**King Saud University**
**College of Computer and Information Sciences**
**Computer Science Department**

College of Computer & Information Sciences
Computer Science Department

| | |
|---|---|
| **Course Code:** | CSC 339 |
| **Course Title:** | Theory of Computation |
| **Semester:** | 2nd (1443) |
| **Exercises Cover Sheet:** | Homework#1 |
| **Due-Date :** | **Thursday 21 April 11:59** |

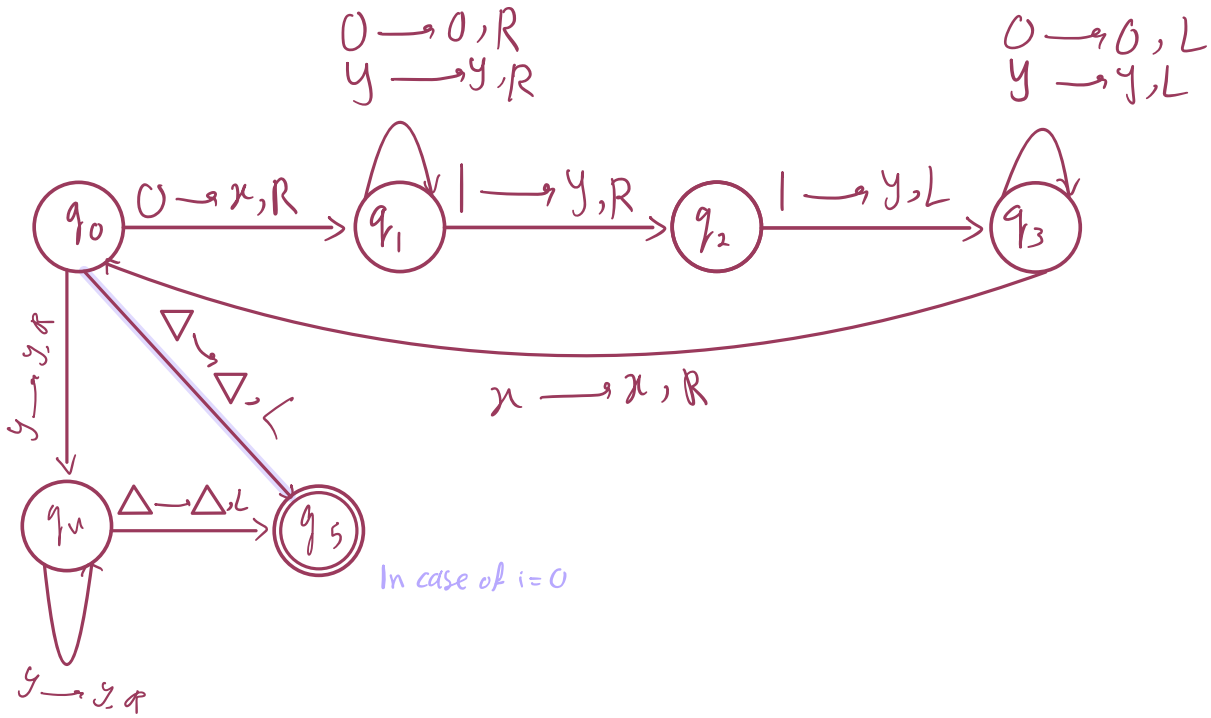
/ 10

| **Name** | | **ID** | |
|---|---|---|---|

| **Course Learning Outcomes** | | **Relevant Question No** | **Full Mark** | **Student Mark** |
|---|---|---|---|---|
| CLO 1 | Identify regular and non-regular languages (K1) | | | |
| CLO 2 | Identify decidable and non-decidable, NP-complete, and reducible problems (K1) | | | |
| CLO 3 | Produce computing-based solutions using regular expressions, and context free grammar (K2) | | | |
| CLO 4 | Design different machine models (DFA, NFA, PDA, TM) (S1) | **Part 1** | **5** | |
| CLO 5 | Evaluate the language accepted by a machine, a regular expression, and a context free grammar (S1) | **Part 2** | **2** | |
| CLO 6 | Evaluate the time and space complexity of a Turing machine (S1) | **Part 3** | **3** | |

