

BINDURA UNIVERSITY OF SCIENCE EDUCATION  
DEPARTMENT OF PHYSICS AND MATHEMATICS  
MASTER OF SCIENCE EDUCATION IN MATHEMATICS: MT505

**OPERATIONS RESEARCH**

AUG 2024

**TIME: 3 hours**

Candidates may attempt **FOUR** questions. Each question should start on a fresh page.

- A1.** a. A firm produces two products X and Y, and has a total production capacity of 9 tons per day. The firm has a permanent contract to supply at least 2 tons of X and at least 3 tons of Y daily to another company. Each ton of X requires 20 machine hours of production time and each ton of Y requires 50 machine hours of production time. The daily maximum possible number of machine hours is 360. All the firm's output can be sold and the profit is \$80 per ton of X and \$120 per ton of Y. Solve graphically to determine the production schedule for maximum profit and calculate this profit.

[10]

- b. Barclays Bank is in the process of devising a loan policy that involves a maximum of \$12 million dollars. The following table provides the pertinent data about available types of loans.

TYPE OF LOAN	INTEREST RATE	BAD DEBT RATIO
PERSONAL	0.140	0.10
CAR	0.130	0.07
HOME	0.120	0.03
FARM	0.125	0.05
COMMERCIAL	0.100	0.02

Bad debts are unrecoverable and produce no interest revenue.

Competition with other financial institutions requires that the bank allocate at least 40% of the funds to farm and commercial loans. To assist the housing industry in the region, home loans must equal at least 50% of the personal, car and home loans. The bank also has a stated policy of not allowing the overall ratio of bad debts on all loans to exceed 4%. The objective of Barclays is to maximize the net return. Develop an LP model for this data assuming that all loans are issued at approximately the same time.

[15]

**Total [25 marks]**

- A2.** CAZ-TECH produces four types of electric motors, each on a separate assembly line. The respective capacities of the lines are 500, 500, 800 and 750 per day. Type 1 motor uses 8 units of a certain electronic component, type 2 motor uses 5 units, type 3 motor uses 4 units and type 4 motor uses 6 units. The supplier of the component can provide 8000 pieces a day. The prices per motor for the respective types are \$60, \$40, \$25 and \$30.

- a. Develop an LP model for the problem so as to maximize revenue. [5]
- b. Determine the optimum daily production mix. [15]
- c. The present production schedule meets CAZ-TECH's needs. However, because of competition, CAZ-TECH may need to lower the price of type 2 motor. What is the most reduction that can be effected without changing the present production schedule? [5]

**Total [25 marks]**

A3. Nyamz Generations Pvt LTD produces electric generators in 3 locations, Mutare, Rusape and Nyanga. Production capacities for the 3 plants, over the next 3 months are as follows:

ORIGIN	PLANT	PRODUCTION CAPACITY (UNITS)
1	Mutare	5000
2	Rusape	6000
3	Nyanga	2500
TOTAL		13500

The firm distributes its generators to 4 distribution centres in Bulawayo, Gweru, Gwanda and Nkayi. 3 month forecast of demand is as follows.

Destination	Distribution Centre	Demand Forecast (units)
1	Bulawayo	6000
2	Gweru	4000
3	Gwanda	2000
4	Nkayi	1500
Total		13500

The cost for each unit shipped from each source to destination is as follows.

Origin	DESTINATION			
	Bulawayo	Gweru	Gwanda	Nkayi
Mutare	3	2	7	6
Rusape	7	5	2	3
Nyanga	2	5	4	5

Management would like to determine how much of its products should be shipped from each plant to each distribution center, at a minimum total transportation cost.

