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: 35BAM	**LEVEL:** 7
COURSE CODE: MMO702S	**COURSE NAME:** MATHEMATICAL MODELLING 2
SESSION: NOVEMBER 2019	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINERS	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 pencils.
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 3 PAGES (including this front page)

QUESTION 1 [30 MARKS]

(a) Discuss Post-optimality analysis in linear optimisation modelling and the basic question it answers. (3 Marks)

(b) Consider a furniture maker that realises a net unit profit of $25 per desk and $30 per locker. Assume that he has up to 690 metres of wood to devote weekly to the project and up to 120 hours of labour. He estimates that it requires 20 metres of wood and 5 hours of labour to complete a desk and 30 metres of wood and 4 hours of labour for a locker. Moreover, he has signed contracts to deliver four desks and two lockers every week. Formulate and solve the model maximizing his profits for desks and lockers. (7 Marks)

(c) Define post-optimality analysis for the problem defined in (b) and hence discuss the analyses for changes in his profits on both lockers and desks stating your observations for the two furniture items and providing a summary for your two analyses. (10.5 Marks)

(d) State the mathematical definition of RELIABILITY and its expression. Specifically describe Serial and Parallel systems and their reliability equations. Hence for a system whose component reliabilities are 0.94 and 0.97, determine the system reliability when the components are assembled serially and in parallel, stating your observations for the two assemblies. (9.5 Marks)

QUESTION 2 [27 MARKS]

(a) Discuss the basic characteristics of Queuing system and state three basic performance measures of the system. (10 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

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

QUESTION 3 [20 MARKS]

(a) Discuss Markov Chain and its associated concepts, providing specifically a general 2-state Markov process representation. (7 Marks)

(b) Consider a model for the value of a stock. At the end of a given day, the price is recorded. If the stock has gone up, the probability that it will go up tomorrow is 0.7. If the stock has gone down, the probability that it will go up tomorrow is only 0.5. Construct an appropriate transition matrix for the 2-state Markov process model for the fluctuating stock problem and using appropriate percentage variables and their definitions, formulate the model equations to determine the long-term percentage increase and decrease for the stock problem. (13 Marks)

QUESTION 4 [23 MARKS]

(a) A spring with a mass of 2kg has natural length 0.5m. A force of 25.6N is required to maintain it stretched to a length of 0.7m and then released with initial velocity 0, find 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. (14.5 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. (8.5 Marks)

END OF QUESTION PAPER

TOTAL MARKS = 100