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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2013/2014

COURSE NAME	:	CONTROL SYSTEM
COURSE CODE	:	DAE 32103
PROGRAMME	:	3 DAE
EXAMINATION DATE	:	JUNE 2014
DURATION	:	2 ½ HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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Q1 (a) Sketch a block diagram of open and closed loop control system.

(4 marks)

(b) Discuss the differences between open and closed loop control system.

(6 marks)

(c) Solve the ramp response for a system whose transfer function is

$$G(s) = \frac{5s}{(s-2)(s+3)^2}$$

(15 marks)

Q2 (a) There are **six (6)** steps involved in designing a control system. Briefly explain the control system design process.

(6 marks)

(b) Solve the transfer function, G(s) = C(c)/R(s), corresponding to the differential equation and state your initial condition.

$$16\frac{d^3c}{dt^3} - 3\frac{d^2c}{dt^2} + 9\frac{dc}{dt} - 5c = 7\frac{d^2r}{dt^2} + 4\frac{dr}{dt} - 3r$$

(4 marks)

(c) For the following transfer function, calculate

$$\frac{\theta_o(s)}{\theta_i(s)} = \frac{80}{s^2 + 15s + 80}$$

(i) The natural frequency (ω_n).
(ii) The damping ratio (ζ).
(iii) The type of response and sketch the damping ratio, ζ response.
(iv) Rise time, t_r
(v) Peak time, t_p
(vi) Percent overshoot, $\%M_p$
(vii) Settling time t_s for 2% criterion

(15 marks)

Q3 (a) Solve the transfer function, G (s) = Vo (s) / Vi (s) for the following RLC network in Figure Q3(a).

(10 marks)

(b) The polynomial function is given.

$$\frac{C(s)}{R(s)} = \frac{(s+5)(s-3)}{s\,(s-2)(s+7)}$$

Plot the poles and zeros for the system.

(5 marks)

(c) The stability is the most important specification in control system analysis. Briefly describe the definition of stable, unstable and marginally stable.

(3 marks)

(d) Figure Q3(d) show the unity feedback system. By using zero-poles plot, determine whether the unity feedback system is stable or unstable.

(7 marks)

Q4 (a) Explain the fundamental difference between analogue and digital control systems.

(1 mark)

(b) Figure Q4(b) shows a block diagram of an analogue control system. Based on Figure Q4(b), sketch a digital control system to replace the analogue control system.

(10 marks)

(c) Give **six (6)** advantages of digital control system compared to analogue system.

(6 marks)

(d) Sketch **four (4)** types of signal in digital control system respectively.

(8 marks)

Q5 (a) Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer.

(i) Sketch a complete block diagram of data acquisition system.

(8 marks)

(ii) Explain the function of each component based on your block diagram.

(8 marks)

(b) Explain sampling process by sketching the band limited analogue signal and its spectra.

(9 marks)

Q6 (a) Based on Figure Q6(a),

(i) Classify the process control used.

(1 mark)

(ii) Explain how the process is executed.

(10 marks)

(b) Explain **five (5)** terminologies of process control and include an example where appropriate.

(12 marks)

(c) Give **two (2)** types of process control loop other than open loop and closed loop.

(2 marks)

- END OF QUESTION –

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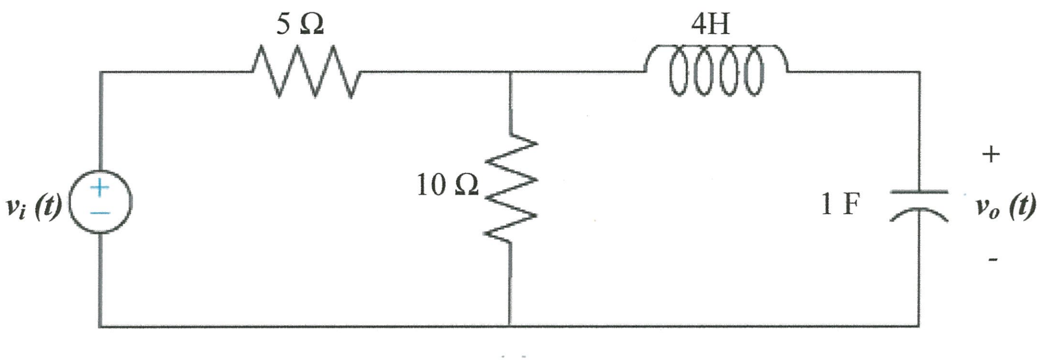

