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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2015/2016

COURSE NAME	:	CONTROL SYSTEM
COURSE CODE	:	DAE 32103
PROGRAMME	:	2 DAE
EXAMINATION DATE	:	DECEMBER 2015/ JANUARY 2016
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

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Q1 (a) Based on a closed loop control system,

(i) Sketch the general block diagram of the system.

(4 marks)

(ii) Briefly explain all the terms involved in constructing the system.

(10 marks)

(b) As an engineer in BMW Automobiles, you are assigned to design a power windows control system. Explain the **six (6)** steps in designing the control system.

(6 marks)

(c) State **three (3)** major objectives of systems analysis and design.

(3 marks)

(d) List **two (2)** example control system classifications.

(2 marks)

Q2 (a) Based on the following differential equation,

$$\frac{d^2y(t)}{dt^2}+8\frac{dy(t)}{dt}+15y(t)=7u(t)$$

(i) Solve y(t) if the initial condition is zero.

(14 marks)

(ii) Determine the transient response and steady state response base on your result.

(2 marks)

(b) Convert the spring mass damper system as shown in **Figure Q2(b)** to a free body diagram.

(5 marks)

(c) Simplify the block diagram shown in **Figure Q2(c).** Obtain the transfer function relating C(s) and R(s).

(4 marks)

Q3 (a) For the following transfer function, calculate

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{100}{s^2 + 18s + 100}$$

(i) The natural frequency (ω_n).

(3 marks)

(ii) The damping ratio (ζ).

(3 marks)

(iii) The type of response and sketch the damping ratio, ζ response.

(3 marks)

(iv) Rise time, t_r.

(3 marks)

(v) Settling time, t_s for 2% criterion.

(2 marks)

(b) Determine the stability of the system shown in **Figure Q3(b)** with aid of pole-zero plot.

(11 marks)

Q4 (a) Nowadays, digital control system has been used extensively in complex applications while analogue control system is kept for much simpler applications.

(i) Describe the fundamental difference between analogue and digital control systems.

(1 marks)

(ii) Draw the block diagram of a digital control system.

(10 marks)

(iii) Describe **two (2)** types of signal in digital control system by the aid of graph.

(6 marks)

(b) ADC converts analog signal (voltage and current) into a digital signal.

(i) List **four (4)** types of ADC frequently used.

(4 marks)

(ii) Calculate the output of 16-bit ADC when the input voltage V_{in} is 5V and reference voltage, V_{ref} is 10V. Write the final answer in binary.

(4 marks)

Q5 (a) Determine the meaning of acronym 'P-I-D' controller.

(3 marks)

(b) Describe the function of 'P' component in the PID controller by the aid of graph.

(5 marks)

(c) **Figure Q5(c)** shows a closed loop control system using PID controller.

(i) Given the transfer function for the PID controller, $G_c(s)$ and also the plant's transfer function, G(s):

$$G_c(s) = K_p + \frac{K_i}{s} + K_d s \qquad G(s) = \frac{1}{s+a}$$

Derive expressions for $T(s) = \frac{Y(s)}{R(s)}$ and $T_{err}(s) = \frac{E(s)}{R(s)}$ in terms of parameters a, K_d, K_i and K_p.

(12 marks)

(ii) Set a = 2 and K_d = 1. Calculate the value of K_p and K_i in order for the poles of the closed loop system, H(s) to be positioned at the s-plane locations:

$s = -4$ and $s = -5$

(5 marks)

Q6 (a) Temperature is one of the parameters measured in process control.

(i) List **three (3)** types of temperature sensor

(3 marks)

(ii) Determine the most suitable sensor to measure the temperature of a gas turbine exhaust.

(1 mark)

(iii) Justify your answer in **(ii)** above.

(3 marks)

(b) Determine the most significant differences between sequential control and continuous control.

(2 marks)

(c) Based on **Figure Q6(c)**,

(i) Classify the process control used.

(1 mark)

(ii) Explain how the process is executed.

