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SET B

UNIVERSITI KUALA LUMPUR
Malaysia France Institute

FINAL EXAMINATION
JANUARY 2010 SESSION

SUBJECT CODE	:	FAD30203
SUBJECT TITLE	:	CONTROL ENGINEERING
LEVEL	:	DIPLOMA
TIME / DURATION	:	12.00 noon – 3.00 pm (3 HOURS)
DATE	:	26 APRIL 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 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) Define and give the example of manual and automatic control system.

(4 marks)

(b) Determine the reference input, controller, manipulate (final control elements), feedback and loop (repeat) if the human reach a book on a table.

(5 marks)

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

(4 marks)

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

(2 marks)

Question 2

(a) Reduce the block diagram of a system shown in **Figure 1** to a single block representing the transfer function, $TF(s) = \frac{C(s)}{R(s)}$

(15 marks)

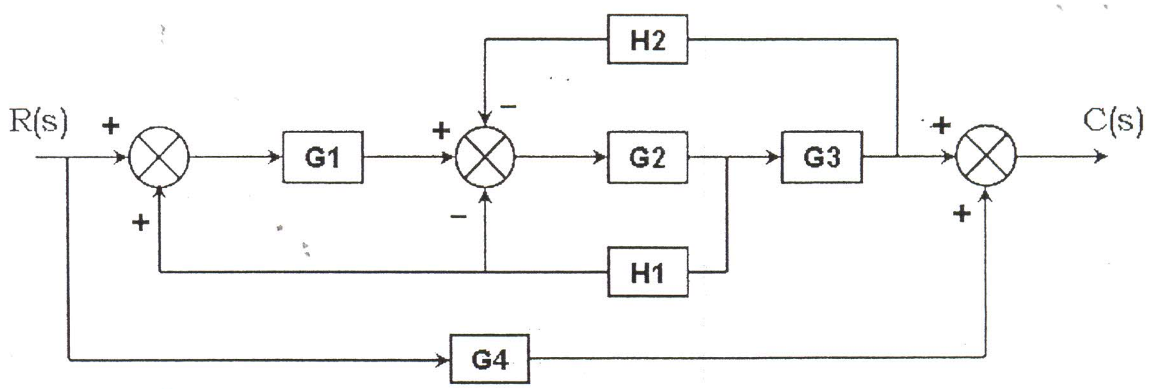


Figure 1: The block diagram of a system

Question 3

A spring mass damper system is shown in **Figure 2**. The system is fixed at ends between two supports. Mass is supported by the spring and is free to oscillate about the position of rest. An equation of motion relating vertical motion of mass to applied force will be developed.

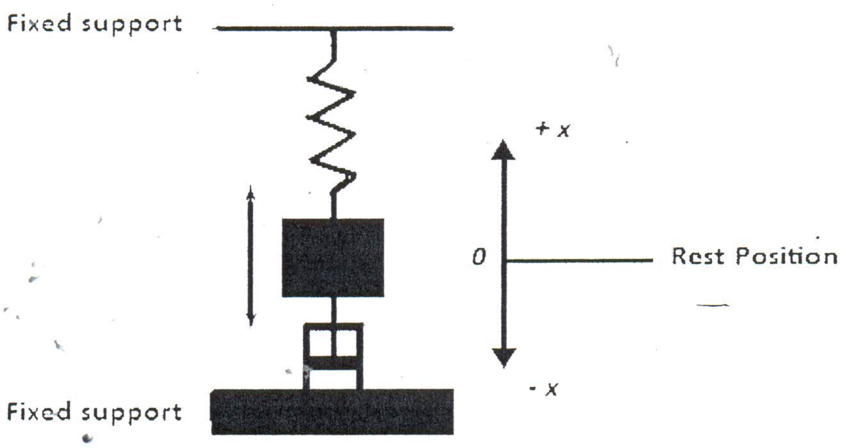


Figure 2: Spring Mass Damper system

(a) Find the Transfer Function of the system where *X(s)* = Mass movement and *F(s)* = Applied Force

and $$TF(s) = \frac{X(s)}{F(s)}$$

All the initial condition = 0

(7 marks)

(b) If the Force = 1000 Newton, Mass=1 Newton-second ^{2} /meter, Viscous Damper= 9 Newton-seconds/meter, and Spring Stiffness= 20 Newton/meter, find the expression of mass movement in time domain *x(t)*.

