Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

VII SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

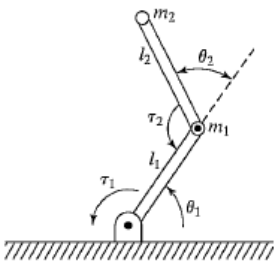
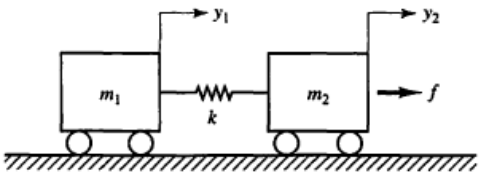
SUBJECT: ROBOT DYNAMICS AND CONTROL [MTE 4007]

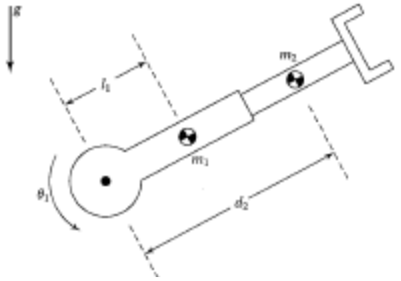
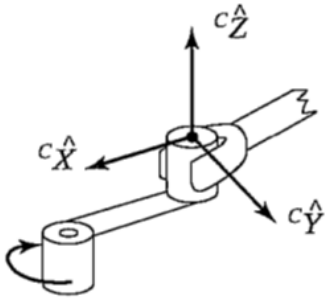
(/11/2019)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A.	Determine the torque required at each joint of a 2R surgical robot (Symbolic representation) as shown in Fig. 1A. Use newton Euler method to identify the dynamic equation.  Fig.1A	**04**	CO1
1B.	Develop state space representation of the dynamic equation and suggest an appropriate control method for the system shown in Fig.1A.	**04**	CO3
1C.	Discuss on the Computational issues of the control algorithm developed in question 1B and compare it with other known methods.	**02**	CO3
2A	 Fig. 2A Two masses m_1 and m_2 are connected by a spring with spring constant k, as shown in Fig.2A. Consider frictional forces is zero, derive a state-space representation of the system, which is at rest for $t < 0$. The displacements y_1 and y_2 are the outputs of the system and are measured from their rest positions relative to the ground. Consider that m_1 = 40 kg, m_2 = 100 kg, k = 40 *N/m*, and/is a step force input of magnitude of 10 N.	**4**	CO2
2B	Develop a suitable control method for the system shown in Fig. 2A with a neat block diagram.	**4**	CO2
2C	Discuss on how does each component of a P,I,D controller contribute towards the control of a dynamic system.	**2**	CO2

3A	Develop the state space matrix of the PR manipulator equation shown in equation1 $\tau_1 = m_1(d_1^2 + d_2)\ddot{\theta}_1 + m_2 d_2^2 \ddot{\theta}_1 + 2m_2 d_2 \dot{d}_2 \dot{\theta}_1$ $+g\cos(\theta_1)[m_1(d_1 + d_2\dot{\theta}_1) + m_2(d_2 + \dot{d}_2)]$ --------- 1 $\tau_2 = m_1 \dot{d}_2 \ddot{\theta}_1 + m_2 \ddot{d}_2 - m_1 d_1 \dot{d}_2 - m_2 d_2 \dot{\theta}^2 + m_2(d_2 + 1)g\sin(\theta_1).$	**4**	CO3
3B	Develop the partitioned model based control law for the system equation shown in equation 1	**4**	CO3
3C	State and prove the Asymptotic stability criterion for equation developed in question 3B	**2**	CO3
4A	Derive the dynamic equation of a RP manipulator shown in Fig.3A using Lagrangian method.  Fig.3A	**4**	CO1
4B	Develop hybrid control method with the help of an appropriate block diagram for the torque equation developed in question 4A, and explain each term associated with the control equation.	**4**	CO3
4C	Compare and contrast centralized and distributed cooperative control method.	**2**	CO2
5A	Develop the state space matrix of a 2R manipulator equation shown in equation2 $\tau_1 = m_2 l_2^2(\ddot{\theta}_1 + \ddot{\theta}_2) + m_2 l_1 l_2 c_2(2\ddot{\theta}_1 + \ddot{\theta}_2) + (m_1 + m_2)l_1^2\ddot{\theta}_1 - m_2 l_1 l_2 s_2 \dot{\theta}_2^2$ $-2m_2 l_1 l_2 s_2 \dot{\theta}_1 \dot{\theta}_2 + m_2 l_2 g c_{12} + (m_1 + m_2) l_1 g c_1,$ --------- 2 $\tau_2 = m_2 l_1 l_2 c_2 \ddot{\theta}_1 + m_2 l_1 l_2 s_2 \dot{\theta}_1^2 + m_2 l_2 g c_{12} + m_2 l_2^2(\ddot{\theta}_1 + \ddot{\theta}_2).$	**4**	CO1
5B	Discuss on the independent joint control architecture with the help of a neat block diagram. And explain with the help of a generalized dynamic equation.	**4**	CO3
5C	Discuss on the Artificial and natural constraints of a turning crank mechanism shown in Fig.4A  Fig.4A	**2**	CO3