FIGURE Q3(a)

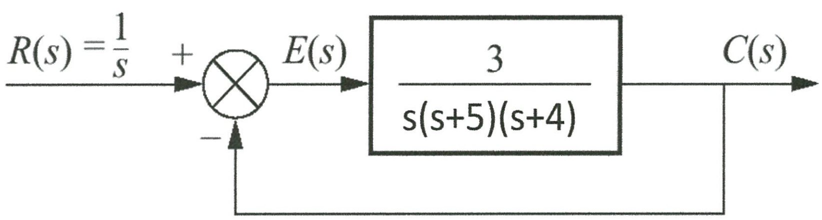

FIGURE Q3(d)

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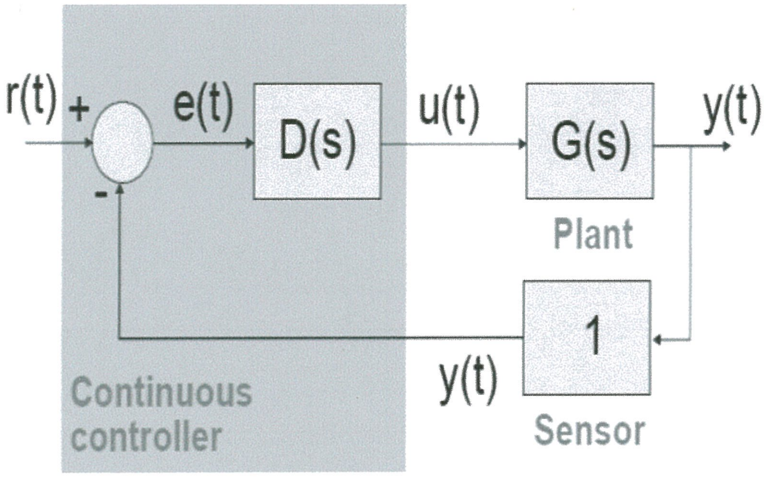

FIGURE 4(b)

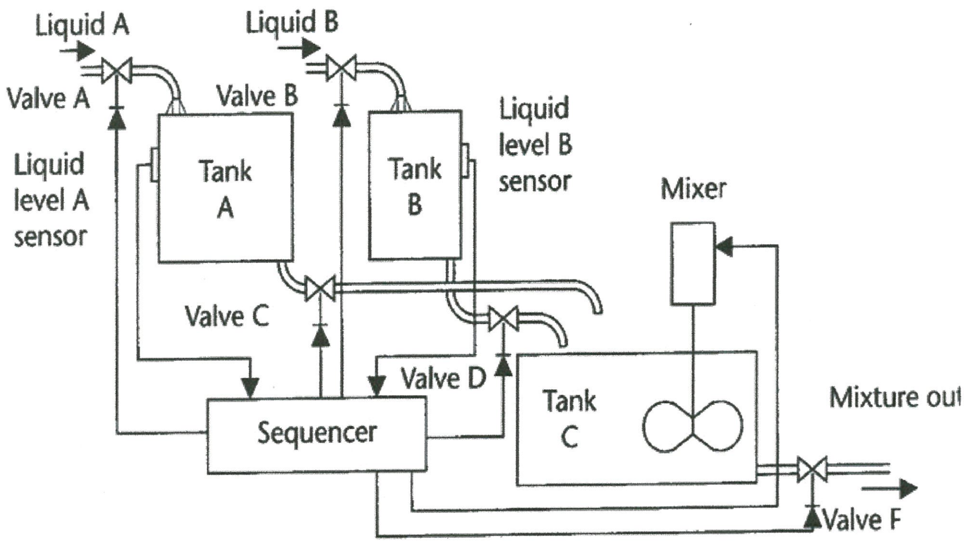

FIGURE 6(a)