**Question 1**

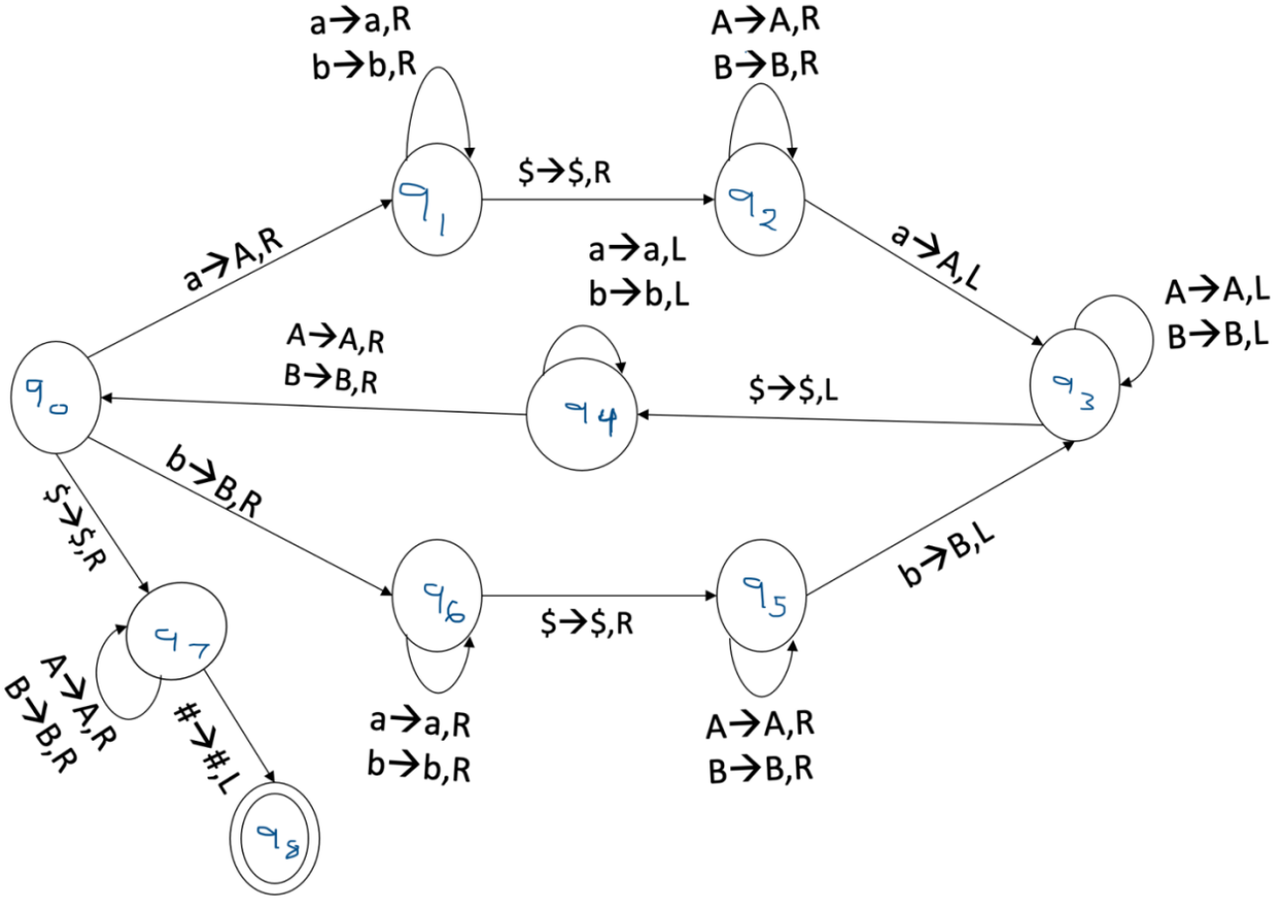
- Design a Turing machine with input alphabet $\boldsymbol{\Sigma} = \{\mathbf{0}, \mathbf{1}\}$ that accepts the language $\boldsymbol{L} = \{\mathbf{0}^{\boldsymbol{i}}\mathbf{1}^{\mathbf{2}\boldsymbol{i}} \mid \boldsymbol{i} \geq \mathbf{0}\}$.