(7 marks)

(c) Give one example of system that consist of mass, spring and damper system.

(1 marks)

Question 4

A dc motor-speed control system regulates the motor velocity based upon the control voltage applied to it. The motor transfer function (velocity/control voltage) is:

$$TF(s) = \frac{125}{s+5}$$

(a) Determine the velocity in time-domain if it is applied a control voltage of 25 V dc.

(9 marks)

(b) Hence, determine the velocity at time, t = 1s, 10s, and 100s.

(6 marks)

SECTION B (Total: 40 marks)

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

Question 5

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

(4 marks)

(b) Derive the transfer function of PID controller.

(5 marks)

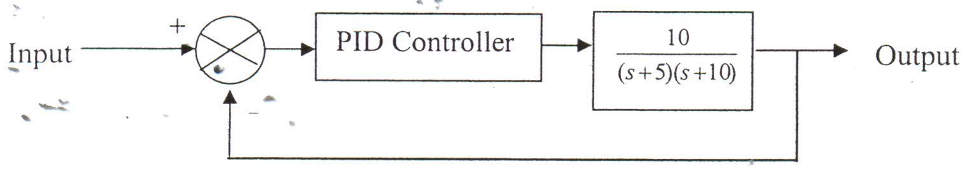


Figure 3: PID controller with plant module system

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

(5 marks)

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

(6 marks)

Question 6

Figure below show the underdamped response of control system.

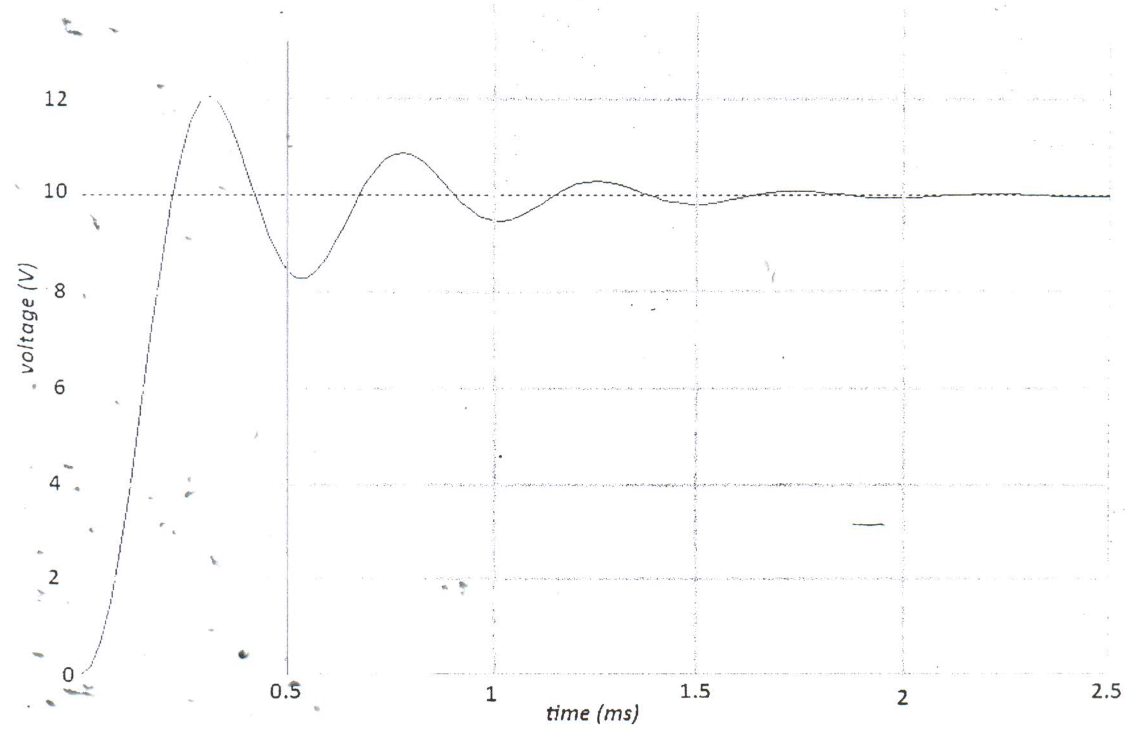


Figure 4: Underdamped response case of second-order

(a) Consider the underdamped response case of second-order system shown in **Figure 4** and determine the following:

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. (10 marks)

Question 7

(a) Draw a Bode plot of the unity feedback system shown in **Figure 5**: (14 marks)

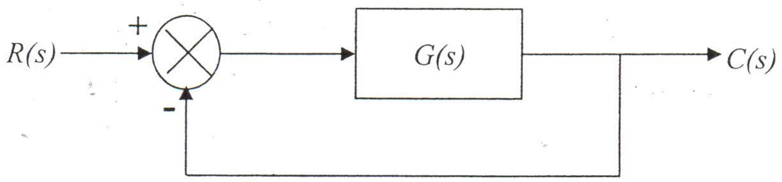


Figure 5: The unity feedback system

Where $G(s) = \dfrac{20K}{s(s+2)(s+60)}$ and K=12

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

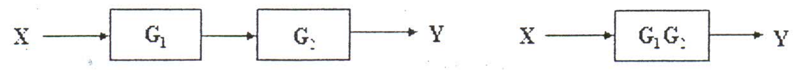
i. gain margin (1 mark)
ii. phase margin (1 mark)
iii. gain cross over frequency (1 mark)
iv. phase cross over frequency (1 mark)

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

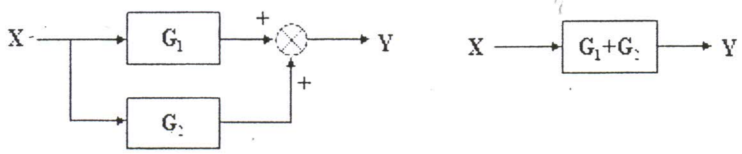
END OF QUESTION

APPENDIX 1 : BLOCK DIAGRAMS

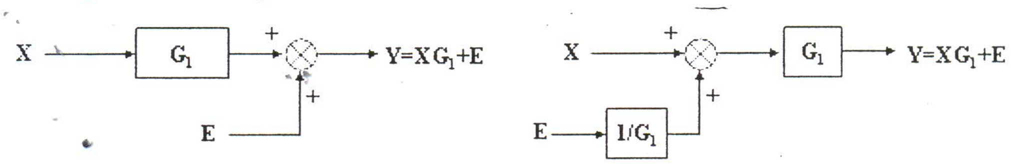
1. **Cascading Blocks:**



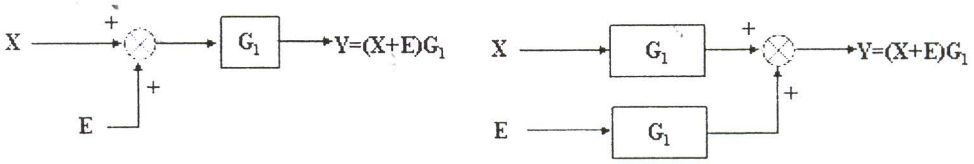
2. **Blocks in parallel: Forward Loop**



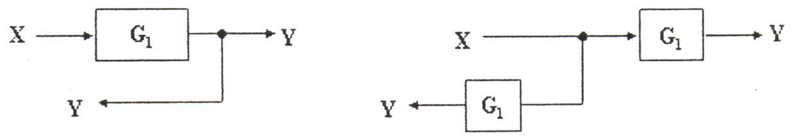
3. **Moving the summing ahead of the block:**



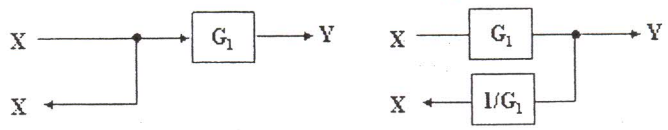
4. **Moving the summing beyond the block:**



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	$\%OS = \dfrac{c_{\max} - c_{final}}{c_{final}}$ x 100
5	$\xi = \dfrac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$