École de gestion TELFER School of Management

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Fall 2012
MIDTERM EXAMINATION
ADM3305
Business Simulation

November 1, 2012

Duration: 80 minutes

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 9 pages.

STUDENT NAME: ____

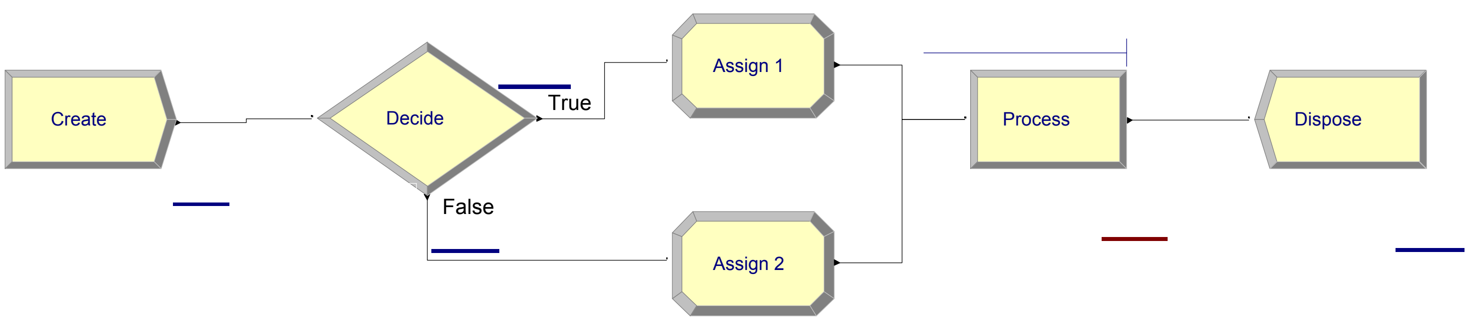
STUDENT NUMBER: __________________ SIGNATURE: __________________________

Question	Value	Mark
1	25	
2	25	
3	20	
4	30	
TOTAL	100	

QUESTION 1 (25 points) **Simulation Modelling using *Arena***

(a) Consider the following *Arena* system diagram with a single machine/server at Process 1 and the following module parameters:

```
;      Model statements for module:  Create
             TimeBetween=Constant,Value=12; FirstCreationTime=10; Max Arrivals=5;
;      Model statements for module:  Decide
             If,TNOW > 25 Then TRUE; else FALSE; "TNOW = Current Simulation Time"
;      Model statements for module:  Assign 1
             Attribute 1= UNIF(20,20.0001);
;      Model statements for module:  Assign 2
             Attribute 1= TRIA(8.99999,9,9.0001);
;      Model statements for module:  Process
             SEIZE, Resource 1,1;
             DELAY: Attribute 1;
             RELEASE: Resource 1,1;
;      Model statements for module: Dispose
```



(i) Fill in the dashes above with the standard *Arena* results for the end of the simulation. (5 points)

(ii) Complete the table below to for the passage of the 5 entities through this system. (10 points)

Entity Number	*Time between arrivals*	*Actual Arrival Time*	*ASSIGN 1 or 2 Value*	*Start Service Time*	*Service Time*	*End of Service Time*	*Wait Time*	*Time In System*
1	0							
2								
3								
4								
5								

QUESTION 1 (25 points) **Simulation Modelling (continued)**

(b) In the space below, draw the time plot for the "Number of Entities in the System" for the following data observed for arrivals and service to the Tim Horton's Shop in Montpetit. At the time of these data collection, there was a single-server queue. It is assumed that time starts at t=0. (10 points)

Customer	Time Between Arrivals	Service Time
C1	3	5
C2	1	8
C3	4	4
C4	6	7
C5	2	3
C6	5	3

