

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ARCHITECTURE AND THE QUANTITY SURVEYING

DEPARTMENT OF QUANTITY SURVEYING

AQS 4102: Construction Planning Simulation and Scheduling

January 2008

Time: 3hours

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

- 1** The installation of an artificial turf at Rufaro stadium is a new project in Zimbabwe and as a result the total time to complete each one of the activities is estimated by the three time estimates as shown below.

Activity	Predecessor	Optimistic Time (months)	Most Likely Time (months)	Pessimistic Time (months)
A	-	4	6	8
B	-	1	4.5	5
C	A	3	3	3
D	A	4	5	6
E	A	0.5	1	1.5
F	B,C	3	4	5
G	B,C	1	1.5	5
H	E,F	5	6	7
I	E,F	2	5	8
J	D,H	2.5	2.75	4.5
K	G,I	3	5	7

Draw the network for this project and calculate the critical path. **[10 marks]**

- 2** Briefly explain the importance of each of the following in construction planing and scheduling:
- (a) Program Evaluation and Review Technique (PERT);
 - (b) Critical Path Method (CPM);
 - (c) Minimal Spanning tree;
 - (d) Simulation;
 - (e) Hungarian Algorithm.

[10 marks]

- 3** The ABC Manufacturing company makes two products. The profit estimates for each unit of product 1 sold is \$25 and \$30 for each of product 2 sold. The labor-hour requirements for the products in each of three production departments are summarized below:

Department	Product 1	Product 2
A	1.50	3.00
B	2.00	1.00
C	0.25	0.25

The production supervisors in the departments have estimated that the following number of labor-hours will be available during the next month: 450 hours in department A, 350 hours in department B, and 50 hours in department C. The company is interested in maximising profit.

- (a) Formulate the above problem as a linear programming problem.
- (b) By using the graphical method find the optimal solution

[5 + 7 marks]

- 4** Peco Construction Pvt Ltd provides assistance to families whose houses have been destroyed by natural disasters. In a certain disaster, an average of 2.5 customers arrive each hour for assistance. One design consultant is available to answer customer questions and make construction recommendations. The consultant averages 10 minutes with each customer.

- (a) Calculate;
 - (i) the average number of customers in the waiting line,
 - (ii) the average time a customer spends in the system
 - (iii) the probability that an arriving customer has to wait for service.
- (b) If the consultant can reduce the average time spent per customer to 8 minutes, what is the mean service rate.

[6 + 2 marks]

Section B
Answer any 3 questions from this section

- 5 NUST has decided to modernize and refit its Administration block. They have awarded the contract to a local builder. The table below gives details of the activities involved together with immediately preceding activities. Also given are the normal cost of each activity, together with extra costs involved in reducing the duration of some of the activities. In addition to the cost of each activity, there are on-site cost of \$20 000 per day. The contract includes a penalty of \$10 000 per day that the project takes over 27 days.

Activity	Immediately Preceding Activity	Normal Duration (Days)	Normal Cost (\$'000)	Minimum Duration (Days)	Crash Cost (\$'000)
A	-	4	20	2	30
B	-	5	30	4	45
C	A	6	40	5	50
D	B	8	55	6	75
E	B	7	45	6	50
F	C	2	15	1	20
G	A	5	47	4	60
H	D	4	25	3	33
I	E,F	4	25	3	30
J	E,F	6	60	6	60
K	G,H,I	3	18	2	20
L	J,K	7	35	6	40
M	E,F	10	60	9	70
N	L	4	25	3	31

- a) Draw a network for the project and using the normal duration times find the earliest and latest event times and the critical path. Hence state the expected duration of the project.

[10 marks]

If the normal durations are expected durations calculated from the project manager's estimates of the most likely, optimistic and pessimistic durations and if the variance of the expected duration of the project is 3.3, what is the probability that the project will be completed in 27 days or less?

[2 marks]

- b) Specify which activities should be speeded up (by employing extra resources) and by how many days in order to complete the project in the shortest possible time and also calculate the total cost for this crashing.

[8 marks]

- 6 Emson Motors Pvt. Ltd. repairs gear cars tires and other electrical problems for its customers. In normal operation, on average 2.5 customers arrive each hour. One mechanic is available for all

the repairs that will be brought by customers. The mechanic spends 10 minutes with each customer.

