

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

SMA 5192

DEPARTMENT OF APPLIED MATHEMATICS

SMA 5192: APPLICATIONS OF QUANTITATIVE ANALYSIS

NOV/DEC 2004

Time: 3 HOURS

ANSWER **ALL QUESTIONS**

1. Commuter Airways is a regional airline with a hub in Harare and regular commuter flights to Johannesburg and Gaborone as shown in figure 1 below:

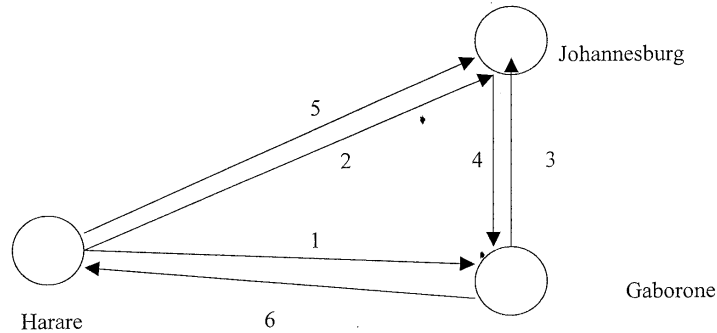


Fig 1: Flight Network of Commuter Airway

Each node in Figure 1 represents a city. Each arc or arrow, represents a flight between the connected cities (the flight number is shown next to the arc). Management requires that each of the six flights has at least one supervisor and the minimum number of cabin attendants indicated in table 1.

Table 1: Management requirements for crew members needed on each flight.

FLIGHT	FROM	TO	MINIMUM SUPERVISION	NO. OF CABIN ATTENDANTS
1	Harare	Gaborone	1	3
2	Harare	Johannesburg	1	4
3	Gaborone	Johannesburg	1	3
4	Johannesburg	Gaborone	1	2
5	Johannesburg	Harare	1	5
6	Gaborone	Harare	1	2

The airline has only eight cabin attendants and five supervisors currently working for them. In addition, FAA regulations require that there be at least one supervisor for every two-cabin attendants on each flight. Based on the estimated arrival and departure times, crew members can be assigned to more than one flight. However, management wants to ensure that all crew members start and return to Harare. This avoids overnight stays because all personnel live in the hub city of Harare. Five flight plans meeting these and other requirements (such as total flight time per day) have been identified in table 2.

Table 2: Cost of each crew member on each flight plan.

FLIGHT PLAN	FLIGHT SEQUENCE	SUPERVISOR	CABIN ATTENDANT
A	1-6	300	200
B	2-5	300	200
C	1-3-5	500	400
D	2-4-6	500	400
E	1-3-4-6	800	640

For example, plan D consists of flights 2, 4 and 6 which is a trip from Harare to Johannesburg to Gaborone and back to Harare as seen as in figure 1. Table 2 also provides the cost of assigning each type of crew member to the corresponding flight plan. As manager of the Personnel Department, you have been asked to determine the number of each type of crew members to assign to each flight plan to satisfy the given staffing and FAA requirements with least total cost. [15 marks]

- Air Zimbabwe wishes to schedule a bus service in the City of Harare between the Airport and a downtown terminal. The buses are rented from ZUPCO company at \$2 500 for a round trip from downtown to the airport, plus \$9 000 per waiting time at the airport. The service must give a passenger leaving on a flight at least 20 minutes but not more than 45 minutes to check in at the airport before flight departure. Similarly, a bus must leave the airport between 15 minutes and 30 minutes of each flight arriving. It takes a bus at least

10 minutes to turn around at the airport. A simplified daily flight schedule is given in the table below. The airline wants to minimise the cost of the bus service.

DEPARTURES		ARRIVALS	
Flight No. i	Time a_i	Flight No. k	Time b_k
1	460	1	590
2	655	2	660
3	675	3	780
4	890	4	930
5	995	5	1110

a_i and b_k is time measured from midnight. [22 marks]

3. Mr Moyondizvo enjoys to gamble in horse racing. On a particular horse race the information is as follows:

	HORSE	ODDS
1	Fair Lady	3:2
2	Sound of Music	8:3
3	Tino Tanya	5:2
4	Desert Song	7:1

Mr Moyondizvo has a problem of how he should distribute his capital on this race. As a specialist in Management Science can state his strategy to distribute his capital on this race and calculate his chance for a win.

4. ZISCO steel has received annual orders from four countries, Japan, Korea, Taiwan and Mexico, for two different types of steel it produces: high-grade and low-grade. These steels are produced at its two plants, located in Redcliff and Kwekwe, using iron ores supplied by two mining companies, Buchwa Minerals and ZIS Mines. The management of ZISCO Steel needs an overall annual purchase/production/distribution plan to minimise total costs. Various departments have collected the necessary data regarding the sales commitment, ore availability and cost, production characteristics and distribution costs of ore and finished steel.
ZISCO Steel can obtain up to 1000 tons of Grade A iron ore from Buchwa Minerals and up to 2000 tons of Grade B iron ore from ZIS Mines. ZISCO Steel can specify how much of each ore is to be transported to each of its steel mills. The associated purchase cost and distribution charge per ton are given in Table 1:

Table 1: Ore Purchase and Distribution Costs (\$/ton)

	Purchase Cost	Shipping Cost to Redcliff	Shipping cost to Kwekwe
Buchwa Minerals	130	10	13
ZIS Mines	110	14	17

Each of ZISCO Steel's two mills can produce high grade steel and low grade steel. High grade steel requires blending Grade A and Grade B iron ore in the ratio 1 to 2. Low grade steel requires a ratio of 1 to 3. The Kwekwe mill can process up to 1500 tons of iron ore and the Redcliff facility can handle at most 700 tons. The mill at Redcliff is a modern facility and has a lower processing cost per ton of steel produced than does the facility at Kwekwe as indicated in Table 2 below:

Table 2: Processing Costs (\$/ton)

	Redcliff Mill	Kwekwe Mill
High grade steel	32	40
Low grade steel	27	32

The finished steel is shipped to Japan, Korea, Taiwan and Mexico. The International Sales Division of ZISCO steel has received orders for each type of steel, given in Table 3 below. This table also includes the shipping costs per ton for each type of steel.

Table 3: Demands and Unit Shipping Costs of Steel

COUNTRY	Steel Type	DEMAND (tons)	Shipping cost Redcliff	(\$/ton) from Kwekwe
Japan	High grade	400	110	115
	Low grade	200	100	110
Korea	High grade	200	140	150
	Low grade	100	130	145
Taiwan	High grade	200	130	135
	Low grade	100	125	127
Mexico	High grade	150	80	90
	Low grade	50	80	85

As manager of Management Science Group of ZISCO Steel, you have been asked to make recommendations on the purchasing, processing and shipping functions with the objective of minimising the total annual cost.

[48 marks]

END OF QUESTION PAPER