



**NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY**

FACULTY OF ENGINEERING AND SPATIAL SCIENCE

DEPARTMENT OF Mining and Process Engineering

QUALIFICATION : Bachelors of Engineering in Mining Engineering	
QUALIFICATION CODE: BEMIN	LEVEL: 8
COURSE CODE: OPC 711S	COURSE NAME: OPERATIONS RESEARCH
SESSION: JUNE 2022	PAPER: THEORY
DURATION: 3 HOURS	MARKS: 100

FIRST OPPORTUNITY QUESTION PAPER	
EXAMINER(S)	Lawrence Madziwa
MODERATOR:	Dr Mallikarjun Rao Pillalamarry

INSTRUCTIONS
<ol style="list-style-type: none">1. Answer all questions.2. Read all the questions carefully before answering.3. Marks for each questions are indicated at the end of each question.4. Please ensure that your writing is legible, neat and presentable.

PERMISSIBLE MATERIALS

1. Examination paper.

THIS QUESTION PAPER CONSISTS OF 5 PAGES (Including this front page)

1. All loaded mine trucks traveling from the mine pit to the plant are required to stop at a weigh and scan station. Trucks arrive at the station at a rate of 200 per 8-hour shift, and the station can weigh, on the average, 220 trucks per shift.
 - a. Determine the following
 - I. the average number of trucks waiting [3]
 - II. the average time spent waiting and being weighed at the station by each truck, and [5]
 - III. the average waiting time before being weighed for each truck. [5]
 - b. Truck drivers find out they are queueing at the station longer than 15 minutes as planned, on average, they will start driving slower thus reducing mine productivity. The mine estimates that it loses \$10,000 in downtime per year for each extra minute the trucks must wait at the station. A new set of scales would have the same service capacity as the present set of scales, and it is assumed that arriving trucks would line up equally behind the two sets of scales. It would cost \$50,000 per year to operate the new scales. Should the mine install the new set of scales? [8]

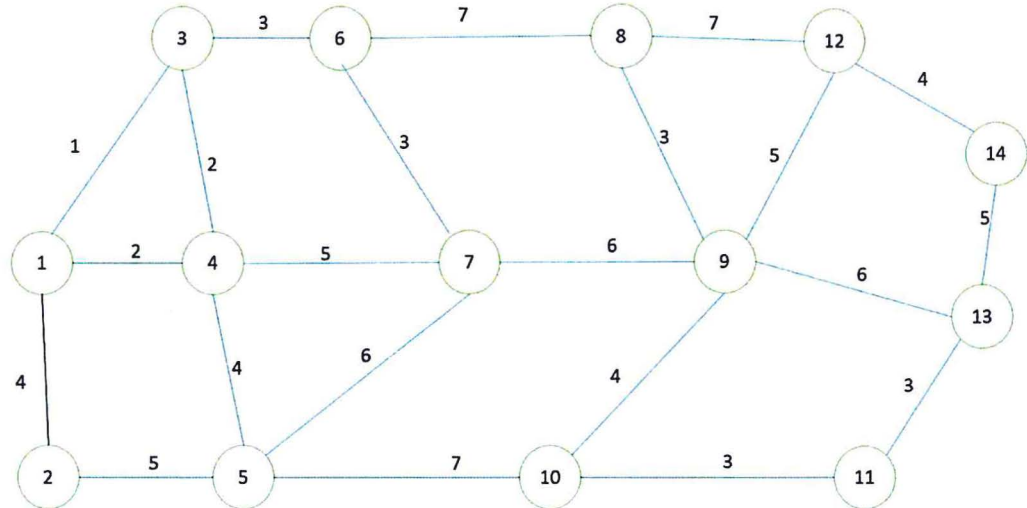
2. You are responsible for transporting five items on a limited space of 13 tons from Windhoek to Swakopmund. There are five different items that your company can transport between Windhoek and Swakopmund. Each item has a weight in tons, a net profit in thousands of dollars, and an unlimited number of items that are available for shipping as shown in Table below. Use dynamic programming to determine how many of each item should be shipped to maximize profits. [20]

