Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	SYSTEM MODELLING AND SIMULATION
COURSE CODE	:	MDC 10203
PROGRAMME	:	MDM
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. PART A: ANSWER **ONE** (1) QUESTION ONLY 2. PART B: ANSWER **ALL** QUESTIONS 3. THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

PART A

Q1 **(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 Q1. 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 $Y = \phi\beta + e$, where e is a vector of correlated errors.

(7 marks)

Q2 **(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 Q2, calculate the least squares estimate of the unknown parameters (a, b).

(13 marks)

(b) If the system in part (a) 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 then estimates of the parameters (a, b, c) be unbiased.

(7 marks)

PART B

Q3 (a) As the state equation in the following form

$$\dot{\vec{x}} = A\vec{x} + B\vec{u}$$
$$\vec{y} = C\vec{x} + D\vec{u}$$

adapt state equations to a transfer function, $\frac{y(s)}{u(s)}$ by using Laplace transform.

(4 marks)

(b) Evaluate the transfer function for the system described in part **Q3(a)** if state space model matrices consists of

$$A = \begin{bmatrix} 0 & 1 \\ -3 & -3 \end{bmatrix}; \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}; \quad C = [0 \quad 1]$$

(10 marks)

(c) Draw the signal flow simulation diagram represents the transfer function obtained in part Q3(b).

(6 marks)

Q4 (a) Elaborate on **SIX(6)** steps in physical modelling.

(6 marks)

(b) Figure Q4 shows a two-mass translational mechanical system. The applied force $f_a(t)$ acts on mass m_1. Displacements z_1 and z_2 are absolute positions of masses m_1 and m_2, respectively, measured relative to fixed coordinates (the static equilibrium positions with $f_a(t) = 0$). An oil film with viscous friction coefficient b separates masses m_1 and m_2.

(i) Derive all the mathematical equations to represent the system.

(ii) Without solving the above equations as in part (i), draw the block diagram for the system

(iii) Using signal flow graph, find the transfer function. ($f_a(t)$ as the input, z_2 as the output).

(14 marks)

Q5 **(a)** In simulation study, iterative schematic is involved as shown in **Figure Q5**. Elaborate the whole process when it involves simulation of a room air conditioner.

(10 marks)

(b) Discuss on the **ELEVEN (11)** basic steps with respect of simulation model development in it sequence order.

(10 marks)

Q6 Verification, validation and calibration are important integral parts in model development.

(a) Explain **TWO (2)** importance of of validation in model development

(2 marks)

(b) Elaborate with a good example the difference between verification and validation

(3 marks)

(c) List **EIGHT (8)** suggestions on how verification can be performed

(8 marks)

(d) Explain the three-steps approach for validation with a proper example

(3 marks)

(e) Distinguish between validation and calibration

(4 marks)

- END OF QUESTIONS -

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Table Q1 : The data sequences of experiment

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

Table Q2 : Input output data sequences

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

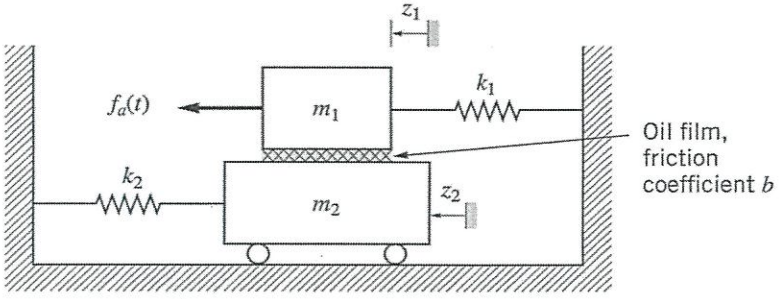

Figure Q4 : The translational mechanical system

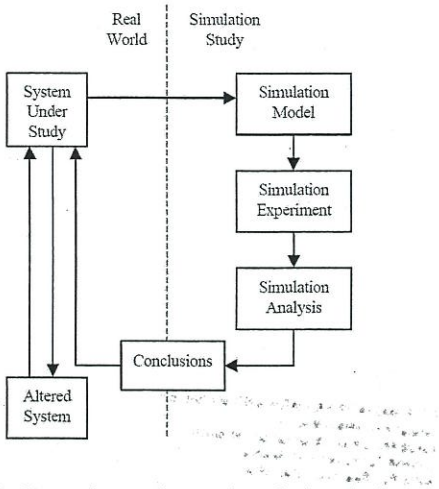

Figure Q5 : Iterative schematic of simulation study