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CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2014 SESSION

SUBJECT CODE	:	**FAD 30203**
SUBJECT TITLE	:	**CONTROL ENGINEERING**
LEVEL	:	**DIPLOMA**
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 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 is appended**

THERE ARE 6 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) A Segway® Personal Transporter (PT) is a two wheeled vehicle in which human act as operator stands vertically on a platform. As the driver leans left, right, forward and backward, a set of sensitive gyroscopic sensors sense the desired input. These signals are fed to a computer that amplifies them and commands motors to propel the vehicle in the desired direction. Determine whether the system is an open-loop or a closed-loop control system and provide your justification.

(4 marks)

Figure 1: The Segway® Personal Transporter (PT)

(b) Consider the human is trying to reach for a book in the table. Determine the reference input and the controller of the task.

(2 marks)

(c) Describe how does an open-loop system differs from closed-loop systems. List **one (1)** advantage of each system.

(4 marks)

(d) Find the forward Laplace for: (4 marks)

i. $5\frac{d^2y(t)}{dt^2}+8\frac{dy(t)}{dt}+3y(t)$.

ii. $\frac{t^{6-1}e^{-2t}}{6-1!}$.

(e) Find the inverse Laplace for $\frac{8}{s(s^2+5s+6)}$. (6 marks)

Question 2

(a) Prove that for a positive-feedback closed-loop control system, the system transfer function is $TF=\frac{G}{1-GH}$, where ***G*** is forward gain and ***H*** is feedback gain.

(5 marks)

(b) Simplify the block diagram of a system shown in **Figure 2** to a single block representing the transfer function, $TF(s)=\frac{C(s)}{R(s)}$.

(12 marks)

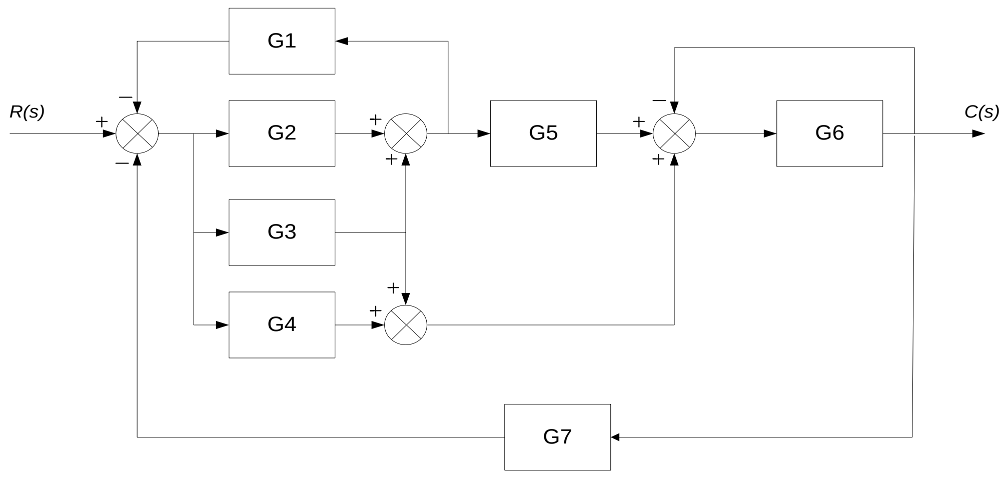


Figure 2: Block Diagram

(b) Obtain the transfer function, *TF(s)* if G1(s)=1, G2(s)=2, G3(s)=4, G4(s)=2, G5(s)=1, G6(s)=2 and G7(s)=1.

(3 marks)

Question 3

(a) Define mathematical modeling. (2 marks)

(b) Determine the transfer function of the circuit in **Figure 3** for output voltage $Vo(s)$, versus input voltage $Vi(s)$. Output voltage is measured across the $R2$ and C .

