NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

MASTER OF MANUFACTURING ENGINEERING/SYSTEMS AND OPERATIONS MANAGEMENT

OPERATIONS RESEARCH

TIE 6130

Stage 1 Examination Paper

March 2025

This examination paper consists of 10 printed pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: None

Examiner's Name: Dr Nicholas Tayisepi (Pr Eng)

INSTRUCTIONS AND INFORMATION TO CANDIDATE

1. Answer any four (4) questions. Attempt a maximum of two (2) questions from each section.
2. Each question carries 25 marks.
3. Use of calculators is permissible.

MARK ALLOCATION

QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
5.	**25**
6.	**25**
TOTAL MARKS ATTAINABLE BY CANDIDATE	**100**

SECTION A

QUESTION ONE

a) Explain the Operations Research Techniques that you would use for the following respective applications:

i) Customer Segmentation **[3]**

ii) Fraud Prevention **[3]**

iii) Traffic Flow Optimisation **[3]**

iv) Resource Allocation **[3]**

b) A freight plane has three large compartments to carry cargo. Weight and volume limitations of these compartments are shown in Table QU1 (a) below:

Table QU1 (a): Weight and Volume limitations

Compartment	**Weight (Tons)**	**Volume (m^3)**
Front	10	6800
Centre	16	8700
Rear	8	5300

There are four (4) cargoes waiting to be loaded in this plane. Properties of these cargoes are shown in Table QU1 (b).

Table QU1 (b): Properties of Cargoes

Cargo	Total Weight (Tons)	Total Volume (m3)	Profit (TL/ton)
K1	18	8640	310
K2	15	9750	380
K3	23	13340	350
K4	12	4680	285

Furthermore, the weight of the cargo in the respective compartments must be the same proportion of that compartment's weight capacity to maintain the balance of the plane. Any proportion of these cargoes can be accepted.

i) Formulate a linear programming model to maximize the profit by choosing how many tons of which cargo to load on the plane under these circumstances. **[8]**

Draw the Initial Simplex Tableau only and explain what it means.

QUESTION TWO

(a) Explain how the transportation algorithm can be modified for profit maximization rather that the minimisation of costs. **[5]**

(b) A company manufactures one product which is currently in short supply. The company's four (4) outlets A, B, C and D, already have requirements which in total exceed the combined capacity of its three production plants at X, Y and Z. The company needs to know how to allocate

its production capacity to maximize profit. Distribution costs per unit from each production plant to each shop are given in Table QU2.

Table QU2: Distribution costs per unit

To From	A	B	C	D
X	22	24	22	30
Y	24	20	18	28
Z	26	20	26	24

Since the four (4) shops are in different parts of the country, and as there are different transportation costs between the production plants and the shops, along with slightly different production costs at each of the production plants, there is a pricing structure that enables different prices to be charged at the four (4) shops. Currently the price per unit charged is $230 at A, $235 at B, $225 at C and $240 at D. The variable unit production costs are $150 at plants X and Z, and $155 at plant Y.

i. Set up a matrix showing the unit contribution to profit associated with each production

plant/shop allocation. **[5]**

ii. The demands at A, B, C and D are 850, 640, 380 and 230 respectively. The plant capacity t X is 625, at Y is 825 and at Z is 450. Use the transportation algorithm to determine the optimal allocation. **[10]**

iii. Determine the contribution to profit for the optimal allocation. **[5]**

QUESTION THREE

a) Describe the following two terms used in Decision Theory:

i) State of Nature **[3]**

ii) Alternative **[2]**

b) The Gas Company of Zimbabwe has completed a study and is aware that there are gas reserves and they want to invest for the extraction of gas. Management of the Company is considering whether or not to build a plant. Their decision is summarized in Table QU3 below

Table QU3: Decision Table

Alternatives	**Favourable Market**	**Unfavourable Market**
Build a Large Plant	$250,000	-$150,000
Build a Small Plant	$70,000	-$10,000
Don't Build	$0	$0
Market Probabilities	0.4	0.6

i) Construct a Decision Tree **[7]**

ii) Determine the best strategy, using the Expected Monetary Value (EMV). **[4]**

iii) What is the expected value of perfect information? **[9]**

SECTION B

QUESTION FOUR

(a) A Manufacturing Company has options to engage in six manufacturing projects during the next two-year period. There is, however, only approximately $500,000 available for manufacturing costs. The expected costs and expected net profits for the individual projects are listed in the Table QU4.

