UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2018/2019

COURSE NAME	:	INSTRUMENTATION AND PROCESS CONTROL
COURSE CODE	:	BNL 30603
PROGRAMME CODE	:	BNL
EXAMINATION DATE	:	JUNE / JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) Explain briefly the differences between feedback and feedforward control system.

(4 marks)

(b) Interpret the response for the transfer function ($G(s)$) of the system below when the input signal is a step input.

$$G(s) = \frac{s+4}{s+8}$$

(4 marks)

(c) Determine the transfer function $Y(s)/R(s)$ of the block diagram shown in **Figure Q1(c)** using block diagram reduction method.

(7 marks)

(d) The dynamic responses of second order system depend on the ζ value. Sketch and describe **FOUR (4)** different second order responses with their respective ζ value with the input of step input function. Explain the definition of Maximum overshoot (M_p) in the transient response characteristics.

(5 marks)

Q2 (a) Demonstrate the concept of interacting and non-interacting system. Show the appropriate diagram for the systems.

(4 marks)

(b) Describe the following basic elements of electronic instrument.

(i) Transducer

(ii) Piezoelectric Sensor

(iii) Thermocouple

(6 marks)

(c) Classify the stability for linear, time-invariant systems using the natural response.

(4 marks)

(d) Determine the stability of the system whose characteristics equation is:

$a(s) = 2s^5 + 3s^4 + 2s^3 + s^2 + 2s + 2$

(6 marks)

Q3 (a) Discuss the concept of root locus.

(2 marks)

(b) Give **THREE (3)** rules of sketching the root locus

(6 marks)

(c) Plot unity locus for unity feedback closed loop system whose open loop transfer function is

$$G(s) = \frac{K}{s(s+4)(s^2+2s+2)}$$

Clearly locate all poles and zeros on a graph paper.

(12 marks)

Q4 (a) Define the concept of cascade control and override control system.

(2 marks)

(b) Identify **TWO (2)** advantages of each cascade and override control system.

(8 marks)

(c) A block diagram for a cascade loop is shown in **Figure Q4 (c).**

(i) Determine a transfer function from input Y_{sp2} to output Y_2 assuming $D_2 = 0$

(ii) Redraw the block diagram, replacing with your single block transfer function at the suitable place, but still incorporate the disturbance effect from D_2

(iii) What is the characteristic equation for the inner loop?

(iv) If the inner loop has proportional-only controller for Gc2, and Gv=3, and $G_{p2} = \frac{6}{2s+1}$, calculate a constraint (inequality) for the value of Kc so that the inner loop still has stable behaviour.

(10 marks)

Q5 (a) Describe the basic concept of the feedforward control and list **TWO (2)** disadvantages using this type of control.

(5 marks)

(b) **Figure Q5(b)** shows the translation mechanical system of a robotic control system. Force, $f(t)$ is an input; $x_1$and x_2 are the output displacements. Formulate the transfer function, $X(s)/F(s)$ of the system.

(15 marks)

–END OF QUESTIONS –

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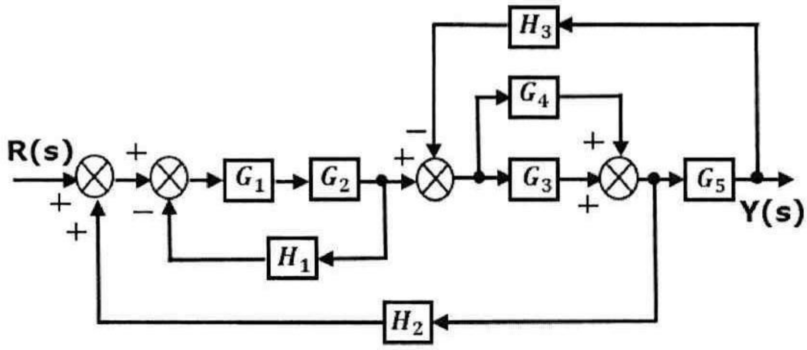

Figure Q1(c)

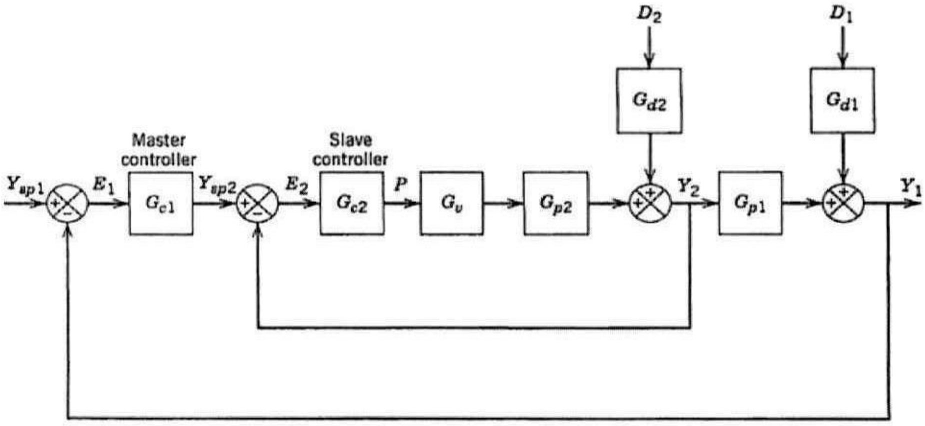

Figure Q4(c)