(10 marks)

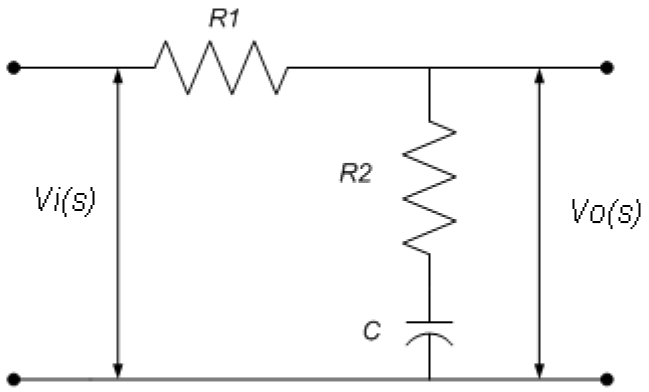


Figure 3: Series RC circuit

(c) A basic mechanical system consist of three passive and linear components; mass, spring and viscous damper. Derive the **mathematical model** that describe the relationship between force *f(t)* and displacement *x(t)* for each components.

(6 marks)

(d) Provide an example of mechanical system that you know.

(2 marks)

SECTION B (Total: 40 marks)

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

Question 4

(a) Find the transfer function for the unit step response of the first order response below.

(10 marks)

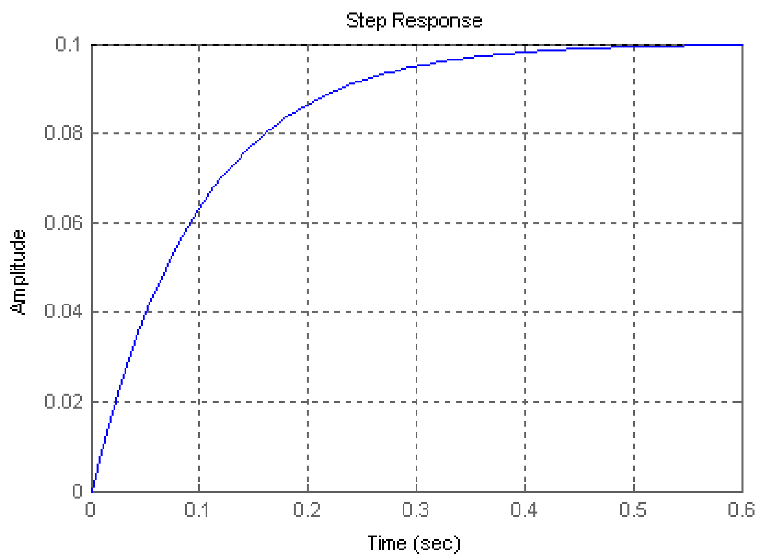


Figure 4: First Order response

(b) Given that the settling times (*Ts*) of the second order response below is 3.54s and find the transfer function of the system.

(10 marks)

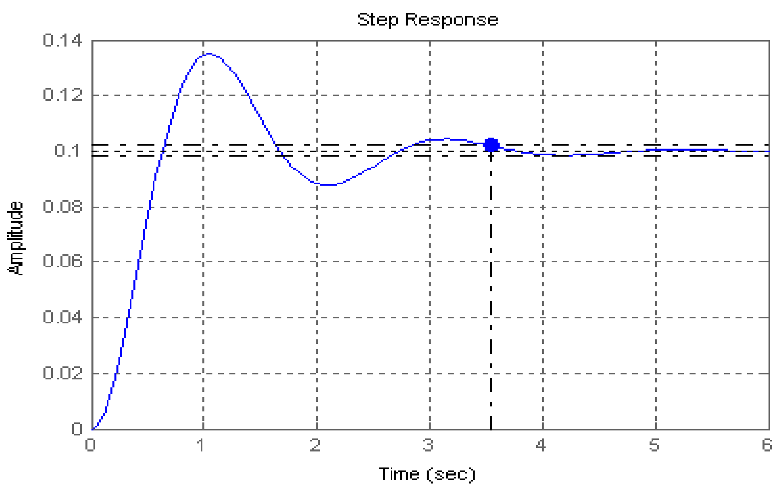


Figure 5: Second Order response

Question 5

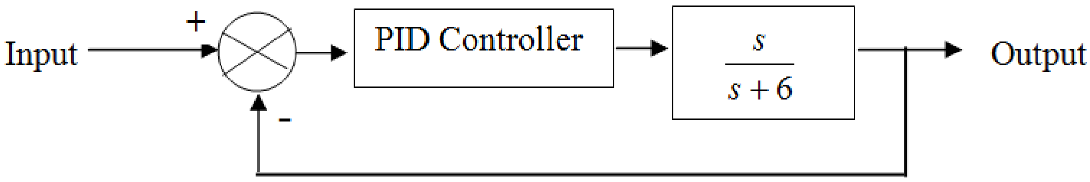


Figure 6: PID controller with plant module system

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

(4 marks)

(b) Find the transfer function of PID controller.

