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 2010
DATE: December 10, 2009
TIME: 9:30 to 12:30 (3 hours)

FINAL EXAMINATION
Solution

Name and Student Number: _____/_____

There are four (4) parts in this examination.

Question 1	Short answer questions	20 marks	
Question 2	Conceptual Model	30 marks	
Question 3	Simulation Model	10 marks	
Question 4	Experimentation and Output Analysis	15 marks	
Total		75 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: 16

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

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

1) What does Welchs procedure provide?
   Warm-up time.

2) A piece wise continuous (PWC) function can be drawn for sample set output variables, trajectory set output variables or both sample set and trajectory set output variables?
   Trajectory set output variables

3) What form of differential equations is used in continuous conceptual models??
   First order differential equations or normal form.

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

5) Circle the three terms that are unique to the Activity Object Simulation World View?

Transaction	SBL (Scheduled Behaviour List)	Future Event
Time Advance	Entity	Event Scheduling
Activity Instance	BootStrapping	Behaviour Object

6) Which intervention in the ABCmod conceptual modeling framework does not use preconditions?
   Pre-emption.

7) ABCmod Entities are characterized by *scope* and *role*? What value of scope is used to define temporary entities?
   Class.

8) Are simple scalar output variables (SSOV) based on point set output variables?
   No.

9) Which ABCmod behaviour construct has the following characteristics: it's duration cannot be seperated into disjoint time periods, an instance of the construct is created when specific conditions are true?
   Activity construct.

10) Express the following set of differential equations in a form that MatLab can solve.

$$x_1'(t) = \alpha x_2(t) + \beta x_1(t)$$
$$x_2'(t) = \gamma x_2(t)$$

```
function dxdt = dyn(t, x)
    global alpha, beta, gamma
    dxdt = [
               alpha*x(2) + beta*x(1)
               gamma*x(2)
           ];
```

Question 2 – Conceptual Modelling (30 marks)

Review the Electronic Assembly and Test System Project provided in the exam annex and complete the following activity constructs for the project.

Scheduled Action: PartAArrivals	
The arrival of part A units.	
TimeSet	t = tk Є CDS[uPartA] as defined by DM.PartAArrival()
Event	iC.Part ← Derive[Part] iC.Part.Type ← A iC.Part.ArrivalTime ← t iC.TimeEnteredQueue ← t SM.InsertQue(Q.PrepALine, iC.Part)

Scheduled Action: PartBArrivals	
Arrivals of batches of part B units.	
TimeSet	t = tk Є CDS[uPartB] as defined by DM.PartBBatchInterArr()

Event	i ← 0
	WHILE i < 4
	  iC.Part ← Derive(Part)
	  iC.Part.Type ← B
	  iC.Part.ArrivalTime ← t
	  iC.Part.TimeEnteredQueue ← t
	  SM.InsertQue(Q.PrepBLine, iC.Part)
	ENDWHILE

Activity Construct: PreparationA	
The preparation of Part A units.	
Precondition	Q.PrepALine.N > 0 AND R.PrepA.Busy = FALSE
Event	R.PrepA.Busy ← TRUE iC.Part ← SM.RemoveQue(Q.PrepALine) SM.Put(PHI[PrepAWaitingTimes], t - iC.Part.TimeEnteredQueue)
Duration	DM.PrepATime()
Event	iC.Part.TimeEnteredQueue ← t SM.InsertQue(Q.SealerLine) R.PrepA.Busy ← FALSE

Activity Construct: PreparationB	
The preparation of Part A units.	
Precondition	Q.PrepBLine.N > 0 AND R.PrepB.Busy = FALSE
Event	R.PrepB.Busy ← TRUE iC.Part ← SM.RemoveQue(Q.PrepBLine) SM.Put(PHI[PrepBWaitingTimes], t - iC.Part.TimeEnteredQueue)
Duration	DM.PrepBTime()
Event	iC.Part.TimeEnteredQueue ← t SM.InsertQue(Q.SealerLine) R.PrepB.Busy ← FALSE

Activity Construct: Sealing	
Activity where the electronic components are inserted, the case is assembled and sealed, and the sealed unit is tested	
Precondition	Q.SealerLine.N > 0 AND R.Sealer.Busy = FALSE
Event	R.Sealer.Busy ← TRUE iC.Part ← SM.RemoveQue(Q.SealerLine) SM.Put(PHI[SealerWaitingTimes], t - iC.Part.TimeEnteredQueue)

Activity Construct: Sealing	
Duration	DM.SealingTime(iC.Part.Type)

Event	IF(PassTesting() = TRUE)
	THEN
	SM.Put(PHI[CycleTimesShipped], t - iC.Part.TimeArrived)
	SM.Leave(iC.Part)
	ELSE
	iC.Part.TimeEnteredQueue ← t
	SM.InsertQue(Q.ReworkLine, iC.Part)
	ENDIF
	R.Sealer.Busy ← FALSE

Activity Construct: Rework	
Parts are disassembled, repaired, cleaned, assembled, and re-tested.	
Precondition	Q.ReworkLine > 0 AND R.Rework.Busy = FALSE
Event	R.Rework.Busy ← TRUE iC.Part ← SM.RemoveQue(Q.ReworkLine) SM.Put(PHI[ReworkWaitingTimes], t - iC.Part.TimeEnteredQueue)
Duration	DM.ReworkTime()

Event	IF(PartSalvaged() = TRUE)
	SM.Put(PHI[CycleTimesReworkShipped], t - iC.Part.TimeArrived)
	ELSE
	SM.Put(PHI[CycleTimesScrapped], t - iC.Part.TimeArrived)
	ENDIF
	SM.Leave(iC.Part)
	R.Rework.Busy ← FALSE