- a. Develop an LP model that minimizes the transportation costs. [7]
- b. Find the initial basic feasible solution using
  - i. The North West Method [3]
  - ii. The Vogel's Method [3]
- c. Use the transportation Simplex Algorithm to find the optimal solution. [7]
- d. Aladeen's four children want to earn some money to take care of personal expenses during a school trip to the local zoo. Mr Aladeen has chosen four chores for his children. To avoid the anticipated sibling competition, he asked them to submit (secret) bids for what they feel is fair pay for each of the 4 chores. The undertaking is that all four children will abide by their father's decision as to who gets which chore. Table below summarizes the bids received.

	Job 1	Job 2	Job 3	Job 4
Child 1	\$1	\$4	\$6	\$3
Child 2	\$9	\$7	\$10	\$9
Child 3	\$4	\$5	\$11	\$7
Child 4	\$8	\$7	\$8	\$5

Based on the information, how should Mr Aladeen assign chores? [5]

**Total [25 marks]**

- A4. (a) The State University campus has six minicomputers. The distance between each pair of computers (in city blocks) is given in Fig. 1. The computers must be interconnected by underground cable. What is the minimum length of cable required? Note that if no arc is drawn connecting a pair of nodes, this means that (because of the underground rock formations) no cable can be laid between these two computers.

[6]

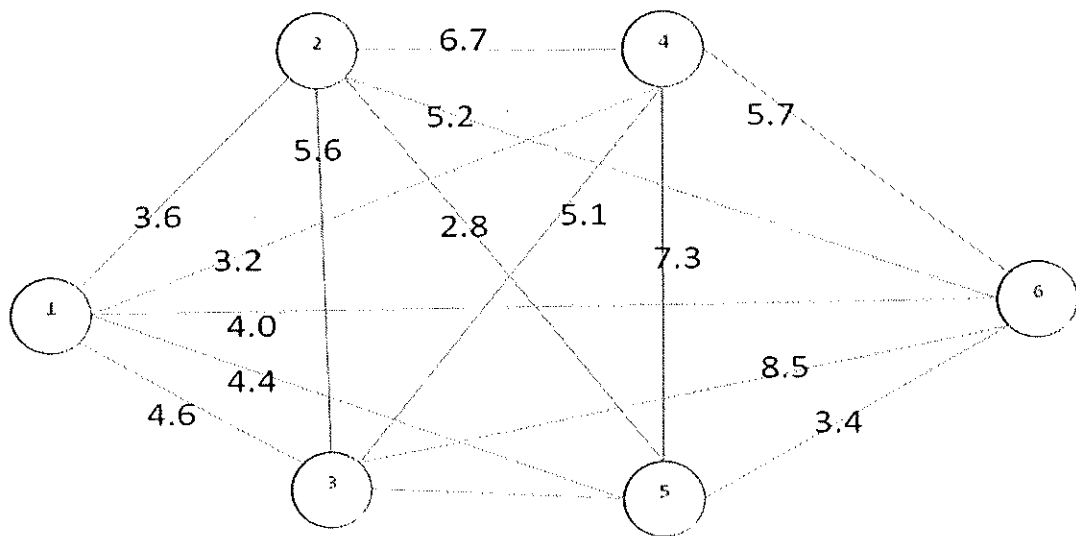


Fig. 1: Distances (km) between State University Computers

- (b) Fig. 2 below is a network diagram.

