

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF APPLIED SCIENCES

DEPARTMENT OF APPLIED MATHEMATICS

SMA 2207: Operations Research Techniques

May-June 2004

Time: 3 hours

Answer ALL questions from Section A and any THREE questions from Section B

1 Briefly explain the following:

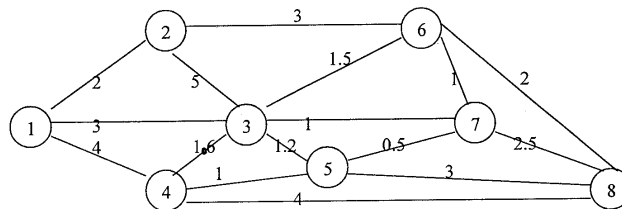
- (a) Critical path;
- (b) Minimal Spanning tree;
- (c) Lead time;
- (d) Opportunity loss;
- (e) Project Management.

[10 marks]

2 Considering a single item that is manufactured by a company and has a deterministic demand of D items per annum. Let Q be the quantity produced on each run, C_h is the holding cost per item, and C_o is the cost of setting a production run, and P the annual rate at which items can be produced. Derive the Economic Production Lot Size formula and show that when this is used, annual production set-up costs are equal to annual holding costs.

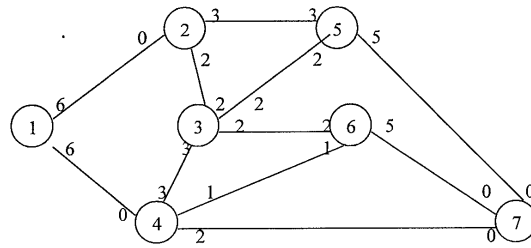
[6 Marks]

3 NUST is installing a computerized electronic mail system that will enable messages to be transmitted instantly among eight departments. The network with possible electronic connections among the departments is shown below. Distances between departments are shown (in hundreds of meters). Develop a design for the department communication system that will minimise the total length of connections among the eight departments. Also calculate the minimum length.



[6 marks]

- 4 Comoil company owns a pipe line network that is used to transmit oil from its source to several garages. The network is as below: (figures indicate flow in thousand litres/hour)



- (a) How long will it take to satisfy garage 7 demand of 100 000 litres?
 (b) If a break occurs on line 2-3 and is closed down, what is the maximal flow for the system?

[5+5 Marks]

- 5 A company has prepared its next year's budget and has collected information from its sales, production, accounting, and operations departments. The table indicates the activities and their duration.

Activity	Description	Immediate Predecessor(s)	Duration (days)
A	Forecast sales volume	-	10
B	Study Competitive market	-	7
C	Design item and facilities	A	5
D	Prepare production schedule	C	3
E	Estimate cost of production	D	2
F	Set sales price	B,E	1
G	Prepare budget	E,F	14

- (a) Draw the network model of the problem.
 (b) Find the critical path.

[3+5 marks]

SECTION B

Answer any Three Questions in this section

- 6 Consider the following information with activity times shown in days, and the crash data for the project being as follows:

Activity	Predecessor	Time (days)		Total Cost (\$)	
		Normal	Crash	Normal	Crash
A	-	3	2	800	1400
B	-	2	1	1200	1900
C	A	5	3	2000	2800
D	B	5	3	1500	2300
E	C,D	6	4	1800	2800
F	C,D	2	1	600	1000
G	F	2	1	500	1000

- (a) Show the network for the project.
 (b) Find the critical path and the expected project completion time.
 (c) What is the total project cost using the normal times?
 (d) Assume that management desires a 12-day project completion time;
 (i) Which activities should be crashed?
 (ii) What is the project cost for the 12-day completion time?