Table QU4. The expected costs and expected net profits

Manufacturing Project	Expected Net Profit (000)	Expected Cost (000)
A	180	125
B	120	90
C	100	60
D	140	125
E	105	50
F	200	150

Corporate policy places several additional restrictions on the project selection decision.

1. Exactly one of projects A, B and C must be selected
2. Exactly one of projects B, C, D, E and F must be selected
3. At most, one of the two projects E and F can be selected
4. At most, two of projects A, B, C, D and E must be selected

Model the problem as an Integer programming Model **[20]**

(b) Indicate the main steps which you would go through in order to solve this model using a stated computer package. **[5]**

QUESTION FIVE

QU5(a) Discuss the importance of Goal programming as an important branch of operations research. **[10]**

QU5(b) A factory produces two kinds of machined components on machines model type A and B. Table QU5(b) shows the variety of production conditions:

Table QU5(b). Machine constraints

Process	Model		Maximum weekly processing capacity
	A	B	
Ⅰ. (Hours/ units)	4	6	150
Ⅱ. (Hours / units)	3	2	70
Profits ($ / units)	300	450	

If the expectations of the factory business objectives and the priority is as follows:

P_1: Weekly total profits not less than $10,000.

P_2: Due to contractual requirements, A-type machine per week has to produce at least 10. B-type machine has to produce at least 15 per week.

P_3: It is hoped that the process I weekly production time is just 150 hours, and that process II weekly production time is just 70 hrs.

Develop a goal programming model for this problem. **[15]**

QUESTION SIX

(a) Determine the minimum spanning tree for the telecommunication supply services network shown in Figure QU6(a). **[12]**