(5 marks)

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

(5 marks)

(d) Give the characteristic of P, I and D controller.

(6 marks)

Question 6

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

(14 marks)

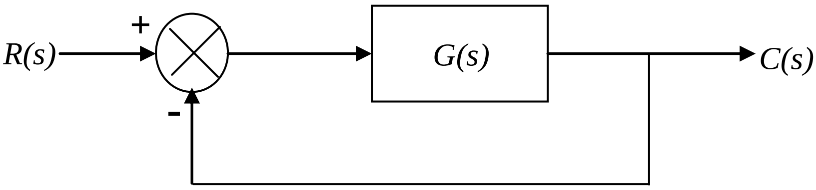


Figure 7: The unity feedback system

Where $G(s) = \dfrac{60}{s(s+5)(s+12)}$

(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)

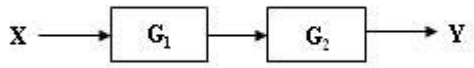
iv. Phase cross over frequency, ω_{pco} (1 mark)

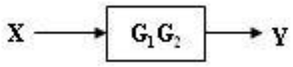
(c) Give your comment on the stability. (2 marks)

END OF QUESTION

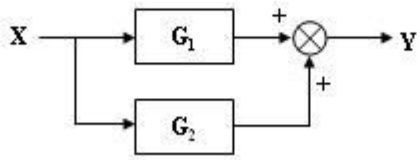
APPENDIX 1: BLOCK DIAGRAMS

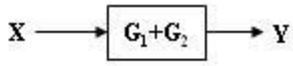
1. **Cascading Blocks:**



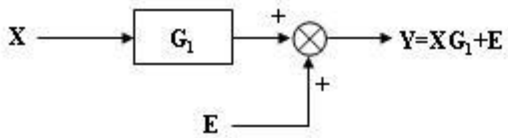


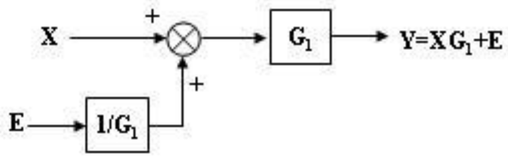
2. **Blocks in parallel: Forward Loop**



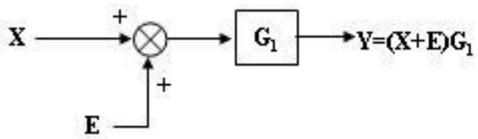


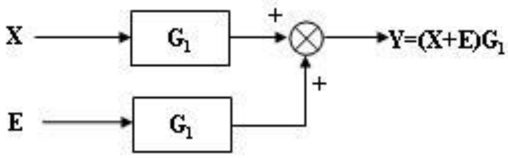
3. **Moving the summing ahead of the block:**



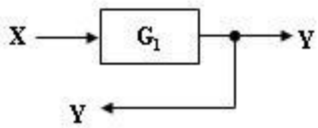


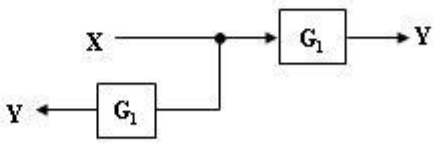
4. **Moving the summing beyond the block:**



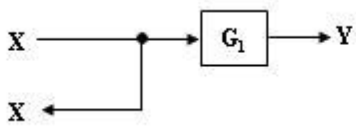


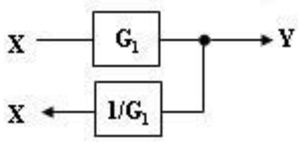
5. **Moving the takeoff point ahead of a block:**





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: FORMULAS

1	$T_s \approx 4T = \frac{4}{\xi\omega_n}$, if 2% of final value $T_s \approx 3T = \frac{3}{\xi\omega_n}$, if 5% of final value
2	$\%OS = \frac{c_{\max} - c_{final}}{c_{final}}$ x 100
3	$\xi = \frac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$
4	$T_p = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$