CONFIDENTIAL

SET A

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
SEPTEMBER 2014 SESSION

SUBJECT CODE	:	**FAD30203**
SUBJECT TITLE	:	**CONTROL ENGINEERING**
LEVEL	:	**DIPLOMA**
TIME / DURATION	:	**9.00 PM – 12.00 PM (3 HOURS)**
DATE	:	**10 JANUARY 2015**

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 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) Determine the closed-loop transfer function of a negative-feedback control system if the forward gain and feedback gain are given by 25 and 5 respectively.

(3 marks)

(b) Give **one (1)** example of feedback control systems in which a human brain acts as a controller.

(1 mark)

(c) A temperature control system operates by sensing difference between the thermostat setting and the actual temperature using a temperature sensor. The signal will be processed by a controller and a fuel valve will be opened or closed for an amount that proportional to the differences. Draw a functional block diagram for this system indicating input, output, sensor, controller and actuator.

(3 marks)

(d) Find the forward Laplace transform of the following :-

i. $f(t) = 5cos\frac{5t}{25} + 4sin7t$ (3 marks)

ii. $f(t) = \frac{t^2}{3!} - te^{-6t}$ (3 marks)

(e) Find the inverse Laplace transform of the following :-

$$F(s) = \frac{2}{s(s^2 + 15s + 56)}$$

(7 marks)

Question 2

(a) Simplify the block diagram of a system shown in **Figure 1** to a single block representing the transfer function, $TF(s) = C(s)/R(s)$.

(13 marks)

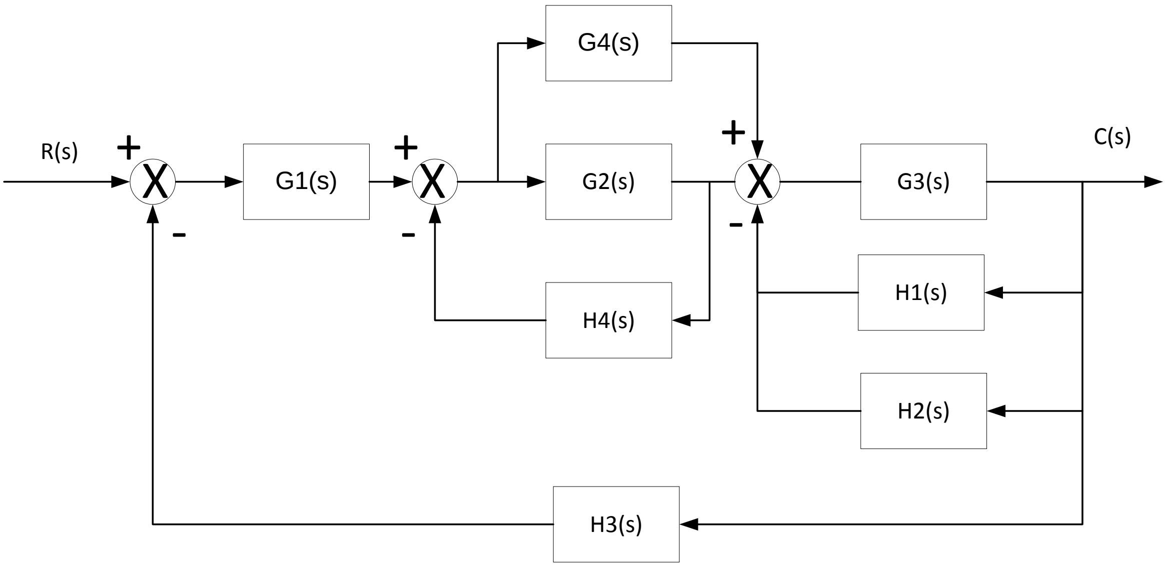


Figure 1: Block Diagram

(b) Obtain the transfer function, *TF(s)* in numeric value if given G1(s) = 2, G2(s) = 4, G3(s) = 2, G4(s) = 3, H1(s) = 2, H2(s) = 1, H3(s) = 5 and H4(s) = 1.

(2 marks)

Question 3

(a) A basic electrical system normally consists of resistor, capacitor and inductor components. Derive **three (3)** general transfer functions $\frac{I(s)}{V(s)}$ for each series circuit that contains one resistor only, one capacitor only and one inductor only.

(6 marks)

(b) Consider the RL circuit in **Figure 2** and answer the following questions.

