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SCHOOL OF MANAGEMENT

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MIDTERM EXAMINATION
ADM3305
Business Simulation

October 25, 2006

INSTRUCTIONS TO STUDENTS:
Answer all questions on the examination question sheets.
Show all work and make assumptions explicit where necessary.
Calculators, course notes and course textbook are permitted.
Please verify that your examination contains 11 pages.

STUDENT NAME: ____

STUDENT NUMBER: ___________________ SIGNATURE: _________________________

Question	Value	Mark
1	20	
2	30	
3	15	
4	35	
TOTAL	100	

Statement of Academic Integrity:
This work conforms to the rules on academic integrity of the University of Ottawa:

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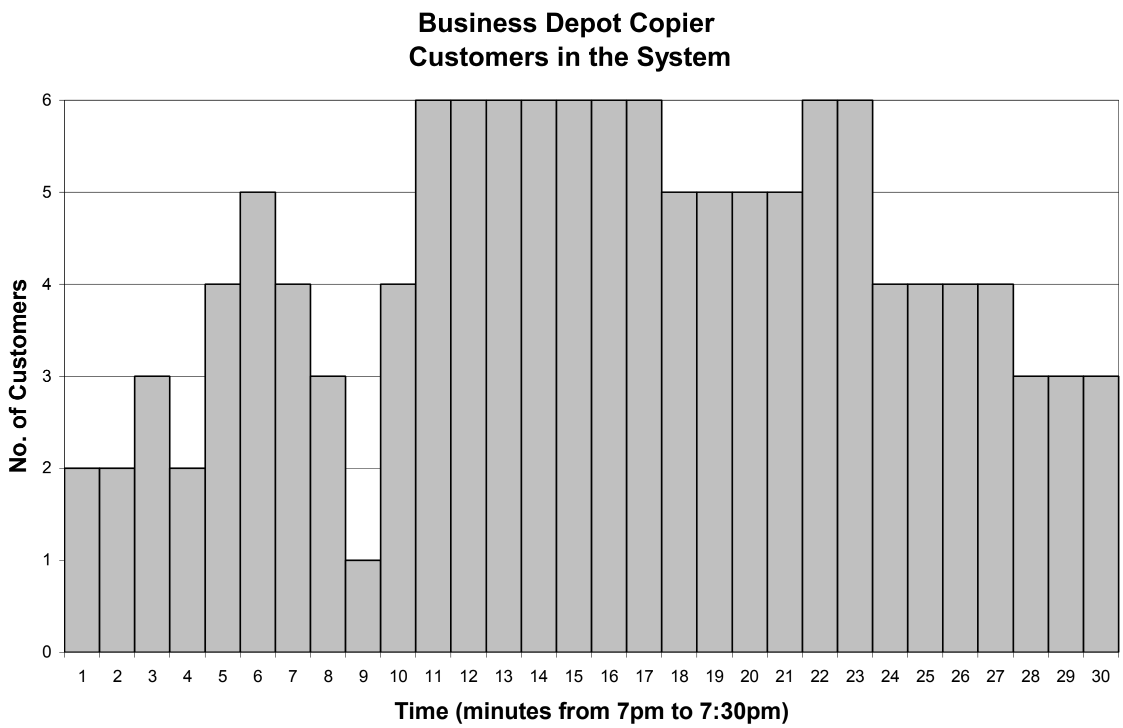
Please note that any submission in a course (homework, assignment, report, etc) that does not include that signed statement will not be corrected and will get a grade of zero.

QUESTION 1 (20 points) Simulation Modelling

(a) The time plot below records the number of customers in the system (waiting and in-service) at the only functional copier at the Business Depot outlet in Orleans between 7pm and 7:30pm last Friday night. In the space below, draw a histogram of the numbers of customers in the system corresponding to this time plot. Use 6 cells in your histogram and clearly identify the cell definitions and the counts of customers in each cell. (10 points)



QUESTION 1 (continued)

(b) Your new iPod contains a linear congruential pseudo random number generator (PRNG) used to play a random selection of a set of songs. The PRNG has parameters: a=3, b=7, and z0=99. You have just downloaded 6 songs (Tracks #1 through #6) from John Mayer's new CD "Continuum" and you want these songs to play in a random order. Determine the ordered list of tracks that the iPod will play using the defined PRNG. (10 points)

QUESTION 2 (30 points) Manual Simulation and Random Number Generation

The Ottawa Hospital Emergency Room. Halloween is a dark time for hospital emergency rooms. Suppose you have come down with a fever (from eating too much Halloween candy) and you must go directly to the General Hospital Emergency Department. Once you arrive, you find that there is a single doctor on duty who will eventually need to see you. Other sick people like you have already arrived with times between their arrivals that are exponentially distributed with a mean time between arrivals of 6 minutes. Doctor consultation (service) times are uniformly distributed with times varying between 8 and 12 minutes.