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TABLE 1: Laplace Transform Theorem

Item no.	Theorem		Name
1.	$\mathcal{L}[f(t)] = F(s)$	$= \int_{0-}^{\infty} f(t)e^{-st}dt$	Definition
2.	$\mathcal{L}[kf(t)]$	$= kF(s)$	Linearity theorem
3.	$\mathcal{L}[f_1(t) + f_2(t)]$	$= F_1(s) + F_2(s)$	Linearity theorem
4.	$\mathcal{L}[e^{-at}f(t)]$	$= F(s+a)$	Frequency shift theorem
5.	$\mathcal{L}[f(t-T)]$	$= e^{-sT}F(s)$	Time shift theorem
6.	$\mathcal{L}[f(at)]$	$= \frac{1}{a}F\left(\frac{s}{a}\right)$	Scaling theorem
7.	$\mathcal{L}\left[\frac{df}{dt}\right]$	$= sF(s) - f(0-)$	Differentiation theorem
8.	$\mathcal{L}\left[\frac{d^2f}{dt^2}\right]$	$= s^2F(s) - sf(0-) - \dot{f}(0-)$	Differentiation theorem
9.	$\mathcal{L}\left[\frac{d^nf}{dt^n}\right]$	$= s^nF(s) - \sum_{k=1}^{n} s^{n-k}f^{k-1}(0-)$	Differentiation theorem
10.	$\mathcal{L}\left[\int_{0-}^{t} f(\tau)\,d\tau\right]$	$= \frac{F(s)}{s}$	Integration theorem
11.	$f(\infty)$	$= \lim_{s\to 0} sF(s)$	Final value theorem[1]
12.	$f(0+)$	$= \lim_{s\to\infty} sF(s)$	Initial value theorem[2]

TABLE 2: 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.	$t^nu(t)$	$\frac{n!}{s^{n+1}}$
5.	$e^{-at}u(t)$	$\frac{1}{s+a}$
6.	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
7.	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

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TABLE 3: Electrical Component Table

Component	Voltage-current	Current-voltage	Voltage-charge	Impedance $Z(s) = V(s)/I(s)$	Admittance $Y(s) = I(s)/V(s)$
Capacitor	$v(t) = \frac{1}{C}\int_0^t i(\tau)d\tau$	$i(t) = C\frac{dv(t)}{dt}$	$v(t) = \frac{1}{C}q(t)$	$\frac{1}{Cs}$	Cs
Resistor	$v(t) = Ri(t)$	$i(t) = \frac{1}{R}v(t)$	$v(t) = R\frac{dq(t)}{dt}$	R	$\frac{1}{R} = G$
Inductor	$v(t) = L\frac{di(t)}{dt}$	$i(t) = \frac{1}{L}\int_0^t v(\tau)d\tau$	$v(t) = L\frac{d^2q(t)}{dt^2}$	Ls	$\frac{1}{Ls}$

Note: The following set of symbols and units is used throughout this book: $v(t)$ = V (volts), $i(t)$ = A (amps), $q(t)$ = Q (coulombs), C = F (farads), R = Ω (ohms), G = $\mho$ (mhos), L = H (henries).

TABLE 4: Formula for Second Order System Paramaters

Parameters	Formula
Peak Time	$t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$
Rise Time	$t_r = \frac{\pi - \cos^{-1}\zeta}{\omega_n\sqrt{1-\zeta^2}}$
Maximum Overshoot	$M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}$
Settling Time (2% criterion)	$T_s = \frac{4}{\zeta\omega_n}$
Settling Time (5% criterion)	$T_s = \frac{3}{\zeta\omega_n}$