(7 marks)

(d) **Figure Q6(d)** shows the cascade control where two feedback controllers are incorporated in the system. Draw the control system block diagram

(8 marks)

- END OF QUESTION -

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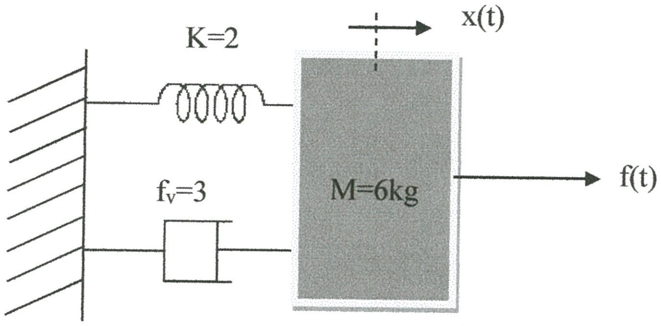

FIGURE Q2(b)

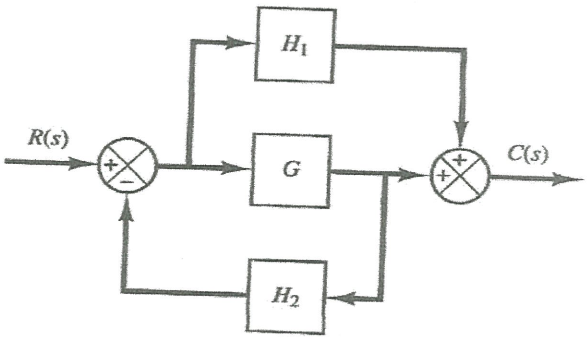

FIGURE Q2(c)

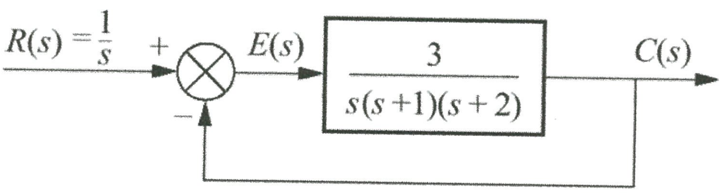

FIGURE Q3(b)

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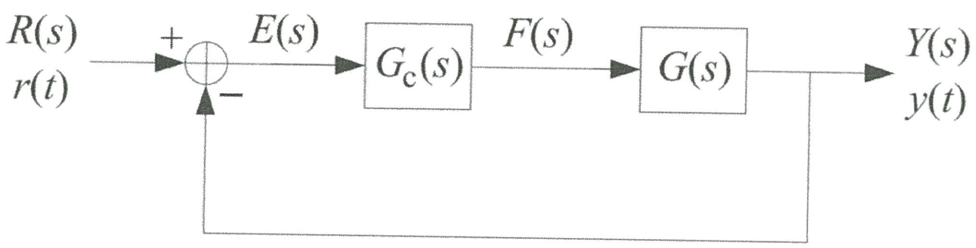

FIGURE Q5(c)

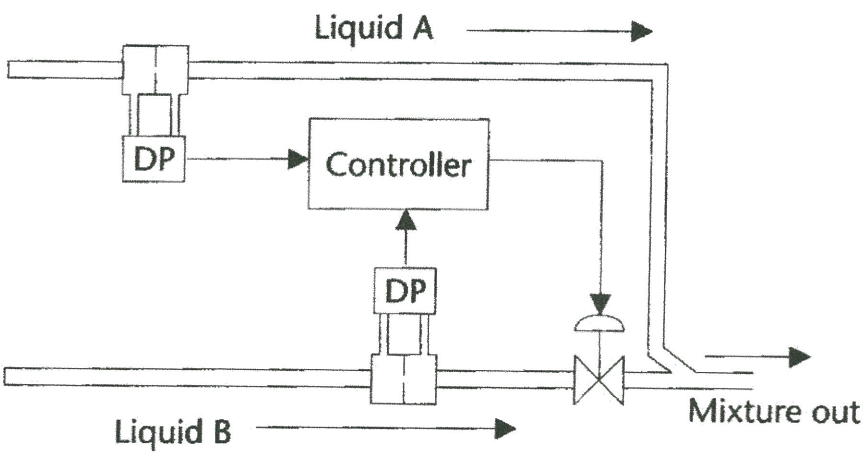

FIGURE Q6(c)