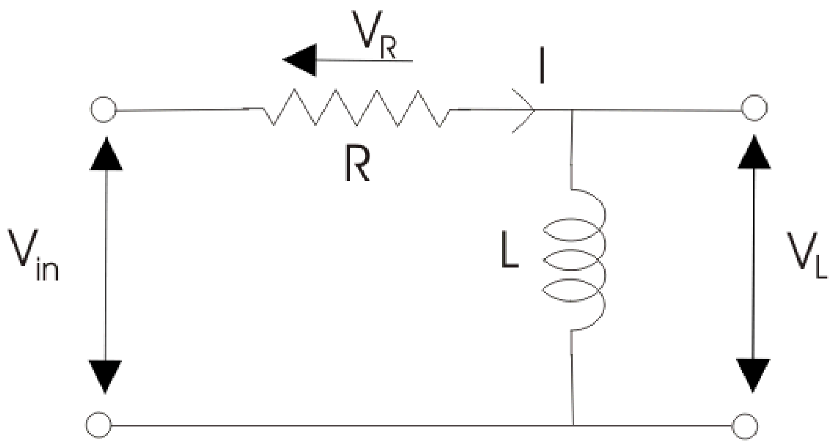


Figure 2: RL Circuit

i. Determine the Kirchhoff's voltage equation of the circuit.

(2 marks)

ii. Given R = 450Ω and L = 650mH, determine the transfer function $\frac{I(s)}{V_{in}(s)}$.

(5 marks)

(c) Consider the mass-spring-damper system as shown in **Figure 3**. It represents the single degree of freedom system; that is, the mass is allowed to move only horizontal direction. The spring reaction force reacts when the mass is displaced from its equilibrium, while the damper reaction force acts when the mass is in motion. Answer the following question :-

i. Develop the mathematical model and transfer function of the system.

(6 marks)

ii. If $M = 1kg, B = 20Ns^{-1}\ m, K = 100N\ m$. Find the response *x(t)* for a unit step input.

(6 marks)

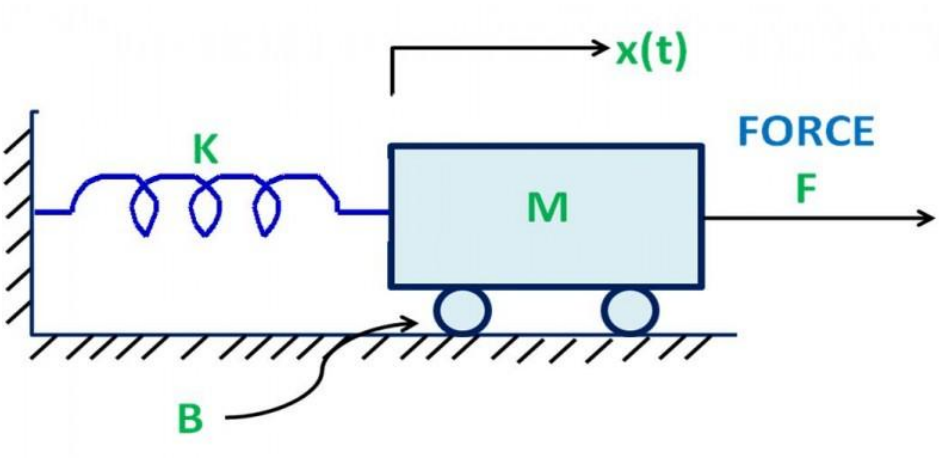


Figure 3: Spring-mass-damper system

SECTION B (Total: 40 marks)

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

Question 4

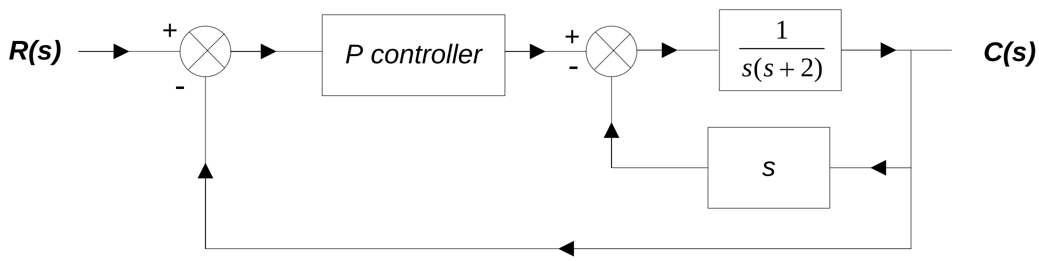
(a) Derive the transfer function of PI controller and identify the characteristics of this controller.

