One bonus mark for neatly written student information: Papers that have all the names and student numbers written exactly as requested in the regulations (found at the end), will receive one bonus mark.

1. (4 marks) Using the method described in Section 9.1 (and in class), convert the following regular expression into a state diagram:

$$(01^+ + 10)^*1*$$

Your answer should indicate how you arrived at the result:

- As intermediate steps write down the state diagrams that you construct for subexpressions of the given regular expression, and for each intermediate step clearly indicate which subexpression it corresponds to.
- Please do not simplify/modify the state diagrams.

Please note: The question is marked based on how well you follow the steps of the algorithm of section 9.1.¹

Note also that concatenation has highest precedence (page 164 in the text). Thus the expression $01^*$ denotes exactly one 0 followed by any number of 1’s.

2. (2 marks) Using the method described in Section 9.2 (and in class), convert the state diagram given in Figure 1 into an equivalent regular expression. Here $\Sigma = \{a, b, c, d\}$.

Your answer should include the intermediate step(s) used in the construction.

3. (4 marks) Are the following languages $A$ and $B$ over the alphabet $\Sigma = \{a, b, c, d\}$ regular or nonregular?

- For a language that is regular, give a regular expression that defines it.
- For a nonregular language, using the pumping lemma prove that it is not regular.

(a) $A = \{a^{4j+2}b^ke^{2j+1} \mid j \geq 0 \text{ and } k \geq 0\} \cdot \{d^{3m+1} \mid m \geq 0\}$

¹An NFA produced by some other method is considered incorrect independently of whether or not it may define the same language.
(b) $B = \{a^{2j+3}b^{k+2} \mid j \geq k \geq 0\} \cdot \{b^{r+2}c^{2s+3} \mid r \geq 0 \text{ and } s \geq 0\}$

Above “·” stands for language concatenation.

*Hint:* The languages $A$ and $B$ are each expressed as concatenation of two components. If one (or both) of the components is non-regular, this does not imply anything about the non-regularity of the concatenation. When trying to show that a language $C$ is non-regular, we have to apply the pumping lemma to the entire language $C$ (and not to the individual components).

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**Regulations on assignments**

- **The assignments may be done in groups consisting of one, two, three or four students.** If more than one student are collaborating on an assignment, they must submit a single **joint solution.**

- At the top of the first page, for each student collaborating on the assignment, type or write in clear capital letters the following information:
  - LAST-NAME, FIRST-NAME (name as it appears on solus, e.g., “SMITH, NANCY”)
  - the student number (e.g., “1234 4321”)
  - “CISC 223” or “CMPE 223” (depending on which course you are in)
  - signature (the signature need not be easily readable)

The information for each one student should be written on one line and in the order specified above.

- **Bonus mark:** Papers that have the above information, for all the participants, written exactly correctly and perfectly clearly and legibly will receive one bonus mark. The assignment is worth 10 marks. Papers that receive the bonus mark, may get more than 10 marks. For the bonus mark there is **no partial credit** for incomplete information or unclear handwriting.
• The assignment should be put into the locked CISC 223 drop-off box on the 2nd floor of Goodwin hall by the due date. The assignments must be submitted in hardcopy. Assignments sent by email are not accepted.

• If the submission consists of more than one page, the pages must be stapled together.

• Note: You are asked to write your solutions using non-erasable pen (or to type the solutions). Solutions written in pencil or erasable ink will be marked, but they will not be considered for remarking after the assignments are returned.