



**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: 07BAMS	LEVEL: 7
COURSE CODE: MMO702S	COURSE NAME: MATHEMATICAL MODELLING 2
SESSION: JANUARY 2020	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

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

INSTRUCTIONS
<ol style="list-style-type: none">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.4. Marks will not be awarded for answers obtained without showing the necessary steps leading to them (the answers).

PERMISSIBLE MATERIALS

1. Non-programmable calculator without a cover.

THIS QUESTION PAPER CONSISTS OF 4 PAGES (including this front page)

QUESTION 1 [18 MARKS]

- (a) What is the usefulness of simulation in Mathematical modelling? Hence discuss Monte Carlo methods of simulation. (3 Marks)
- (b) Describe the Monte Carlo procedure for plotting the area between the quarter of a circle below

$$x^2 + y^2 = r^2$$

and the following ellipse.

$$\left[\frac{x}{a}\right]^2 + \left[\frac{y}{b}\right]^2 = 1$$

Then sketch the region of focus. (10 Marks)

- (c) Study the following MATLAB code and hence correct and edit it for plotting the region described in (a) using 42,000 random numbers when the minor and major radi of the ellipse are respectively 1 and 2, while the circle radius is 5; and computing the value of the region. (5 Marks)

```
r=5; a=2; b=1; N=100; A=0; for i=1:N
p=r*abs(rand(1,2)); x=p(1);y=p(2); q1=((x/a).^2)+((y/b).^2); q2=sqr((x.^2)+(y.^2));
if (q1>=1.00 & q2<=r)
A=A+1; plot(x,y,'*'); hold on;
```

QUESTION 2 [32 MARKS]

- (a) Consider a small-scale engineering firm that produces two farming implements: hoes and shovels and realizes 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 farming project plus a signed contract of supplying 10 hoes and 15 shovels to a family farm during the period of the project. Moreover, it requires 2 square metres of iron and 0.65 metre of wood to fabricate 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. (8 Marks)
- (b) Define post-optimality analysis for linear optimisation problems and hence discuss the analysis for change in the firm's profits on hoes, showing all expressions to support your conclusion. (10 Marks)
- (c) Consider the following production profit maximisation model:

$$\left. \begin{array}{l} \text{Maximise } f(x_1, x_2) = 25x_1 + 30x_2 \\ \text{subject to} \\ 20x_1 + 30x_2 \leq 690 \\ 5x_1 + 4x_2 \leq 120 \\ x_1 \geq 4 \\ x_1 \geq 2 \end{array} \right\} \quad (2.1)$$

Discuss the sensitivity analysis for increasing the resource in the second constraint equation of the above production model (2.1) from 120 to 150, showing all expressions to support your conclusion. (14 Marks)

QUESTION 3 [27 MARKS]

- (a) Discuss the basic characteristics of Queuing system and state three basic performance measures of the system. (4 Marks)
- (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 constructing an appropriate simulation table, obtain the following performance measures of the warehouse unloading service system (correct to 2 decimal places): (17 Marks)

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

Then

- (v) When do the 3rd and the last trucks leave the warehouse?

QUESTION 4 [23 MARKS]

- (a) Consider a general 2nd degree polynomial

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

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)

- (b) 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

- (i) Obtain the normal equations for $f(x)$ defined by (a) above using the above data. (11 Marks)
 - (ii) State the 3-line MATLAB commands for solving the system of three equations (without determining the values of the regression coefficients). (4 Marks)
- (c) Using the MATLAB built-in functions that obtain the regression coefficients of a best

polynomial approximation of a data pair (x, y) and the predicted values of y at given x values, respectively, state the MATLAB expressions for the regression coefficients for $f(x)$ in (a) and the predicted values of y at given x values. (2 Marks)

END OF QUESTION PAPER

TOTAL MARKS = 100