



# MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

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## University Examinations 2023/2024

SECOND YEAR, FIRST SEMESTER EXAMINATION THE DEGREE OF BACHELOR OF  
SCIENCE IN ACTUARIAL SCIENCE

### SMS 3255: OPERATIONS RESEARCH

DATE: DECEMBER 2023

TIME: 2 HOURS

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**INSTRUCTIONS:** Answer question one and any other two questions

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#### QUESTION ONE (30 MARKS)

- a) A railway Company specializing in coal handing had empty cars at the following towns in quantities indicated

Town	Supply of Cars
M	35
Y	60
P	25

The following towns need coal cars and the mileage table is as follows:

From	To			
From	CV	CT	CJ	CS
M	50	30	60	70
Y	20	80	10	90
P	100	40	80	30
Demand for cars	30	45	25	20

You are required to minimize total miles over which cars are moved to new locations. Use North West corner rule to determine the initial feasible solution (6 marks)

- b) The Kenya Defense Forces wishes to assign ships to patrol four sections in a bandit prone area. The commander rates each ship in terms of its profitable efficiency in each section. These are the relative efficiencies

	SECTIONS			
SHIP	A	B	C	D
1	20	60	50	55
2	60	30	80	75
3	80	100	90	80
4	65	80	75	70

Based on the ratings above, the commander wants to determine the patrol assignments producing the greatest overall efficiencies. Assist him assign (6 marks)

- c) A mechanic at a muffler shop is able to install new mufflers at an average of 1 car every 20 minutes, according to a negative exponential distribution. Customers seeking this service, arrive at the shop on the average of 2 per hour, following a poisson distribution. They serve on first-in first out basis and come from a large population of possible buyers.

Determine:

- i) Average time a customer spends on the queue (4 marks)
- ii) Probability that more than 3 customers are in the system (2 marks)
- d) A project has the activities show in the following dependency table

Activity	Depends on	Activity	Depends on
A	-	G	B
B	-	H	G
C	A	I	E,F
D	A	J	H,I
E	C	K	E,F
F	B,D	L	K

- I) Draw a network diagram for the project (4 marks)
- II) Determine Critical Activities and project duration (2 marks)
- e) Use simplex method to find the maximum value of: (6 marks)

$$z = x_1 - x_2 - 2x_3$$

Subject to;

$$\begin{aligned} 2x_1 + x_2 &< 10 \\ x_1 + 2x_2 - 2x_3 &< 20 \\ x_2 + 2x_3 &< 5 \end{aligned}$$

Where  $x_1 > 0, x_2 > 0, x_3 > 0$

**QUESTION TWO (20 MARKS)**

a) A communication Company intends to build a satellite receiving station for rural areas in Kenya. The table below shows the activities involved, expected duration and dependencies

Activity	Description	Duration	Depends on
A	Design of Equipment	10	-
B	Design building	5	A
C	Order parts for Equipment	3	A
D	Order materials for building	2	B
E	wait for equipment parts	15	C
F	Wait for building materials	10	D
G	Employ equipment Assemblers	5	A
H	Employ building Workers	4	B
I	Install Equipment	20	E,G,J
J	Complete building	30	F,H

Required:

- i) Draw a network diagram for the project (5 marks)
- ii) Find the project duration (2 marks)
- iii) Calculate project timings (3 marks)
- iv) Calculate total Float (2 marks)

b) The table below shows the dependencies and estimated duration of its activities

Activity	Depends on	Duration		
		O	M	P
A	-	2	3	10
B	-	4	5	12
C	-	8	10	12
D	A,G	4	4	4
E	B	3	6	15
F	B	2	5	8
G	B	6	6	6
H	C,F	5	7	15
I	D,E	6	8	10

Required:

- i) Determine the expected duration (3 marks)
- ii) Determine critical Activities (2 marks)
- iii) Find the probability that the project is not finished before day 26 (3 marks)

**QUESTION THREE (20 MARKS)**

- a) Use Simplex method to find the Maximum value of (16 marks)

$$Z = 4x_1 + 6x_2$$

Subject to the following Constraints

$$-x_1 + x_2 < 11$$

$$x_1 + x_2 < 27$$

$$2x_1 + 5x_2 < 90$$

$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$$

- b) A fruit farmer has 150 acres of land available to raise crops A and B. It takes one day to trim an acre of Crop A and two days to trim an acre of Crop B and there are 240 days per year for trimming. It takes 0.3 days to pick an acre of Crop A and 0.1 days to pick an acre of Crop B and there are 30 days per year available for picking. The profits for Crop A are Ksh. 140,000 and Ksh. 235,000 per acre for Crop A and Crop B respectively.

Develop an LPP for the problem above and solve by analytical methods (4 marks)

**QUESTION FOUR (20 MARKS)**

- a) A construction company has four bulldozers located at four different garages. The bulldozers are to be moved to four different construction sites. The distances in Kilometers between the bulldozer and the construction sites are given below

	SITE			
Bulldozer	A	B	C	D
1	90	75	75	80
2	35	85	55	65
3	125	95	90	105
4	45	110	95	115

Determine how the Bulldozer would be moved to the construction sites in order to minimize the total distance moved. (10 Marks)

- b) There is a single photocopy machine in the Students Centre. Students arrive in the Centre for photocopy services at the rate of 40 students per hour, according to Poisson distribution. Copying takes an average of 40 seconds, according to an exponential distribution  
Determine:

- i) Percentage of time the machine is utilized (2 marks)
- ii) Average number of students in the queue (2 marks)
- iii) Average number of students in the system (2 marks)
- iv) Average time spent waiting in the queue (2 marks)
- v) The average time spent in the system (2 marks)

**QUESTION FIVE (20 MARKS)**

A construction Company has plants in three locations and is currently working on three major construction projects each located in a different site. The transportation cost per truck load (in ‘0000’) of concrete, daily plant capacity and daily project requirement are provided in the table below:

	TO			
From	Mombasa	Nakuru	Meru	Capacity
Nairobi	5	4	3	100
Thika	8	4	3	300
Narok	9	7	5	300
Requirement	300	200	200	700

Required:

- i) Use VAM to determine the basic feasible transportation solution to the problem (6 marks)
- ii) Apply Modified distribution to find the optimal solution for the problem (14 marks)