NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

DEPARTMENT OF Civil, Mining and Process Engineering

QUALIFICATION : Bachelors of Engineering in Mining Engineering	
QUALIFICATION CODE: 08BMEG	**LEVEL:** 7
COURSE CODE: ORC711S	**COURSE NAME:** OPERATIONS RESEARCH
SESSION: JUNE 2023	**PAPER:** THEORY
DURATION: 3 HOURS	**MARKS:** 100

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

INSTRUCTIONS

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. A mine crusher serves haul trucks. It has a single access lane and one truck controller to guide the trucks. It takes 12 minutes to navigate the lane, tip and clear the lane. Trucks arrive at the crusher at the rate of 4 per hour. [14]

   a. Determine the average number of trucks that will stack up waiting to dump the ore.[2]

   b. Find the average time a truck must wait in line before it can dump the ore. [4]

   c. Calculate the average time it takes a truck to clear the lane once it has notified the crusher that it is in the vicinity and want to dump the ore. [4]

   d. The crusher site has a rule that a truck controller can on the average tip a maximum of 45 minutes out of every hour. There must be 15 minutes of idle time available to relieve the tension. Will this crusher site have to hire an extra air truck controller? [4]

2. You are responsible for transporting three items on a limited space of 4 tons from Windhoek to Swakopmund. There are three 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]

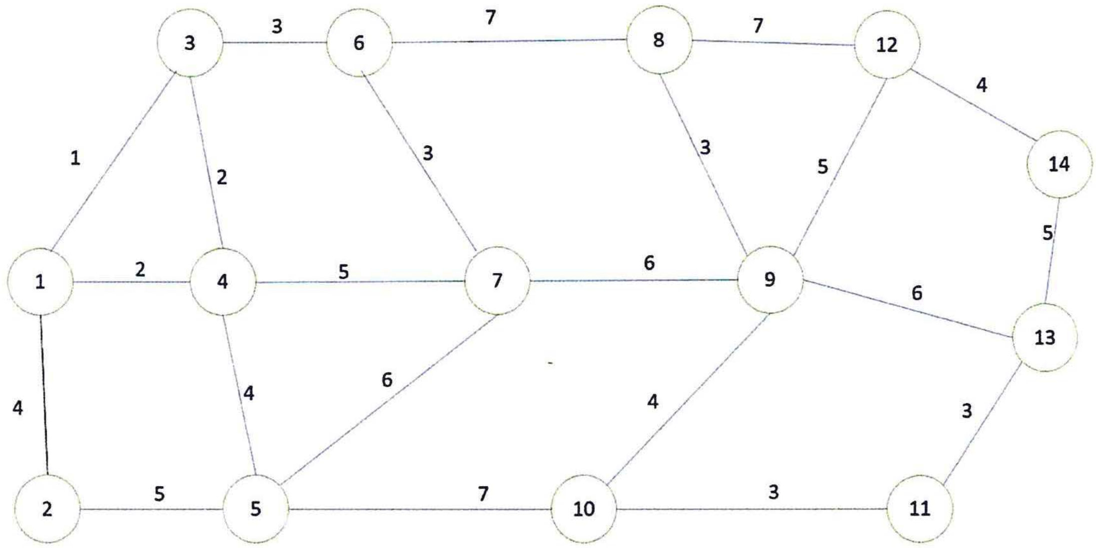
Item	**Weight**	**Profit / Unit ($)**	**Number Available**
1	2	31	unlimited
2	3	47	unlimited
3	1	14	unlimited

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. Neon lights on the processing plant are replaced at the rate of 100units per day. The physical plant orders the neon lights periodically. It costs $100 to initiate a purchase order. A neon light kept in storage is estimated to cost about $0.02 per day. The lead time between placing and receiving an order is 12 days. Determine the following optimal order level for this situation, at what point is the order placed and the associated costs. [10]

5. A project which is about to start comprises the following activities:

Table 1: Activities description and predecessors

Activity	Immediate preceding activities	Duration
A	-	4
B	A	13
C	A	5
D	C	11
E	C	3
F	D, E	4
G	_-	3
H	A, G	5
I	G	4
J	H	17
K	H	2
L	J, K	3
M	F, L	3
N	B, M	3
O	I, M	2
P	O	3
Q	N, P	4

Ignoring holiday periods, the project must be completed by the end of week 38. If the project is delayed beyond this date it is estimated that it will cost the firm $5,000 a week.

a. Draw a critical part network to present the project and determine the critical path. What is the earliest time at which the project can be completed and what penalty cost (if any) will be incurred? [10]

b. Activity K is a two week course to train new salesmen. The hotel which will be used for the course has been booked for weeks 12 and 13. In light of your analysis should this booking be changed? [2]

c. If activities L and E can be done in parallel, some savings can be made as they use common resources. What are the minimum savings that must be made to justify these activities being done at the same time? [4]

d. Briefly outline how the critical path method can be adapted to deal with projects where the activity durations involve uncertainty. [4]

(End of Exam)

QUEUING PERFORMANCE (m/m/s)

Average server utilization	p	$p = \frac{\lambda}{s\mu}$
Average number of customers in queue	L_q	$L_q = \frac{(\lambda/\mu)^s \lambda\mu}{(s-1)!\,(s\mu - \lambda)}$
Avg. number of customers in system	L	$L = L_q + \frac{\lambda}{\mu}$
Avg. time cust. spends waiting in queue	W_q	$W_q = \frac{L_q}{\lambda}$
Avg. time customer spends in system	W	$W = W_q + \frac{1}{\mu}$
Probability of zero customers	P_0	$P_0 = \frac{1}{[\sum_{k=0}^{s-1} \frac{1}{k!}\left(\frac{\lambda}{\mu}\right)^k] + \frac{1}{s!}\left(\frac{\lambda}{\mu}\right)^s \frac{s\mu}{(s\mu - \lambda)}}$
Prob. there are n customers in system	P_n	$P_n = \frac{(\lambda/\mu)^n}{n!} P_0 \; for \; n \le s$ $P_n = \frac{(\lambda/\mu)^n}{s!\, s^{(n-s)}} P_0 \; for \; n > s$

QUEUING PERFORMANCE (m/m/1)

Average server utilization	p	$p = \frac{\lambda}{\mu}$
Average number of customers in queue	L_q	$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)}$
Avg. number of customers in system	L	$L = L_q + \frac{\lambda}{\mu}$
Avg. time cust. spends waiting in queue	W_q	$W_q = \frac{L_q}{\mu} = \frac{\lambda}{\mu(\mu - \lambda)}$
Avg. time customer spends in system	W	$W = W_q + \frac{1}{\mu}$
Probability of zero customers	P_0	$P_0 = 1 - \frac{\lambda}{\mu}$
Prob. there are n customers in system	P_n	$P_n = \left(\frac{\lambda}{\mu}\right)^n P_0$