Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

V SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2016

SUBJECT: DYNAMICS AND CONTROL OF MECHATRONICS SYSTEMS [MTE 4105]

REVISED CREDIT SYSTEM
(05/12/2016)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** questions.
- Missing data may be suitable assumed.

1A. Design an observer based controller to stabilize the Segway system Fig 1 given by **10**

$$\begin{bmatrix}\dot{x}\\ \ddot{x}\end{bmatrix} = \begin{bmatrix}0 & 1\\ 4 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix} + \begin{bmatrix}0\\ 1\end{bmatrix}u$$

$$Y = [1\ 0]\ X$$

Where y is the vertical angle and is desired to be maintained at zero with 1.67 sec settling time and damping factor 1.2.

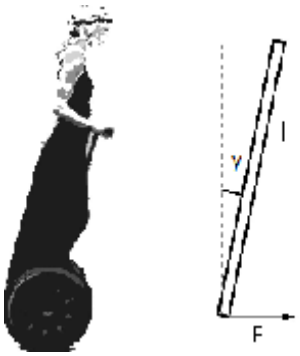

Fig 1

2A. A shock absorber system is having a nonlinear spring dynamics and is given as **4**
$\ddot{x} + x + (1 - x)\dot{x} = u$. Obtain a linear state space model around its equilibrium point.

2B. Synthesis a Lyapunov function for the linearized system in 2A to check the stability of the system. **3**

2C. Check whether the following Lyapunov function is a valid candidate function for the system in 2A. **3**

$V(x) = 2x_1^2 + x_2^2 + 4x_1x_2$, for $x_1 \geq 0$, x_2 is unconstrained.

3A. Obtain the diagonalized form for the following system and then find the response of a homogeneous system for intial conditions $X = [\ 1\ 0]^T$ **6**

$$\dot{X} = \begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}X + \begin{bmatrix}0\\ 1\end{bmatrix}U; Y = [1\ 0] + [0]U$$

3B. Write a matlab function to take up the A, B,C, D matrices of a state space model in 3A and obtain the observer based controlled plot of states for a step input. Assume that the controller poles be at -6 ± 2j. **4**

4A. The slosh dynamics of a fuel tank in a motor bike is causing the unnecessary motions while riding. The test bench at R&D has identified the dynamics as frequency response characteristics Fig 2 given below. Formulate the transfer function. **4**

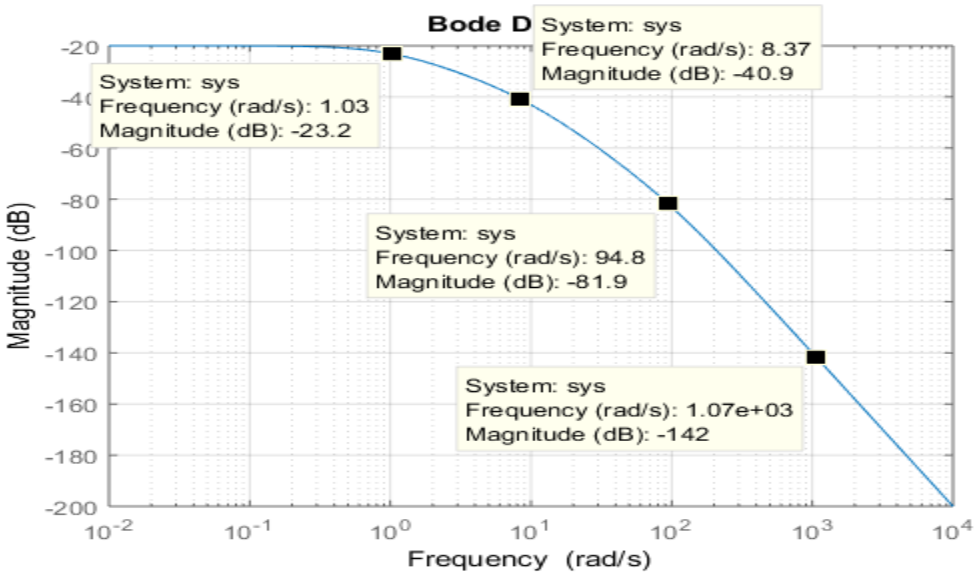

Fig 2

4B. Design a PID controller using ZN tuning methods to control the slosh dynamics. **6**

5A. A robotic tennis player **fig 3.,** the position Θ_1 is controlled by a geared armature controlledDC motor having J_m = 0.1 kgm^2 , B_m = 1 Nms and gear ratio 1:1. The handle has J_L = 0.9 kgm^2 , B_L = 3 Nms. The electrical parameters are R_a = 2ohms. L_a = 1 H and K_b = 3 v/rad/s = K_t. Formulate the system dynamics in state space model. Verify whether the system is controllable and estimatable **5**

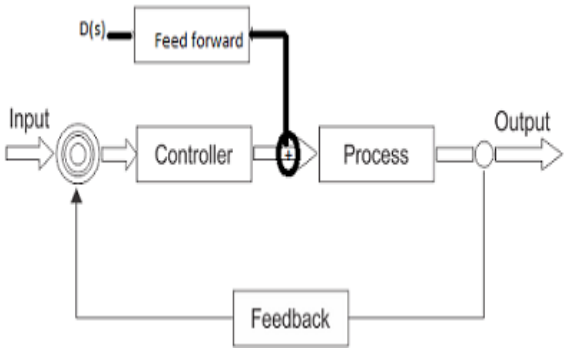

Fig 4) Cruise control System

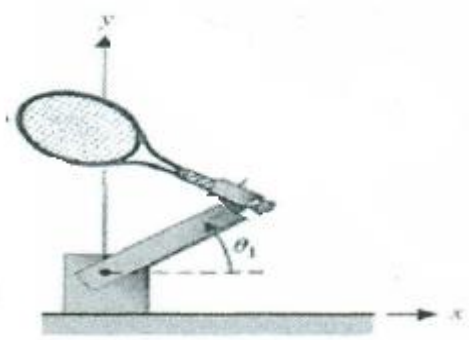

Fig 3) Robot player

5B. The automatic active cruise control system **Fig 4.**, is responding to the cruise command changes with transfer function . On OFF road conditions, the road disturbances are previously known and is given by $D_1(s) = \frac{s}{(s+4)}$. Design a controller to reduce the disturbances in the cruise control. Given the unity feedback control with process $G(s) = \frac{2s+1}{(s)}$, and the controller $Gc(s) = \frac{1}{(s+4)}$ **5**