Université d'Ottawa · University of Ottawa
SCHOOL OF INFORMATION TECHNOLOGY AND ENGINEERING

COURSE: CSI4124/SYS5110 Foundations on Modeling and Simulation
PROFESSOR: Gilbert Arbez

SEMESTER: FALL 2009
DATE: December 9, 2009
TIME: 14h00 to 17h00 (3 hours)

FINAL EXAMINATION

NAME and STUDENT NUMBER:_____/_____

There are four (4) parts in this examination.

Part 1	Short answer questions	20 marks	
Part 2	Conceptual Modelling	35 marks	
Part 3	Simulation Modelling	20 marks	
Part 4	Experimentation and Output Analysis	25 marks	
Total		100 marks	

All questions are answered in the examination paper. If you require more space, use the back of the pages.

Calculators are permitted.

Total number of pages: 14

Part 1 – Short Answer Questions (20 points – 2 points each)

Complete the following questions using a few words or a simple phrase.

1) The ABCmod conceptual modeling framework is based on which DEDS World View?

2) What list is used to advance time in Event Scheduling simulation programs?

3) In the case of a steady-state study, an initial experimentation is required before experiements are used to generate output for final analysis. What does this initial step provide?

4) What construct is used in the ABCmod conceptual modeling framework to specify status changes that occur at points in time?

5) Circle the three traditional World views used with DEDS modeling and simulation?

UML	Process Oriented	Event Notice
Activity Scanning	FEL	Transaction
Time Advance	Entity	Event Scheduling

6) Which intervention in the ABCmod conceptual modeling framework uses a precondition?

7) ABCmod Entities are characterized by *scope* and *role*? Which one determines whether entities have a temporary or permanent existance in the model?

8) What are the two ABCmod output variable types used to specify sets of output values to be recorded during simulation?

9) An interaction between entities, which cannot be interrupted and is initiated under certain conditions, is modeled with what ABCmod framework behavioural construct?

10) Ensuring that the simulation model implements properly the conceptual model is called **Verification** or **Validation**?

Part 2 – Conceptual Modelling (35 marks)

For the Painting Parts Project (see the provided project description in the Annex), complete the ABCmod conceptual model sections below. Note that the model is a closed system, that is, no inputs are defined in the model.

2 ABCmod Conceptual Model

2.1 High Level Conceptual Model

2.1.1 Structural Diagram

2.1.2 Data Model List

2.1.3 Behavioural Diagram

2.2 Detailed Conceptual Model

Structural Components (Entity Structures)

Attributes	**Description**

Attributes	**Description**

Attributes	**Description**

Attributes	**Description**

Data Modelling Components

Constants		
Name	**Description**	**Value**
Parameters		
Name	**Description**	**Value**

Data Modules		
Name	**Description**	**Data Model**

Output Components

OUTPUTS			
Simple Scalar Output Variables (SSOVs)			
Name	**Description**		
Trajectory Sets			
Name	**Description**		
Sample Sets			
Name	**Description**		
Derived Scalar Output Variables (DSOV's)			
Name	**Description**	**Data Set Name**	**Operator**

Behavioural Components

Time units:

Observation interval:

Initialize

User Defined Modules	
Name	**Description**

Activity Construct:	
Precondition	
Event	
Duration	
Event	

Activity Construct:	
Precondition	
Event	
Duration	
Event	

Triggered Activity Construct:	
Event	
Duration	
Event	

Triggered Activity Construct:	
Event	
Duration	
Event	

Part 3 – Simulation Modelling (20 marks total)

As part of creating an Activity Object Scheduling Simulation program for the Painting Parts Project, provide the Java Classes used to implement the Behaviour constructs (Activities and Triggered Activities) you specified in the conceptual model from Question 2. Please limit yourself to implementing the contents of the behaviour constructs, that is, it is not necessary to implement the initialization, data modules, user-defined modules, etc.

Part 3 (continued)

Part 4 – Experimentation and Output Analysis (25 marks total)

A) Validation

Consider the following output for validating the model, where the number of stations was first set to 1 and then to 10. Explain how the output can be interpreted to validate the model.