The table below provides the results from a generated uniform zero-one values series, U(0,1) obtained from a pseudo random number generator (and recorded in columns (1) and (2) in the table below). You are required to generate simulated arrival times and simulated service times (each measured in minutes) for four successive emergency arrivals as in the table below.

(a) Determine from the results of this table below the average wait time for the four emergency department arrivals assuming that the first case arrives at 9:00pm on Halloween night when the system is idle. (16 points)

Case	*(1) U(0,1)*	*Time Btwn Arrivals*	*Simulated Arrival Time*	*(2) U(0,1)*	*Simulated Service Time*	*Start of Service*	*End of Service*	*Wait Time*
1	-			0.62				
2	0.11			0.17				
3	0.59			0.53				
4	0.38			0.48				

(b) You are the last of the four arrivals noted above and assume there are no others after you. Draw below the time plot of the number of arrivals to the emergency department from 9:00p.m. until you leave the system and state the time (on the clock) that you will be able to leave the hospital after your doctor's consultation has ended. (10 points)

(c) Calculate the average number of emergency patients in the hospital between 9:00pm and when you finally leave the hospital. (4 points)

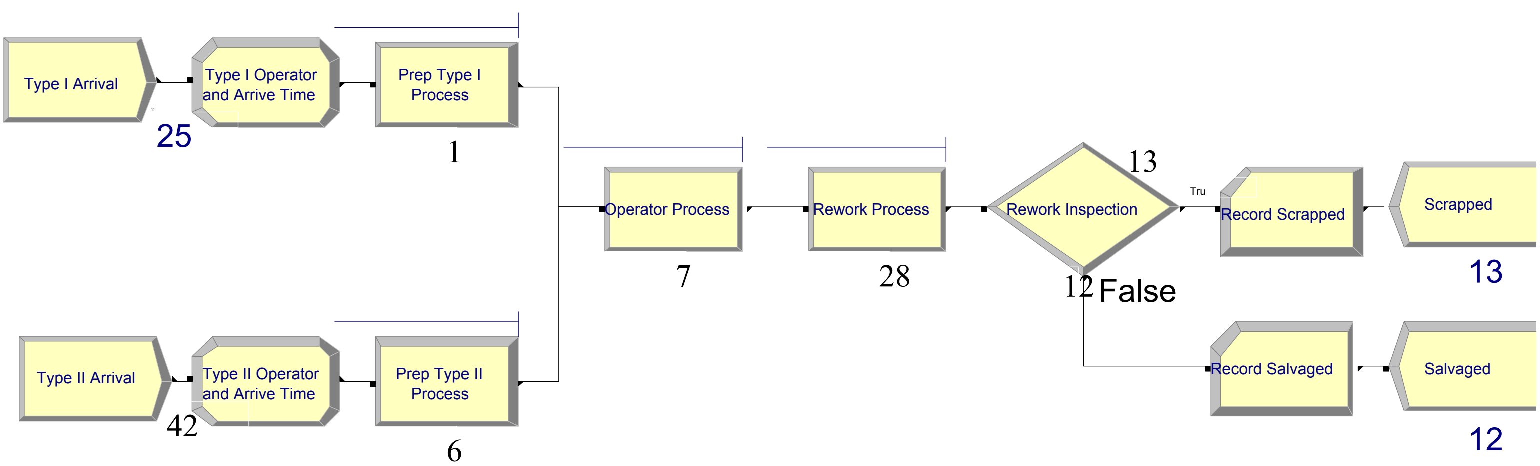
QUESTION 3 (15 points) Interpreting *Arena* Output

The NRC Simulator. NRC scientists are experimenting with heated concrete highways in winter. They have designed a system designed to handle two different vehicles – Type I and Type II vehicles (e.g., passenger and commercial vehicles). Type I and Type II entities have exponential interarrival times with means of 10 minutes and 5, respectively.

