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SET B

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2011 SESSION

SUBJECT CODE	:	FAD30203
SUBJECT TITLE	:	CONTROL ENGINEERING
LEVEL	:	DIPLOMA
TIME / DURATION	:	9.00am – 12.00pm (3 HOURS)
DATE	:	10 MAY 2011

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) Define and give the example of open-loop and closed-loop control system.

(4 marks)

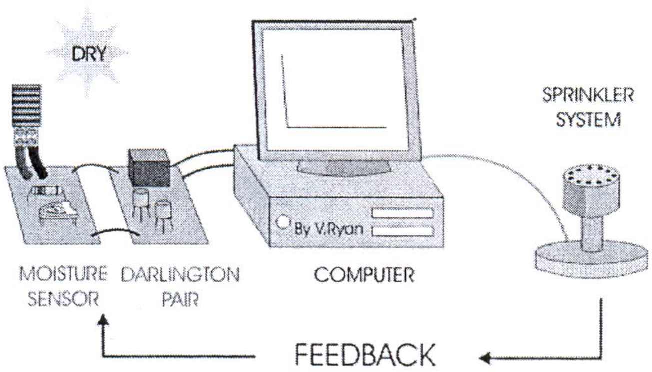


Figure 1: Water sprinkler system

(b) Consider the diagram in **Figure 1** state the system open-loop or closed-loop control system and give explanation for your answer.

(3 marks)

(c) Draw the block diagram for Question 1 (b).

(3 marks)

(d) Give two (2) examples of feedback control systems in which a human acts as a controller.

(2 marks)

(e) Determine the overall gain of positive feedback closed-loop system if the forward gain and feedback gain are given by 50 and 5 respectively.

(3 marks)

Question 2

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

(12 marks)

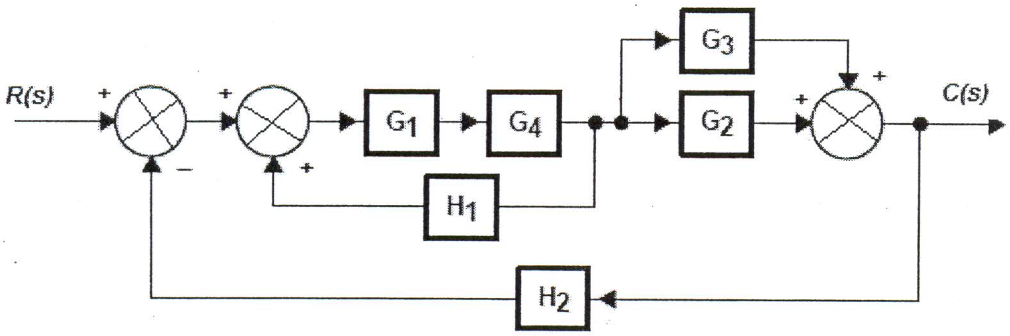


Figure 2 : Block Diagram.

(b) Obtain the transfer function, *TF(s)* if $G_1(s) = 1$, $G_2(s) = 2$, $G_3(s) = 1$, $G_4(s) = 2$, $H_1(s) = 2$ and $H_2(s) = 1$.

(3 marks)

Question 3

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

(2 marks)

(b) Derive the transfer function of PID controller.

(4marks)

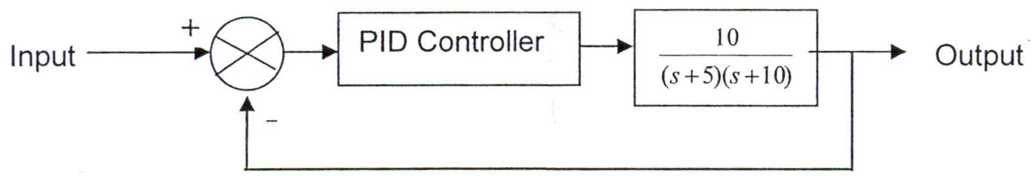


Figure 3: PID controller with plant module system

(c) Based on **Figure 3** find the overall transfer function of the system when the PID controller is connected in series with the plant module.

(6 marks)

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

(3 marks)

Question 4

(a) List and draw four (4) types of transient responses.

(4 marks)

(b) Define impulse function.

(2 marks)

(c) Sketch the impulse functions of $\delta(t-1.50)$ and $\delta(t-0.10)$.

