NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

BACHELOR OF ENGINEERING (HONS) INDUSTRIAL AND MANUFACTURING ENGEEERING

MANUFACTURING SYSTEMS ENGINEERING

TIE 5215

SECOND SEMESTER MAIN EXAMINATION

APRIL / MAY 2015

This examination paper consists of 5 pages

Time Allowed: **3 hours**

Total Marks: **100**

Special Requirements: **Nil**

Examiner's Name: **Eng. T R Chikowore**

INSTRUCTIONS AND INFORMATION TO CANDIDATE

1. Answer ALL questions in SECTION A, and any THREE questions from SECTION B.
2. Each question carries 20 marks.
3. Use the formula table in Appendix A.

SECTION A (COMPULSORY)

Question 1

a) Despite management's best efforts, in some instances it is not feasible to shorten waiting times. Outline five actions that mangers can take to make the situation more acceptable to those waiting in the queue. [10]

b) The shipping department of a large plant receives about 20 shipping orders per day. Orders arrive either because all parts have been completed or the shipment is late and a partial order is being shipped. Most orders are small, requiring little packing and paper preparation. However, some orders are large and the average number of person-hours to fill an order is 1.5. Five workers are employed. Each is available 7.5 hours per day. Find the average number of jobs waiting to be shipped and the average time from receipt of an order until the order is completed. [10]

Question 2

a) A manufacturing company manufactures non-alcoholic beverages. Using this as an example, briefly discuss the steps involved in a simulation study. [10]

b) Using examples distinguish between the functions of the input analyser and the process analyser in Arena simulation software. [6]

c) Customers arrive at a workstation for service by a single worker. Arrivals have to wait in an infinitely large queue before getting service. Draw the event graph for the single-worker station system. [4]

SECTION B

Question 3

Two part types are processed at a workstation. Four part type A and six part type B arrive at the workstation per week. The service rate is 12 parts per week.

a) Suppose the parts are processed on a First Come First Served (FCFS) basis, determine:
   i) The throughput of each part type, [2]
   ii) The number of parts in queue of each part type. [2]

b) If part type A is given more priority, determine:
   i) The throughput of each part type, [6]
   ii) The number of parts in queue of each part type. [6]

c) Comment on any differences between the results in part *(a)* and those in part *(b)* of the question. [4]

Question 4

a) A shoe repair shop has one server. Customers arrive in the shop with a Poisson arrival distribution at a mean rate of 15 customers per hour. The server has an exponential service time distribution with mean service rate of 17 customers per hour. Determine the following system parameters:

   i) Average number of customers in the queue, [1]
   ii) Average throughput time, [1]
   iii) Average waiting time, [1]
   iv) The probability of waiting. [1]

b) Management has received complaints from customers on the length of queues and the waiting times. As a result, management wants to improve customer service and is therefore considering the following two approaches:

   Approach 1: Speed up service rate by reducing service time by 50% through mechanisation.
   Approach 2: Increase the number of customers in service per given time by increasing number of servers to 2.

   If the objective is to improve customer satisfaction, use the above listed system parameters to recommend the best approach to management. [12]

c) Briefly discuss the cost implications of your recommended approach. [4]

Question 5

a) Explain what is meant by steady state. Give reasons why this is an important concept in the analysis of queuing models. [6]

b) A fuel station has one attendant serving all customers. The inter-arrival times and service distributions, and the random digits are shown in Table Q5a, Q5b and Table Q5c respectively.

Table Q5a: Inter-arrival times distributions

Inter-arrival Time (min)	1	2	3	4	5	6	7	8
Probability	0.05	0.10	0.15	0.15	0.30	0.10	0.10	0.05

Table Q5b: Service times distributions

Service Time (min)	1	2	3	4	5	6
Probability	0.05	0.15	0.25	0.25	0.25	0.05

Table Q5c: Random Digits for Arrival and Service

Customer	1	2	3	4	5	6	7	8	9	10
Random Digits for Arrival	-	26	98	90	26	42	74	80	68	22
Random Digits for Service	95	21	51	92	89	38	13	61	50	49

a) Develop the simulation table and analysis for 10 customers. [12]
b) What is the average waiting time for a customer? [1]
c) What is the utilization of the attendant? [1]

Question 6

a) Briefly describe three classification methods for simulation models [9]

b) A computer consists of three processors. Their main task is to execute jobs from users. These jobs arrive according to a Poisson process with rate 15 jobs per minute. The execution time is exponentially distributed with mean 10 seconds. When a processor completes a job and there are no other jobs waiting to be executed, the processor starts to execute maintenance jobs. These jobs are always available and they take an exponential time with mean 5 seconds. But as soon as a job from a user arrives, the processor interrupts the execution of the maintenance job and starts to execute the new job. The execution of the maintenance job will be resumed later at the point where it was interrupted. Determine:

i) The mean number of processors busy with executing jobs from users [3]
ii) The mean number of maintenance jobs completed per minute [3]
iii) The probability that a job from a user has to wait [3]
iv) The mean waiting time of a job from a user [2]

Question 7

a) A three-machine workcell has a limited storage of four jobs. Additional jobs are held outside the cell until space is available. All jobs flow through machine 1, then machine 2, and then machine 3 before leaving the system. Jobs arrive randomly at a rate of 6 orders per day. Service times are also random and machines 1, 2 and 3 have mean service times of 0.125, 0.1 and 0.25 days respectively. Find the average number of jobs waiting to enter the system. [8]

b) You have been hired as a consultant for an insurance company. The company has a call centre handling questions of customers. Nearly 40 calls per hour have to be handled. The time needed to help a customer is exponentially distributed with mean 3 minutes. Determine the number of operators needed such that only 5% of the customers have to wait longer than 2 minutes? [6]

c) Determine the maximum length of a waiting line for specified probabilities of 90% and 98%, for a system in which the number of servers is 2, the arrival rate is 10 customers per hour, and the service rate is 12 customers per hour. [6]

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

END OF EXAMINATION PAPER