Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

A Constituent Institution of Manipal University

IV SEMESTER B.TECH. (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, MAY/JUNE 2017

SUBJECT: LINEAR CONTROL THEORY [MTE 2203]

REVISED CREDIT SYSTEM
(26/04/2017)

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed
- Graph sheets will be provided

1A. Using block diagram reduction technique, reduce the block diagram shown in figure 1A to a single transfer function. **04**

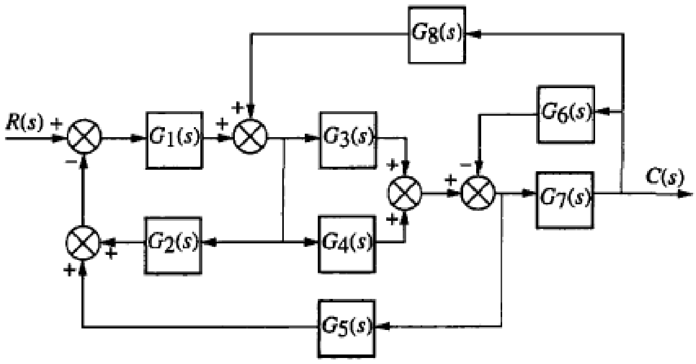
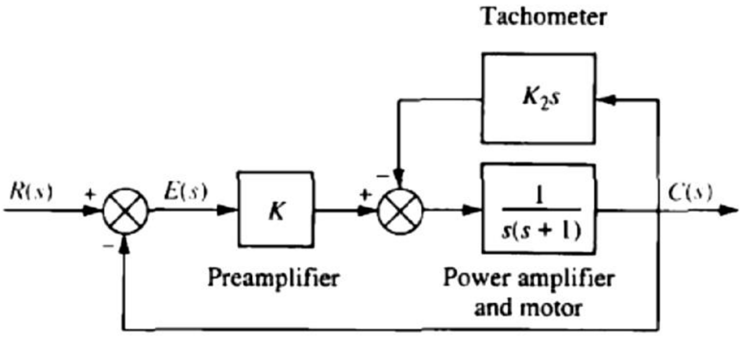


Figure 1A

1B. A Position control system shown in the figure 1B below will have its transient response altered by adding a tachometer. Design K and subsequently K_2 in the system to yield a damping ratio of 0.69. The natural frequency of the system before the addition of the tachometer is 10 rad/s. **04**

Figure 1B



1C. Compare and contrast between open loop systems and closed loop systems. **02**

2A. The read/write head assembly arm of a computer hard disk drive (HDD) can be modeled as a rigid rotating body with inertiaI_b. Its dynamics can be described with the transfer function **03**

$$P(s) = \frac{X(s)}{F(s)} = \frac{1}{I_b s^2}$$

where, *X(s)* is the displacement of the read/write head and *F(s)* is the applied force.
Show that if the HDD is controlled in the configuration shown in Figure 2A, the arm will oscillate and cannot be positioned with any precision over a HDD track. Also, find the expression for oscillation frequency.

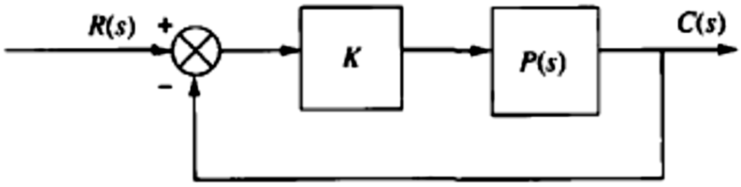


Figure 2A

2B. The OLTF of a system is represented as follows **04**

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

Using the Routh Hurwitz Criterion, for the unity feedback system, do the following
(i) Comment on the stability of system
(ii) Find the range of gain that keeps the system stable
(ii) Value of gain that makes the system oscillate and the frequency of oscillation at this gain value

2C. For the rotational mechanical system shown in figure 2C, find the transfer function **03**

$$G(s) = \frac{\theta_2(s)}{T(s)}$$

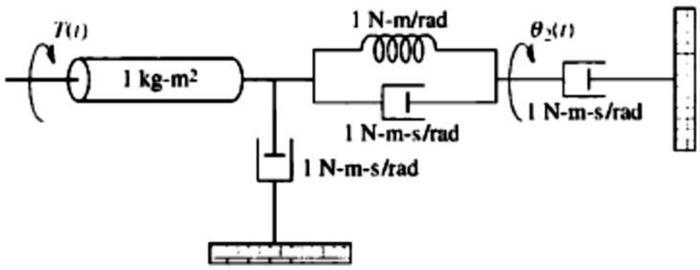


Figure 2C

3A. A robotic arm is described by an OLTF given below. Construct a root locus diagram for it. **07**

