Menofia University
Faculty of Electronic Eng., Menof
Final-Term Exam, for 2nd year

Control Engineering
Time Allowed: 3 H
30 December 2019

Answer the following questions: (Part one)

Question (1) [10 Marks]

[1-a] Define the following terms: Disturbances, Feedback control and Transfer function.

(3 Marks)

[1-b] Find the transfer function, $G(s) = X_2(s)/F(s)$, for the system shown in Figure 1.

(7 Marks)

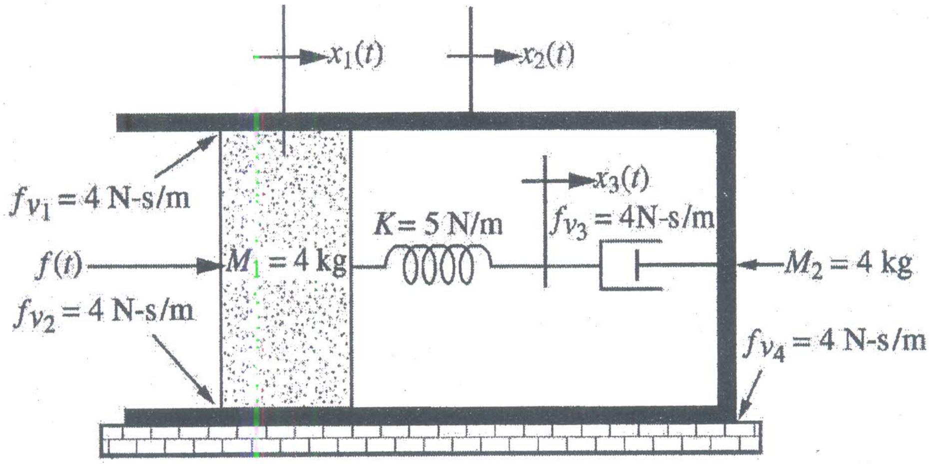

Figure 1

Question (2) [10 Marks]

[2-a] For the rotational system shown in Figure 2, find the transfer function, $G(s) = \frac{\theta_2(s)}{T(s)}$.

(5 Marks)

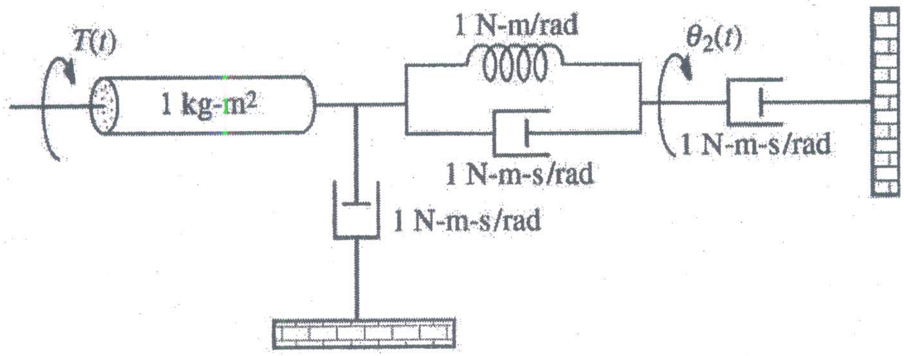

Figure 2

[2-b] Simplify the block diagram shown in Figure 3. Obtain the transfer function relating C(s) and R(s). (5 Marks)

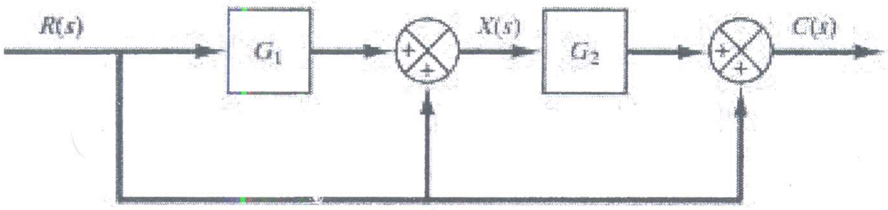

Figure 3

<u>Question (3) [10 Marks]</u>

[3-a] For the motor, load, and torque-speed curve shown in Figure 4, find the transfer function, $G(s) = \theta_L(s)/E_a(s)$. (5 Marks)

