MAE 478, Spring 2017

**Homework Assignment #1**

**Due Date: January 26th, 2017**

1. (5) A certain nozzle expands a gas under isentropic conditions. Its chamber or nozzle entry velocity equals 70 m/s, its final velocity 1500 m/s. What is the change in enthalpy of the gas? What percentage of error is introduced if the initial velocity is neglected?

2. (5) The following data are given for an optimum rocket:

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| --- | --- |
| Average molecular mass | 24 kg/kmol |
| Chamber Pressure | 2.533 MPa |
| External Pressure | 0.090 MPa |
| Chamber Temperature | 2900 K |
| Throat Area | 0.00050 m2 |
| Specific Heat Ratio | 1.30 |

Determine the (a) throat velocity, (b) specific volume at throat, (c) propellant mass flow rate and specific impulse, (d) thrust, and (e) Mach number at throat.

3. (5) Design a supersonic nozzle to operate at 10 km altitude with an area ratio of 8.0. For the hot gas take T0=3000K, R=378 J/(kg-K), and k=1.3. Determine the exit Mach number, exit velocity, and exit temperature, as well as the chamber pressure. If this chamber pressure is doubled, what happens to the thrust and the exit velocity? Assume no change in the gas properties. How close to optimum nozzle expansion is this nozzle?

4. (5) The German World War II A-4 propulsion system had a sea level thrust of 25,400 kg and a chamber pressure of 1.5 MPa. If the exit pressure is 0.084 MPa and the exit diameter is 740 mm, what is the thrust at 25,000m.

5. (5) An ideal rocket has the following characteristics:

|  |  |
| --- | --- |
| Chamber Pressure | 27.2 atm |
| Nozzle Exit Pressure | 3 psia |
| Chamber Temperature | 4200 °F |
| Average molecular mass | 21.0 lbm/lb-mol |
| Specific Heat Ratio | 1.20 |

Determine the critical pressure ratio, the gas velocity at the throat, the expansion area ratio, and the theoretical nozzle exit velocity.

6. (5) For an ideal rocket with a characteristic velocity c\* of 1220 m/s, a mass flow rate of 73.0 kg/s, a thrust coefficient of 1.50, and a nozzle throat area of 0.0248 m2, compute the effective exhaust velocity, the thrust, the chamber pressure , and the specific impulse.