Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

IV SEMESTER B.TECH (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, MAY 2016

SUBJECT: LINEAR CONTROL THEORY [MTE 2203]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. A vehicle towing a trailer through a spring-damper coupling hitch is shown in Figure 1. The following parameters and variables are defined: M is the mass of the trailer; K_h,, the spring constant of the hitch; B_h, the viscous-damping coefficient of the hitch; B_t the viscous-friction coefficient of the trailer; $y_1(t)$, the displacement of the towing vehicle; $y_2(t)$, the displacement of the trailer; and f(t), the force of the towing vehicle. Find the transfer function of the system by considering $y_2(t)$ as output. **4**

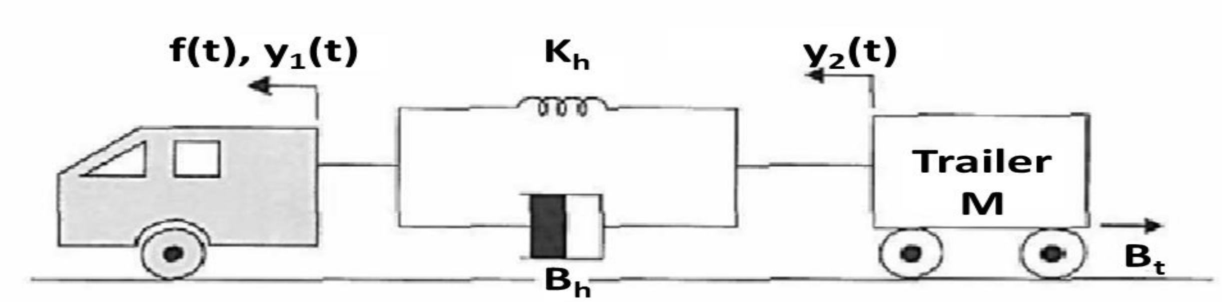

Figure 1

1B. Determine the transfer function Y_6 / Y_1 **4**

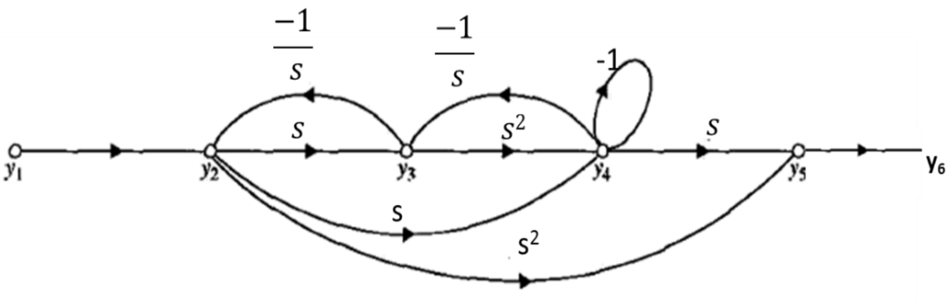

Figure 2

1C. Compare and contrast between OLCS and CLCS **2**

2A. For the circuit shown in Figure 3, Determine the transfer function, $G(s)=I_2(s)/V_i(s)$. **3**

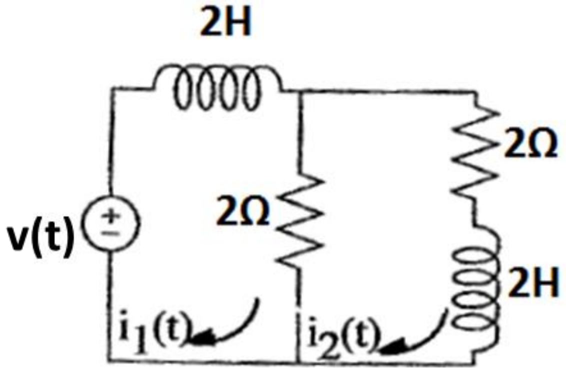

Figure 3

2B. For the system given in question 2A, determine natural frequency, damping ratio, settling time, peak time. **2**

2C. The motor and load shown in Figure 4 are used as part of the unity feedback system shown in Figure 5 for controlling the position of an antenna. Find the value of the coefficient of viscous damping, D_L, that must be used in order to yield a closed-loop transient response having a 20% overshoot. **5**

