AAE 439 Hourly Exam #1
Fall, 2011 Semester

Open Book & Notes
Attempt all Problems

1. (20 pts) A cold gas system is used for attitude control on a spacecraft orbiting the earth in preparation for a deep space mission. The thrusters used in the system have a chamber pressure of 100 psi and employ an expansion ratio of 40. To minimize the amount of fluid required, the gases exiting the cold gas tank are heated using residual heat from the main engine that is boosting the stage. The propulsion requirements demand a total impulse capability of 10,000 lbf-sec, but the overall propellant mass(weight) budget is 150 lbf. If nitrogen is used as the cold gas, what temperature must it be heated to in order to achieve this objective?

2. (40 pts) A mixture of 2 moles CO_2 and one mole of N_2 is placed in a container and heated to high temperature while maintaining a pressure of 10 Atm. We wish to produce CO in this process in via dissociation of the CO_2 into CO and O_2. A fixed amount of CO is required for an experiment to be conducted on the dissociated mixture.

    i) Determine the temperature we must heat the mixture to assuming we wish to produce 0.5 moles of CO in the process. Compute the mass fractions of each of the constituents at this condition.
    ii) Suppose we wanted to double the amount of CO in the container by lowering the pressure and keeping the mixture temperature fixed. What pressure would be required?

3. (10 pts) In class we talked about the aerospike or "plug" nozzle that is advertised as being altitude compensating. Because there is no physical exit cone on this nozzle, it is difficult to use our ideal rocket analysis on this type of engine. Can you suggest a way that we might estimate the performance (Cf) of this nozzle over a range of flight conditions (i.e. over a range of altitudes)?

4. (30 pts) You are asked to design components of an underwater solid rocket motor designed to protect Navy vessels from torpedo attack. The rocket is designed to function at a depth of 5 meters below the ocean surface as indicated in the sketch below. Other known/specified information include:

Desired thrust = 4000 N, Desired chamber pressure = 5 MPa, c*=1600 m/s

i) Using this information and assuming ideal engine performance with $\gamma=1.2$ determine the Isp and massflow produced by the engine.

ii) Determine the nozzle throat and exit diameters.

iii) To minimize drag on the vehicle, it is desirable to adjust the Pc such that the nozzle exit diameter matches the vehicle diameter of 8 cm as indicated in the sketch. Outline a process for determining the Pc that will meet this requirement. Is the optimal Pc higher or lower than the 5 MPa value selected?