Document No : UniKL MFI_SD_AC41
Revision No: 02
Effective Date: 01 December 2008

CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
SEPTEMBER 2013 SESSION

SUBJECT CODE	**:**	**FAB 30803**
SUBJECT TITLE	**:**	**CONTROL SYSTEM**
LEVEL	**:**	**BACHELOR**
TIME / DURATION	**:**	**(3 HOURS)**
DATE	**:**	

INSTRUCTIONS TO CANDIDATES

1. **Please read the instructions given in the question paper CAREFULLY.**
2. **This question paper is printed on both sides of the paper.**
3. **Please write your answers on the answer booklet provided.**
4. **Answer should be written in blue or black ink except for sketching, graphic and illustration.**
5. **This question paper consists of SIX (6) questions. Answer FIVE (5) questions only.**
6. **Answer all questions in English.**
7. **The semi-log paper, Nichol's chart, graph paper and formula are appended.**

THERE ARE 5 PAGES OF QUESTIONS AND 1 PAGE OF APPENDIX, EXCLUDING THIS PAGE.

Question 1

(a) Analysis of a system can be done by studying the transient response, the steady state response and stability. Describe transient response, steady state response and stability of a system.

(3 marks)

(b) Describe an example of close loop system in our home appliance.

(2 marks)

(c) An automobile driver uses a control system to maintain the speed of the car at a prescribed level. Draw a functional block diagram of a system.

(4 marks)

(d) **Figure 1** is a schematic diagram of a water flow control system. Draw the transfer function, $\frac{\theta_O(s)}{\theta i(s)}$.

(11 marks)

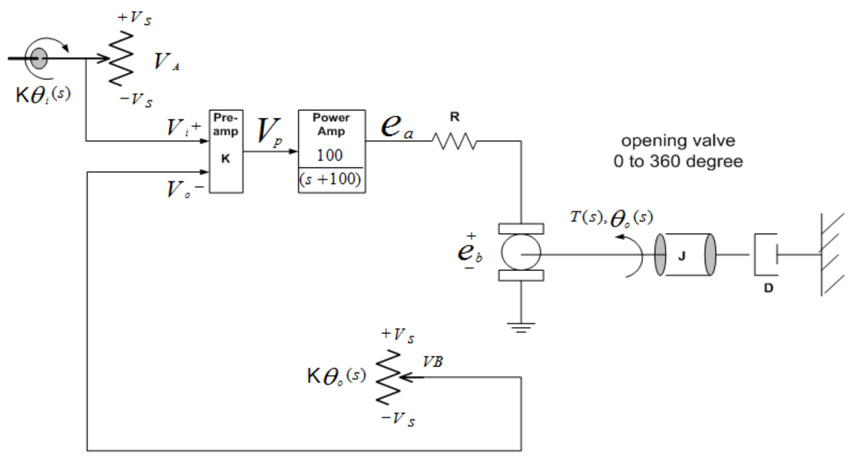

Figure 1: An electromechanical open-loop control system

where,

K_a – amplifier gain constant
K_m - motor torque constant
K_b – back emf constant
K – potentiometer constant
J – inertia
D – viscous friction

Question 2

(a) Find the transfer function, $\frac{C(s)}{R(s)}$ for the block diagram of a system in **Figure 2** by using the block diagram reduction method.

(10 marks)

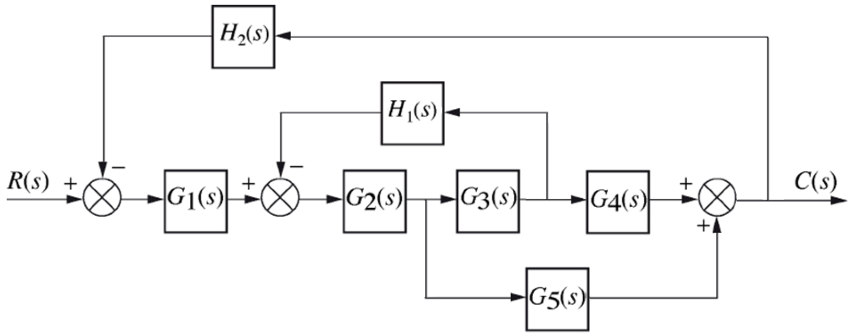

Figure 2: A block diagram of a system

(b) Referring to a block diagram of a unity feedback system shown in **Figure 3**, determine the natural frequency (ω_n), damping ratio (ζ), settling time (T_s) and peak time (T_p).