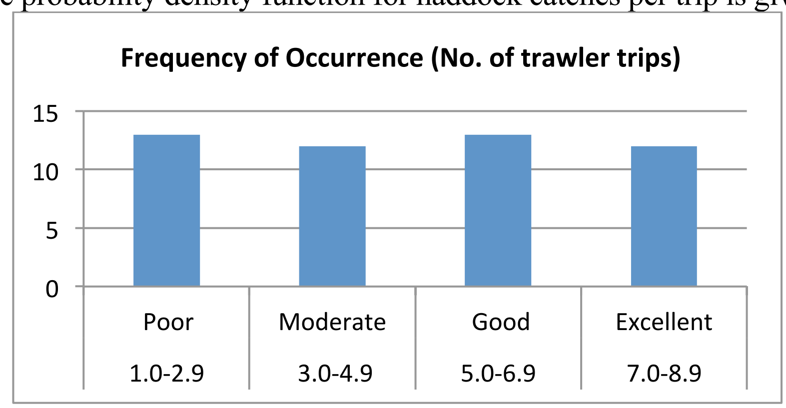
QUESTION 2 (20 POINTS) **Random Variables and the Inverse Transformation**

Inshore Fisheries of Pubnico, Nova Scotia catch haddock using 65 foot mobile trawlers in the region known as George's Bank. In 2011, Fisheries and Oceans, Canada scientists declared the George's Bank haddock fishery as "healthy" given its high level of estimated abundance. In turn, the fishery has "netted" *Inshore* a healthy profit. Haddock catches per trip by their trawlers over the lucrative Christmas season (November-December) have ranged from a low of 1018kg to an all-time high of 8820kg. The distribution of trawler haddock catches per trip (in thousands of kilograms) is summarized into 4 cell categories in the table below.

Inshore Haddock Catches – Trawler Trips to date

Cells of catches amounts (000s kg): *Verbal Catch Description:*	1.0-2.9 Poor	3.0-4.9 Moderate	5.0-6.9 Good	7.0-8.9 Excellent	**Total no. 2011 trips**
Frequency of Occurrence (No. of trawler trips)	13	12	13	12	50

The histogram of the probability density function for haddock catches per trip is given below:



(a) Draw the corresponding cumulative probability distribution function for these data and characterize this distribution for the continuous random variable "haddock catches per trip (in 000s kg)". (10 points)

QUESTION 2 (continued) **Random Variables and the Inverse Transformation**

(b) In the space below, write down the inverse transformation function corresponding to the characterized cumulative probability distribution function above in (a). (7 points)

(c) Use the linear congruential generator with $a=3$, $b=7$, $c=96$, and $z_0=51$ to generate three (3) Z scores and corresponding u values as U(0,1) random numbers in the table below. Use the inverse transformation function from (b) above to transform the three u values into simulated *Inshore* haddock catches, x. Record the values in the table below. (8 points)

