The exam is split into two parts. To pass the exam you need:

1. At least 5/10 points from the first part.
2. A high enough total score.

**Part I Question series A**

Write your answers on the separate answering sheet. Remember also to indicate to which question series you are answering to.

1. Let $\Sigma = \{a, b\}$. Which of the following regular expressions define the language: $L = \{ w \in \Sigma^* \mid w$ has at least one substring $ab \}$

   a) $b^*a*a**$  
   b) $(a \cup b)^*(ab)^*(b \cup a)^*$  
   c) $(a^*b^*)^*a(b^*a^*)^*$  
   d) $b^*a^*(ab \cup \emptyset^*)b^*a^*$

2. Which one of the following statements is **not** true?
   
   a) All regular languages are also context-free.
   
   b) For every $\mu$-recursive function there is a corresponding Turing machine.
   
   c) All Turing-acceptable languages are also Turing-decidable.
   
   d) All Turing-decidable languages are also Turing-acceptable.

3. Which of the deterministic automata is equivalent with the nondeterministic automaton in the picture?

4. Which one of the following statements is **true**?

   a) For each type 0 (unrestricted) grammar there is a corresponding nondeterministic pushdown automaton
   
   b) The regular languages are undecidable.
   
   c) The intersection of two regular languages is not necessarily regular.
   
   d) The intersection of two context-free languages is not necessarily context-free.

5. Which language does the context-free grammar $G = (V, \Sigma, R, S)$ define?

   $V = \{a, b, c, S, A, B\}$  
   $\Sigma = \{a, b, c\}$  
   $R = \{S \rightarrow aSb, S \rightarrow A, A \rightarrow aA\}$  
   $A \rightarrow B, B \rightarrow bA, B \rightarrow e \}$

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1In the real exam there will 10 multiple choice questions. This practice exam has only 5.
a) \( L = \{a^n b^n \mid n \geq 0\} \)

b) \( L = \{a^k (a \cup b) b^k \mid k \geq 0\} \)

c) \( L = \{(ab)^n a^* b^* \mid n > 0\} \)

d) \( L = \{a^n (a^* b^*)^n b^n \mid n \geq 0\} \)

Part II

1. Construct a deterministic automaton which recognizes the language generated by the regular expression \( R \).

\[ R = (bb^* c \cup a)^* \cup (ba^* \cup ca)^* \]  

(5p.)

2. Show that, the language \( L \) is not regular:

\[ L = \{(ab)^n a^k \mid n > k, k \geq 0\} \]  

(5p.)

3. Construct a context-free grammar which generates the language:

\[ L = \{a^n b^m c^k \mid k = \mid n - m\} \]

What is the corresponding pushdown automaton?  

(5p.)

4. 

a) Show that, the concatenation of two context-free languages is context-free.  

(2p.)

b) Show, on a general level, the operating principle of the universal Turing machine.  

(3p.)