

**Question 1:** [1,5 points]

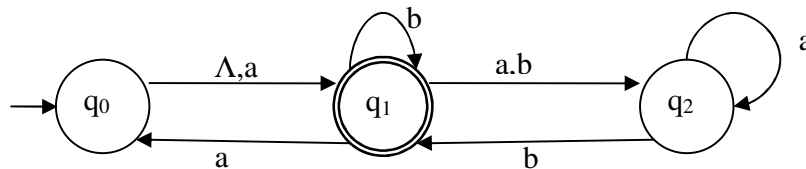
- What languages do the regular expressions  $(\emptyset^*)^*$  and  $a\emptyset$  denote?
- Find a regular expression for  $L = \{ w \in \{a,b\}^* \mid w \text{ has an even number of } a\text{'s} \}$ .
- Find a regular expression for  $L = \{ w \in \{a,b\}^* \mid w \text{ has no pairs of consecutive } a\text{'s} \}$ .

**Question 2:** [2,5 points]

- Let  $L^R$  the language containing exactly the reverse strings of a language  $L$ . Give a nfa accepting the reverse of  $L = \{ w \in \{a,b\}^* \mid w \text{ contains exactly one } a \}$ .
- More generally, show that if a language  $L$  is regular so is  $L^R$ .
- A language  $L$  is said to be palindrome if  $L = L^R$ . Find an algorithm for determining if a given regular language is a palindrome language.

**Question 3:** [1,5 points]

Convert the following non-deterministic automaton into an equivalent determinist one



**Question 4:** [2,5 points]

- Show that the language  $L = \{ w_1w_2 \mid w_1, w_2 \in \{a,b\}^* \}$  is regular.
- Use the pumping lemma to show that the language  $L = \{ ww \mid w \in \{a,b\}^* \}$  is not regular.
- Is the language  $L = \{ w_1w_2 \mid w_1, w_2 \in \{a,b\}^*, w_1 \neq w_2 \}$  regular?

**Question 5:** [2 points]

- Remove all unit productions from

$$S \rightarrow Aa \mid B$$

$$A \rightarrow a \mid bc \mid B$$

$$B \rightarrow A \mid bb.$$

- Eliminate all nullable productions from

$$S \rightarrow AaB \mid aaB$$

$$A \rightarrow \Lambda$$

$$B \rightarrow bbA \mid \Lambda.$$

The final score is given by the sum of the points obtained.