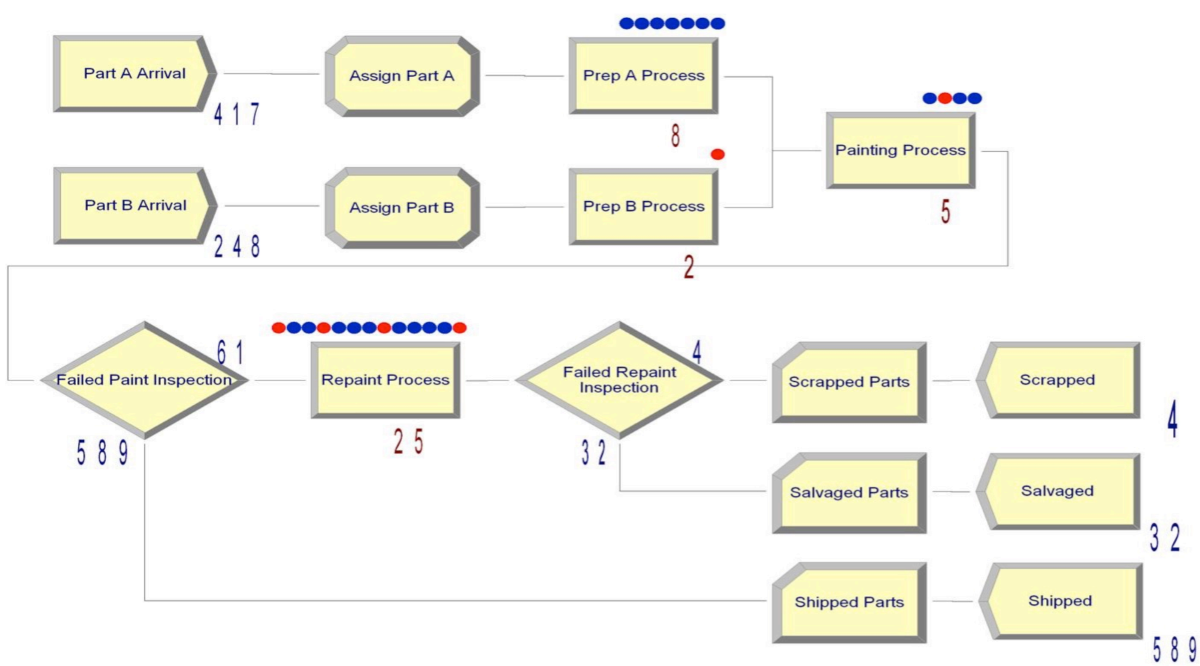
i	Z	u	x
1			
2			
3			

QUESTION 3 (20 points) Interpreting *Arena* Output

The system below represents the last stage of production of ride-on ponies for boys' (Part A-blue) and girls' (Part B-red). All arriving parts are complete and require only a finished custom paint job. All ponies have exponential interarrival times. Boys' ponies (Part A) have an average time between arrivals of 15 minutes; girls' ponies (Part B) have an interarrival mean of 30 minutes.

On arrival, all ponies are immediately sent to their respective painting preparation (seize-delay-release) processes (Prep A and Prep B) with times (in minutes) of TRIAG(1,4,8) and TRIAG(3,5,10) where they are trimmed and cleaned with a solution prior to painting. The Painting process times for As and Bs take TRIAG(1,3,4) and WEIB(2.5,5.3) (in minutes) respectively.

An inspection process sends 9% (failed parts) overall to the "Repainting" process where they are stripped and repainted with a mean of 45 minutes per part distributed exponentially. Finally, 80% of repainted parts are salvaged; the rest are scrapped. The Arena model below collects statistics on parts shipped, salvaged and scrapped. The model is controlled by time and is run for 4-8 hour shifts or a total of 4*8*60=1920 minutes. A single trial of the model is illustrated below.



a) From the system description and the output shown above, identify a possible "bottleneck" in this *Arena* network model, and suggest ways and means of improving the throughput of this model by "fixing" the bottleneck you identified. (5 points)

QUESTION 3 (20 points) Interpreting *Arena* Output (continued)

(b) The *Arena* summary output of this model is shown in the results below. Based on the simulation model description and illustrated results above, fill in the summary output table for the selected items below marked as **BOLD** alphabetic capitals, A through J. (15 points – 1.5 points per item)

ARENA Simulation Results
Summary for Replication 1 of 1
Replication ended at time: 1920.0 Minutes Base Time Units: Minutes

TALLY VARIABLES

Identifier	Average	Minimum	Maximum	Observations
Scrapped Parts	737.18	631.91	829.80	**A:**
Prep A Process.TotalTimePerEntity	**B:**	2.0993	50.783	409
Prep A Process.WaitTimePerEntity	14.608	.00000	46.345	409
Painting Process.TotalTimePerEntity	5.0415	1.0814	15.869	650
Salvaged Parts	503.84	24.977	876.85	32
Repaint Process.VATimePerEntity	50.416	.12483	278.36	**C:**
Shipped Parts	28.759	3.6795	93.481	589
Prep B Process.WaitTimePerEntity	**D:**	.00000	85.951	246
Repaint Process.TotalTimePerEntity	497.36	15.940	854.34	36
Prep B Process.VATimePerEntity	5.8948	3.1809	9.7833	246
Painting Process.VATimePerEntity	2.5354	.96244	3.9210	**E:**
Repaint Process.WaitTimePerEntity	446.94	.00000	810.98	36
Prep A Process.VATimePerEntity	4.2402	1.2564	7.7478	409
Prep B Process.TotalTimePerEntity	32.607	3.8612	90.858	246
Painting Process.WaitTimePerEntity	2.5061	**F:**	14.045	650
Prep A Process.Queue.WaitingTime	14.621	.00000	46.345	410
Prep B Process.Queue.WaitingTime	26.903	.00000	85.951	247
Repaint Process.Queue.WaitingTime	456.35	.00000	810.98	37
Painting Process.Queue.WaitingTime	2.5152	.00000	14.045	651