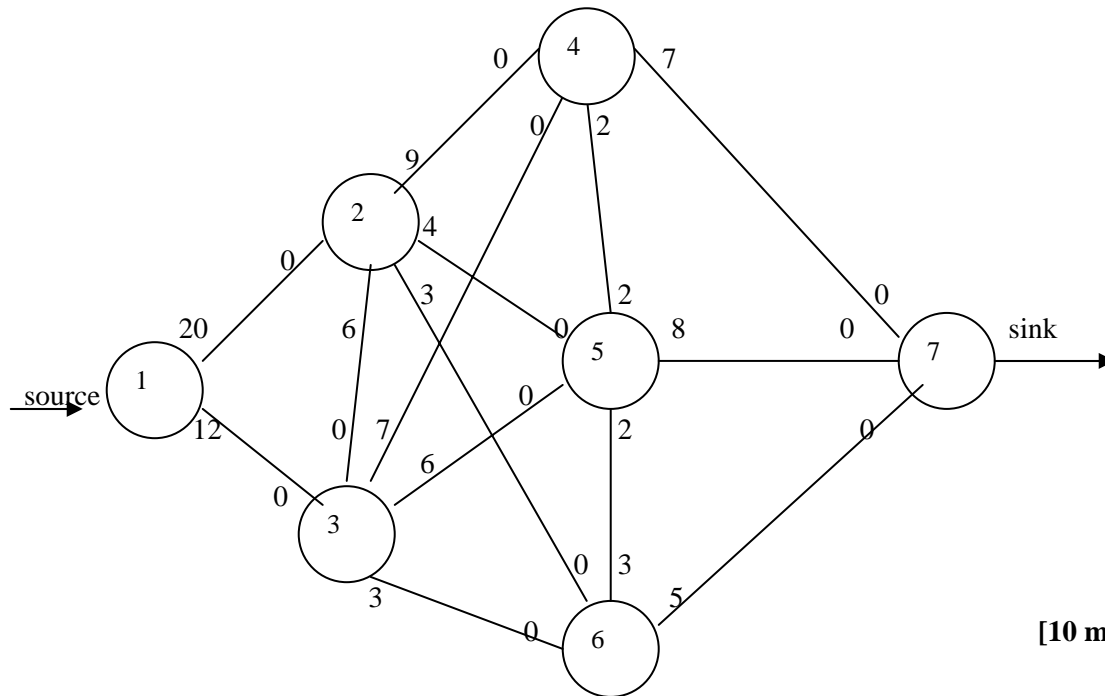
- (a) Calculate the following assuming Poisson arrivals and exponential service time;
- (i) the average number of customers in the queue
 - (ii) the average time (in minutes) a customer spends in the queue
 - (iii) the average time a customer spends in the system
 - (iv) the probability that an arriving customer will have to wait for service.
- [8 marks]**
- (b) Mr. Emson himself would not like his customers to wait for service for an average of 5 minutes. Is his goal being met? If not what would you recommend? **[3 marks]**
- (c) If the mechanic can reduce the time spent on one customer to 8 minutes, what is the mean service rate? **[2 marks]**
- (d) Mr. Emson would like to evaluate two alternatives;
- 1 Use one mechanic with an average service time of 8 minutes per customer.
 - 2 Employ Kutso his son as an additional mechanic each of whom will have an average service time of 10 minutes per customer.
- If the two mechanics are going to be paid \$16 each per hour and the customer waiting time is valued at \$25 per hour for waiting time, should Mr. Emson expand to have the two mechanics? Explain. **[7 marks]**

- 7 The following table shows transportation alternatives for transporting some units from three sources to four destinations. The objective is to maximize total transportation profit. For some reasons, it was given that source 1 cannot supply Destination D and Source 3 cannot also supply Destination B. The figures inside the table indicates the profit obtained by transporting one unit from source i to destination j .

		Destination				
		A	B	C	D	Supply
Source	1	2	3	5	*	5
	2	2	1	3	5	10
	3	3	*	4	6	25
Demand		10	8	4	6	

- (i) Develop a network model of this problem. **[2 marks]**
 - (ii) Formulate a linear programming model of this problem (do not solve).
 - (iii) Use the transportation algorithm to solve this problem.
- [5+13 marks]**

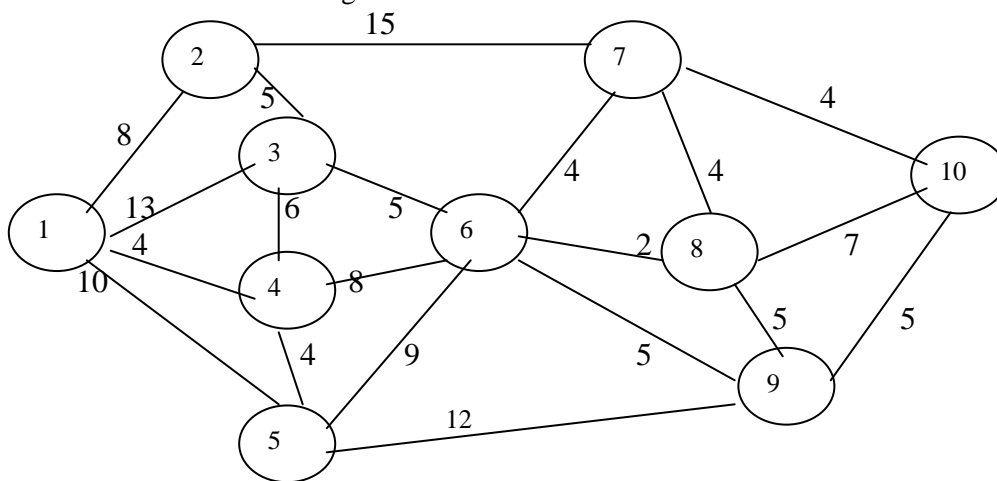
- 8 (a) The diagram below shows the electrical transmission network for Zesa. The source node (node 1) is the power generating station and the sink node (node 7) represents the destination city to which the electric power is directed. The other nodes of the network represent switching stations, at which the electrical flow of the branches of the network can be regulated. The capacities of the various branches of the network are shown on the respective branches. Find the maximum energy flow from the source to the sink.



[10 marks]

(b) Rixi taxis has identified 10 primary pickup and drop off locations for cab riders in Bulawayo. In an effort to minimise travel time and improve customer service and the utilization of company's fleet of cabs, management would like the cab drivers to take the shortest route between locations whenever possible. Using the network of roads and streets shown below (The travel times in minutes are shown on the arcs of the network):

- i. What is the route a driver beginning at location 1 should take to reach location 10?
- ii. Another taxi driver has just dropped a customer at location 8, which route must he take to go back to location 1?



[5+5 marks]

END OF QUESTION PAPER