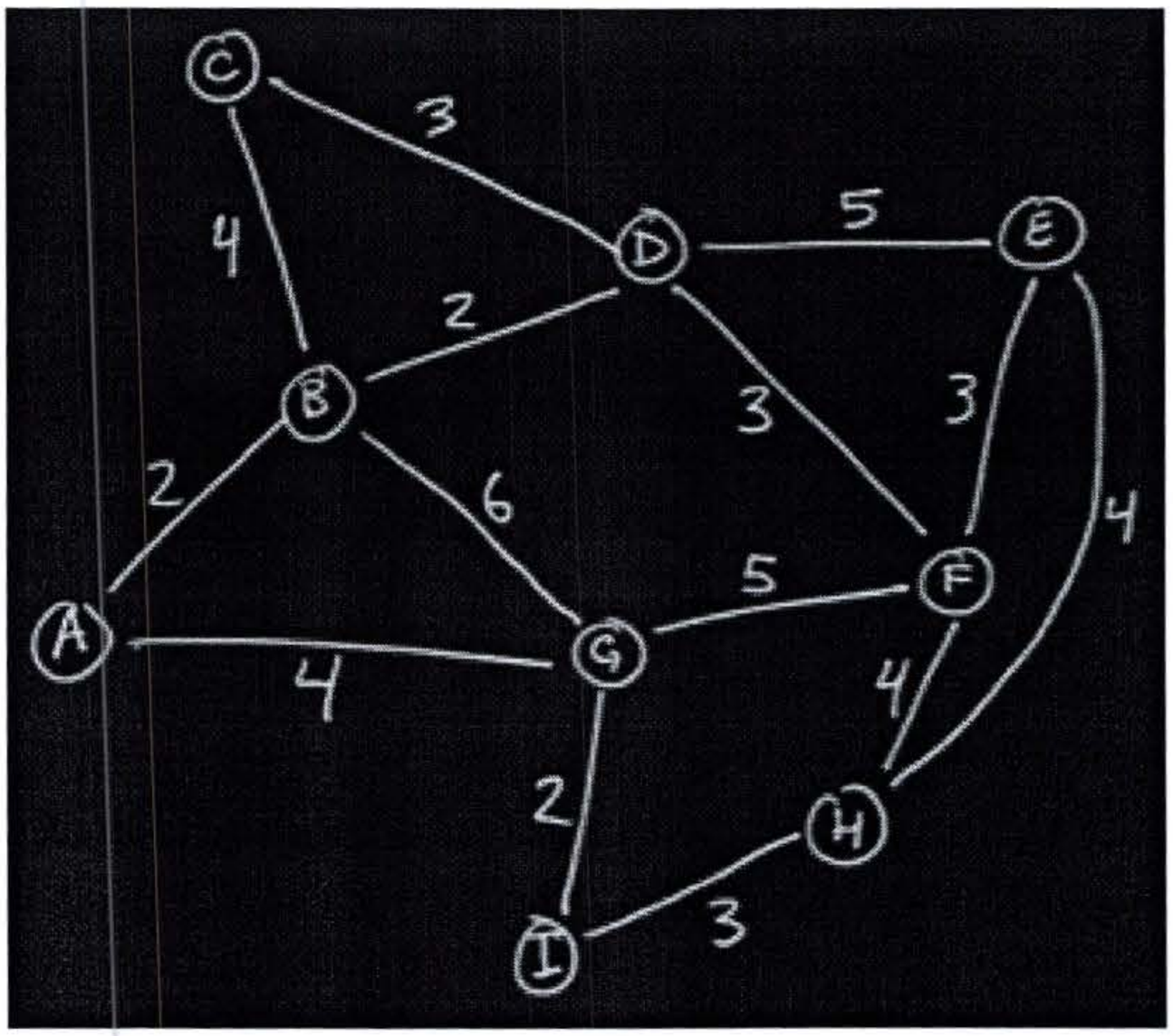

Figure QU(a) Telecommunication network

QU6(b) Determine the maximum vehicle flow from the source to the sink, in the highway network shown in Figure QU6(b), given that the flow capacity from Node i to Node j is the number of vehicles along the branch (i, j) nearest to Node i. **[13]**

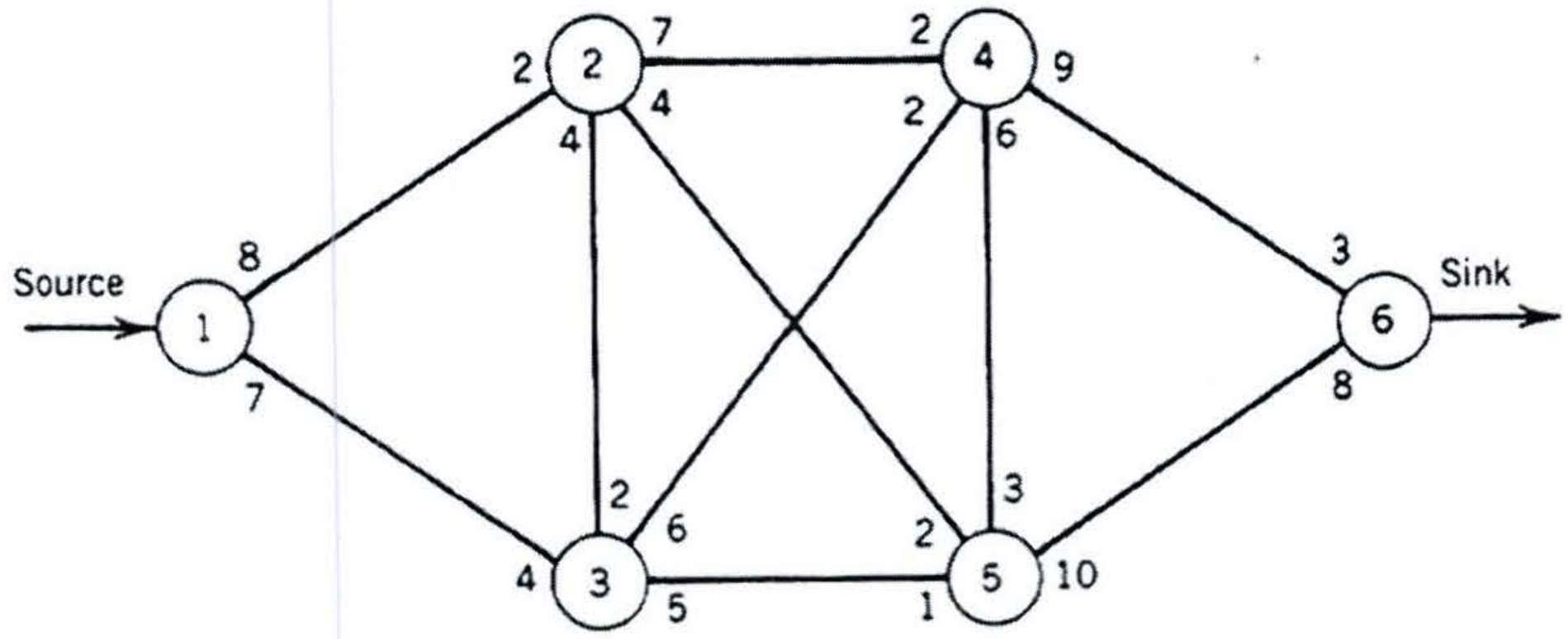

Figure QU6(b) Highway network

End of Examination