NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY
FACULTY OF HEALTH AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

QUALIFICATION: Bachelor of Science in Applied Mathematics and Statistics	
QUALIFICATION CODE: 07BSAM	**LEVEL:** 7
COURSE CODE: MMO702S	**COURSE NAME:** MATHEMATICAL MODELLING 2
SESSION: JANUARY 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 288 (To be Converted to 100%)

SUPPLEMENTARY/2ND OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER	PROF. S. A. REJU
MODERATOR:	PROF. O. D. MAKINDE

INSTRUCTIONS
1. Attempt ALL the questions. 2. All written work must be done in blue or black ink and sketches must be done in pencil. 3. Use of COMMA is not allowed as a DECIMAL POINT.

PERMISSIBLE MATERIALS

1. Non-programmable calculator without a cover.

THIS QUESTION PAPER CONSISTS OF 3 PAGES (including this front page)

QUESTION 1 [115 MARKS]

(a) Define the Middle Square Method for generating pseudo-random numbers. Hence using a seed 622246, obtain ten pseudo-random numbers by the method. (26 Marks)

Is there cycling? (YES/NO). If so, when does it occur? (1 Mark)

(b) Consider a single server freight system model where seven trucks arrive at a warehouse to unload cargo according to the following time data (in minutes):

Trucks	Truck 1	Truck 2	Truck 3	Truck 4	Truck 5	Truck 6	Truck 7
Random Inter-Arrival Times	18	55	65	185	212	40	35
Cargo Unloading Duration	55	45	60.5	75	80	70	90

By completing the following Simulation Table for all the trucks,

Trucks	Inter-Arrivals	Arrival Time	Unload Duration	Start Service	Queue Length	Wait Time	Time at Warehouse	Idle Time	Total Time
?									
Total									
Mean									

(77 Marks)

find the following performance measures of the warehouse system (correct to 2 decimal places): (8 Marks)

(i) Average wait time
(ii) Average unload (service) time
(iii) Average time spent at the warehouse
(iv) Percentage of time the unloading warehouse facility is idle

(c) When do the 3rd and the last trucks leave the warehouse? (3 Marks)

QUESTION 2 [40 MARKS]

(a) Consider a pottery company that produces bowls and mugs and assume that that per unit profit contribution for bowls is given by $(\$4 - 0.1x_1)$ and that per unit profit contribution for mugs is given by $(\$5 - 0.2x_2)$.

(i) Formulate a nonlinear profit maximization problem subject to just a labour constraint given by $x_1 + 2x_2 = 40\ hours$ (19 Marks)

(ii) Solve the nonlinear optimisation problem in (i) using the Substitution Method (19 Marks)

(b) Consider a general 2nd degree polynomial

$$f(x) = a_3x^2 + a_2x + a_1$$

(i) State the normal equations for determining the regression coefficients a_1, a_2 and a_3 of the polynomial $f(x)$ for fitting a set of data. (6 Marks)

(ii) Consider the following data

x	1.2	1.5	2.0	2.6	3.2	4.5	5.2	5.7	6.0	6.8
y	1.1	1.3	1.6	2.0	3.4	4.1	3.2	4.5	2.5	5.2

- Obtain the normal equations for $f(x)$ defined by (a) above using the above data. (43 Marks)
- State the 3-line MATLAB commands for solving the system of three equations (without determining the values of the regression coefficients). (6 Marks)

QUESTION 3 [40 MARKS]

(a) A small-scale vocational business firm produces two farming implements: hoes and shovels and realises a net unit profit of N$125 per hoe and N$140 per shovel. Assume that the firm has up to 250 square metres of iron sheet and 200 metres of wood length to devote to a small farming project plus a signed contract of supplying 10 hoes and 15 shovels to a family farm during the period of the project. Moreover, assume that it requires 2 square metres of iron and 0.65 metre of wood to fabricate a hoe and 3 square metres of iron and 0.85 metre of wood to produce a shovel. Formulate and solve the model for maximising the firm's profits for hoes and shovels. (20 Marks)

(b) (i) Define post-optimality analysis for linear optimisation problems (5 Marks)

(ii) Discuss the analysis for change in the firm's profits on hoes, showing all expressions to support your conclusion. (15 Marks)

QUESTION 4 [40 MARKS]

(a) A spring with a mass of 2kg has natural length 0.5m and a force of 25.6N is required to maintain it stretched to a length of 0.7m and then released with initial velocity 0. Formulate an appropriate model equation and solve to obtain the expression for the position of the mass at any time t, stating all physical laws to support the fundamental equations and associated concepts of your model and its solution before using the given data. (25 Marks)

(b) Then suppose that the mass-spring system in (a) is immersed in a fluid with damping constant $c = 40$. Stating the general model differential equations for the damped system, find the position of the mass at any time t if it starts from the equilibrium position and is given a push to start it with an initial velocity of 0.6m/s. (15 Marks)

END OF EXAMINATION TOTAL MARKS:288 CONVERT TO 100%