(4 marks)

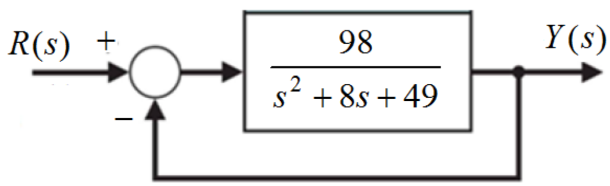

Figure 3: A block diagram of a unity feedback system

(c) For a closed loop control system shown in **Figure 4**, determine the values of K and T, if the percent overshoot, %OS = 20% and peak time, T_p = 2 seconds.

(6 marks)

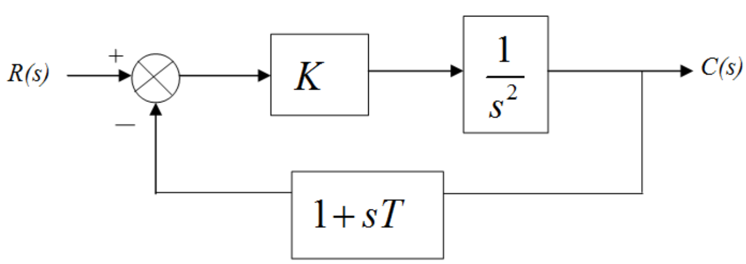

Figure 4: A closed-loop control system

Question 3

(a) **Figure 5** shows a signal flow graphs of a system. Obtain the overall transfer function, $\frac{C(s)}{R(s)}$ of the system by using Mason's rule formula.

(10 marks)

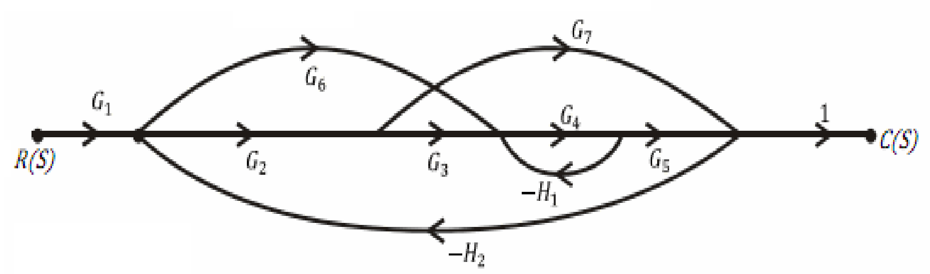

Figure 5: A flow graph of a system

(b) Consider the open loop transfer function of a unity feedback system as follows

$$G(s) = \frac{2(s+25)}{s(s^4 + 2s^3 - 6s^2 - 12s + 23)}$$

i. Find the number of right half plane poles, left half plane poles and on imaginary axis poles using the Routh-Hurwitz Criterion.

(8 marks)

ii. Determine the stability of the closed-loop system.

(2 marks)

Question 4

(a) The block diagram of an electric cart steering system is shown in **Figure 6**.

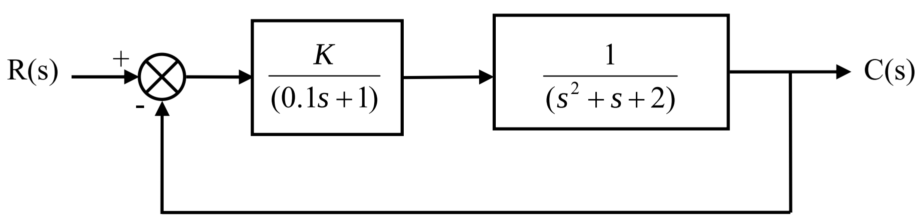

Figure 6: Electric cart steering system

i. Plot the asymptotic Bode diagram for the system if given that $K = 3.2$.

(10 marks)

ii. From the bode plot, determine the gain margin (GM), phase margin (PM), gain cross over frequency (ω_{gco}), phase cross over frequency (ω_{pco}), and hence state and justify the stability of the system.

(5 marks)

(b) An engineer has found the frequency response of an open loop system and tabulated it as shown in **Table 1**.

Table 1: The data of an open loop system.

ω (rad/s)	0.2	0.3	0.5	0.8	1.2	1.4	1.8	2.0	2.5	3.0
|G|dB	17	13	9	4	1	0	-3	-4	-7	-10
$\angle G^{\circ}$	-90	-100	-104	-105	-108	-111	-115	-120	-125	-130

i. Sketch the Nichols plot on the Nichols chart.

(3 marks)

ii. Determine from the Nichol chart, the resonant peak and the bandwidth of the closed loop system.

