AE-777A (Optimal Space Flight Control)

Quiz No. 6

Quiz Procedure

(i) Clearly write out your solution to the quiz problems within the specified time on blank sheets of paper. (Marks will be given only for complete calculation/derivation steps.)

(ii) 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.

(iii) Submit your solution only *once*. In case of multiple submissions, only the *earliest* one will be accepted.

(iv) The time limit will be *strictly enforced*, and late submissions will *not* be accepted.

<u>Quiz No. 6 (Time: 24 hrs)</u>

1. Estimate the total velocity impulse magnitude required for sending a spacecraft from the Earth to Neptune by using:

   (a) Hohmann transfer.

   (b) Outer bi-elliptic transfer (see *Exercise 8* of *Lecture No. 19*).

   Assume that both the planets are in coplanar circular orbits around the Sun ($\mu = 1.327 \times 10^{11}$ km^3/s^2) with the respective orbital radii around solar centre of 1 AU $= 1.495978 \times 10^8$ km for Earth and 30.1 AU for Neptune, and that the gravitational influence of the planets on the spacecraft is negligible.

   (20)

2. 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)

3. 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.

   (20)

Please send your solution to me (ashtew@iitk.ac.in) before 12:00 p.m. tomorrow (15/11/22).