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

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JULY 2010 SESSION

SUBJECT CODE	:	FAD 30203
SUBJECT TITLE	:	CONTROL ENGINEERING
LEVEL	:	DIPLOMA
TIME / DURATION	:	9.00 AM – 12.00 NOON (3 HOURS)
DATE	:	20 NOVEMBER 2010

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 TWO (2) sections. Section A and B. Answer all questions in Section A. For Section B, answer TWO (2) questions only.
6. Answer all questions in English.
7. Semi-log paper and formula are appended

THERE ARE 7 PAGES OF QUESTIONS AND 3 PAGES OF APPENDICES, EXCLUDING THIS PAGE.

SECTION A (Total: 60 marks)

INSTRUCTION: Answer all the questions.
Please use the answer booklet provided.

Question 1

(a) Define and give the example of automatic and manual control system.

(4 marks)

(b) Prove that the transfer function for the block diagram closed-loop system in **Figure 1** is described as: $CLTF = \dfrac{G(s)}{1+G(s)H(s)}$

(6 marks)

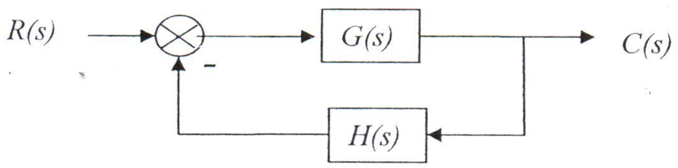


Figure 1: The block diagram of closed-loop system

(c) Determine the overall gain of negative-feedback closed-loop system if the forward gain *G(s)*, and feedback gain *H(s)*, are given by 40 and 5 respectively.

(3 marks)

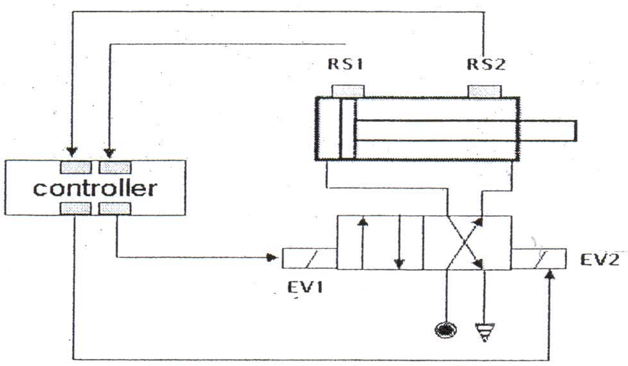


Figure 2: Double acting cylinder control system

(d) Determine the type of control system for **Figure 2**. Give a reason for your answer.

(2 marks)

Question 2

(a) Reduce the block diagram of a system shown in **Figure 3,** to a single block diagram representing the overall transfer function, $TF(s) = \dfrac{C(s)}{R(s)}$.

(12 marks)

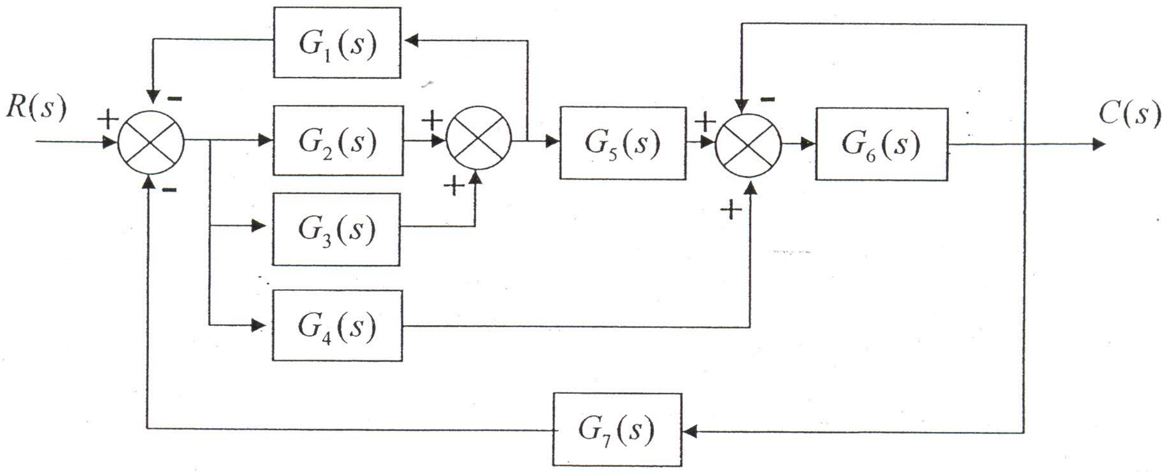


Figure 3: The block diagram of a system

(b) Obtain the transfer function, *TF(s)* if G1(s) =1, G2(s) =2, G3(s) =1, G4(s) =2, G5(s) =1, G6(s) =2 and G7(s) =1.

