Rocket Propulsion (AE40009)

Tutorial Problems Set-01

1. The following data are reported for a rocket a few seconds after it leaves the Launch pad: Thrust is 9 MN; Propellant consumption rate is 3000 Kg/s; Velocity of the rocket is 400 m/s. Calculate the following at the particular instant of time for which data are available.
   (a) Jet velocity
   (b) Propulsive efficiency of the rocket

2. Hot gases are generated at a temperature of 2000 K and a pressure of 15 MPa in a rocket chamber. The molecular mass of the gas is 22 Kg/kmole and the specific heat ratio of the gas is 1.32. The gases are expanded to the ambient pressure of 0.1 MPa in convergent-divergent nozzle having a throat area of 0.1 m2. Calculate (i) Exit velocity, (ii) Characteristic velocity, (iii) Specific impulse, and (iv) Thrust generated. Take ideal optimum thrust coefficient (C_F) = 1.615.

3. A four stage rocket is used to put up a satellite of 70 Kg mass in a Low Earth Orbit (LEO). The approximate values of mass of the propellant, mass of structure and jet velocity for each stage are given below:

STAGE	**I**	**II**	**III**	**IV**
Mass of Propellant (Kg)	9500	4000	1750	270
Mass of structure including inerts (Kg)	1600	650	300	60
V_j (m/s)	2300	2450	2550	2850

   Determine
   (i) The payload mass fraction of the total rocket
   (ii) Structural mass fraction of each stage
   (iii) The ideal ΔV provided by each stage and the total ΔV
   (iv) If the first stage fires for a period of 50 seconds and the rate of mass depletion can be used to be constant, what would be the acceleration of the rocket at take off?

4. For an ideal rocket with C* of 1500 m/s, a nozzle throat diameter of 18 cm, a thrust co-efficient of 1.38 and a mass flow rate of 40 kg/s, determine
   (a) Chamber pressure
   (b) Thrust
   (c) Specific impulse