Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

IV SEMESTER B.TECH. (AUTOMOBILE ENGINEERING)

END SEMESTER EXAMINATIONS, APR/MAY 2017

SUBJECT: LINEAR CONTROL THEORY [AAE 2204]

REVISED CREDIT SYSTEM
(28/04/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

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

1A. Sketch the bode plot for the system with the transfer function as: **(05)**

$$G(s) = \frac{512(s+3)}{s(s^2+16s+256)}$$

Find the gain margin and phase margin of the system and comment on stability.

1B. Obtain the state space model of the system shown in figure 1. **(03)**

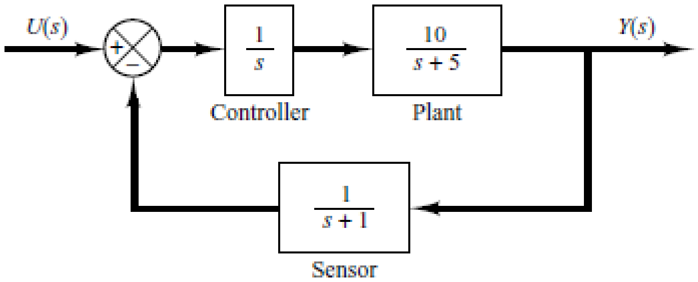

Figure 1

1C. Find the time response of the following transfer functions. **(02)**

$$Y(s) = \frac{2s}{(s+1)^2(s+2)}$$

$$Y(s) = \frac{2s+1}{(s+1+j)(s+1-j)}$$

2A. Consider the system shown in Figure 2. To improve the performance of the system a feedback is added to this system, which results in Figure 3. Determine the value of K so that the damping ratio of the new system is 0.4. Compare the overshoot, rise time, peak time and settling time and the nominal value of the systems shown in Figures 2 and 3. **(05)**

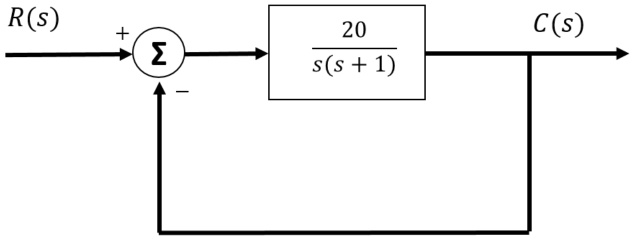

Figure 2

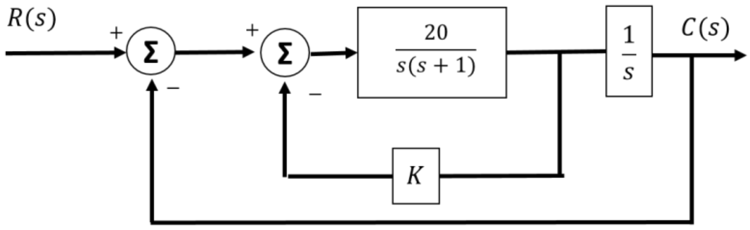

Figure 3

2B. The open loop transfer function of the unity feedback system is given as: **(03)**

$$\boldsymbol{G(s) = \frac{108}{s^2(s+4)(s^2+3s+12)}}$$

Find the static error coefficients and steady state error of the system when applicable to input given by

$$\boldsymbol{r(t) = 2 + 5t + 5t^2}$$

2C. The characteristic equation for a certain feedback system is given as: **(02)**

$$\boldsymbol{s^4 + 4s^3 + 13s^2 + 36s + K = 0}$$

Determine the range of value of $\boldsymbol{K}$ for system to be stable.

