Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

V SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATION DEC 2017

SUBJECT: DYNAMICS AND CONTROL OF MECHATRONICS SYSTEMS

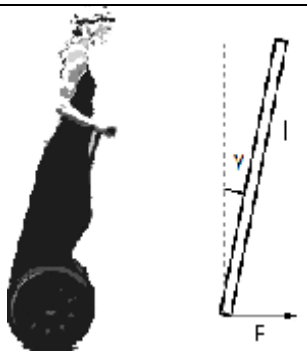
[MTE 4013]

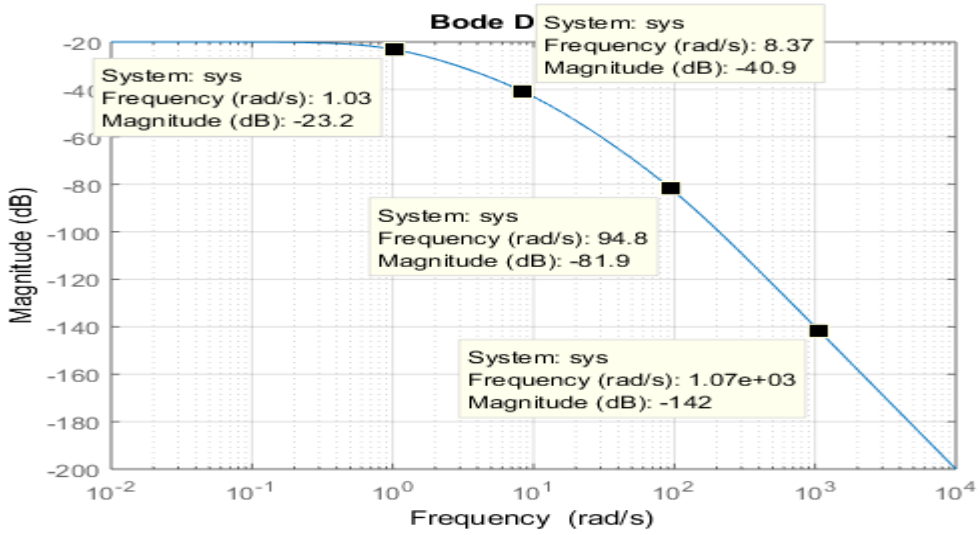
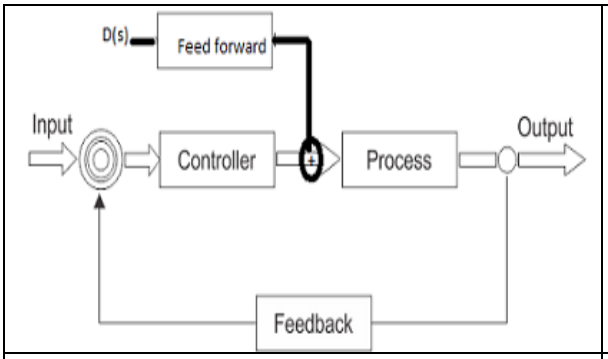
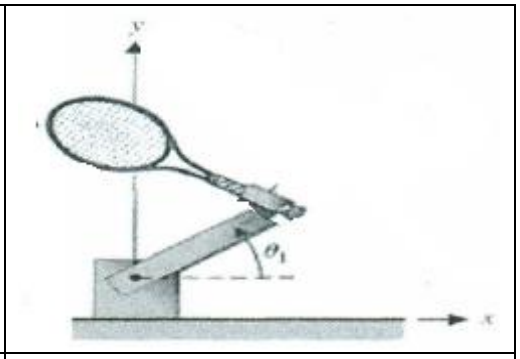
REVISED CREDIT SYSTEM
(../12/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Data not provided may be suitably assumed

1A.	Design a state space controller to stabilize the Segway system given by	**10**
	$\ddot{x} - 4x = u$ 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.  *Figure 1*	
2A.	A shock absorber system is having a nonlinear spring dynamics and is given as $\ddot{x} + x + (1 - x)\dot{x} = u$. Obtain a linear state space model around its equilibrium point.	**4**
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 nonlinear homogeneous system $\ddot{x} + x + (1 - x)\dot{x} = 0$	**3**
	$V(x) = 2x_1^2 + x_2^2 + 4x_1x_2$, for $x_1 \geq 0$, x_2 is unconstrained.	
3A.	Find the response of a homogeneous system for initial conditions $X = [1\ 0]^T$	**6**
	$\dot{X} = \begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix} X + \begin{bmatrix} 1 \\ -1 \end{bmatrix} U; Y = [1\ 1] + [0]U$	

3B.	Write a matlab function to take up the A, B,C, D matrices of a state space model in 3A and obtain the optimal controlled plot of states for a step input. Assume that the controller poles be at -6 ± 2j. Assign Q and R suitably	**4**
4A.	The OL 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 given below. Formulate the transfer function.	**4**
	 *Figure 2*	
4B.	Design a PID controller using ZN tuning methods to control the slosh dynamics.	**6**
5A.	A robotic tennis player **fig b,** the position Θ_1 is controlled by a geared armature controlled DC 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.	**5**
	 Fig a) Cruise control System  Fig b) Robot player	
5B.	The automatic active cruise control system **Fig a**., 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**