AE-641A (Space Dynamics-I)

Quiz No. 5

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. The deadline includes extra ten minutes to submit your solution.

Quiz No. 5 (Time: 24 hr; Total Marks: 60)

(Marks for each problem are indicated in parentheses.)

1. Write "True" or "False" against each of the following statements (two marks for each correct answer):

   (a) An *osculating orbit* is the trajectory followed by a spacecraft under the influence of a perturbing acceleration.

   (b) An arbitrarily shaped central body causes a non-conservative orbital perturbation.

   (c) Oblateness effect causes a variation in the inclination of the orbital plane.

   (d) Third-body gravity causes a change in the semi-major axis and the eccentricity of the orbit.

   (e) A *Molniya* orbit has a fixed argument of perigee.

2. A spacecraft is powered by an ion engine, which applies a radial acceleration,

   $$\mathbf{u} = a\mathbf{r}/r$$

   with a being constant. Derive the expressions for the following due to the applied acceleration:

   (a) The perturbation potential, U. (5)

   (b) The change in the orbital angular momentum. (5)

3. The orbit of a spacecraft around the Earth has the elements, $i = 28.8°$, $e = 0.732$, and period, $T = 10.6$ hr. Find the rotation of apsides and regression of nodes due to Earth's oblateness. (10)

4. Calculate the maximum possible radius of a circular, Sun-synchronous Earth orbit. (10)

5. Calculate the regression of nodes and the rotation of apsides on an Earth satellite in a circular orbit of 12 hr period, inclined at 60° to the equator, due to the Moon's gravity. (10)

6. Estimate the life of a satellite of frontal cross-sectional area, $A = 50$ m^2, drag coefficient based on the frontal area, $C_D = 2.2$, mass, $m = 200$ kg., initially placed in a circular orbit of altitude 250 km around the Earth ($\mu = 398600.4$ km^3/s^2, $r_0 = 6378.14$ km), assuming an exponential atmosphere with $\rho_0 = 1.752$ kg/m^3 and $H = 6.7$ km. (10)

Please send your solution to me (ashtew@iitk.ac.in) before 12:00 noon tomorrow (Thu, 20/04/23).