NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

BACHELOR OF ENGINEERING IN INDUSTRIAL AND MANUFACTURING

SECOND SEMESTER EXAMINATIONS AUGUST 2009

MANUFACTURING SYSTEMS ENGINEERING TIE5215

Duration: 3 hours
Answer: FIVE (5) Questions

Question 1

a) Discuss briefly the steps in simulation study. [12]

b) Discuss the different subsystems in a queuing system and their characteristics [8]

Question. 2

a) Define simulation. [2]

b) Briefly explain two categories of modeling methods. [4]

c) SM departmental Store in Bulawayo, maintains a successful catalogue sales department in which a clerk takes orders by telephone. If the clerk is occupied on one line, incoming phone calls to the catalogue department are answered automatically by a recording machine and asked to wait. As soon as clerk is free the party that has waited the longest is transferred and answered first. Calls come in at a rate of 12 per hour. The clerk is capable of taking an order in an average of four minutes. Calls tend to follow a Poisson distribution and service tends to be exponential. The clerk is paid $5 per hour but because of lost goodwill and sales SM loses about $25 per hour per customer time spent waiting for the clerk to take an order.

i. What is the average number of callers waiting to place an order? [3]

ii. What is the average time that catalogue customers must wait before their calls are transferred to order clerk? [3]

iii. SM is considering adding a second clerk to take calls. The store must pay the person the same rate as the first operator. Through an analysis decide on whether SM should hire a second operator. [8]

Question 3

a) Calls arrive at NUST switchboard at a rate of two per minute. The average time to handle each of these is 20 seconds . There is only one switchboard operator. The poisson and exponential distributions appear to be relevant in this situation:

i) What is the probability that the operator is busy? [2]

ii) What is the average time that a call must wait before reaching the operator? [2]

iii) What is the average number of calls waiting to be answered? [2]

b) Three workers “kits” orders by pulling the required number of parts from a warehouse and placing them in a tote. Orders are always ready to be kitted. In fact the computer scheduling system maintains a one-hour supply of kitting orders in queue at all times in front of the kitters. The time to kit an order is exponential with mean 40 minutes. Kits then go to an assembly area. Two assemblers are available. Assembly time is exponential with mean 10 minutes. Assembled kits are then inspected. Two inspectors are available. Inspection time is exponential with mean 7.5 minutes and the failure rate is 20% and returned to the assembly.

i) Find the average number of orders in process at each station [7]
ii) Find the average time for an order to go through the system. [7]

Question 4

NUSTBANK has one drive-in-teller and room for one additional customer to wait. Customers arriving when the queue is full, park and go inside the bank to transact business. The time between arrivals and service time distributions are given in Table 4.1 and Random digits in Table 4.2.

Table 4.1: Arrival and Service time distributions

Time between Arrivals (min)	Probability	Service Time (min)	Probability
0	0.09	1	0.20
1	0.17	2	0.40
2	0.27	3	0.28
3	0.20	4	0.12
4	0.15		
5	0.12		

Table 4.2: Random digits for Arrival and Service Times

Customer	1	2	3	4	5	6	7	8	9	10
Random Digits for Arrival	93	69	60	73	29	7	64	56	6	91
Random Digits for service	39	40	55	60	77	79	78	66	12	80

i) Simulate the operation of the drive-in-teller for 10 new customers. The first of the 10 new customers arrive at a time determined at random. Start the simulation with one customer being served, leaving at clock time 3 and one in the queue whose service time is 3min. [10]
ii) How many customers went into the bank to transact business? [2]
iii) What was the average time in the queue for the 10 new customers? [4]
iv) What the maximum time in the system for the 10 new customer? [2]
v) What is the utilization of the teller? [2]

Question 5

A small manufacturing shop wishes to produce five part families shown in Table Qu. 5. Five workstations, milling (M), drilling (D), turning (T), bending (B), and polishing (P) produce five part families. The 0.25 factors indicate split, probabilistic routing for parts as certain type 3 and 5 parts skip polishing. The workstations are available 8 hours per day and 5 days per week. There are two machines each in the milling and drilling workstations respectively, one machine each in the turning, bending workstations and polishing workstation respectively.

i) Sketch the manufacturing system. [3]
ii) Sketch the queue model. [3]
iii) Evaluate the manufacturing system as an open queuing network. (Hint: this involves determining the queue and system throughput and expected number of jobs respectively. [14]

Table Qu. 5: Part Data

Part	Demand	Route (machine, hour per part)			
Family	Per week	1			
1	4	M,4	T,2	B,4	P,4
2	16	M,8	D,10	T,4	P,2
3	12	M,15	T,2	D,5	P,4 (25%)
4	6	D,10	M,5	B,5	P,2
5	8	T,4	D,4	B,2	P,2 (25%

Question. 6

a) Discuss the different assumptions of open and closed queuing network models. [4]

b) A job shop has three types of machines: two mills, one drilling presses and one surface grinder. Orders arrive at the shop at a rate of 2 per day. About 60% of these go to milling first and 40% start at drilling. Half of the drilling jobs go to milling next, 30% go to grinding next and the rest leave the system. 30% of jobs being milled go to grinding and the other leave the shop. Jobs always leave the shop after grinding. Operation times are exponential distributed, averaging one day per job for each of milling, drilling and grinding machine.

i) Sketch the queue model for the manufacturing system. [2]

ii) Find the average number of jobs in the system. [14]

Table M/M/C Queueing Results		
	M/M/1	M/M/C
L	$L_s = \dfrac{\lambda}{\mu - \lambda}$	$L_q + \dfrac{\lambda}{\mu}$
L_q	$L_q = \dfrac{\lambda^2}{\mu(\mu - \lambda)}$	$\dfrac{\rho(c\rho)^c p(o)}{c!(1-\rho)^2}$
W_q	$W_q = \dfrac{\lambda}{\mu(\mu - \lambda)}$	$\dfrac{(c\rho)^c p(o)}{c!c\mu(1-\rho)^2}$
W	$w_s = \dfrac{1}{\mu - \lambda}$	$W_q + \mu^{-1}$
P(0)	$P_o = 1 - \dfrac{\lambda}{\mu}$	$\left[\dfrac{(c\rho)^c}{c!(1-\rho)} + \sum_{n-o}^{c-1} \dfrac{(c\rho)^n}{n!}\right]^{-1}$
	$\rho = \dfrac{\lambda}{\mu}$	

End of Exam