AE-777A (Optimal Space Flight Control)

Quiz No. 4

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.

Quiz No. 4 (Time 60 min)

(Marks for each problem are indicated in parentheses.)

1. The system of a sliding block on a horizontal, frictionless table governed by

$$\ddot{y} = u$$

where $y(t)$ is the displacement of the block measured from one end of the table, and $u(t)$ is the applied acceleration input, is to be controlled such that beginning from $y(0) = 0$ and $\dot{y}(0) = 0$ at $t = 0$, it reaches a final displacement $y(t_f) = 10$ m, and final velocity $\dot{y}(t_f) = 0$, at unspecified time t_f, while minimizing the following performance index w.r.t. $u(t)$:

$$J = 900\, t_f^2 + \frac{1}{2}\int_0^{t_f} u^2(t)\mathrm{d}t$$

Find an extremal trajectory, and determine whether it is an optimal trajectory.

(25)

2. Suppose the sliding block in Problem 1 is to be moved from initial state $y(0) = 0$ and $\dot{y}(0) = 1$ m/s at $t = 0$, such that it reaches a final displacement, $y(t_f) = 10$ m, with a zero velocity, $\dot{y}(t_f) = 0$, in the minimum final time t_f, while having the input acceleration bounded by

$$\mid u(t) \mid \leq 1 \text{ m/s}^2$$

Solve for the optimal trajectory and control history.

(25)

3. Write either "True" or "False" against each of the following statements:

   (a) *Orbital dynamics* refers to the translational motion of the spacecraft's centre of mass.

   (b) *Space navigation* is the control of the rotational dynamics of the spacecraft about its centre of mass.

   (c) The navigational *feedforward controller* compares the actual trajectory with the specific waypoints, and generates corrective inputs.

   (d) The attitude control system acts as a slave to the navigational control system.

   (e) The idealized navigational control system neglects the time scale of the attitude control system.

(10)

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