(2 marks)

SECTION B (Total: 40 marks)

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

Question 5

Figure 5 shows the 2 tanks connected in series that fluid level in downstream tank does not affect the fluid-level dynamics of the upstream tanks.

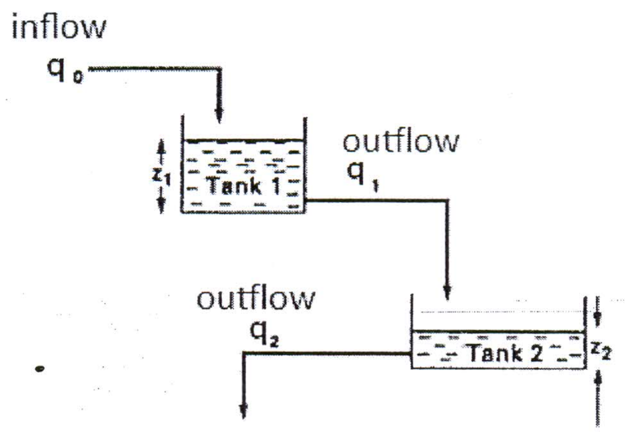


Figure 5: Noninteracting tanks

Variables used:

z_1 = fluid level in the upstream tank (1)
z_2 = fluid level in the upstream tank (2)
q_0 = fluid flow rate into tank 1
q_1 = fluid flow rate out of tank 1 and into tank 2
q_2 = fluid flow rate out of tank 2
R_1 = resistance of the tank 1 outlet
R_2 = resistance of the tank 2 outlet

(a) Define noninteracting tanks.

(2 marks)

(b) Find the transfer function; $\dfrac{Z_1(s)}{Q_0(s)}$ of tank 1.

(5 marks)

(c) Find the transfer function; $\dfrac{Z_2(s)}{Q_1(s)}$ of tank 2.

(5 marks)

(d) Find the overall transfer function; $\frac{Z_2(s)}{Q_0(s)}$ of tank 1 and tank 2 when the tanks arranged in series.

(8 marks)