		NumStations			
		1		10	
	Run	Manipulator Utilisation	Station Utilisation	Manipulator Utilisation	Station Utilisation
	1	0.200	0.796	0.9965	0.3895
	2	0.206	0.789	0.9969	0.3902
	3	0.199	0.796	0.9965	0.3878
	4	0.199	0.796	0.9968	0.3905
	5	0.202	0.793	0.9962	0.3910
	6	0.203	0.794	0.9968	0.3863
	7	0.203	0.793	0.9964	0.3895
	8	0.202	0.793	0.9964	0.3907
	9	0.204	0.792	0.9963	0.3888
	10	0.197	0.798	0.9965	0.3932
	11	0.202	0.793	0.9968	0.3918
	12	0.202	0.794	0.9964	0.3897
	13	0.202	0.793	0.9961	0.3897
	14	0.205	0.791	0.9965	0.3873
	15	0.205	0.791	0.9968	0.3895
	16	0.207	0.790	0.9968	0.3900
	17	0.205	0.790	0.9967	0.3900
	18	0.205	0.791	0.9963	0.3923
	19	0.200	0.796	0.9967	0.3926
	20	0.205	0.791	0.9965	0.3868
Sample Mean		0.203	0.793	0.997	0.390
Std Dev (s)		0.003	0.002	0.0002	0.002
	ζ	0.001	0.001	0.000	0.001
Min Value		0.202	0.792	0.996	0.389
Max Value		0.204	0.794	0.997	0.391

B) Output Analysis

Consider the following results obtained from 20 simulation runs for the Painting Parts Project.

		NumStations							
		3		4		5		6	
	Simul. Run	Manipulator Utilisation	Station Utilisation	Manipulator Utilisation	Station Utilisation	Manipulator Utilisation	Station Utilisation	Manipulator Utilisation	Station Utilisation
	0	0.593	0.773	0.768	0.747	0.910	0.708	0.994	0.645
	1	0.593	0.769	0.768	0.747	0.914	0.712	0.990	0.644
	2	0.597	0.772	0.769	0.750	0.921	0.714	0.993	0.641
	3	0.596	0.773	0.769	0.751	0.921	0.718	0.994	0.647
	4	0.593	0.772	0.766	0.751	0.915	0.716	0.990	0.646
	5	0.598	0.774	0.772	0.748	0.918	0.710	0.994	0.641
	6	0.599	0.770	0.767	0.744	0.915	0.712	0.993	0.645
	7	0.590	0.773	0.767	0.751	0.912	0.714	0.990	0.645
	8	0.592	0.770	0.765	0.743	0.914	0.712	0.994	0.645
	9	0.587	0.777	0.759	0.751	0.908	0.717	0.992	0.651
	10	0.595	0.772	0.767	0.749	0.913	0.714	0.992	0.648
	11	0.593	0.773	0.768	0.752	0.910	0.711	0.992	0.645
	12	0.594	0.772	0.766	0.749	0.912	0.710	0.992	0.645
	13	0.595	0.772	0.764	0.743	0.921	0.715	0.993	0.642
	14	0.597	0.773	0.770	0.749	0.916	0.712	0.993	0.644
	15	0.595	0.767	0.766	0.746	0.917	0.715	0.993	0.646
	16	0.597	0.770	0.772	0.747	0.918	0.713	0.994	0.646
	17	0.590	0.772	0.766	0.754	0.912	0.715	0.991	0.649
	18	0.587	0.775	0.761	0.750	0.912	0.716	0.992	0.649
	19	0.601	0.771	0.772	0.744	0.921	0.712	0.994	0.642
Sample Mean		0.594	0.772	0.767	0.748	0.915	0.713	0.993	0.645
Std Dev (s)		0.004	0.002	0.003	0.003	0.004	0.003	0.001	0.003

- Provide output analysis of the above results (be sure to provide appropriate confidence intervals) and discuss the results relative to the project goal.
- Make a recommendation of another possible Modelling and Simulation Study to explore balancing the use of stations and manipulators to improve their utilization (if possible).

Part 4b (continued)