Vehicles are "prepared" for the highway (e.g., are brought up to speed) with uncertain times measured as a triangular random variable with parameters (2,4,6) minutes for Type I vehicles, and parameters (3,5,7) minutes for the Type II vehicles. The concrete highway is then "prepared" (turned on) by an operator as the vehicle passes a check point after vehicle preparation ("Operator Process"). The Operator Process takes zero time. If a vehicle "fails" on the road (e.g., its stopping distance is tested) for either Type, then it is recorded in the simulation and the station "reworked" for the next vehicle. The Rework Process has an exponential service rate with a mean time of 10 minutes. Laboratory tests expect about 50% of all vehicle tests (Type I and II) to fail.

It is NRC's particular problem in this model to know how many vehicles of each type do not fail the test. The scientists are also interested in: (i) how many vehicles may end up in a "back-up" wait process while others are being prepared, observed (operator process), and reworked, (ii) the total number of successfully processed vehicle counts through the system by Type, as well as (iii) the total number of scrapped (failed) vehilce results.

A simulation model of the road experiments is provided in the *Arena* model given below.



Based on this simulation model described and shown above, fill in the summary output table on the next page with the required *Arena* results (marked as **BOLD** alphabetic capitals, A through) that correspond to the road simulation model results above. (15 points – 1 point per item)

QUESTION 3 (continued) Interpreting *Arena* Output

ARENA Simulation Results
Summary for Replication 1 of 1

Replication ended at time : 4.0 Hours Base Time Units: Hours

TALLY VARIABLES

Identifier	Average	Minimum	Maximum	Observatns
Record Scrapped	1.5878	.37998	2.6399	**A=**
Record Salvaged	1.6029	.56301	2.2761	12
Operator Process.WaitTimePerEntity	.20259	**O=**	.69313	53
Operator Process.VATimePerEntity	.06673	.00567	.31853	53
Operator Process.TotalTimePerEntity	.26932	.01041	.76719	53
Rework Process.VATimePerEntity	.15658	.00505	.57566	**B=**
Rework Process.WaitTimePerEntity	1.1862	**O=**	2.1005	25
Rework Process.TotalTimePerEntity	**C=**	.28637	2.1640	25
Prep Type I Process.VATimePerEntity	.06703	.03596	.09522	24
Prep Type I Process.WaitTimePerEntity	.01602	**O=**	.10786	24
Prep Type I Process.TotalTimePerEntity	.08305	.04473	.16457	24
Prep Type II Process.VATimePerEntity	.08644	.05474	.11494	36
Prep Type II Process.WaitTimePerEntity	.16776	.00000	.37867	36
Prep Type II Process.TotalTimePerEntity	.25420	.07818	.45867	36
Type I.VATime	.24861	.08764	.61562	12
Type I.WaitTime	**D=**	.00000	2.2607	12
Type I.TotalTime	1.4233	.37998	2.4125	**E=**
Type II.VATime	**F=**	.15269	.89336	13
Type II.WaitTime	1.4025	.26421	2.1634	**G=**
Type II.TotalTime	1.7536	.42322	2.6399	13
Prep Type I Process.Queue.WaitingTime	.01538	**I=**	.10786	25
Prep Type II Process.Queue.WaitingTime	.17440	**H=**	.41329	37
Operator Process.Queue.WaitingTime	.20664	.00000	.69313	54
Rework Process.Queue.WaitingTime	1.2201	.00000	2.1005	26

OUTPUTS

Identifier	Value
Operator Process Number Out	**J=**
Prep Type II Process Number In	42.000
Prep Type I Process Number Out	**K=**
Prep Type I Process Number In	25.000
Prep Type II Process Accum Wait Time	6.0394
Rework Process Accum VA Time	3.9144
Prep Type II Process Number Out	**L=**
Prep Type II Process Accum VA Time	3.1117
Prep Type I Process Accum Wait Time	.38452
Operator Process Number In	60.000
Rework Process Number In	53.000
Operator Process Accum Wait Time	10.737
Prep Type I Process Accum VA Time	1.6087
Rework Process Accum Wait Time	29.656
Rework Process Number Out	25.000