(6 marks)

(b) Determine the overall transfer function $\frac{C(s)}{R(s)}$ for each system in **Figure 4**.

(14 marks)

i.



ii.

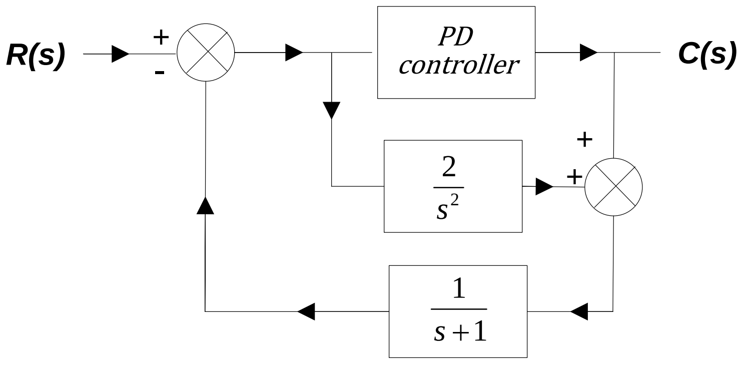


Figure 4: PID controller compensation

Question 5

(a) List **four (4)** types of output response for second order system.

(2 marks)

(b) Find the output response, *c(t)* for each of the system in **Figure 5**.

(8 marks)

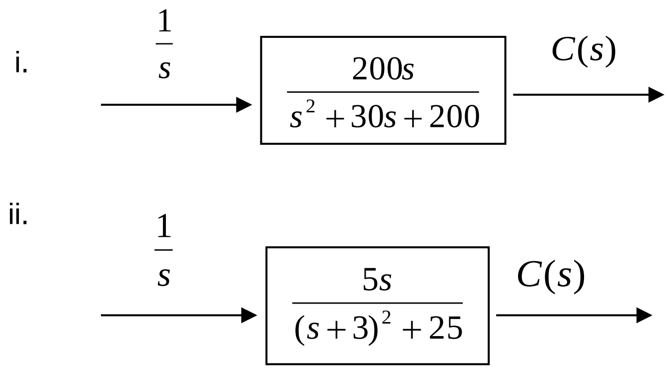


Figure 5: Block Diagram of second order system

(c) Determine the damping ratio (ξ), natural frequency (ω_n), and estimate the transfer function of an output response of a second order system shown in **Figure 6**.

(10 marks)

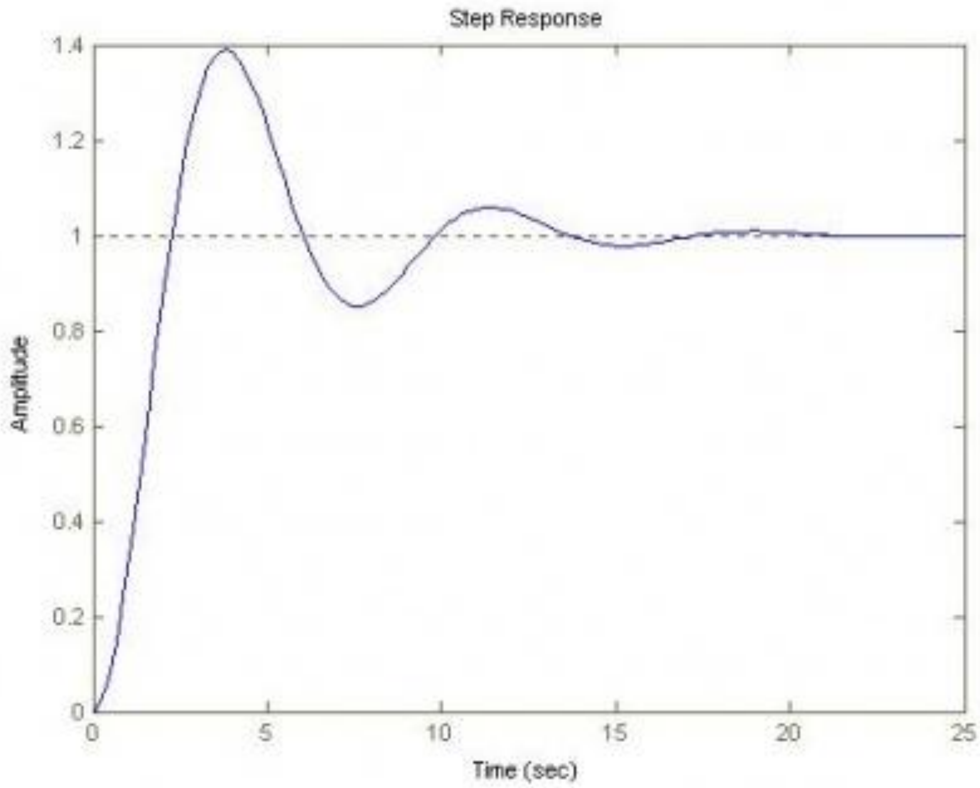


Figure 6: Output response case second-order system

Question 6

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

(14 marks)

