



NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

MASTER OF ENGINEERING IN MANUFACTURING ENGINEERING/SYSTEMS AND OPERATIONS

MANAGEMENT

OPERATIONS RESEARCH

TIE 6130

First Semester Main Examination Paper

December 2014

This examination paper consists of 8 printed pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: None

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INSTRUCTIONS AND INFORMATION TO CANDIDATE

1. Answer a total of four (4) questions: Attempt at most 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

Answer any two questions

Question 1

- a) Briefly explain each of the seven major steps in solving an Operations Research problem.[14]
- b) What are the main characteristics of Linear Programming problems [3]
- c) A company is involved in the production of two items (X and Y). The resources needed to produce X and Y are twofold, namely machine time for automatic processing and craftsman time for hand finishing. Table QU1 below gives the number of minutes required for each item:

Table QU1: Number of minutes required for each item

	Machine time	Craftsman time
Item X	13	20
Item Y	19	29

The company has 40 hours of machine time available in the next working week but only 35 hours of craftsman time. Machine time is costed at \$10 per hour worked and craftsman time is costed at \$2 per hour worked. Both machine and craftsman idle times incur no costs. The revenue received for each item produced (all production is sold) is \$20 for X and \$30 for Y. The company has a specific contract to produce 10 items of X per week for a particular customer. Formulate and Solve the problem of deciding how much to produce per week as a linear programming problem. [8]

Question 2

- a) What is the aim of the Transportation Algorithm? [3]
- b) Explain the pros and cons of using the Interdisciplinary Team Concept approach in solving Operations Research problems. [6]
- c) A factory has three warehouses W1, W2 and W3 which supply to four stores S1, S2, S3 and S4. Monthly capacities of the warehouses are W1 = 100 units, W2 = 40 units and W3 = 60 units. Monthly demands at the stores are S1 = 30 units, S2 = 50 units, S3 = 65 units and S4 = 55 units. The shipping cost in US\$ from warehouses to stores is as given in Table QU2 below:

Table QU2: Shipping costs

Stores				
Warehouses	S1	S2	S3	S4
W1	14	16	12	20
W2	12	14	10	8
W3	10	16	8	15

Determine the optimum distribution for the factory to minimize shipping costs. [16]

Question 3

- a) Distinguish Modeling and Simulation as used in Operations Research. [2]
- b) Discuss the major limitations of using Models as an Operations Research tool and how these limitations can be mitigated. [8]
- c) Describe using examples, the major considerations for decision making under the following conditions:
- i) Decision making under uncertainty [3]
 - ii) Decision Making under risk [3]
- d) The ABC Company is faced with four decision alternatives relating to investments in a capital expansion program. Since these investments to be are made in the future, the company foresees different market conditions as expressed in the form of States of Nature. Table QU3 summarises the decision alternatives, the various States of Nature and the rate of return associated with each State of Nature.

Table QU3: Decision alternatives and States of Nature

Decision	States – of – nature		
	q ₁	q ₂	q ₃
D ₁	17%	15%	8%
D ₂	18%	16%	9%
D ₃	21%	14%	9%
D ₄	19%	12%	10%

If the company has no information regarding the probability of the occurrence of the three States of Nature, give the recommended decision for the decision criteria listed below:

- i) Maximax criterion [3]
- ii) Maximin criterion [3]
- iii) Equally Likely [3]

SECTION B

Answer any two questions

Question 4

- a) Explain, with the aid of typical application situation examples, the concept of goal programming. **[5]**
- b) The Engineering Operations Manager of Water Pumps Manufacturing Company is faced with the problem of jobs allocation between his two production teams. The production rate of team A is 6 units/hour, while the production rate of team B is 4 units/hour. Both production teams work 40 hours/week. The Operations Manager has prioritised the following goals for the coming week, where goals 3 and 4 are prioritised in being assigned different weights according to the relative productivity of the two teams, thus:
- P1: Avoid underachievement of the desired production level of 600 units,
P2: Avoid overtime operations for team A beyond 5 hrs,
P3: The sum of overtime for both teams (i.e., 80 hours) should be minimised,
P4: Any underutilisation of regular working hours should be avoided,
- Formulate jobs allocation problem as a goal programming model. **[20]**

Question 5

- a) Willowvale Mazda Motor Industries (WMMI) is considering manufacturing three types of cars:

Mazda B1800, Mazda B2500 and Mazda Eagle. The resources required for and the profits yielded by, each type of car are shown in Table QU5. The resources available are 6000 tons of steel and 60 000 hours of labour. In order for production of a type of car to be economically viable, atleast 1000 units of that type of car must be produced. Formulate the problem as an Integer Programming (IP) model in order to maximise WMMI profit. [15]

Table QU5: Resources and Profits for the Three Types of cars

	Mazda B1800	Mazda B2500 and	Mazda Eagle
Steel Required	1.5 tons	3 tons	5 tons
Labour Required	30 hours	25 hours	40 hours
Profit Yielded	\$2000	\$3000	\$4000

