UNIVERSITY EXAMINATIONS

2022/2023 ACADEMIC YEAR

THIRD YEAR SECOND SEMESTER

MAIN EXAMINATION

FOR THE DEGREE OF BACHELOR OF SCIENCE

COURSE CODE: **MAA 322**

COURSE TITLE: OPERATION RESEARCH II

DATE: 17/04/2023 **TIME:** 9:00 AM - 11:00 AM

INSTRUCTIONS TO CANDIDATES

Answer Question One and Any other TWO Questions

TIME: 2 Hours

This Paper Consists of 6 Printed Pages. Please Turn Over.

QUESTION 1: [30 Marks]

a) Explain the following terms as used in critical path analysis

i. Length of critical path [1mk]

ii. Critical path [1mk]

iii. Independent float [1mk]

iv. Float of an activity and event [1mk]

v. Free float [1mk]

b) Determine an initial basic feasible solution using Vogel's approximation method to the transportation problem shown in the table below

		DESTINATION				
		D_1	D_2	D_3	D_4	SUPPLY
SOURCE	S_1	29	40	60	20	7
	S_2	80	40	50	70	9
	S_3	50	18	80	30	18
DEMAND		5	8	7	14	34

[5mks]

c) An organization is planning to diversify its business with a maximum outlay of Ksh 5 million. It has identified three different locations to install plants. The organization can invest in one or more of these plants subject to the availability of the fund. The different possible alternatives and their investments (in millions of shillings) and present worth of returns during the useful life (in millions of shillings) of each of these plants are summarized in the table below. The first row has zero cost and zero returns for all the plants known as do-nothing alternative.

Proposal	Plant 1		Plant 2		Plant 3	
	C_1	R_1	C_2	R_2	C_3	R_3
1	0	0	0	0	0	0
2	1	4	2	15	1	16
3	2	8	3	19	2	19
4	-	-	4	22	4	29

Find the optimal allocation of the capital to different plants using the forward recursive dynamic programming model which will maximize the corresponding sum of the present worth of return [10mks]

d) An electronic device consists of four components each of which must function for the system to function. The system reliability can be improved by installing parallel units in one or more components.

The reliability of components, R with one, two, or three parallel units, and the corresponding cost, C are given below. The maximum amount available for this device is 100.

Number of parallel units	Components							
	1		2		3		4	
	R	C	R	C	R	C	R	C
1	0.70	10	0.50	20	0.70	10	0.60	20
2	0.80	20	0.70	40	0.90	30	0.70	30
3	0.90	30	0.80	50	0.95	40	0.90	40

Using forward recursive equation, determine the number of parallel units in each components to maximize the overall system reliability **[10mks]**

QUESTION 2: [20marks]

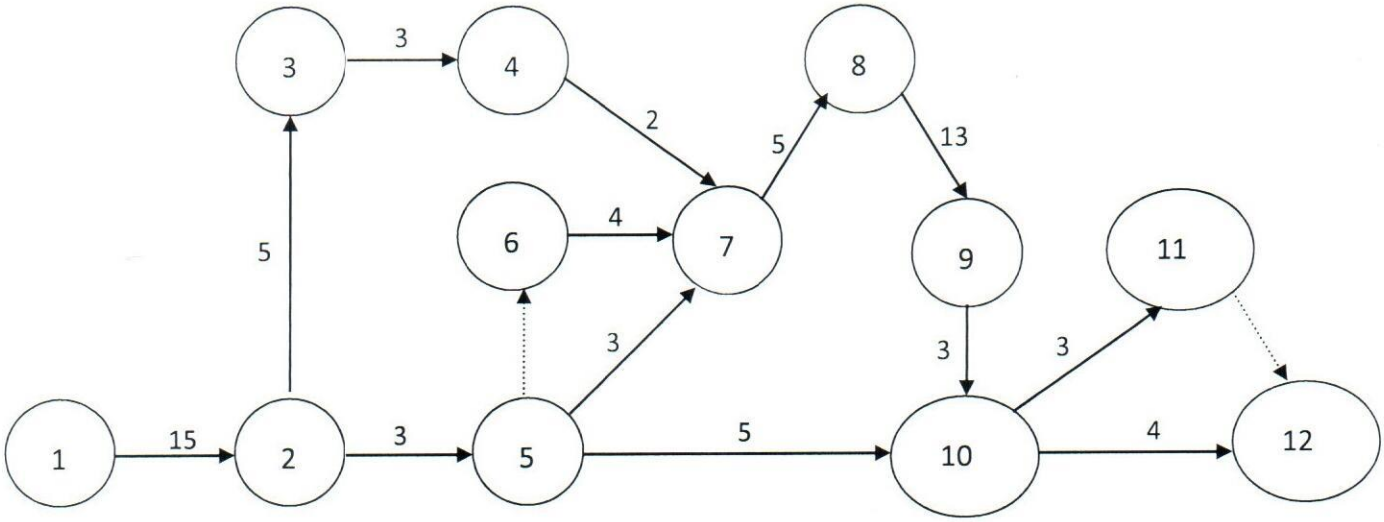
a) Explain briefly the following as used in the transportation problem

