

## Unified Engineering Spring Term 2004

### Problem P6. (Propulsion) (L.O. E)

Evaluate the performance of a single stage sounding rocket to be used for atmospheric research.

You are given the following design parameters:

Combustion chamber temperature = 4000 K

Combustion chamber pressure = 5 MPa

Nozzle throat area = 0.0006 m<sup>2</sup>

Nozzle exit area = 0.01 m<sup>2</sup>

Propellant mass = 35 kg

Total mass at takeoff = 50 kg

Gas constant = 300 J/kg-K

Ratio of specific heats = 1.35

- a) What are the Isp and take-off thrust for this rocket?
- b) Assuming the rocket is launched vertically, and neglecting drag, how high will it go?

[Note: To solve this problem you will have to use relationships from thermodynamics (steady flow energy equation) and fluid mechanics (compressible flow relations). These can all be found in the Unified Propulsion notes (Chapters V and VI). Most of the relations are written in terms of the exit Mach number,  $M_e$ . To find this you will have to try several values of  $M_e$  in the relationship for  $A^*/A_e$  until the equation gives you the same ratio as given in the problem statement.]