3A. Consider the control system whose signal flow graph is shown in Figure 4. Determine the system transfer function using Mason's formula. **(05)**

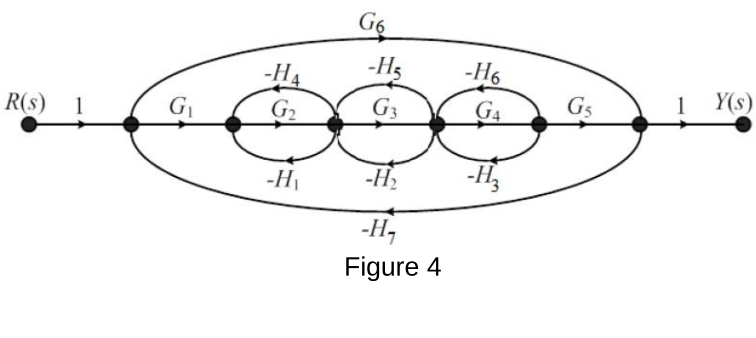

Figure 4

3B. A thermometer has a time constant of $\mathbf{15.33}$ sec. It is quickly taken from a temperature $\mathbf{0^0 c}$ to a water bath of temperature of $\mathbf{100^0 c}$. What temperature will be indicated after $\mathbf{60}$ sec. the transfer function for temperature '$\boldsymbol{\theta}$' associated with the system is: **(03)**

$$\frac{\theta_O(s)}{\theta_i(s)} = \frac{1}{1 + sRC}$$

3C. Measurement conducted on the servomechanism shows the system response to be **(02)**

$$c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}$$

When subjected to the unit step input. Obtain the open loop transfer function and determine the undamped natural frequency and damping ratio.

4A. Sketch the polar plot of the following transfer function of the system and comment on stability. **(05)**

$$G(s) = \frac{K}{s^2(s+1)(s+2)}$$

4B. Obtain the state space model of the system shown in figure 5 using the modelling technique. **(03)**

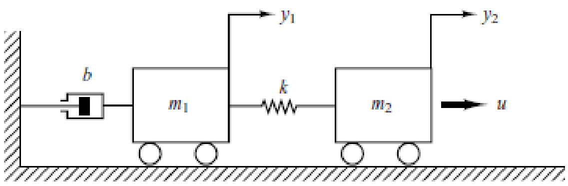

Figure 5

4C. Show that the steady state error with unit ramp input for type '1' system is $\mathbf{1/K}$. **(02)**

5A. The open loop transfer function of the control system is given as: **(05)**

$$G(s)H(s) = \frac{K}{s(s+6)(s^2+4s+13)}$$

Sketch the root locus and find the breakaway point, angle of departure and stability conditions.

5B. Consider the spring-loaded pendulum system shown in Figure 6. Assume that the spring force acting on the pendulum is zero when the pendulum is vertical, or u=0. Assume also that the friction involved is negligible and the angle of oscillation u is small. Show that mathematical model of the system as **(03)**

$$\ddot{\theta} = -\left(\frac{2ka^2}{ml^2} + \frac{g}{l}\right)\theta$$

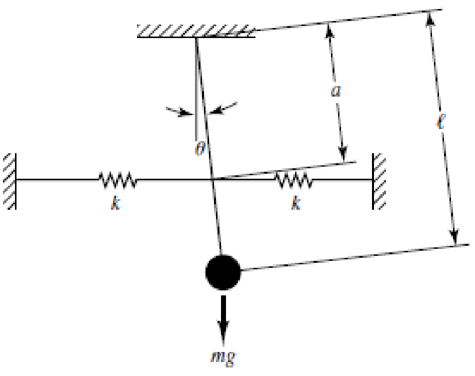

Figure 6

5C. Consider the block diagram of the system shown in the figure 7. Determine the range of $\boldsymbol{K}$ for which the system is stable **(02)**

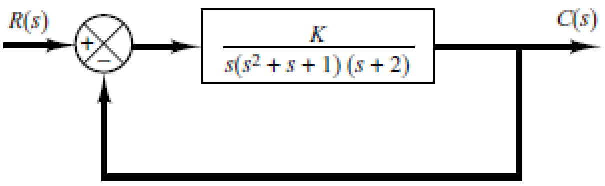

Figure 7