[4+6+2+5+3 marks]

- 7 Amakhosi Productions is considering producing a comedy series “Amakorokoza” for ZBC TV. While ZBC may reject the comedy, it may also purchase the program for 1 or 2 years. Amakhosi may decide to produce the series or transfer the rights to a competitor for \$100 000. Amakhosi ‘s profits are summarised in the following profit (\$1000s) payoff table:

	States of Nature		
	Reject	1 year	2 Years
d_1 (Produce comedy)	-100	50	150
d_2 (Sell to competitor)	100	100	100

Assuming the probability estimates for the states of nature are $P(\text{reject}) = 0.2$, $P(1 \text{ year}) = 0.3$, and $P(2 \text{ years}) = 0.5$

- (a) What should Amakhosi Productions do?
 (b) What is the maximum that Amakhosi should be willing to pay for inside information on what ZBC will do?
 (c) The payoff table (profit in \$1000s) for Amakhosi Productions is as follows:

		States of Nature		
		s_1	s_2	s_3
Decision Alternatives	d_1	-100	50	150
	d_2	100	100	100
Probability of states of nature		0.2	0.3	0.5

For a consulting fee of \$2500, an agency will review the plans of the comedy and indicate the overall chances of a favorable ZBC reaction to the series. If the special agency review results in a favorable (I_1) or unfavorable (I_2) evaluation, and assume that Amakhosi believes that the following conditional probabilities are realistic appraisals of the agency's evaluation accuracy:

$$\begin{array}{ll}
 P(I_1 / s_1) = 0.3 & P(I_2 / s_1) = 0.7 \\
 P(I_1 / s_2) = 0.6 & P(I_2 / s_2) = 0.4 \\
 P(I_1 / s_3) = 0.9 & P(I_2 / s_3) = 0.1
 \end{array}$$

- (i) Show the decision tree for this problem and its corresponding probabilities;
 (ii) What is the recommended decision strategy and the expected value, assuming that the agency information is obtained?

[5+3+7+5 marks]

- 8 A fast-food franchise is considering operating a drive-up window food-service operation. Assume that customer arrivals follow a Poisson probability distribution, with mean arrival rate of 24 cars per hour, and that service times follow an exponential probability distribution. Arriving customers place orders at an intercom station at the back of the parking lot and then drive up to the service window to pay for and receive their order. The following three service alternatives are being considered.
- 1 A single-channel operation where one employee fills the order and takes the money from the customer. The average service time for this alternative is 2 minutes.
 - 2 A single-channel operation where one employee fills the order while a second employee takes the money from the customer. The average service time for this alternative is 1.25 minutes.

- 3 A two-channel operation with two service windows and two employees. The employee stationed at each window fills the order and takes the money for customers arriving at the window. The average service time for this alternative is 2 minutes for each channel.

Compute the following operating characteristics for each alternative, and recommend an alternative design for the fast-food franchise:

- (a) What is the probability that there are no customers in the system?
 (b) What is the average number of cars waiting for service?
 (c) What is the average time a car waits for service? **[12 marks]**

The following cost information is available for the fast-food franchise

- Customer waiting time is valued at \$25 per hour to reflect that waiting time is costly to the fast-food business.
- The cost of each employee is \$6.50 per hour.
- To account for equipment and space, additional cost of \$20 per hour is attributed to each channel.

- (d) What is the lowest-cost design for the fast-food business? **[8 marks]**

- 9 (a) Kingstones Publishing company produces books for the retail market. Demand for a current book is expected to occur at a constant annual rate of 7200 copies. The cost of one copy of the book is \$14.50. The holding costs are based on an 18% annual rate, and production setup costs are \$150 per setup. The equipment on which the book is produced has an annual production volume of 25 000 copies. There are 250 working days per year and the lead-time for a run is 15 days. Use the production lot size model to compute the following values:

- (i) Minimum-cost production lot size;
 (ii) Number of production runs per year;
 (iii) Maximum inventory level;
 (iv) Total annual costs.

[12 marks]

- (c) Assume that the following quantity discount schedule is appropriate:

Order Size	Discount (%)	Unit Cost (\$)
0 to 49	0	30.00
50 to 99	5	28.50
100 or more	10	27.00

If annual demand is 120 units, ordering costs are \$20 per order, and the annual holding costs rate is 25%. What order quantity would you recommend? **[8 marks]**

END OF QUESTION PAPER