DISCRETE-CHANGE VARIABLES

Identifier	Average	Minimum	Maximum	Final Value
Painting.NumberBusy	.85949	.00000	1.0000	1.0000
Painting.NumberScheduled	1.0000	.00000	1.0000	1.0000
Painting.Utilization	.85949	.00000	1.0000	1.0000
Prep A.NumberBusy	.90385	.00000	1.0000	1.0000
Prep A.NumberScheduled	1.0000	.00000	1.0000	1.0000
Prep A.Utilization	.90385	.00000	1.0000	1.0000
Prep B.NumberBusy	.75753	**G:**	1.0000	1.0000
Prep B.NumberScheduled	1.0000	.00000	1.0000	1.0000
Prep B.Utilization	**H:**	.00000	1.0000	1.0000
Prep A Process.Queue.NumberInQueue	3.1680	.00000	11.000	7.0000
Prep B Process.Queue.NumberInQueue	3.5017	.00000	14.000	1.0000
Repaint Process.Queue.NumberInQueue	12.953	.00000	26.000	24.000
Painting Process.Queue.NumberInQueue	.86311	.00000	6.0000	4.0000

OUTPUTS

Identifier	Value	Identifier	Value
Painting Process Number Out	650.00	Prep A.NumberSeized	**I:**
Repaint Process Accum VA Time	1814.9	Prep A.ScheduledUtilization	.90385
Prep B Process Accum VA Time	1450.1	Prep B.NumberSeized	247.00
Repaint Process Number Out	36.000	Prep B.ScheduledUtilization	.75753
Prep B Process Number In	248.00	Repaint.NumberSeized	37.000
Repaint Process Number In	61.000	Repaint.ScheduledUtilization	.94954
Prep A Process Number Out	409.00	Painting Process Accum Wait Time	1628.9
Prep B Process Accum Wait Time	6571.4	Paint.NumberSeized	651.00
Repaint Process Accum Wait Time	16090.	Paint.ScheduledUtilization	.85949
Prep A Process Number In	417.00	Prep A Process Accum VA Time	1734.2
Prep A Process Accum Wait Time	5974.6	Painting Process Number In	**J:**
Prep B Process Number Out	246.00	Painting Process Accum VA Time	1648.0

QUESTION 4 (30 POINTS) ***Arena* Modelling**

The Wal-Mart store in the Greenboro Shopping Centre is open from 8am until 10pm daily (14 open hours). The Wal-Mart security staff monitor customers classified into two types: (1) browsers ("shoppers" who do not actually buy anything) and (2) buyers. Throughout the day, buyers enter at an average rate of 30 per minute, while browsers arrive at a rate of 10 per minute (both mean times are estimated parameters for exponential times between arrivals). All customers spend between 20 and 40 minutes (uniformly distributed) browsing and shopping in the store. On completion of shopping, buyers proceed to one of the 3 open cashiers (selecting cashiers according to the current length of their queue lines), line-up, and pay for their purchases before exiting the store. Browsers simply leave the store.

(a) Simulate, for one business day, the daily dynamics of browsers and buyers at Wal-Mart by drawing the *Arena* system diagram below (you may also use the back pages of the exam booklet, if needed). Indicate clearly on your diagram the necessary parameters and their values for the *Arena* modules, as needed, as well as how you will control the simulation. (12 points)

QUESTION 4 (30 POINTS) *Arena* Modelling (continued)

(b) Experienced Wal-Mart buyers (about 25% of all buyers) know that between Noon and 4pm, while the Wal-Mart 'Jewellery Counter' is open, you may checkout your purchases at this single server site. Draw the additional network diagram using *Arena* modules to accommodate this occurrence and show how this diagram is connected to the original diagram in part (a) above. (10 points)

(c) Wal-Mart has announced in its flyers that on Thursday, November 1 – the day after Halloween - a big "everything must go" sale will be held on all its Halloween decorations. Wal-Mart security anticipates that customers will begin arriving to the store (at the normal arrival rate) at 7:30am to take advantage of this – even though the store will not open until 8am as usual. Moreover, they anticipate that they will need to keep the store open until 10:30pm in the evening on November 1 in order to process customers through cash. However, security will close the doors (to new entrants) at 10pm as usual. Modify the problem parameters above to simulate the Wal-Mart sale between 8am and until all customers have left the store. (8 points)