Question (1):

1. a. M2M: Interaction of billions of devices and machines that are connected to the internet and to each other. Physical objects integrate computing capabilities to capture data about the world around them and share this with other connected devices.

1. b. Industry 4.0: The ongoing transformation of traditional manufacturing and industrial practices combined with the latest smart technology.
Also sometimes referred to as IIoT or smart manufacturing, combines physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better connected ecosystem for companies that focus on manufacturing and supply chain management.

2. a.
Determinacy: A state machine is said to be deterministic if, for each state, there is at most one transition enabled by each input value.
Reachable states: The set of reachable states comprises all states that can be reached from the initial state on some input sequence, may be smaller than the set of states.

2. b. Car Traffic Light (Fig. 1): Deterministic,
Pedestrian Traffic Light (Fig. 2): Non-deterministic.

2. c. For Fig. 1:
The count variable has 61 possible values and there are 4 bubbles, so the total number of combinations is 61×4=244. The size of the state space is therefore 244.
The number of reachable states, therefore, is 61×3+6=189.

2. d. Mathematical model for Fig. 2**:**

$$\begin{aligned}
States &= \{\text{none}, \text{waiting}, \text{crossing}\} \\
Inputs &= (\{sigG, sigY, sigR\} \rightarrow \{present, absent\}) \\
Outputs &= (\{pedestrian\} \rightarrow \{present, absent\}) \\
initialStates &= \{\text{crossing}\}
\end{aligned}$$

$$possibleUpdates(s,i) = \begin{cases} \{(\text{none}, absent)\} & \\ \quad \text{if } s = \text{crossing} & \\ \quad \wedge\, i(sigG) = present & \\ \{(\text{none}, absent), (\text{waiting}, present)\} & \\ \quad \text{if } s = \text{none} & \\ \{(\text{crossing}, absent)\} & \\ \quad \text{if } s = \text{waiting} & \\ \quad \wedge\, i(sigR) = present & \\ \{(s, absent)\} & \text{otherwise} \end{cases}$$

Question (2):

1. Model of Computation (MoC):
A collection of three sets of rules that govern the semantics of a concurrent composition of actors:
The first set of rules specifies what constitutes a component.
The second set specifies the concurrency mechanisms
The third specifies the communication mechanisms.

2. a. SDF is a constrained form of dataflow where for each actor, every firing consumes a fixed number of input tokens on each input port and produces a fixed number of output tokens on each output port.

2. b. Unbounded execution: A dataflow model may be able to execute forever or for a very long time. It requires scheduling policies that deliver bounded buffers.

Deadlock: A situation that happens when there are cycles, and a directed loop has insufficient tokens to satisfy any of the firing rules of the actors in the loop.

2. c.

$$\begin{aligned} q_A &= q_B \\ 2q_B &= q_C \\ 2q_A &= q_C \end{aligned}$$

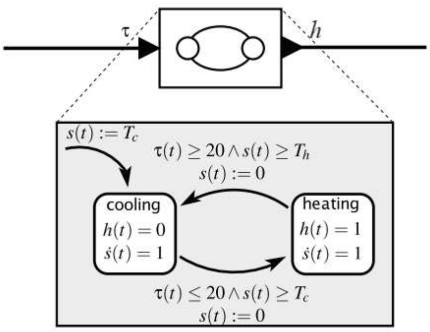
$$\Gamma = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 2 & -1 \\ 2 & 0 & -1 \end{bmatrix}, q = \begin{bmatrix} q_A \\ q_B \\ q_C \end{bmatrix}, \Gamma q = \vec{0}$$

2. d. The least positive integer solution to these equations is $q_A = q_B = 1$, and $q_C = 2$.

2. e. Scheduling pattern: A, B, C, C.

Question (3):

1.



2. a. Accuracy: The degree of conformity between the sensor's measurement and the true value.
Precision: The ratio of the sensor's output range to the standard deviation.

2. b. (3)→(1) →(4) →(2).

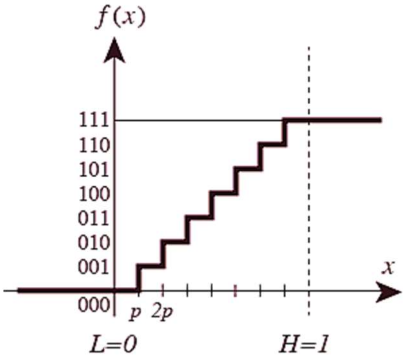
3. a. $f\colon \mathbb{R} \to \{0, 1, \cdots, 7\}$

3. b. The precision is $p = \frac{1}{8}$.

Dynamic range:

$$D_{dB} = 20\log_{10}\left(\frac{H-L}{p}\right) \approx 18dB.$$

3. b. Sensor distortion function is a function that defines the output of a sensor as a function of its input.



Question (4):

1. A memory model defines how memory is used by programs. The hardware, the operating system (if any), and the programming language and its compiler all contribute to the memory model.

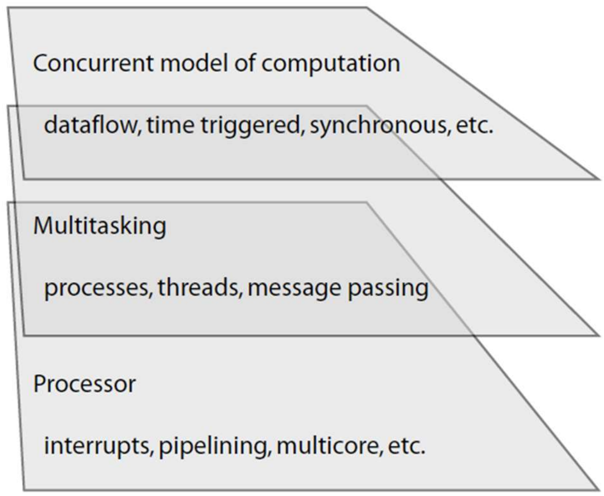
2. Garbage collection in memory: Automatic techniques that often require stopping everything and reorganizing the allocated memory.

It is prohibited as it is deadly for real-time programs and usually unpredictable.

3.

Highest level of concurrency is considered at the MoC layers: Dataflow, time triggered, SR ….

Lowest level (Processor) is at the hardware: Interrupts, pipelining, multicore … , Mid-level (Multi-tasking): Mechanisms that are implemented using the low-level layer and can provide infrastructure for realizing the high-level layer.



4. A scheduling decision is a decision to execute a task, and it has the following three parts:

Assignment: Which processor should execute the task.

Ordering: In what order each processor should execute its tasks.

Timing: The time at which each task executes.

- A fully-static scheduler makes all three decisions at design time .
- A static order scheduler (off-line scheduler) performs the task assignment and ordering at design time, but defers until run time the decision of when in physical time to execute a task.
- A static assignment scheduler performs the assignment at design time and everything else at run time. Each processor is given a set of tasks to execute, and a run-time scheduler decides during execution what task to execute next.
- A fully-dynamic scheduler performs all decisions at run time.