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**UNIVERSITI TUN HUSSEIN ONN
MALAYSIA**

**FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023**

COURSE NAME : MODELLING AND
SIMULATION
COURSE CODE : BDC 40703
PROGRAMME : BDD
EXAMINATION DATE : JULY/AUGUST 2023
DURATION : 3 HOURS
INSTRUCTIONS : 1) ANSWER **ALL** QUESTIONS
IN PART A, AND ONE (1)
QUESTION IN PART B.
2) THIS FINAL EXAMINATION
IS CONDUCTED VIA **CLOSED
BOOK.**
3) STUDENTS ARE
PROHIBITED TO CONSULT
THEIR OWN MATERIAL OR
ANY EXTERNAL RESOURCES
DURING THE EXAMINATION
CONDUCTED VIA CLOSED
BOOK.

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

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PART A: Answer ALL Questions**Q1** (a) A system is described by the model

$$y(k) = \frac{bz^{-1}}{1 + az^{-1}} u(k) + \xi(k)$$

Where $u(k)$ and $y(k)$ are the measured input and output sequences, respectively and $\xi(k)$ is a zero mean discrete white noise. From the data sequences in **Table Q1**. Calculate the least squares estimate of the unknown parameters (a, b) .

(9 marks)

(b) Elaborate the approach of practical system identification with the help of a detailed workflow. (8 marks)

(c) Illustrate and explain the iterative procedure for design of experiments together with all the workflow feedbacks. (8 marks)

(8 marks)

Q2 (a) Distinguish the advantages and disadvantages of modelling. (6 marks)

(6 marks)

(b) A mechanical system as shown in **Figure Q2** is subjected to a known displacement $X_3(t)$ with respect to the reference $X_1(t)$. Determine all the equations of motion (4 marks)

(4 marks)

(c) Obtain the equations of motion in terms of the Laplace transform, assuming that the initial conditions are zero (4 marks)

(4 marks)

(d) Construct the signal flow graph from the equations with $X_1(s)$ as the output and $X_3(s)$ as the input of the system (11 marks)

(11 marks)

- Q3** Figure Q3 shows a Liquid-Level Systems with Interaction. The transfer function of the system is not the product of two first-order transfer functions and assume only small variations of the variables from the steady-state values. Using the symbols as defined in Figure Q3,
- (b) Derive equations that relate q to q_1 , q_1 to q_2 , q_1 to h_1 and q_2 to h_2 . (4 marks)
- (c) Convert the equations into frequency domain using Laplace transform and construct the sub block diagrams from the derived equations in Q3 (a). (4 marks)
- (d) Construct the system block diagram from the sub block diagrams obtained in Q3 (b) by assuming Q as the system input and Q_2 as the system output. (4 marks)
- (e) Obtain the system Transfer Function using Block Diagram Reduction Method (13 marks)

PART B: Answer ONE (1) Question Only.

- Q4** (a) A dynamical system can be described by the model

$$y(k) = -ay(k-1) + bu(k-1) + e(k)$$

Where $u(k)$ and $y(k)$ represent the measured input and output sequences, respectively and $e(k)$ is a noise sequence. Experimentation on the system produces the data sequences in Table Q4. Compute the ordinary least squares estimate of the unknown parameters (a, b) . (13 marks)

- (b) Derive an expression for the bias of the least squares estimates of the parameter vector β in the measurement equation $Y = \phi\beta + \underline{e}$, where \underline{e} is a vector of correlated errors. (12 marks)

Q5 (a) A system is described by the model

$$y(k) = -ay(k-1) + bu(k-1) + \xi(k)$$

Where $u(k)$ and $y(k)$ are the measured input and output sequences, respectively and $\xi(k)$ is a zero mean discrete white noise. From the data sequences in **Table Q5**. Calculate the least squares estimate of the unknown parameters (a, b) .

(13 marks)

(b) If the system in (a) above is now changed so that the model takes the form

$$y(k) = -ay(k-1) + bu(k-1) + cu^3(k-1) + \xi(k)$$

Examine how the least squares procedure could be modified to accommodate the new model will estimates of the parameters (a, b, c) be unbiased.

(12 marks)

-END OF QUESTION -

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Table Q1

k	1	2	3	4
$u(k)$	-1	1	-1	1
$y(k)$	0.44	-0.648	0.481	-0.615

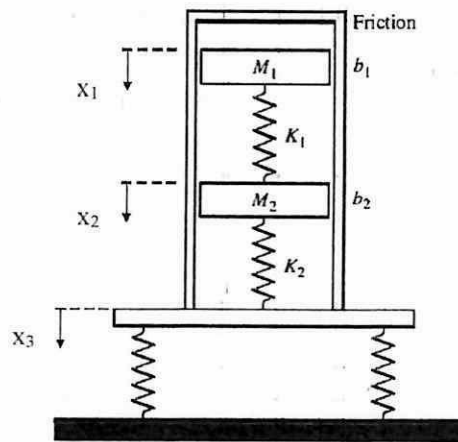


Figure Q2

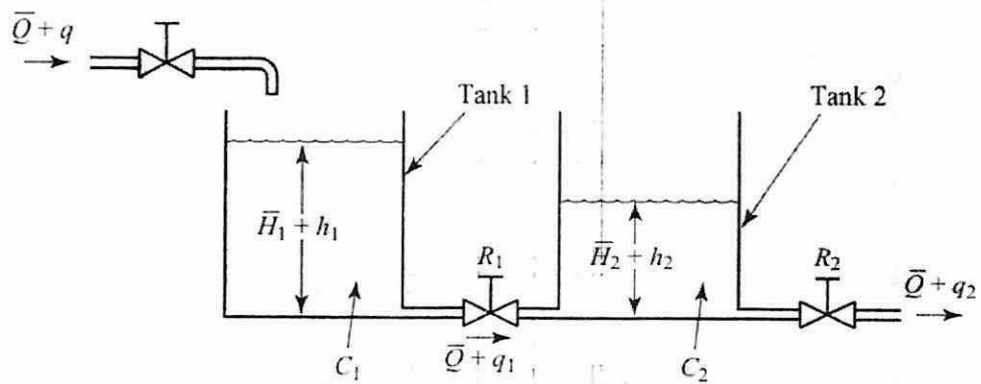


Figure Q3

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Table Q4

k	1	2	3	4
$u(k)$	1	-1	-1	1
$y(k)$	6	2	-6	-1

Table Q5

k	1	2	3	4
$u(k)$	-1	1	-1	1
$y(k)$	0.54	-0.748	0.581	-0.515

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