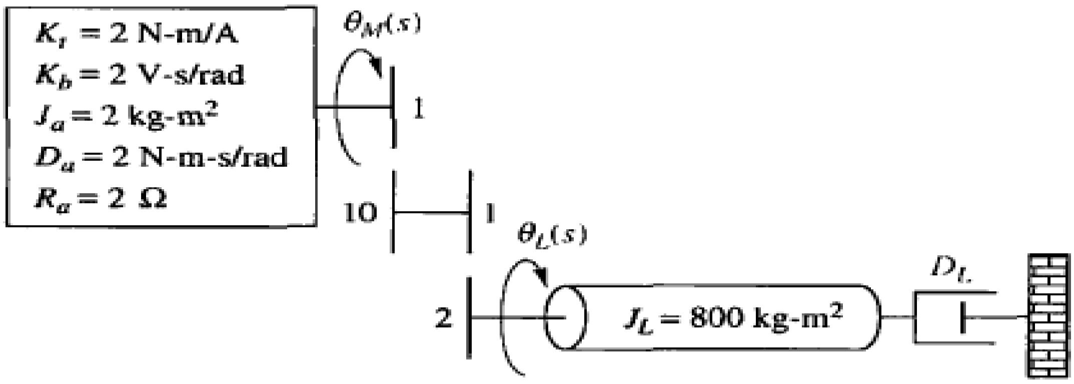

Figure 4

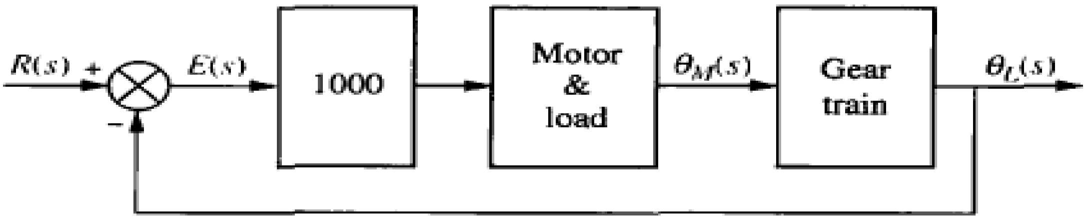

Figure 5

3A. An intelligent car travelling with a velocity of 18kmph is taking a turn on the road having radius of curvature 500m with zero bank angle shown in Figure 6. A simplified model of the system is shown in Figure 7. The control system designed to provide required steering angle to the wheels, so as to avoid skidding of the car irrespective of the radius of curvature is given(where $\Theta_i(s)$ is the radial distance covered by the vehicle and $\Theta_o(s)$ is the corrected position). Design the value of gain K to prevent the car from skidding. **2**

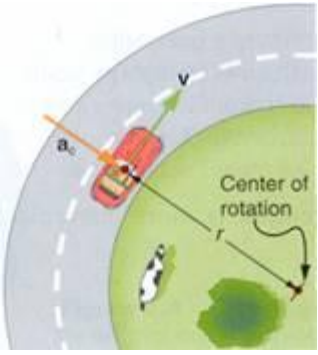

Figure 6

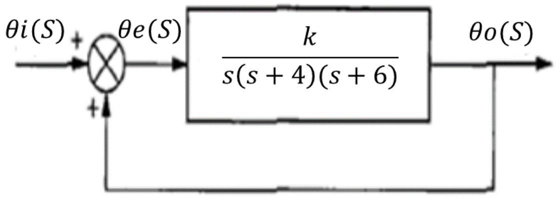

Figure 7

3B. Identify the value of K for the system given in question 3A to control the steering angle required with 0.2 degree error, at the given conditions. **3**

3C. For the system shown in Figure, determine the following **5**

- The system type
- The appropriate static error constant
- The input waveform to yield a constant error and the steady-state error for a unit input of the waveform found.

