Astronomy Club, IITK
SnT Summer Project
Blast Off
Assignment 2

Submission Deadline: 23:59:59, 17/06/2022

Try to attempt all the questions

1. Assuming Ideal Rocket equation, what fraction of the Initial Wet Mass of the rocket should be propellant (fuel + oxidiser) in order to attain an orbital velocity of 7.6 kmps with a specific impulse of 400 seconds. (Take $g_0 = 9.8\ ms^{-2}$)

2. Consider the thrust force acting on the rocket to be = -C$\frac{dm}{dt}$. Assume a rocket launching perpendicularly from the surface of the Earth. You may neglect drag force, but not gravitational force.

   Define $n = \frac{F_{thrust}}{m_0 g}$ and $\mu = \frac{m(t)}{m_0}$

   - Estimate the velocity of the rocket, $v(t)$ in terms of mass fraction (μ).
   - Estimate the displacement of the rocket, $z(t)$ in terms of mass fraction (μ).
   - What is the total time of flight of the rocket?
   - What is the physical significance of n?

3. In order to achieve an orbital speed of 6.4 kmps, we require an ideal Δv of about 8 kmps, where the extra speed is required to overcome the effects of gravitation and drag. Conventional chemical propellant based rockets produce exhaust jet velocities of $v_e = 2.5$ to 4.5 kmps. Using highest v_e value for:

   - Single stage rocket
   - Double stage rocket

   Find the approximate mass of payload which the rocket could potentially carry in both the conditions. Which one provides a higher payload capacity and why is it qualitatively so? (In case of double stage rocket, you may assume that equal distribution of Δv is achieved by both the stages.)

4. Given an attainable Δv of 8 kmps, with specific impulses of [350, 400, 450] sec, and a fixed payload mass of 2000 kg, plot a graph between Initial Wet Mass of the rocket and Structural Coefficient (λ) of a SSTO rocket. What observations can you make from the slope of the curve so obtained? (You may plot the graph on DESMOS or use Python.)