(2 marks)

Question 5

(a) A block diagram of a unity feedback system shows in **Figure 7** is referred.

i. Determine the system type

(1 mark)

ii. Find the value of K if the steady state error is 10%

(3 marks)

iii. Find the static error constants and steady state errors for inputs of $5u(t), 15tu(t)$ and $24t^2u(t)$ for $K = 100$.

(6 marks)

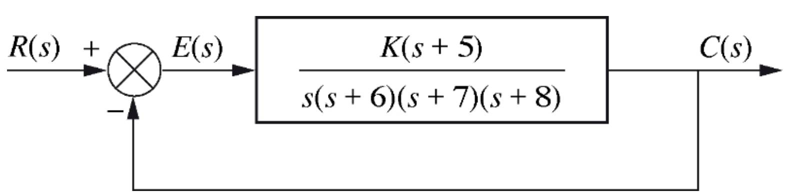

Figure 7: A unity feedback of a closed loop system

(b) Consider a unity feedback of a system shown in **Figure 8**. Obtain the followings by using the Nyquist criterion.

i. Sketch the Nyquist plot of the system for $(0<\omega<\infty)$

(8 marks)

ii. Determine the system stability of the system

(2 marks)

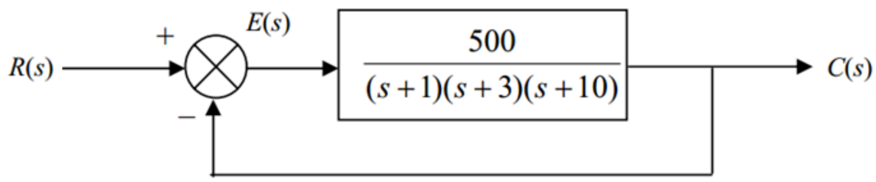

Figure 8: A unity feedback of a system

Question 6

(a) The block diagram of a unity feedback closed loop system is shown in **Figure 9**.

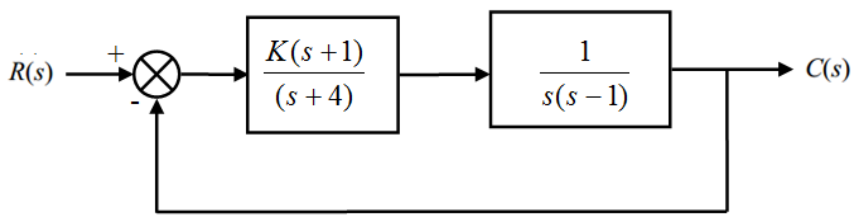

Figure 9: Unity feedback closed-loop system

i. Sketch the root locus of the closed loop system as K varies from zero to infinities, in the s-plane. Indicate the asymptotes, break points on the real axis, cross-over points at the imaginary axis, angle of departure or arrival, where appropriate.

(15 marks)

ii. Determine the maximum damping ratio, ζ of the stable complex closed loop pole.

(5 marks)

END OF QUESTION

Appendix 1

1. $G(s) = \dfrac{\omega_n{}^2}{s^2 + 2\zeta\omega_n s + \omega_n{}^2}$

2. $\%OS = e^{-\left(\zeta\pi/\sqrt{1-\zeta^2}\right)} \times 100$

3. $\zeta = \dfrac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$

4. $T_p = \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

5. $T_s = \dfrac{4}{\zeta\omega_n}$ for 2% criteria

6. $T_r = \dfrac{\pi/2 + \phi}{\omega_n\sqrt{1-\zeta^2}}$

   where, $\phi = \tan^{-1}\dfrac{\zeta}{\sqrt{1-\zeta^2}}$

7. $e(\infty) = e_{step}(\infty) = \dfrac{1}{1 + \lim_{s\to 0} G(s)}$

8. $e(\infty) = e_{ramp}(\infty) = \dfrac{1}{\lim_{s\to 0} sG(s)}$

9. $e(\infty) = e_{parabola}(\infty) = \dfrac{1}{\lim_{s\to 0} s^2 G(s)}$

10. $K_p = \lim_{s\to 0} G(s)$

11. $K_v = \lim_{s\to 0} sG(s)$

12. $K_a = \lim_{s\to 0} s^2 G(s)$

Laplace Transform Table

Item no.	*f(t)*	*F(s)*
1.	$\delta(t)$	1
2.	$u(t)$	$\frac{1}{s}$
3.	$tu(t)$	$\frac{1}{s^2}$
4.	$t^n u(t)$	$\frac{n!}{s^{n+1}}$
5.	$e^{-at}u(t)$	$\frac{1}{s+a}$
6.	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
7.	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$