AE-777A (Optimal Space Flight Control)

Quiz No. 6

Quiz Procedure

1. Clearly write out your solution to the quiz problems within the specified time on blank sheets of paper. (Marks will be given only for clear and complete calculation/derivation steps.)
2. Take low-resolution pictures of your solution, convert them into a single PDF file (about 1MB), and send it to me by email (ashtew@iitk.ac.in) from your registered email account.
3. The time limit will be strictly enforced, and late submissions will not be accepted for any reason.

Quiz No. 6 (Time: 60 min; Total Marks: 60)

1. A spacecraft is in an orbit of eccentricity, $e = 0.7$, around the Earth ($\mu = 398600.4$ km^3/s^2). When the radius is 6900 km and the speed is 7.4 km/s, a velocity impulse of magnitude 500 m/s is applied at an angle 60° from the initial velocity direction, in order to increase both the speed and flight-path angle simultaneously, but without changing the orbital plane. Determine the new orbit (a, e) of the spacecraft.

   (15)

2. Estimate the smallest total velocity impulse magnitude required for sending a spacecraft from the Earth (orbital radius 1 AU = 1.495978×10^8 km) to Mars (orbital radius 1.524 AU). Assume that both the planets are in coplanar circular orbits around the Sun ($\mu = 1.327 \times 10^{11}$ km^3/s^2), and that the gravitational influence of the planets on the spacecraft during the transfer is negligible.

   (10)

3. Spacecraft A is orbiting the Moon ($\mu = 4902.8$ km^3/s^2) in a circular orbit of radius 2000 km, and a lander spacecraft has landed on the Moon's surface (radius 1737.1 km) at a point B in the orbital plane of A. Now the lander has to return to the orbiting spacecraft A. What minimum velocity impulse (magnitude and direction) should be provided to the lander such that it reaches the orbit of A, when A is exactly 180° ahead of B?

   (20)

4. A spacecraft flying in a spherical gravity field of gravitational constant, μ, is powered by a continuous-thrust engine, which has its thrust acceleration magnitude, $a(t)$, limited as follows:

   $$0 \leq a(t) \leq a_m$$

   where $a_m \ll \mu/r^2$ is a constant. Formulate the boundary-value problem to be solved (differential equations, boundary conditions, and control laws for both magnitude and direction) for optimally transferring the spacecraft from an initial circular orbit of radius, r_1, to a final circular orbit of radius, r_2, in a fixed time, t_f.

   (15)

Please send your solution to me (ashtew@iitk.ac.in) before 1:00 p.m. today.