum stagnation pressure possible at the end of the diffuser (with subsonic flow only in the divergent portion).

In each of these optimizations, consider the flight Mach number fixed at the design value while the final pressure (at the end of the diffuser) is allowed to vary.

END.