i. Least cost method **[1mk]**

ii. Vogel's approximation method **[1mk]**

iii. North –west corner method **[1mk]**

b) Determine the critical path in the following network that starts at node 1 and terminates at node 12. Obtain its length and hence for each non-critical activity find the total and free float values.



[8mks]

c) A firm has five workers who have to be allocated to three departments. The return (or profit) from each department depends upon the number of workers working in that department. The expected return for different number of workers in different zones, as estimated from the past records are given below;

Number of workers	Department		
	1	2	3
0	35	19	24
1	48	34	34
2	59	49	41
3	71	59	53
4	82	68	61
5	90	79	71

Using backward recursive equation, determine the optimal allocation policy. **[9mks]**

QUESTION 3: [20marks]

a) Determine an initial basic feasible solution to the following transportation problem by using

		Distribution center				Supply
		D_1	D_2	D_3	D_4	
Plant	P_1	16	17	25	21	10
	P_2	15	14	20	15	5
	P_3	19	22	29	23	14
Demand		10	8	6	5	

i. North –west corner rule **[3mks]**

ii. least cost method **[3mks]**

iii. Vogel's approximation method **[4mks]**

If the objective is to minimize the total transportation

b) A company has five salesmen, who have to be allocated to three marketing zones. The return (or profit) from each zone depends upon the number of salesmen, working in that zone. The expected return for different number of salesmen in different zone, as estimated from the past records are given below

Number of salesmen	**Marketing zone**		
	1	**2**	**3**
0	30	25	40
1	40	40	53
2	47	55	65
3	59	65	77
4	67	74	88
5	77	85	96

Using forward induction, determine the optimal allocation policy **[10mks]**

QUESTION 4: [20marks]

a) Determine an initial feasible solution to the following transportation problem by using the North-west method.

SOURCE	Destination				
		D_1	D_2	D_3	D_4	SUPPLY
	S_1	16	17	16	19	30
	S_2	18	18	17	16	50
	S_3	19	17	20	24	20
	Demand	20	40	30	10	

[4mks]

b) An established company had decided to add a new product to its line. It will buy the product from a manufacturing concern, package it, and sell it to a number of distributors selected on a geographical basis. Market research has indicated the volume expected and the size of sales force required. The steps shown in the following table are to be planned

Activity	Description	Duration (days)	Predecessors
A	Organize sales office	8	-
B	Hire salesmen	6	A
C	Train salesmen	9	B
D	Select advertising agency	4	A
E	Plan advertising campaign	6	D
F	Conduct advertising campaign	12	E
G	Design package	4	-
H	Set-up packaging facilities	12	G
I	Package initial stocks	8	J,H
J	Order stock from manufacturer	15	-
K	Select distributors	11	A
L	Sell to distributors	5	C,K
M	Ship stock to distributors	7	I,L

