Practice Questions

Set 1

1. A sounding rocket is to be launched vertically from the earth's surface. It is designed for a 340 kg payload and the maximum acceleration during the burning period should not be greater than 4 g. The maximum propellant mass is 950 kg and $\varepsilon = 0.1$. Let the $I_{sp} = 250$ s.
   Neglecting aerodynamic drag and considering constant g, determine:
   (a) The minimum allowable burning period.
   (b) The maximum height attainable.

2. A sounding rocket vehicle whose instantaneous total mass is 180 kg is at an elevation of 10 km from the surface of the earth and is moving up with a velocity of 1 km/s at the burnt out. The cross sectional area of the rocket is 0.06 m^2. What is the drag an the instantaneous rate of deceleration?

Set 2

1. Consider a single stage rocket with a payload of 100 kg and an I_{sp} = 450s. The structural factor is 0.2 and the ideal ΔV is 2000 m/s. Calculate the mass at liftoff.

2. Determine the maximum ΔV for free space with a 3 stage rocket and the following conditions:
   (a) $s_1 = s_2 = s_3 = 0.1$
   (b) $I_{sp1} = 250$ s; $I_{sp2} = 300$ s; $I_{sp3} = 350$ s
   (c) $M_l/M_{01} = 0.01$

3. Determine the ΔV for free space with a 3 stage rocket and the conditions of problem 2 but assuming that $l_1 = l_2 = l_3 = l = 0.21544$

4. Determine the maximum free space ΔV for a 3 stage rocket with following conditions:
   (a) $s_1 = 0.15$, $s_2 = 0.10$, $s_3 = 0.05$
   (b) $I_{sp1} = I_{sp2}\ I_{sp3} = 270$ s
   (c) $M_l/M_{01} = 0.01$

5. Determine the ΔV for free space with a 3 stage rocket and the conditions of problem 4 but assuming that $l_1 = l_2 = l_3 = l = 0.21544$.

6. Determine the maximum free space ΔV for a 3 stage rocket with following conditions:
   (a) $s_1 = s_2 = s_3 = 0.1$
   (b) $I_{sp1} = I_{sp2}\ I_{sp3} = 270$ s
   (c) $M_l/M_{01} = 0.01$ and $l_1 = l_2 = l_3 = l = 0.21544$.

<u>Set 3</u>

1. We want to launch a satellite of 1500 kg into an elliptical orbit with a desired perigee of 7000 km and a desired apogee of 30000 km. Estimate the velocity of the vehicle at the apogee.

2. What is the orbital period of the satellite in question 1 around the earth?

Set 4

1. A rocket is to be designed to produce 5 MN thrust at the sea level. The working fluid is assumed to be a perfect gas with properties of air at room temperature. Determine (a) I_{sp}, (b) mass flow rate, (c) throat diameter and (d) exit diameter for the following conditions:
   (i) P_c = 7 MPa and T_c = 3000 K
   (ii) P_c = 7 MPa and T_c = 3500 K
   (iii) P_c = 20 MPa and T_c = 2800 K

2. Consider the performance of a solid-propellant rocket whose stagnation pressure changes slowly with time according to

$$P_0 = 30 - 0.06t, \;\; 0 < t < 50$$

for pressure in MPa and time in seconds. The stagnation temperature is constant at 3000 K. The nozzle area ratio is 5 and the throat area is 0.25 m^2. It exhausts into ambient conditions at sea level. Consider γ = 1.4 and molecular weight of the products to be 20. How do the following vary with time?
   (i) Exhaust velocity
   (ii) Mass flow rate
   (iii) Thrust

Set 5

1. Compute I_{sp} for an H_2 – O_2 engine at sea level with P_{c0} = 2 Mpa for oxider/fuel mass ratio of 8 and 3.5. Assume a fully expanded nozzle with no nozzle losses and a constant γ. Assume the following reaction

$$aH_2 + O_2 \rightarrow 2H_2O + (a-2)H_2$$

use

$$h_{c0} = -\sum \frac{\dot{m}_J}{\dot{m}_m} \frac{\Delta H^0_{f,j}}{\overline{W_J}}$$