This exam consists of 3 questions located in 2 pages. Attempt all the questions and assume any missing data or logical assumptions.

Question (1): (30 marks)

1. Compare between the four industrial revolutions. Define the distinctive theme or feature for each of them. *(5 marks)*
2. Mention three technologies that are mainly applied in *Industry 4.0*. *(5 marks)*
3. Consider the following synchronous composition of two state machines A and B shown in Figure 1.

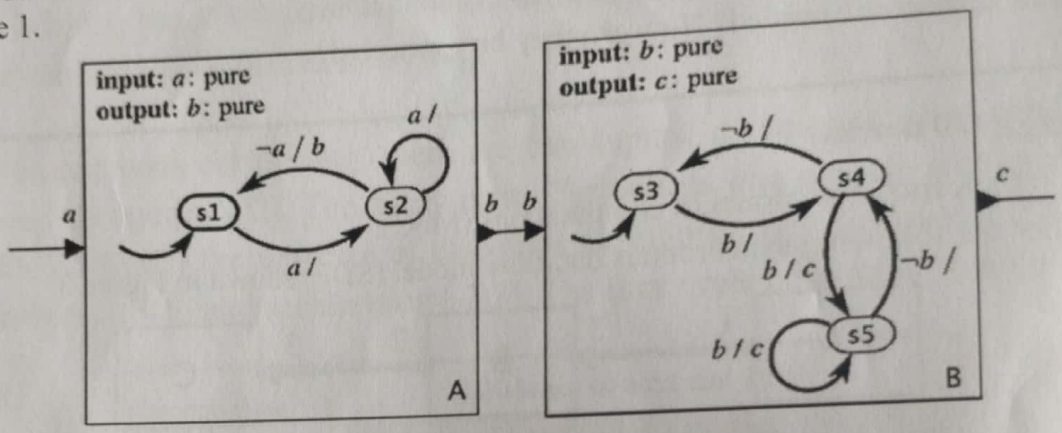

Figure 1

a. Construct a single state machine C representing the composition. *(8 marks)*
b. Which states of the composition are unreachable? *(2 marks)*

4. Consider the following synchronous feedback composition shown in Figure 2. Notice that machine A is non-deterministic (Gray arcs indicate non-deterministic transitions).

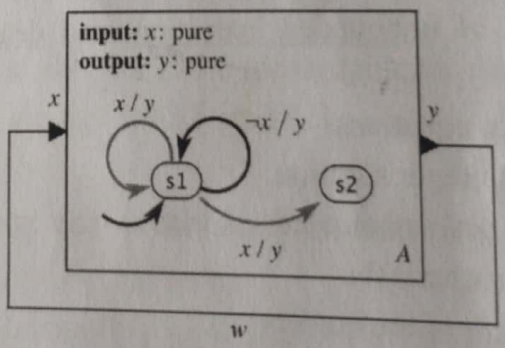

Figure 2

a. Explain if this composition is well formed and constructive, or not. *(5 marks)*
b. Give an equivalent flat FSM (with no input and no connections) that produces the same possible sequences w. *(5 marks)*

Question (2): (30 marks)

1. What are modal models? Why are they are considered as a preferred description for cyber physical systems? *(10 marks)*
2. Construct a timed automaton that provides the pulse-width modulated (PWM) voltage input to a DC motor model. Your hybrid system should assume that the PWM circuit delivers a 25 kHz square wave with a duty cycle between zero and 100%, inclusive. The input to your hybrid system should be the duty cycle, and the output should be the voltage. *(10 marks)*
3. Consider a feature for a door lock detector in an automobile as follows. The dome light is turned on as soon as any door is opened. It stays on for 30 seconds after all doors are shut.
   a. Implement the described feature as a timed automaton. *(8 marks)*
   b. What sensors are needed? How can they be connected? *(2 marks)*

Question (3): (30 marks)

1. Explain the concept of model of computations (MoC). *(10 marks)*
2. Consider the following synchronous dataflow model (SDF) shown in Figure 3.

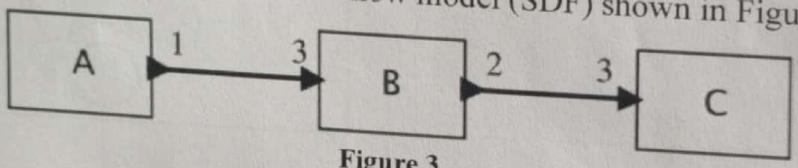

Figure 3

The numbers adjacent to the ports indicate the number of tokens produced or consumed by the actor when it fires. Let q_A, q_B, and q_C denote the number of firings of actors A, B, and C, respectively. Answer the following questions about this model:

a. What is meant by a synchronous dataflow model (SDF)? *(5 marks)*
b. Explain the meaning of unbounded execution, and deadlock, regarding buffering in dataflow models. *(5 marks)*
c. Write down the balance equations. *(3 marks)*
d. Find the least positive integer solution. *(2 marks)*
e. Find a schedule for an unbounded execution that minimizes the buffer sizes on the two communication channels. *(3 marks)*
f. What is the resulting size of the buffers? *(2 marks)*

With my best wishes,
Dr. Ahmed Mahmoud