(3 marks)

Question 3

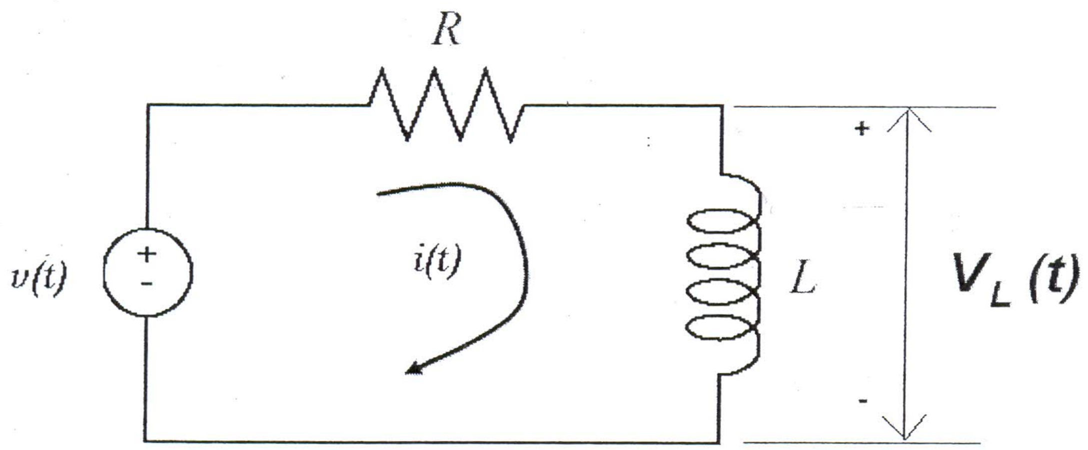


Figure 4: The RL network

(a) Based on the **Figure 4**, find the transfer function $\frac{V_L(s)}{V(s)}$ of the series RL network.

(8 marks)

(b) Draw a block diagram for the RL circuit transfer function that shows inductor voltage, $V_L(s)$ versus applied voltage, $V(s)$.

(3 marks)

(c) Determine an expression for the inductor voltage if the input voltage is unit step response.

(4 marks)

Question 4

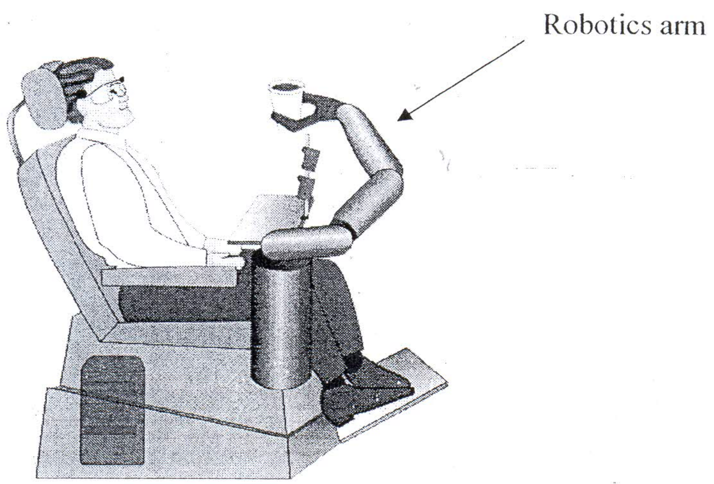


Figure 5: Robotic Arm

A position control system for a robotic arm is designed to accept a voltage (volts dc) signal from external source and move the arm correspondingly. Displacement is measured in meters. The transfer function for output displacement *x(t)* and input voltage *e(t)* is given by.

$$\frac{X(s)}{E(s)} = \frac{400}{s+2}$$

Determine the output displacement *x(t)* if the input are given as follows:

(a) 10V dc (5 marks)

(b) Unit step, $u(t)$ (5 marks)

(c) Unit ramp, t (5 marks)

SECTION B (Total: 40 marks)

INSTRUCTION: Answer TWO (2) questions only.
Please use the answer booklet provided.

Question 5

(a) List 3 types of analog controller.

(3 marks)

(b) A proportional controller has a gain of 10. Determine the controller output if the input of the controller is 5 units.

(2 marks)

(c) Define and give an application of PID controller.

(2 marks)

(d) Derive the transfer function of PID controller.

(4 marks)

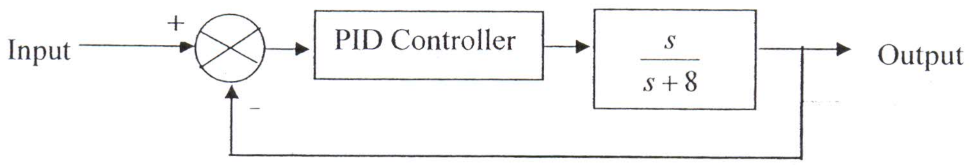


Figure 6: PID controller with plant module system

(e) Based on **Figure 6,** find the transfer function when the PID controller is connected in series with the plant module.