- b) WMMI has a \$20 000 advertising budget. WMMI can purchase full-page advertisements (ads) in two magazines: *Inside Jokes* (IJ) and *Family Square* (FS). An exposure occurs when a person reads Willowvale Mazda Motor Industries ad for the first time. The number of exposures generated by each ad in IJ is as follows: ads 1- 6, 10 000 exposures; ads 7 – 10, 3000 exposures; ads 11 – 15, 2500 exposures; ads 16+, zero exposures. *For example, 8 ads in IJ would generate $6(10\ 000) + 2(3000) = 66\ 000$ exposures.* The number of exposures generated by each ad in FS is as follows: ads 1 – 4, 8000 exposures; ads 5 – 12, 6000 exposures; ads 13 – 15, 2000 exposures; ads 16+, zero exposure. *Thus, 13 ads in FS would generate $4(8000) + 8(6000) + 1(2000) = 82\ 000$ exposures.* Each full-page ad in either magazine costs \$1000. Assume there is no overlap in the readership of the two magazines. Formulate an Integer Programme to maximise the number of exposures that WMMI can obtain with limited advertising funds. [10]

Question 6

- a) Determine the maximum vehicular flow, from the source City A to the sink City G, in the Figure QU6 network which represents a highway road network linking the two cities, given that the flow capacity from Node i to Node j is the number along the branch (i, j). [7]

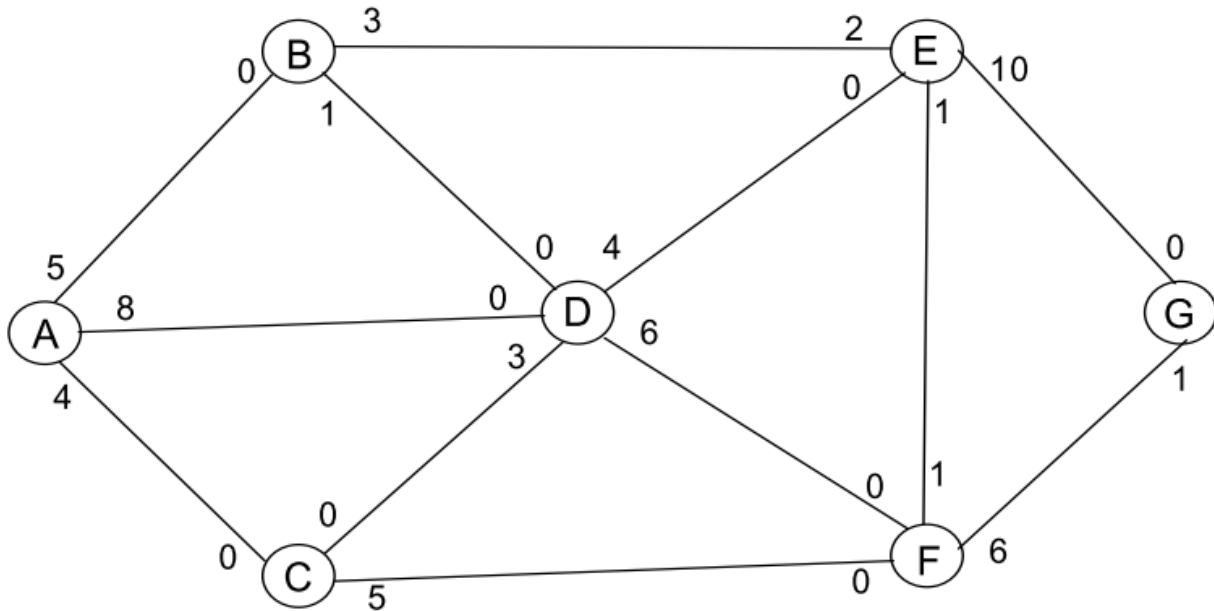


Figure QU6: Flow from A to G

- b) A hiker wishes to hike through a wilderness area in as few days as possible. (S)he will travel and rest intermittently through the wilderness. Table QU6 gives details of the possible hiking routes (branches labelled with numbers, presented as the number of days required to hike between nodes on that branch) and the resting shelter station (the Alphabetical letters representing the nodes which are the resting shelter stations) nodes.
- Draw the network from the data tabulated. [4]
 - What route should be taken to minimise travel time? [7]
 - Find the minimum spanning tree for the network represented in (i). [7]

Table QU6: Branch links and number of days taken to hike on each route

Hiking Route branch links	Number of Days Required
Origin (O) and A	6
O and B	8
O and C	7
O and D	5
A and B	4
A and E	7
B and C	3
B and E	5
C and D	2
C and F	6
D and F	4
D and T (Destination)	9
E and F	6
E and T	3
F and T	8

.....End of Examination.....