DEPARTMENT OF AEROSPACE ENGINEERING

Indian Insitute of Technology Kanpur

Rocket Propulsion (Code: AE441A)

Instructor: Sathesh Mariappan

Assignment due: 28 September 2020

Course assignment Maximum Marks: 10

1. (a) Plot the rocket trajectory (horizontal (x) vs. vertical (h) distance), rocket speed (u vs. t), rocket angle (θ vs. t) and rocket height (h vs. t) until the burn out time ($t = t_b$). Also tabulate the burnout height (h_b), burnout speed (u_b), and angle of rocket at burnout (θ_b). The rocket is fired from the ground (at $t = 0 : x, h = 0$) at an angle of 1 degree from the vertical ($\theta = 1$ degree). Given: constant equivalent exhaust velocity $u_{eq} = 3048$ m/s, initial rocket mass (M_0) = 15000 kg, propellant mass (M_p) = 12000 kg, burnout time (t_b) = 100 s, constant acceleration due to gravity (g_0) = 9.81 m/s^2, neglect drag ($D = 0$), assume constant mass burning rate ($\dot{m}$). Compute the results (overlay the plots for the cases a-d and tabulate other results) if all other parameters are as given above and:

   (b) Only acceleration due to gravity (g) varies (and $D = 0$): with height (h): $g = g_0 \left[R_e/(R_e + h)\right]^2$, where, R_e is the earths radius = 6,400 km.

   (c) Only drag (D) varies (and $g = g_0$): with ambient gas density (ρ) and rocket velocity (u): $D = C_D(1/2)\rho u^2 A_f$, where, C_D is the coefficient of drag = 0.1 (assumed constant), A_f is the frontal cross-sectional area of the rocket = 1 m^2. $\rho(h) = 1.2exp\left(-2.9 \times 10^{-5} h^{1.15}\right)$ kg/m^3, h is in m.

   (d) Both g and D varies: as given in (b) and (c), respectively. Choose the time step (Δt = 0.1 s).

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Student's name: End of exam