MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Aeronautics and Astronautics

Field Exam in Space Propulsion
January – 2014

- There are two problems in this exam
- Read carefully each problem before writing your solution
- Make sure to state and be consistent with your assumptions
- Identify clearly your line of thought in your solutions
- Manage your time with care

Problem #1

Consider the design of a spacecraft initially in an earth-like heliocentric circular orbit (radius = r_0, mass = m_0). This spacecraft would feature an electric propulsion system, which is used to spiral-climb through pure angular thrust until reaching the orbit of Jupiter (radius = r_f) in a fixed time t_m. There are two options for powering the spacecraft: nuclear and solar.

1. (80%) Assume the propulsion system operates with constant efficiency η, but not constant thrust. What are the optimal acceleration profiles in both cases? When minimizing $\int d(1/m)$, there is a constraint, and it might be helpful for its identification to look at the variation of orbital parameters in this "non-Keplerian" but near-circular trajectory.

2. (20%) Explain how one could calculate the maximum payload mass fraction (m_{pay}/m_0).

Problem #2

What axial force is transmitted by the structure across section *aa* through the throat of a rocket? Explain how it could be calculated.
Can the same method, with appropriate modifications, be used for section *bb*? For section *cc*?