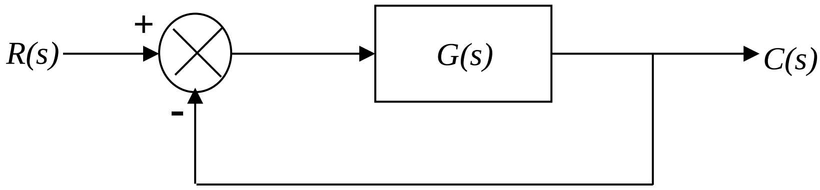


Figure 7: The unity feedback system

Where $G(s) = \dfrac{40}{(s+2)(s+4)(s+5)}$

(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)

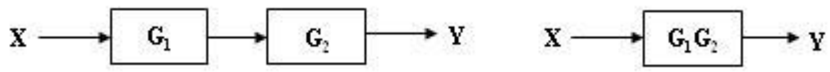
(c) Give your comment on the stability.

(2 marks)

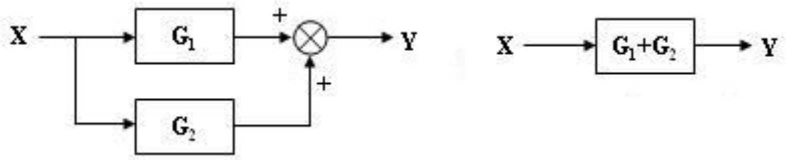
END OF QUESTION

APPENDIX 1: BLOCK DIAGRAMS

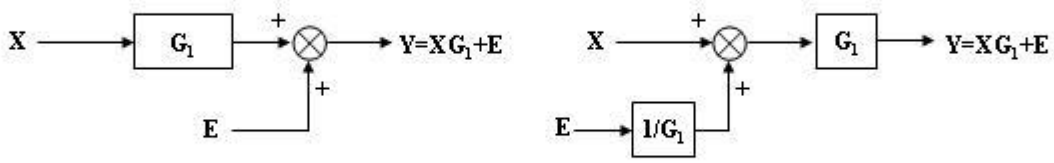
1. **Cascading Blocks:**



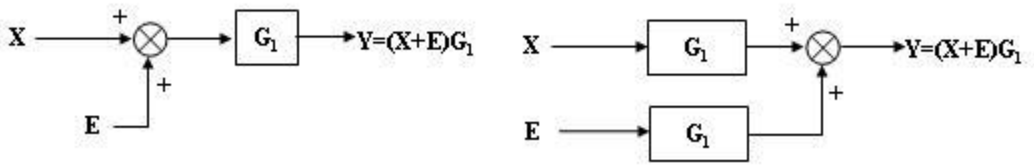
2. **Blocks in parallel: Forward Loop**



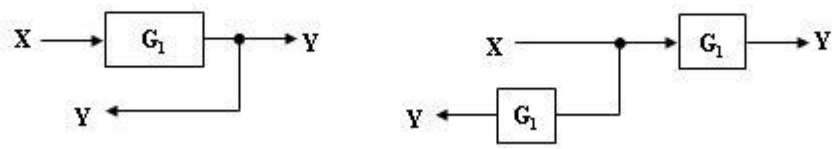
3. **Moving the summing ahead of the block:**



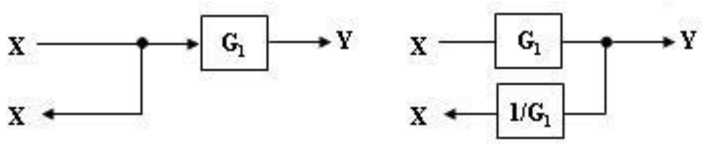
4. **Moving the summing beyond the block:**



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	$\frac{1}{a}(1-e^{-at})$	$\frac{1}{s(s+a)}$
16	$\frac{1}{a^2}(at-1+e^{-at})$	$\frac{1}{s^2(s+a)}$
17	$\frac{1}{b-a}(e^{-at}-e^{-bt})$	$\frac{1}{(s+b)(s+a)}$
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	$\xi = \frac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$