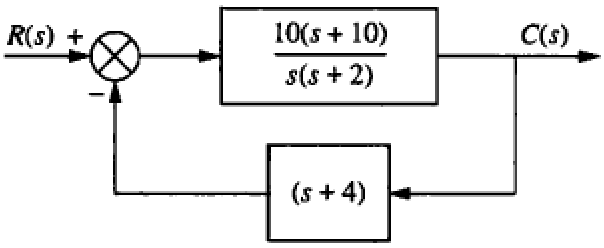

Figure 8

4A. A robot arm is given by the OLTF, $G(s) = \frac{K(s+2)}{s^2+2}$. Construct root locus diagram of a negative unity feedback system. **6**

4B. Determine the value of K for stable undamped oscillations for the system described in for the system given in question 4A and also determine the natural frequency of oscillations. **2**

4C. Design a proportional controller to yield 10% overshoot of a unit step input for the system given in question 4A **2**

5A. Write, but do not solve, the equations of motion for the translational mechanical system shown in Figure **4**

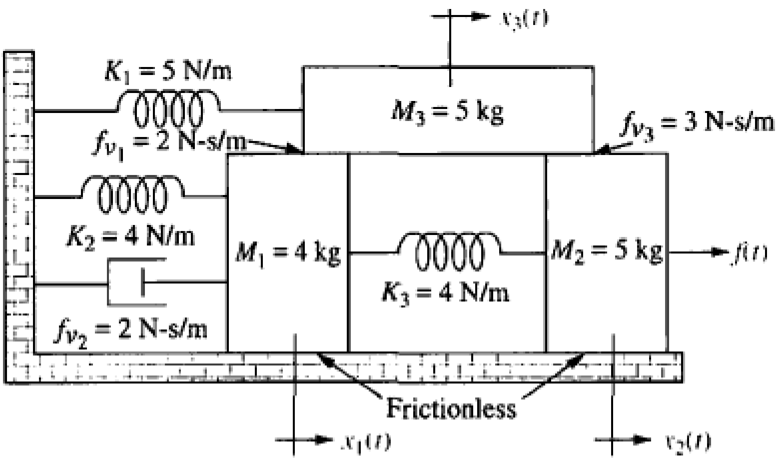

Figure 9

5B. The root locus of the plant is given in the figure 10. Design a lag compensator for a plant with **4**

OLTF as G(s) = $\frac{1}{(s+2)(s+4)}$ to improve the steady-state error by a factor of 10 if the system is operating with 9.47 %overshoot.

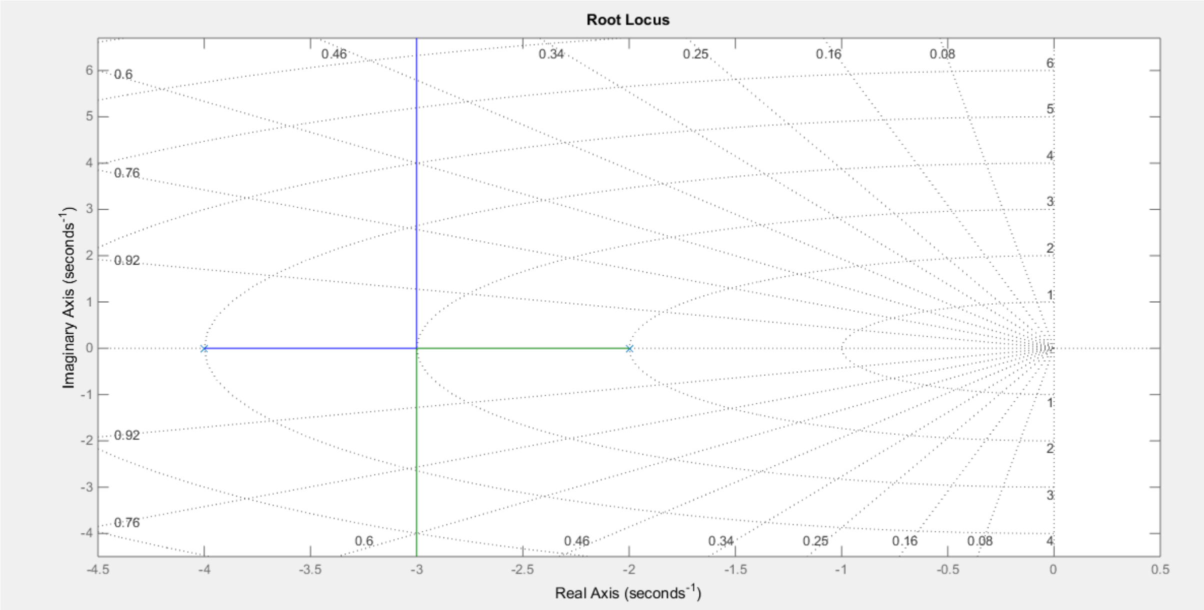

Figure 10

5C. Verify the design. **2**