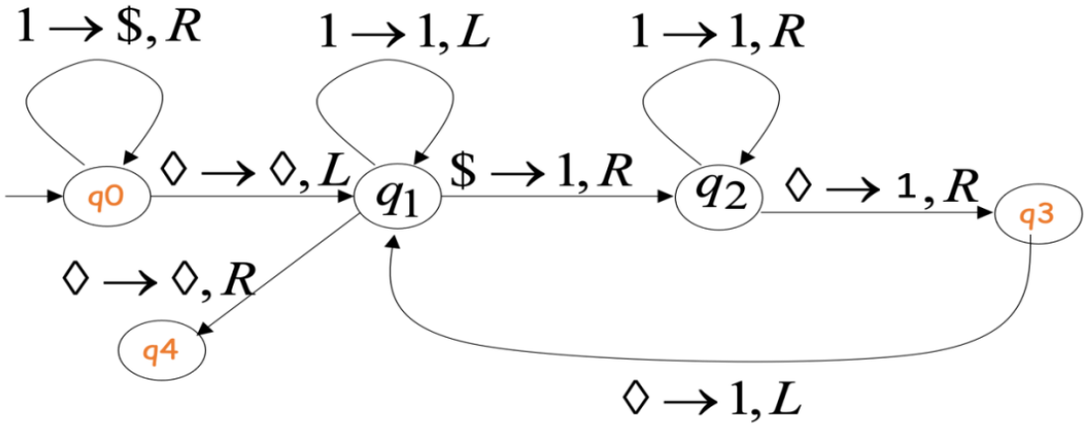
**Question 1**

- Design a deterministic Turing machine with input alphabet $\boldsymbol{\Sigma}$ = {$\boldsymbol{a}$, $\boldsymbol{b}$, \$} that accepts the language $\boldsymbol{L}$ = {**w$w | w** ∈**{a,b}***}.

---

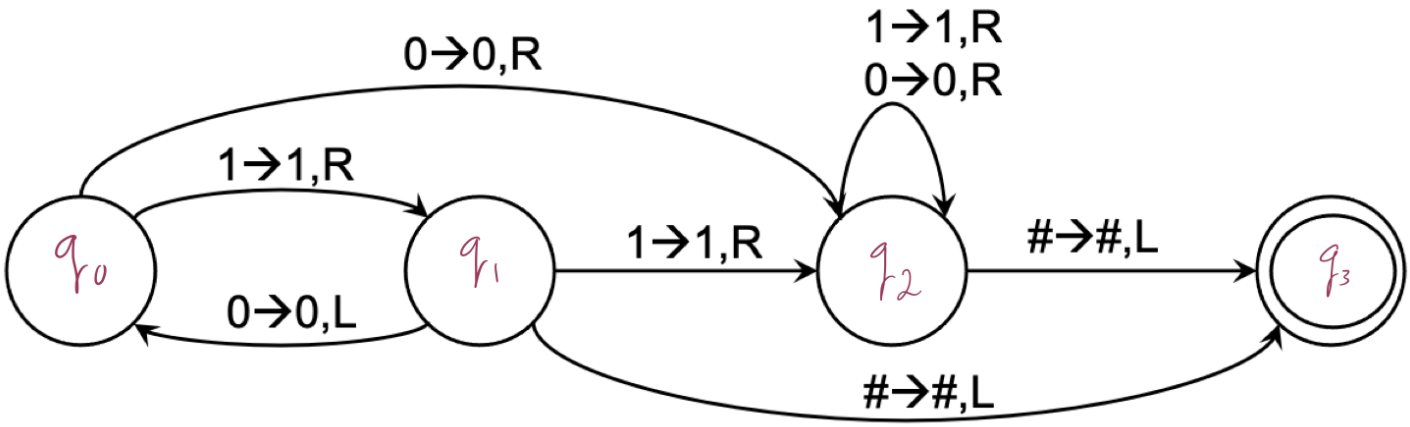



- Construct a Turing machine that computes f (n) = 3n where integers are represented in unary notation



**Question 2**

1. Given the Turing machine M with input alphabet {0, 1} in Figure 1 answer the following question




- Trace the computation for the input string **110**.

$\#q_0110\# \vdash \#1q_110\# \vdash \#11q_20\# \vdash \#110q_2\# \vdash \#11q_30\#$

- Trace the computation for the input string **101**.