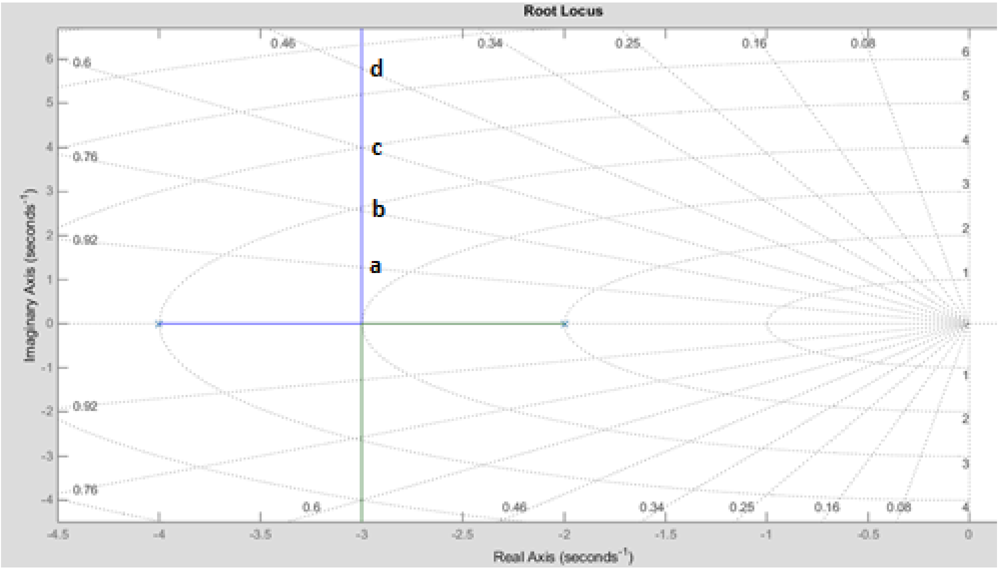
$$\frac{K(s^2-2s+2)}{(s+2)(s+4)(s+5)(s+6)}$$

3B. Comment on the stability of the above system from question 3A. Find the value of K for sustained oscillations and also the frequency of sustained oscillations. **03**

4A. Define the term BIBO Stability. **01**

4B. The root locus of a plant is given in the figure 4A. Design a passive compensator for the plant so as to improve the steady-state error by a factor of 10 if the system is operating with 9.47 % overshoot. Also, verify the design. OLTF of the system is given by **05**

$$G(s) = \frac{1}{(s+2)(s+4)}$$



Pt.	Location
a	-3+1.5i
b	-3+2.5i
c	-3+4i
d	-3+5.5i

Figure 4B

4C. A space station shown in the figure 4C1 will keep its solar arrays facing the sun. If we assume that the simplified block diagram of the 4C2 represents the solar tracking control system that will be used to rotate the array via rotary joints find the following: **04**

(i) Steady state error for step, ramp and parabolic commands in commanded joint angle

(ii) Range of K_c/J to make the system stable

Figure 4C1

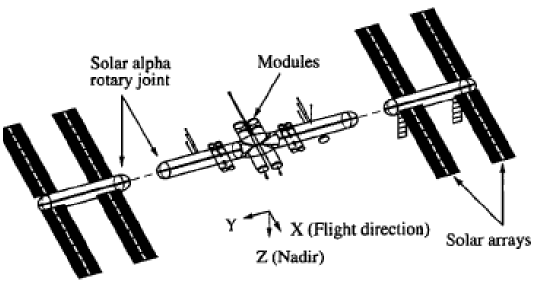
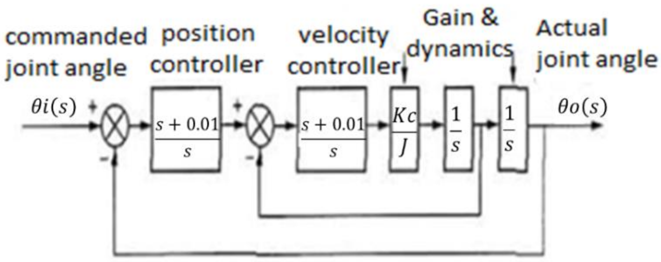


Figure 4C2



5A. An armature controlled motor and load shown in Figure 5A1 are used as part of the unity feedback system shown in Figure 5A2 for controlling the position of an antenna. Determine 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. **05**

Figure 5A1

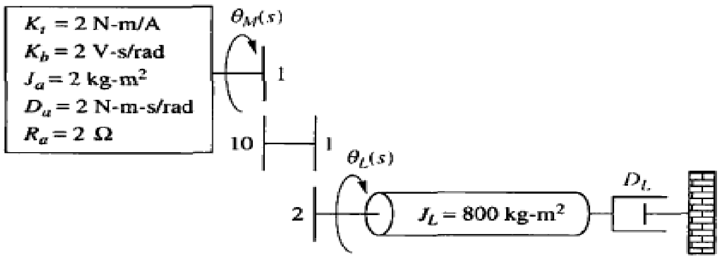
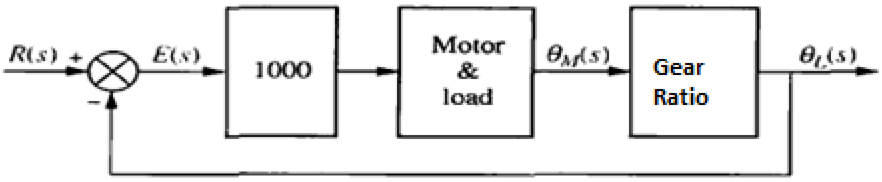
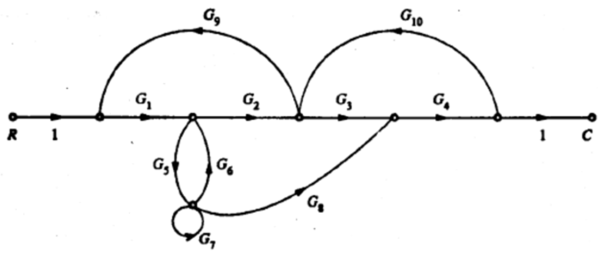


Figure 5A2



5B. For the signal flow graph shown in figure 5B, apply Mason's Gain Formula to compute the transfer function **03**

Figure 5B



5C. What pole locations characterize the following? **02**

(i) Underdamped system

(ii) Critically damped system

Draw relevant response sketches