Operator Process Accum VA Time	3.5367
Type I.NumberIn	**M=**
Type I.NumberOut	12.000
Type II.NumberIn	**N=**
Type II.NumberOut	13.000
Operator.NumberSeized	54.000
Operator.ScheduledUtilization	.89678
Rework.NumberSeized	26.000
Rework.ScheduledUtilization	.98178
System.NumberOut	25.000

QUESTION 4 (35 POINTS)   *Arena* Modelling

On Saturday, October 21, 2006 the Ford Ironman World Championships took place at Kona, Hawaii, site of the original Ironman Triathlon. The Ironman consists of: first event - the swim (2.4 miles in Kona harbour); second event - the bicycle ride (112 miles through the lava fields), and finally the marathon run (26.2 miles – the traditional marathon distance through the town). This year's race attracted some 1700 athletes from around the world all of whom needed to qualify at officially sanctioned local Ironman triathlons. Of all the cities represented at these world championships, Ottawa, Canada sent more athletes than any other city. (See also www.Ironman.com for details). The 2006 race was won by Normann Stadler of Germany (age 33) in a time of 8 hours, 11 minutes, and 56 seconds with splits for the events of 54 minutes and 5 seconds (swim), 4 hours, 18 minutes, 23 seconds (bike), and 2 hours 55 minutes and 2 seconds (run). The women's event was won by Michellie Jones of Australia (age 37) in a time of 9 hours, 18 minutes, and 31 seconds with splits for the events of 54 minutes and 29 seconds (swim), 5 hours, 6 minutes, 9 seconds (bike), and 3 hours 13 minutes and 8 seconds (run). (Lisa Bentley of Canada was third!)

As a triathlon athlete in training, you are interested in estimating your own range of finishing times for the Kona event. The race begins with a mass start on the swim line. After the swim, each racer must return to the bicycle transition area where they served by a volunteer who retrieves the racer's bike and gives the racer his/her bicycle race number. The racer then mounts his/her bike and begins the bike segment of the race. After the bike ride, each racer must return again to the bicycle transition area where they are served by another volunteer who collects the racer's bike and gives the racer his/her running race number. The race ends when the marathon run is completed and you are now an Ironman! Congratulations.

Based on your training times and all the possibilities and unknowns awaiting you at Kona, you determined the following parameters for each event (set your own – pretend - values with reference to the times of the winning performances above):

Event No.	Event	Time (hours) Distribution	Parameter 1	Parameter 2	Parameter 3
1	Swim	Normal			
2	Swim-Bike transition	Exponential	6 minutes		
3	Bike	Uniform			
4	Bike-Run transition	Exponential	12 minutes		
5	Run	Triangular			

QUESTION 4 (continued) *Arena* Modelling

(a) Draw an *Arena* system diagram to simulate your race in the Ironman triathlon. Indicate clearly on your diagram the required module parameters for the race process and state how you will control the simulation. (10 points)

(b) Embellishment: Time tracking. Use your simulation model in (a) to have *Arena* record the split times for each of the 3 triathlon events – swim, bike, and run, as well as the time of the overall event completion. (7 points)

(c) Embellishment: Given your data parameters, the simulation model provides a possible range of total completion times subject to different race uncertainties, e.g., weather, accidents, etc. State how you would determine your possible range of finishing times for the various events of the Ironman and explain how you would use *Arena* to obtain results for 100 simulation races. (6 points)

(d) Embellishment: Augment your model to simulate the Kona 2006 race. At this race there were two categories of competitors: (1) Professionals (men and women) and (2) Age Groupers (men and women). The Pros stated 15 minutes ahead of the Age Groupers. The Pros (200 of them) were all world class athletes with much faster event times than the Age Groupers (1500 of them). Assuming you knew their respective Pro and Age Grouper event time parameters, show how your simulation model could use these data to simulate the entire race. (6 points)

QUESTION 4 (continued) *Arena* Modelling

(e) Embellishment: Race organizers limit the total time to complete the course to 17 hours. Moreover, they will not allow racers to begin the run if more than 12 hours has passed since the start of the race. Show how you could model these terminating conditions by indicating the changes to your simulation model in the space below. (6 points)