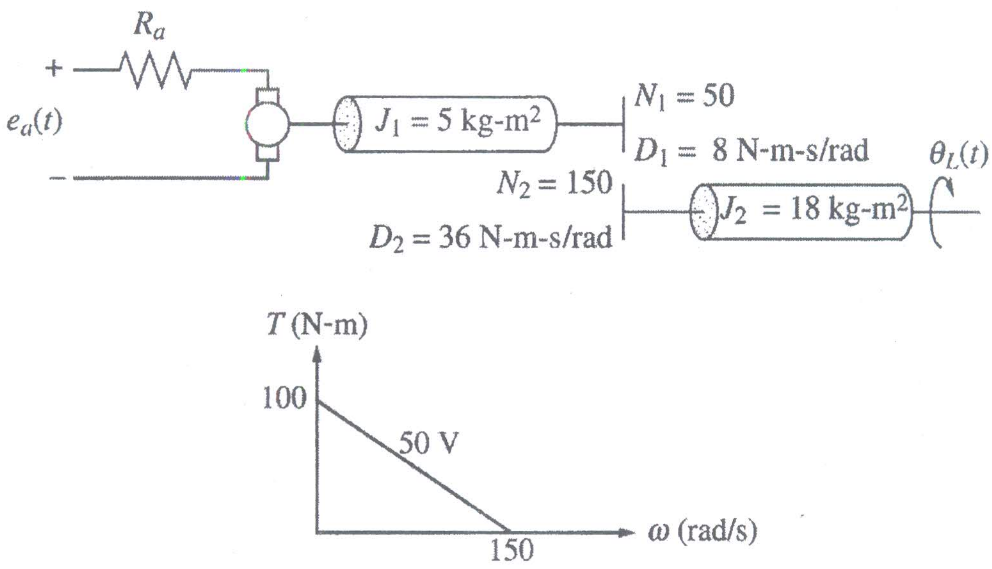

Figure 4

[3-b] For the system shown in Figure 5, write the state equations and the output equation for the phase-variable representation. (5 Marks)

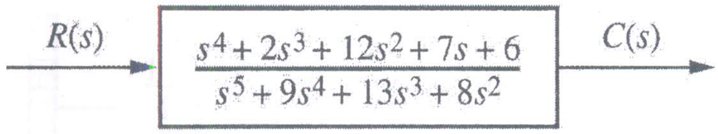

Figure 5

(Part two)

Question (4) [10 Marks]

A system consists of a first order element cascaded with a second order element. The first order element has a time constant of T=5 seconds and a steady state gain K=0.2. The second order element has a natural frequency $\omega n = 4$ radian/s and damping ratio $\xi = 0.25$ and a steady state gain K = 1. If a step input of 10 units is applied to the system, find an expression for the time response. (10 Marks)

Question (5) [12 Marks]

A flaying raket is described by the differential equation: $J\ddot{y} = Ku$, where J is the moment of inertia of the raket, y is the output and u is the input. For the purpose of control a PID controller is used with transfer function:

$$G_c(s) = K_c \frac{(1+T_1 s)(1+T_2 s)}{s} \quad \text{with } K_c, T_1, T_2 > 0$$

a) What are the stability conditions regarding Kc, T_1, and T_2 that can be deduced from Routh stability criteria? (8 Marks)

b) Determine the steady state error $e(t=\infty)$ for a unit step input. (4 Marks)

Question (6) [18 Marks]

(6-a) Regarding the control system shown in Figure 6, $G_1(s) = \frac{2(s+2)}{s}$ and $G_2(s) = 2$.

If the unit step response of the system is: $y_1(t) = 0.5 + e^{-3t} - e^{-4t}$,

i) Determine the transfer function $G_f(s)$. (6 Marks)

ii) Determine $y_2(t)$. (6 Marks)

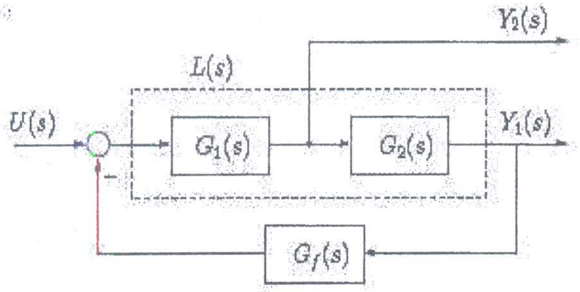

Figure 6

(6-b) Figure 7 shows the step response of a system its steady state gain is K_s. Design a PID controller by means of Ziegler-Nichols criterion for this system. (6 Marks)

Hint: $G_c(s) = K_c(1 + T_d s + \frac{1}{sT_i})$, **with** $K_c = \frac{1.2\tau}{LK_s}$, $T_d = 0.5L$, $T_i = 2L$. **K_s is the steady state gain of the system.**

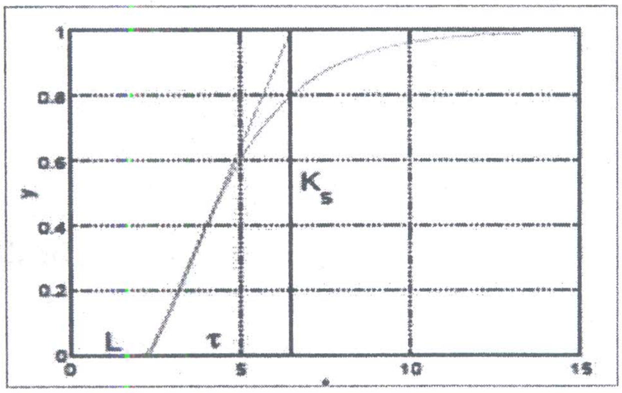

Figure 7