Question 3 – Simulation Modelling (10 marks total)

The following two Java classes are the translation of the PartAArrivals Scheduled Action and the PreparationB Activity. Five logical errors exist in the code; please identify them. Logical errors consist of missing Java statements, missing elements or incorrect elements in the given Java instructions; there are no syntax errors in the Java code.

```
public class PartAArrivals extends ScheduledAction
{
	public PartAArrivals(AOSimulationModel model) {super(model);}
	public double timeset()
	{
		Electronics m = (Electronics)simModel;
		return (m.clock + m.dmPartAInterArrival.nextDouble());
	}
	public void actionEvent()
	{
		Electronics m = (Electronics)simModel;
		Part icPart;
		icPart = new Part();
		icPart.type = Part.Type.A;
		icPart.arrivalTime = m.clock;
		icPart.timeEnteredQueue = m.clock;
		m.qPrepALine.add(icPart);
	}
}

public class PreparationB extends Activity
{
	private Part icPart;
	public PreparationB(AOSimulationModel model) {super(model);}
	public static boolean precondition(Electronics m)
	{
		Electronics m = (Electronics)simModel;
		return( m.qPrepBLine.size() > 0 && m.rPrepB.Busy == false);
	}
	public void startingEvent()
	{
		Electronics m = (Electronics)simModel;
		m.rPrepBBusy = true;
		icPart = m.qPrepBLine.remove();
		m.phiPrepBWaitingTimes.put(m.clock, m.clock-icPart.timeEnteredQueue);
	}
	public double duration()
	{
		Electronics m = (Electronics)simModel;
		return(m.dmPrepBTime.next());
	}
	public void terminatingEvent()
	{
		Electronics m = (Electronics)simModel;
		icPart.timeEnteredQueue = m.clock;
		m.qSealerLine.add(icPart);
		m.rPrepBBusy=true;
	}
}
```

Question 4 – Experimentation and Output Analysis (15 marks total)

A) Output Analysis

The following tables show the results (confidence intervals) of 30 simulation runs with run lenghts of 30 consecutive 8 hour shifts (that is 30 x 8 x 60 minutes). What conclusions can you draw from these results?

Waiting Times in each of the four areas

	MeanPrepAWT	MeanPrepBWT	MeanSealerWT	MeanReworkWT
Point Estimate	15.16367762	56.18341081	0.621646979	1804.925159
Std Dev	2.446876537	15.37506813	0.027717245	459.365841
ζ (90%CI)	1.231	7.737	0.014	231.174
Dev from PE	8.12%	13.77%	2.24%	12.81%

Mean Queue Lengths in each of the four areas

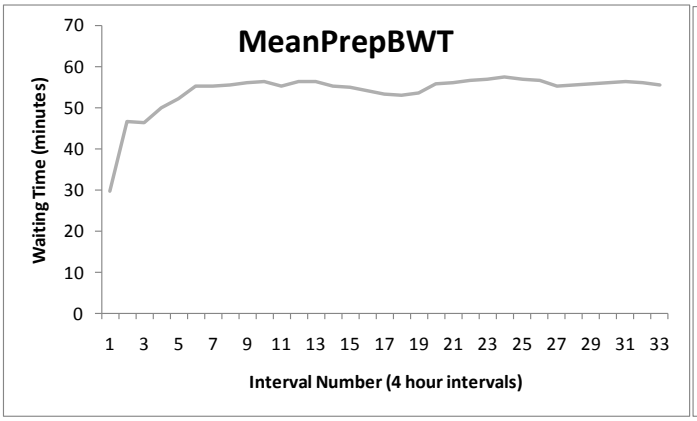
	MeanLineLengthPrepA	MeanLineLengthPre	MeanLineLengthSeal	MeanLineLengthRework
Point Estimate	3.038907429	7.602494629	0.207206358	53.50500538
Std Dev	0.518775047	2.459796258	0.012742265	14.55649915
ζ (90%CI)	0.261	1.238	0.006	7.325
Dev from PE	8.59%	16.28%	3.09%	13.69%

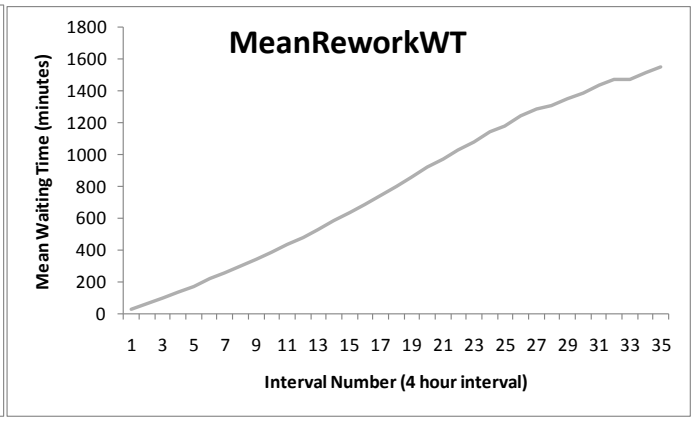
Cycle times

	MeanCycleTimeSh	MeanCycleTimeShip	MeanCycleTimeScrapped
Point Estimate	39.39479371	1870.27931	1932.734257
Std Dev	6.444065687	447.4604385	538.939475
ζ (90%CI)	3.243	225.182	271.219
Dev from PE	8.23%	12.04%	14.03%

B) Warm Up Time

In an attempt to improve results in Part A, an attempt was made to find a warm up time using the outputs MeanPrepBWT and MeanReworkWT ouput variables. The following shows graphs of applying Welchs method to determine warm up time.





What conclusions can you draw from the above graphs?