$\#q_0101\# \vdash \#1q_101\# \vdash \#q_0101\# \vdash \#1q_101\#$

The input string causes an infinite loop

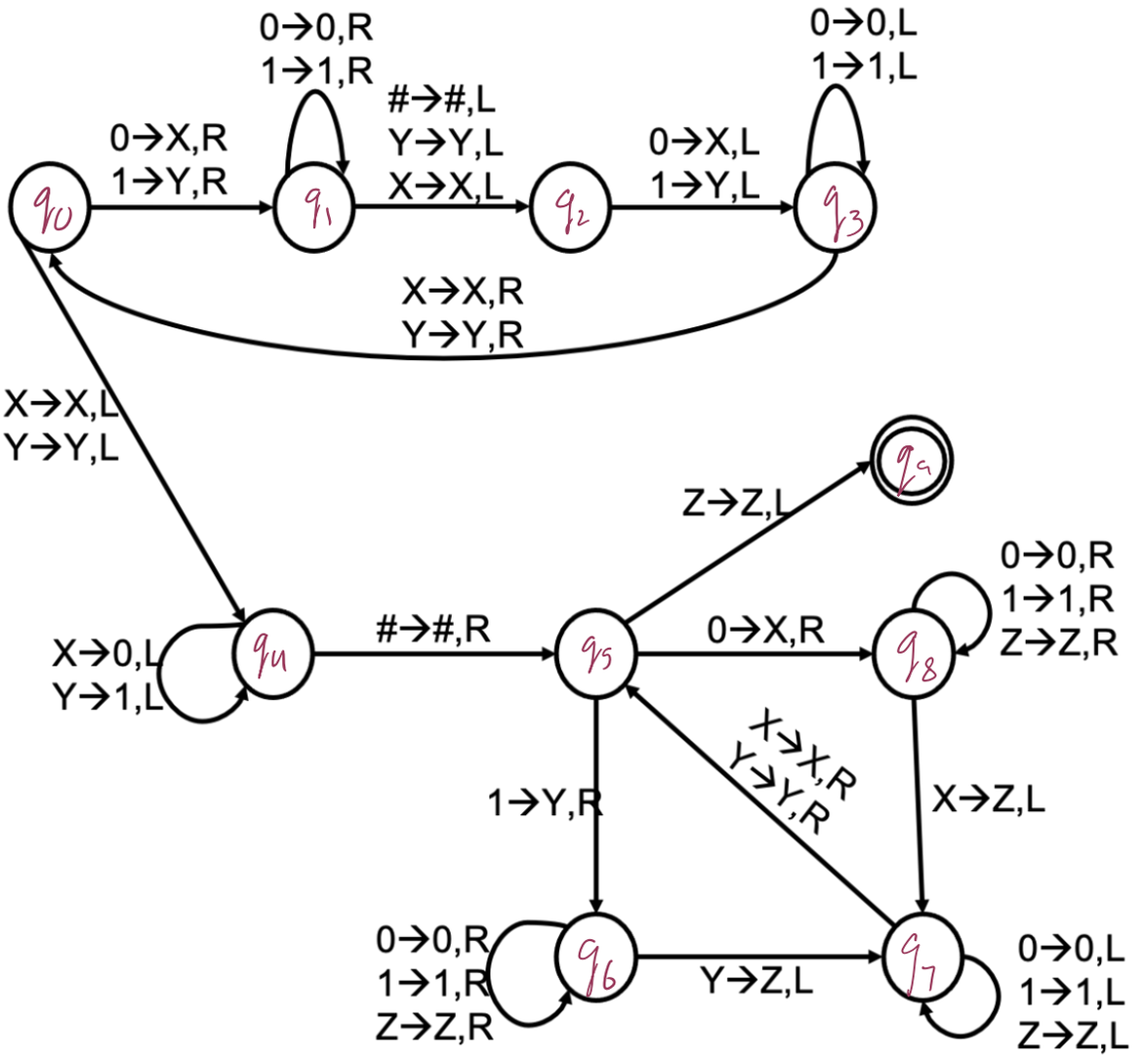
- what is the language accepted by M?

$\{w : w \in \{0,1\}^*$ and does not start with 10 $\}$

- Which statement is correct?
  - A. M halts on all inputs
  - B. M never halts on some inputs
  - C. M does not halt on any input
  - D. None
- The machine M is decidable:
  - A. True
  - B. False

**Question 3**

1. Given the Turing machine M with input alphabet {0, 1} in Figure 1, **give**




- Trace the computation for the input string $\mathbf{1010}$.
- Accepted language
- The time complexity and its corresponding class
- The space complexity and its corresponding class

- Trace the computation for the input string **1010**.

$\#q_0 1010 \# \vdash \# y q_1 010 \# \vdash \# y 0 q_1 10 \# \vdash \# y 01 q_0 0 \# \vdash$
$\# y 010 q_1 \# \vdash \# y 01 q_2 0 \# \vdash \# y 0 q_3 1 x \# \vdash \# y q_3 01 x \# \vdash$
$\# q_3 y 01 x \# \vdash \# y q_0 01 x \# \vdash \# y x q_1 1 x \# \vdash \# y x 1 q_1 x \# \vdash$
$\# y x q_2 1 x \# \vdash \# y q_3 x y x \# \vdash \# y x q_0 y x \# \vdash \# y q_4 x y x \# \vdash$
$\# q_4 y 0 y x \# \vdash q_4 \# 1 0 y x \# \vdash \# q_5 1 0 y x \# \vdash \# y q_6 0 y x \# \vdash$
$\# y 0 q_6 y x \# \vdash \# y q_7 0 z x \# \vdash \# q_7 y 0 z x \# \vdash \# y q_5 0 z x \# \vdash$
$\# y x q_8 z x \# \vdash \# y x z q_8 x \# \vdash \# y x q_7 z z \# \vdash \# y q_7 x z z \# \vdash$
$\# y x q_5 z z \# \vdash \# y q_4 x z z \#$

- Accepted language

$\{ww : w \in \{0,1\}^+$

- The time complexity and its corresponding class

$O(n^2)$ class P

- The space complexity and its corresponding class

$O(n)$ class PS