(6 marks)

(f) List the characteristic of P, I and D controller.

(3 marks)

Question 6

Consider the transient response of second-order system shows in **Figure 6.**

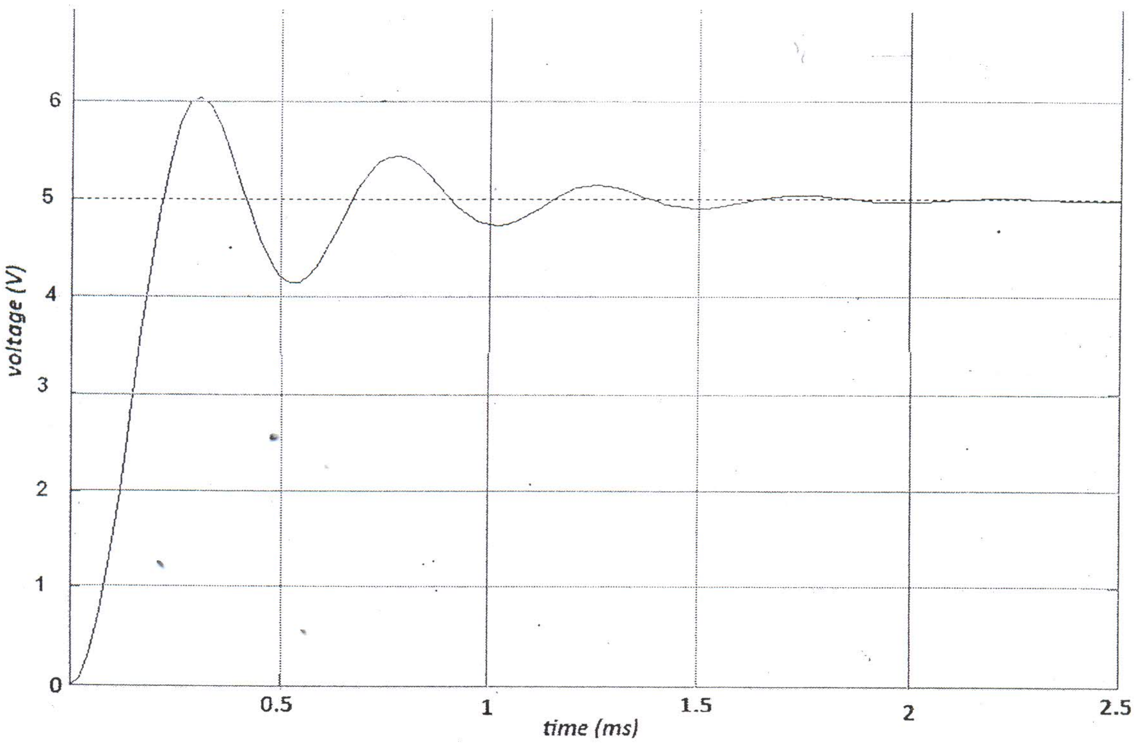


Figure 6: Underdamped response case of second-order

(a) Determine the following by referring to the plot of the transient response:

i. delay time (T_d) (2 marks)

ii. rise time (T_r) (2 marks)

iii. settling time (T_s) of 2% criteria (2 marks)

iv. maximum overshoot (2 marks)

v. steady state error (2 marks)

(b) Determine the damping ratio (ξ), delay time (T_d), rise time (T_r) and settling time (T_s) of the system with the natural frequency, ω_n=10 kHz via calculation.

(**Hint:** refer to appendix 3)

(10 marks)

Question 7

(a) Draw a Bode plot of the unity feedback system shown in **Figure 7**:

(14 marks)

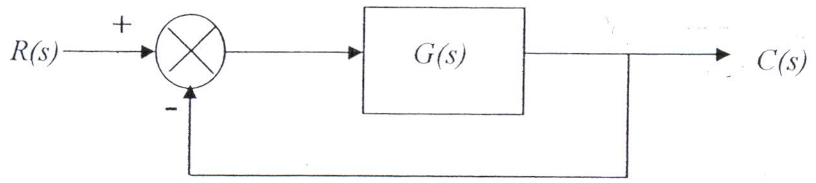


Figure 7: The unity feedback system

Where $G(s) = \dfrac{20K}{s(s+2)(s+50)}$ and K=10

(b) From the Bode plot, determine the following:

i. gain margin, GM (1 mark)

ii. phase margin, PM (1 mark)

iii. gain cross over frequency, ω_{gco} (1 mark)

iv. phase cross over frequency, ω_{pco} (1 mark)

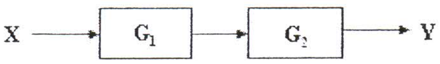
(c) Give your comments on the stability of the system.

