



**NAMIBIA UNIVERSITY  
OF SCIENCE AND TECHNOLOGY**

**FACULTY OF HEALTH AND APPLIED SCIENCES**

**DEPARTMENT OF MATHEMATICS AND STATISTICS**

<b>QUALIFICATION:</b> Bachelor of Science in Applied Mathematics and Statistics	
<b>QUALIFICATION CODE:</b> 35BAM	<b>LEVEL:</b> 7
<b>COURSE CODE:</b> MMO701S	<b>COURSE NAME:</b> MATHEMATICAL MODELLING 1
<b>SESSION:</b> JULY 2019	<b>PAPER:</b> THEORY
<b>DURATION:</b> 3 HOURS	<b>MARKS:</b> 100

<b>SUPPLEMENTARY/SECOND OPPORTUNITY EXAMINATION QUESTION PAPER</b>	
<b>EXAMINERS</b>	PROF. S. A. REJU
<b>MODERATOR:</b>	PROF. O. D. MAKINDE

<b>INSTRUCTIONS</b>	
1. Attempt ALL the questions.	
2. All written work must be done in blue or black ink and sketches must be done in pencils.	
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 [26 MARKS]**

- (a) Discuss mathematical modelling and its process. [5]
- (a) Consider an annuity where a savings account pays a monthly interest of 1% on the amount present and the investor is allowed to withdraw a fixed amount of N\$1000 monthly until the account is depleted. What is the solution of the dynamical system model for the annuity problem and how much of the initial investment will be needed to deplete the annuity in 20 years? [21]

**QUESTION 2 [20 MARKS]**

- (a) Discuss the method of Conjecture in Mathematical modelling. [2.5]
- (b) Employing the Conjecture method, show that the solution of the dynamical system

$$a_{n+1} = ra_n + b, \quad r \neq 1 \quad (2.1)$$

Is given by

$$a_k = r^k c + \frac{b}{1-r} \quad (2.2)$$

for some  $c$  (which depends on the initial condition). [3.5]

- (c) Given the following experimental data from a spring-mass system:

Mass	50	100	150	200	250
Elongation	1.200	1.650	2.000	3.150	4.200

Formulate two different models that estimate the proportionality of the elongation to the mass, clearly showing how your proportionality constant is obtained for each model. [14]

**QUESTION 3 [24 MARKS]**

- (a) Consider a drug that is effective in treating a disease if the concentration remains above 100 mg/L. The initial concentration is 440 mg/L. Laboratory experiments show that the drug decays at the rate of 18% of the amount present each hour.
- (i) Formulate a model representing the concentration at each hour.
- (ii) Build a table of values and determine when the concentration reaches 100 mg/L.

[7.5]

- (b) Consider the following table showing the experimental data of the growth of a micro organism

$n$	0	1	2	3	4	5	6
$y_n$	8.2	15.3	29.2	45.5	71.1	120.1	174.6
$\Delta y_n$	8.7	11.7	16.3	23.9	52	55.5	85.6

where  $n$  is the time in days and  $y_n$  is the observed organism biomass.

- (i) Formulate a linear model for the above organism and show that the model predicts an increasing population without limit.
- (ii) Assume that contrary to your model prediction in (i), there is a maximum population of 665. Hence formulate a nonlinear dynamical system model for the organism using your constant obtained from an appropriate ratio similar to the example given in class, for  $n = 3$  in the above data. **[16.5]**

**QUESTION 4 [30 MARKS]**

- (a) Consider the motion of a raindrop from a motionless cloud, subject to force  $F_d$  due to the air resistance and the gravitational force  $F_g$ . Employing appropriate geometric similarity relationships, state at least four essential assumptions and any physical law to determine the relationship between the terminal velocity of the raindrop and its mass. **[10]**
- (b) Consider the following table of data:

X	1	2.3	3.5	4.5	6.5	7.0
y	3.5	3.2	5.5	6.2	4.5	7.5

- (i) Estimate the coefficients of the straight line  $y = ax + b$  such that the sum of the squared deviations of the data points and the line is minimised. **[7]**
- (ii) If the largest absolute deviations for the Chebyshev's criterion and that of the Least Squares criterion are given respectively by  $c_{max}$  and  $d_{max}$ , define them and then compute their values including their least bound D to express their relationship for the above data and the model line. **[13]**

END OF QUESTION PAPER

TOTAL MARKS = 100