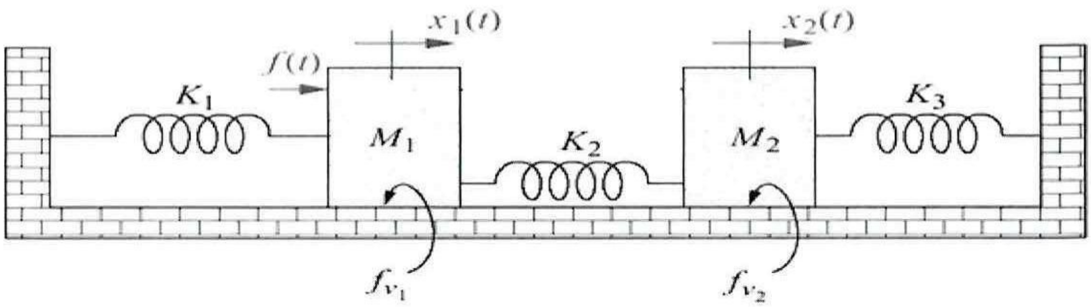

Figure Q5(b)

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FORMULA:

Laplace Transform

Original	Image
a	$\frac{a}{s}$
t	$\frac{1}{s^2}$
t^2	$\frac{2}{s^3}$
$t^n, n \in N$	$\frac{n!}{s^{n+1}}$
e^{at}	$\frac{1}{s-a}$
te^{at}	$\frac{1}{(s-a)^2}$
t^2e^{at}	$\frac{2}{(s-a)^3}$
$t^ne^{at}, n \in N$	$\frac{n!}{(s-a)^{n+1}}$

Original	Image
$\sin(\omega t)$	$\frac{\omega}{s^2+\omega^2}$
$\cos(\omega t)$	$\frac{s}{s^2+\omega^2}$
$\sinh(\omega t)$	$\frac{\omega}{s^2-\omega^2}$
$\cosh(\omega t)$	$\frac{s}{s^2-\omega^2}$
$t\sin(\omega t)$	$\frac{2s\omega}{(s^2+\omega^2)^2}$
$t\cos(\omega t)$	$\frac{s^2-\omega}{(s^2+\omega^2)^2}$
$e^{at}\sin(\omega t)$	$\frac{\omega}{(s-a)^2+\omega^2}$
$e^{at}\cos(\omega t)$	$\frac{s-a}{(s-a)^2+\omega^2}$

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Time Response

$$C(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2} \qquad \zeta = \frac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}} \qquad \%OS = 100e^{-\left(\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)}$$

$$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi}{\omega_d} \qquad T_s = \frac{4}{\zeta\omega_n} = \frac{4}{\sigma_d} \qquad T_f = \frac{1.321}{\omega_k}$$

Test waveforms

Name	**Time function**	**Laplace Transform**
Step	$u(t)$	1/s
Ramp	$tu(t)$	$1/s^2$
Parabola	$\frac{1}{s}t^2$	$1/s^3$
Impulse	$\delta(t)$	1
Sinusoid	sin ωtu(t)	$\frac{\omega}{s^2+\omega^2}$
Cosine	cos ωtu(t)	$\frac{s}{s^2+\omega^2}$

Root Locus

$$K = \frac{1}{|G(s)H(s)|} = \frac{\prod polelength}{\prod zerolength}$$

$$\sigma_c = \frac{(p_1 + p_2 + \cdots + p_n) - (z_1 + z_2 + \cdots + z_m)}{n-m}$$

$$\theta_a = \frac{(2k+1)\pi}{\#finite\_poles - \#finite\_zeroes}$$

$$\theta = \sum finite\_zero\_angles - \sum finite\_pole$$

$$KG(s)H(s) = -1 = 1\angle(2k+1)180°$$

$$e(\infty) = e_{step}(\infty) = \lim_{s\to 0}\frac{s(1/s)}{1+G(s)} = \frac{(1)}{1+\lim_{s\to 0}G(s)}$$

$$e(\infty) = e_{ramp}(\infty) = \lim_{s\to 0}\frac{s(1/s^2)}{1+G(s)} = \lim_{s\to 0}\frac{1}{s+sG(s)} = \frac{1}{\lim_{s\to 0}sG(s)}$$

$$e(\infty) = e_{parabola}(\infty) = \lim_{s\to 0}\frac{s(1/s^3)}{1+G(s)} = \lim_{s\to 0}\frac{1}{s^2+s^2G(s)} = \frac{1}{\lim_{s\to 0}s^2G(s)}$$

$K_p = \lim_{s\to 0} G(s)$
Position Constant

$K_v = \lim_{s\to 0} sG(s)$
Velocity Constant

$K_a = \lim_{s\to 0} s^2G(s)$
Acceleration Constant