Introduction to Flight Simulation (List 0)

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1. Using the formula $F = \frac{Gm_1m_2}{r^2}$, and $G = 6.67384 \times 10^{-11} m^3 kg^{-1} s^{-2}$, the fact that the mass of the earth equals $5.972.10^{24}$ kg, compute the speed that is required to maintain a circular orbit at at an altitude of 150 km above sea level.

2. Compute the difference in energy (both potential and kinetic), between an object standing still on the surface of the earth, and an object in orbit at 150 km.

   The difference in energy consists of two parts, increased potential energy, due to altitude, and increased kinetic energy, due to speed.

   How do the energy components relate?

3. In the previous task, let's for simplicity completely completely translate the energy into kinetic energy. What is the Δv that is necessary to reach orbit from a position standing still on the ground.

   Again grossly simplifying, compute how much rocket fuel is needed, assuming that we use liquid $2H_2 + O_2 \rightarrow 2H_2O$, which has an exhaust velocity of $4500 m.s^{-1}$, using the Ciółkowski rocket equation.

   - Compute $\frac{m_0}{m_1}$, when all Δv is carried out close to the ground.
   - Compute $\frac{m_0}{m_1}$, when (hypothetically) half of Δv is obtained on the ground, and the other half is obtained at an altitude of 150 km.

   The previous task was a gross simplification. In practice, launching is a complicated process, and choosing the most efficient trajectory, and power distribution is extremely difficult.

4. The earth rotates around its axis in 24 hours. This gives the surface of the earth quite a high speed. Compute the speed **(1)** at the equator, and **(2)** in Kourou (Guyana Space Center), which lies at 5 deg, 9 min, 35 seconds latitude.

   What is the ΔV that is required to reach orbit (at 150 km) from Kourou?

   Using the Ciółkowski rocket equation, how much is $\frac{m_0}{m_1}$, for a launch from Kourou.

   How much fuel is saved due to the earth rotation?

5. What is escape velocity from the surface of the earth? What is the $\frac{m_0}{m_1}$ associated to it, when liquid hydrogyen, oxygen is used as fuel?