Question 6

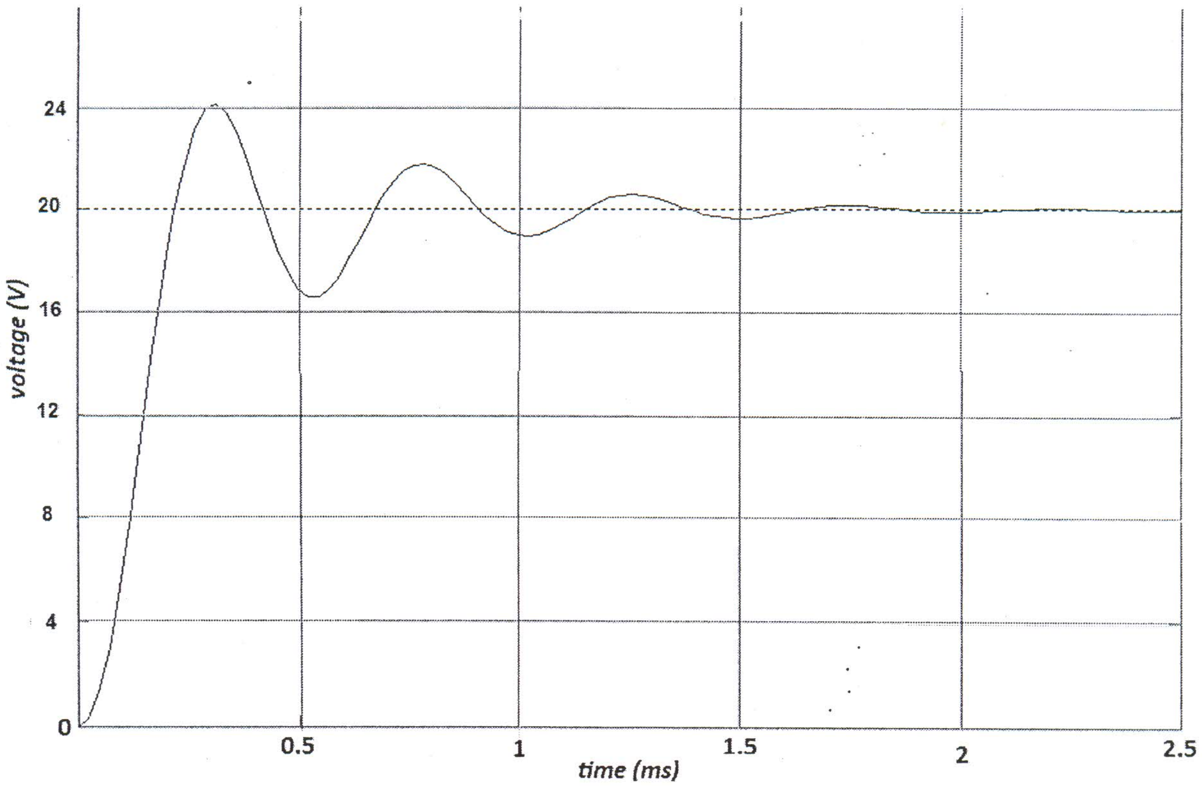


Figure 6: Underdamped response case of second-order

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

(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)

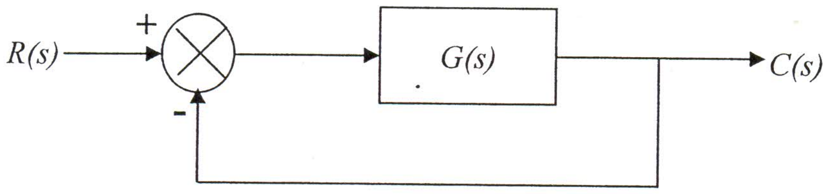


Figure 7: The unity feedback system

Where $G(s) = \dfrac{20K}{s(s+2)(s+60)}$ and K=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)

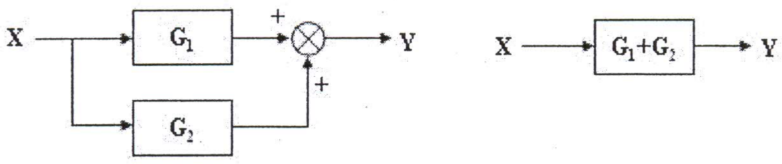
(c) Give your comment on the stability. (2 marks)

END OF QUESTION

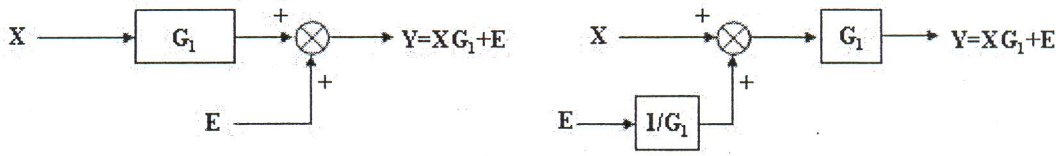
APPENDIX 1: BLOCK DIAGRAMS

1. **Cascading Blocks:**

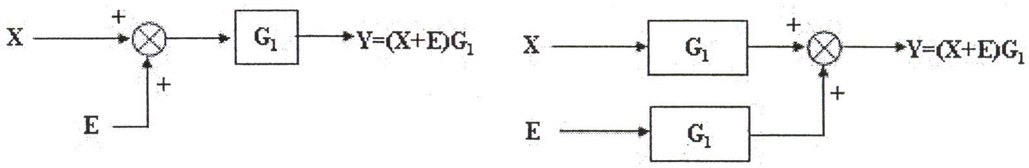
2. **Blocks in parallel: Forward Loop**



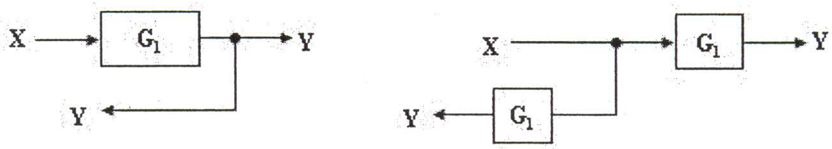
3. **Moving the summing ahead of the block:**



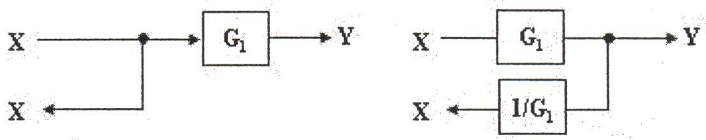
4. **Moving the summing beyond the block:**



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	$T_r \approx \dfrac{1-0.4167\xi+2.917\xi^2}{\omega_n}$
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	$\%OS = \dfrac{c_{\max} - c_{final}}{c_{final}} \text{ x } 100$
5	$\xi = \dfrac{-\ln(\%OS/100)}{\sqrt{\pi^2+\ln^2(\%OS/100)}}$