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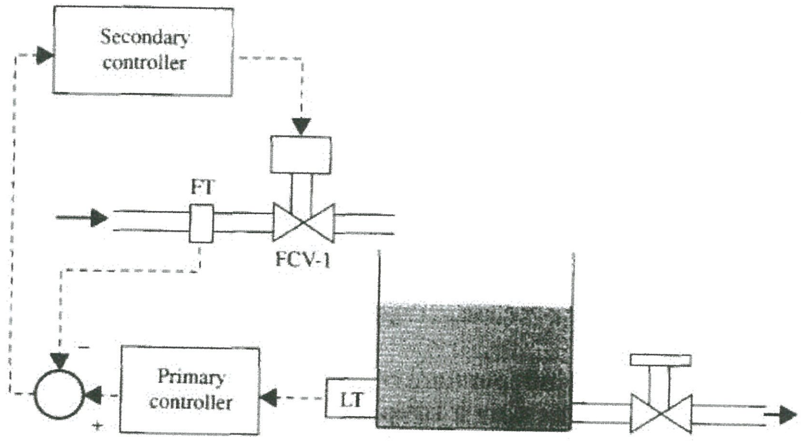

FIGURE Q6(d)

LIST OF FORMULAE

Unity feedback system	$T(s) = \dfrac{G(s)}{1 + G(s)H(s)}$

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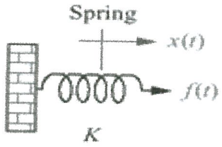
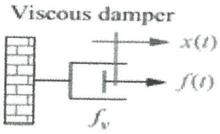
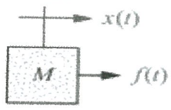
LIST OF FORMULAE: Laplace Transform Table

Item no.	f(t)	F(s)
1.	$\delta(t)$	1
2.	$u(t)$	$\frac{1}{s}$
3.	$tu(t)$	$\frac{1}{s^2}$
4.	$t^n u(t)$	$\frac{n!}{s^{n+1}}$
5.	$e^{-at}u(t)$	$\frac{1}{s+a}$
6.	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
7.	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

LIST OF FORMULAE: Mechanical Components Table

Component	Force-velocity	Force-displacement	Impedance $Z_M(s) = F(s)/X(s)$
Spring 	$f(t) = K\int_0^t v(\tau)\,d\tau$	$f(t) = Kx(t)$	K
Viscous damper 	$f(t) = f_v v(t)$	$f(t) = f_v \frac{dx(t)}{dt}$	$f_v s$
Mass 	$f(t) = M\frac{dv(t)}{dt}$	$f(t) = M\frac{d^2x(t)}{dt^2}$	Ms^2

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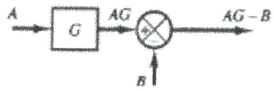
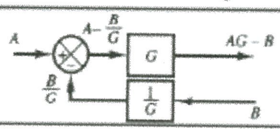
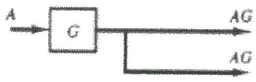
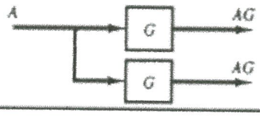
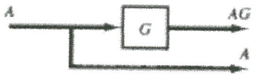
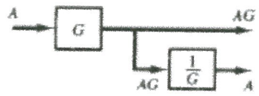
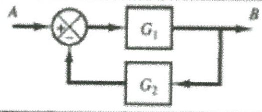
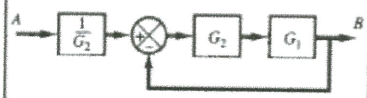
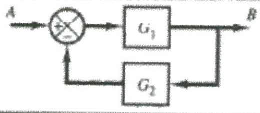
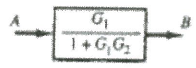
LIST OF FORMULAE: Block Diagram Tranformations

	Original Block Diagrams	Equivalent Block Diagrams
1		
2		
3		
4		
5		

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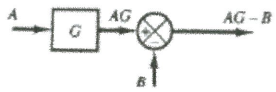
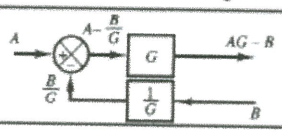
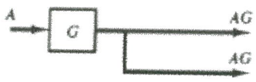
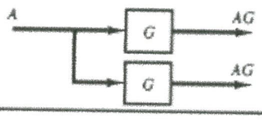
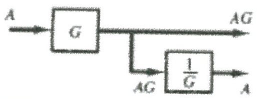
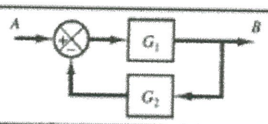
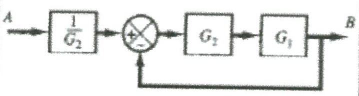
1		
2		
3		
4		
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