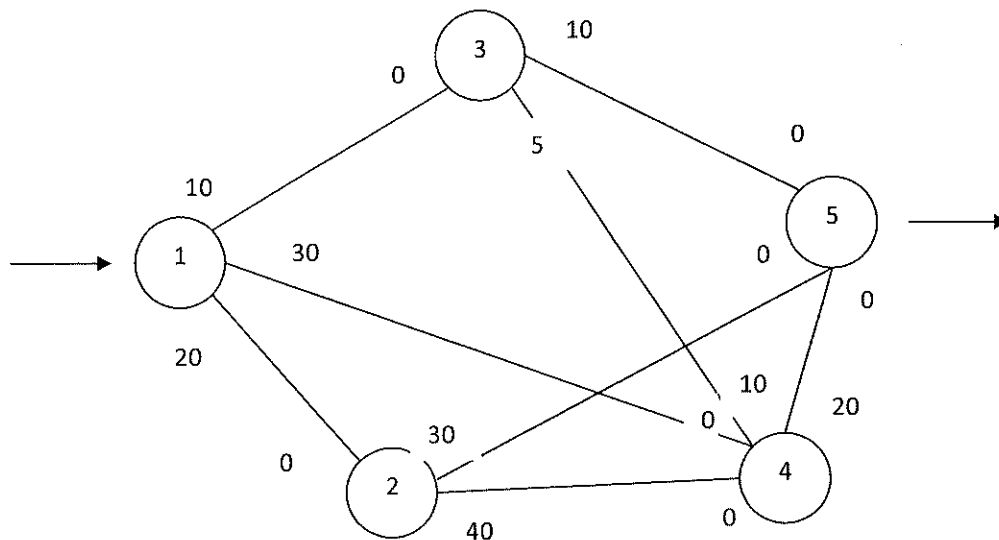


Fig. 2: Network Flow Diagram for Extra Profile Pvt. Limited.

- (i) Determine the maximal flow of the whole network with node 1 and node 5 being the source and sink respectively in Fig. 2, [10]
- (ii) the amount of flow and direction in each arc of the network in Fig. 2, [5]
- (iii) the surplus capacities for all the arcs, and [4]

**Total [25 marks]**

**A5.** (a) Give the meaning of the following terms:

- (i) inventory, [3]
- (ii) holding cost, [3]
- (iii) shortage cost. [3]

(b) Light bulbs at a university campus are replaced at the rate of 100 units per day. The physical plant orders the neon lights periodically. It costs \$100 to initiate purchase order. A neon light kept in storage is estimated to cost about \$0.02 per day. The lead time between placing an order and receiving an order is 12 days.

- i. What is the economic order quantity? [3]
- ii. When does the reorder point occur? [3]
- iii. What is the inventory cost associated with the proposed inventory policy? [2]

(c) Suppose that the demand  $D$  for bicycles follow distributions given below.

$$\varphi_D(\xi) = \begin{cases} \frac{1}{800}, & \text{if } 0 \leq \xi \leq 800 \\ 0, & \text{Otherwise} \end{cases}$$

The production cost is \$35 per item, that is  $c = 35$ ,  $p = \$45$  and  $h = 0.2$ . The discounting factor is 0.995.

- i. Determine the optimal number of Bicycles to be produced. [7]
- ii. If there are 23 bicycles already in inventory, determine the optimal number of spares to produce. [4]

**Total [25 marks]**

**A6.**

- a. Define the following terms
- i. Dual Price [2]
  - ii. Feasible solution [2]
  - iii. Binding constraint [2]
  - iv. Unbounded solution [2]
- b. Outline three basic components of Linear Programming [3]
- c. A company, engaged in producing tinned food, has 300 trained employees on rolls, each of whom can produce one can of food in a week. Due to the developing taste of the public for this kind of food, the company plans to add to the existing labour force by employing 150 people, in a phased manner, over the next five weeks. The newcomers would have to undergo a two-week training programme before being put to work. The training is to be given by employees from among the existing ones and it is known that one employee can train three trainees. Assume that there would be no production from the trainers and trainees during training period as the training is off-the-job. However, the trainees would be remunerated at the rate of \$300 per week, the same rate as for trainers.

The company has booked the following orders to supply during the next five weeks:

**Table 5: Booked orders to supply in the next 5 weeks**

Week		1	2	3	4	5
No.	Of	280	298	305	360	400
cans						

Assume that the production in any work would not be more than the number of cans ordered for, so that every delivery of the food would be “fresh”. Formulate this problem as an LP model to develop a training schedule that minimises the labour cost over the five-week period. [14]

**Total [25 marks]**

**END OF QUESTION PAPER**