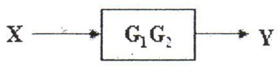
(2 marks)

END OF QUESTION

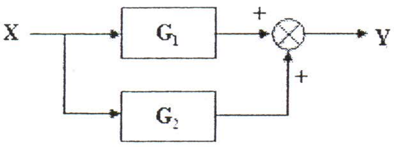
APPENDIX 1: BLOCK DIAGRAMS

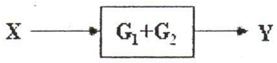
1. **Cascading Blocks:**



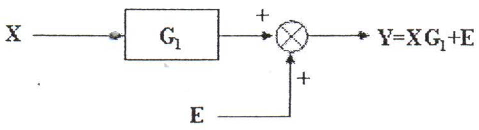


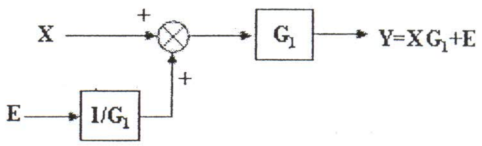
2. **Blocks in parallel: Forward Loop**



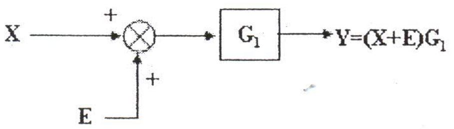


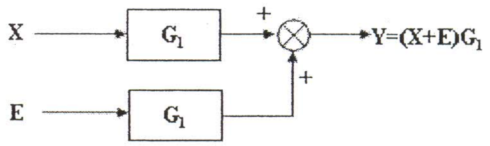
3. **Moving the summing ahead of the block:**



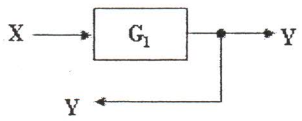


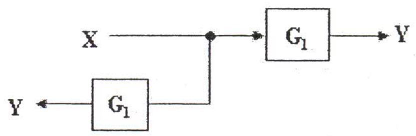
4. **Moving the summing beyond the block:**



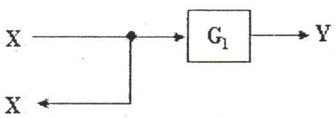


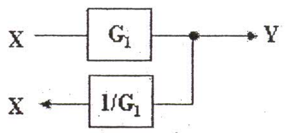
5. **Moving the takeoff point ahead of a block:**





6. **Moving the takeoff point beyond a block:**





APPENDIX 2: TABLE OF LAPLACE TRANSFORMS

	Time domain f(t)	Laplace domain F(s)
1	Unit impulse $\delta(t)$	1
2	Unit Step Function $u(t)$	$\frac{1}{s}$
3	Constant K	$\frac{K}{s}$
4	t	$\frac{1}{s^2}$
5	t^2	$\frac{2!}{s^3}$
6	$\frac{t^2}{2!}$	$\frac{1}{s^3}$
7	t^n	$\frac{n!}{s^{n+1}}$
8	$\frac{t^{n-1}}{n!}$	$\frac{1}{s^n}$
9	e^{-at}	$\frac{1}{s+a}$
10	$t \cdot e^{-at}$	$\frac{1}{(s+a)^2}$
11	$\frac{t^2 e^{-at}}{2!}$	$\frac{1}{(s+a)^3}$
12	$\frac{t^{n-1} e^{-at}}{n-1!}$	$\frac{1}{(s+a)^n}$
13	$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
14	$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
15	$\frac{1}{a}\left(1-e^{-at}\right)$	$\frac{1}{s(s+a)}$
16	$\frac{1}{a^2}\left(at-1+e^{-at}\right)$	$\frac{1}{s^2(s+a)}$
17	$\frac{1}{b-a}\left(e^{-at}-e^{-bt}\right)$	$\frac{1}{(s+b)(s+a)}$
18	$e^{-at} \sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
19	$e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$

APPENDIX 3: FORMULA

1	$T_r \approx \dfrac{1-0.4167\xi + 2.917\xi^2}{\omega_n}$
2	$T_d \approx \dfrac{1.1+0.125\xi + 0.469\xi^2}{\omega_n}$
3	$T_s \approx 4T = \dfrac{4}{\xi\omega_n}$, if 2% of final value $T_s \approx 3T = \dfrac{3}{\xi\omega_n}$, if 5% of final value
4	$\%OS = \dfrac{c_{\max} - c_{final}}{c_{final}}$ x 100
5	$\xi = \dfrac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$