Item	Weight	Profit / Unit (\$)	Number Available
1	7	9	unlimited
2	5	4	unlimited
3	4	3	unlimited
4	3	2	unlimited
5	1	1/2	unlimited

3. A new Uranium mine, in Namibia has decided, as a matter of urgency, to build a new road as an upgrade to the existing one to facilitate efficient transportation of materials. The road works has been divided into five stages which are built simultaneously. Within Namibia, there are six large companies to undertake the construction of any of the five stage and each company has been invited to submit a tender for each stage of the project. The tenders (in millions of Namibian dollars) are as follows:

Company	Stage				
	1	2	3	4	5
A	49	84	63	82	68
B	53	92	62	No bid	67
C	54	86	67	78	68
D	46	86	62	76	No bid
E	57	94	66	83	70
F	50	82	65	80	72

- a. Assuming that none of the companies is large enough to undertake the work of more than one stage, advise the mine how the five contracts should be allocated. What is the minimum total cost for the project? [10]
- b. The mine is installing power lines to different areas on the mine. The mine wants to minimize the total length of the power line. The network of all positions requiring electricity is shown below with the associated distances between all points. Recommend how to best connect all the positions in the network. [10]



- c. Discuss three network models that can be used to resolve some of the mining challenges and give examples of how you can apply them in mining. [6]
4. Show that the average inventory of an inventory model with backorder is:
Average inventory = $(Q-S)2/2Q$ [10]

b. Patterson Electronics supplies your mine with micro processors for your processing plant. Currently, Patterson orders components from various suppliers. One of the components is ordered in batches of 150 units. It has been estimated that annual demand for these components is 250. Furthermore, carrying cost is estimated to be \$1 per unit per year. For the order policy to be optimal, determine what the ordering cost would have to be. [5]

c. Flemming Accessories produces paper slicers used in offices and art stores. The mini slicer has been one of the most popular items: Annual demand is 6750 units. The company produces the mini slicers in batches. On average the company can manufacture 125 units per day. Demand for these slicers during the production process is 30 per day. The set up cost for the equipment necessary to produce the mini slicers is \$150. Carrying costs are \$1 per mini slicer per year. How many mini slicers should the company manufacture in each batch? [4]

5. The following details pertain to a job, and indirect cost for the project is N\$ 1100 per day. Scheduled the project to optimal cost.

Job	Predecessor	Normal		Crash	
		Time in hrs	Cost in N\$	Time in hrs	Cost in N\$
A	-	3	1400	2	2100
B	C	6	2150	5	2750
C	-	2	1600	1	2400
D	A, B	4	1300	3	1800
E	C	2	1700	1	2500
F	D	7	1650	4	2850
G	E, F	4	2100	3	2900
H	D	3	1100	2	1800

- Draw the network diagram and determine the project completion time? [7]
- What is the total cost of the project? [1]
- Given that the project has been given a deadline by management, to what extent can the project be crashed and what is the corresponding cost? [7]

End of Exam

Queuing Model, Single Server Formulas

$$P_0 = \text{Prob} \left[\begin{array}{l} \text{system is} \\ \text{empty (idle)} \end{array} \right] = 1 - \frac{\lambda}{\mu}$$

$$L_q = \begin{array}{l} \text{average number} \\ \text{in the queue} \end{array} = \frac{\lambda^2}{\mu(\mu - \lambda)}$$

$$L = \begin{array}{l} \text{average number} \\ \text{in the system} \end{array} = \frac{\lambda}{\mu - \lambda}$$

$$W_q = \begin{array}{l} \text{average time} \\ \text{in the queue} \end{array} = \frac{\lambda}{\mu(\mu - \lambda)}$$

$$W = \begin{array}{l} \text{average time} \\ \text{in the system} \end{array} = \frac{1}{\mu - \lambda}$$

Note:

λ is the arrival rate.

μ is the service rate.