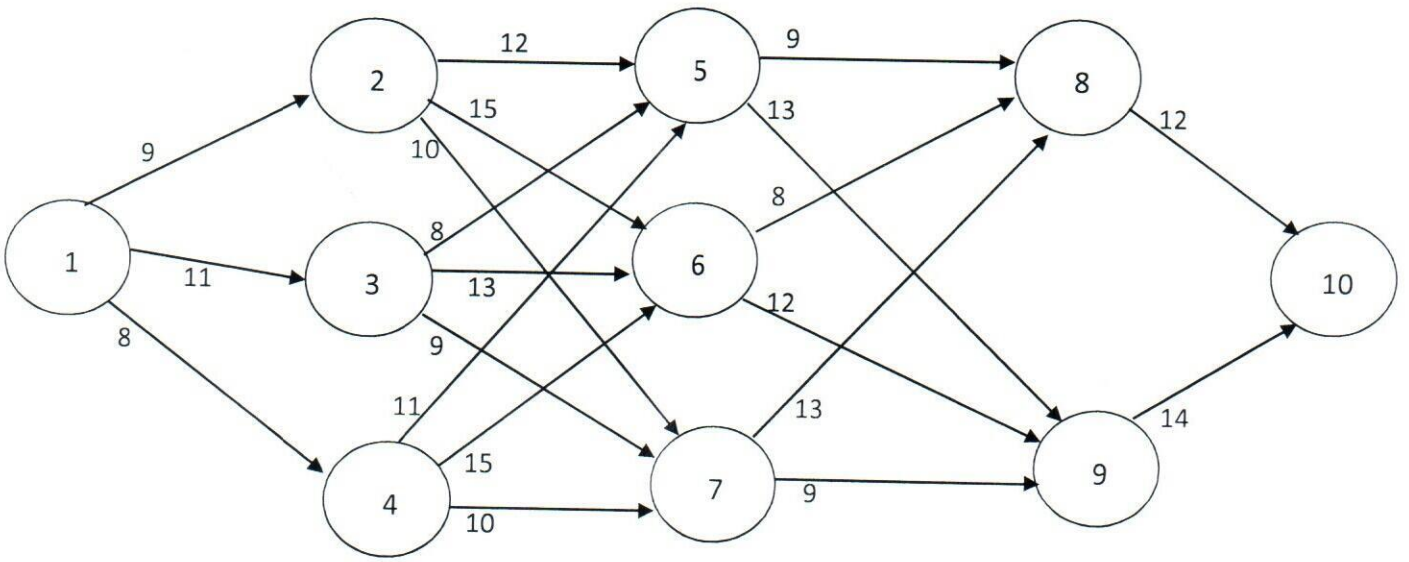
i. Draw the network diagram showing the inter-relations between the various activities of the project. **[9mks]**

ii. Indicate the critical path. **[2mks]**

iii. For each non-critical activity find the total and free float. **[5mks]**

QUESTION 5: (20marks)

a) A lorry located in a town 1 decided to travel to town 10.The distances of alternative routes from town 1 to town 10 are given in a highway network map given in the figure below. The arrow representing routes between towns and distances in kilometers are indicated on each route.



Find the shortest route that covers all the selected towns from 1 to 10 **[8mks]**

b) Consider the reliability problem of an electronic device consisting of four main components. The four components are arranged in series so that the failure of one component will cause the failure of the entire device. The total capital is C=10 and the reliabilities $R_j(k_j)$ and cost $C_j(k_j)$ for the j^{th} components $(j = 1,2,3,4)$ giving k_j parallel units are as summarized in the table below;

k_j	COMPONENTS							
	1		2		3		4	
	R_1	C_1	R_2	C_2	R_3	C_3	R_4	C_4
1	0.4	1	0.4	1	0.5	3	0.3	2
2	0.6	3	0.6	2	0.6	5	0.5	4
3	0.7	7	0.7	3	0.7	6	0.7	5

Using forward recursive equation, determine the number of parallel units k_j^* in component j that will maximize the reliability of the device without exceeding the total capital C **[12mks]**