Answer all questions.

Marks for this test account for 10% of the total credit for COMP218.

Write your answers straight onto the question paper in the space provided below each question. In the unlikely event that you require additional space to answer any question, write on the reverse side of the paper, indicating clearly that you have done this. If you want, you may do rough work on the reverse of the question pages.

Enter your name, University ID Number and degree program and year of study in the spaces below.

Name ____________________ University ID Number ____________________
Degree program and year of study ____________________

Do not write below this line
1. Consider the following regular expressions which are given along with three words: for each word say whether it belongs to the language of the regular expression.

(a) regular expression \( a^* b^* c^* d^* \) and words \( abcd, abbc, aba \). [3 marks]

(b) regular expression \((ab)^* (abb)^*\) and words \( ababab, ababba, ababbab \). [3 marks]

For each pair of regular expressions below, say whether they represent the same language. If they correspond to different languages, give an example of a word that belongs to one language but not the other.

(c) \((a^* \cup b^*) \) and \( \{a, b\}^* \). [2 marks]

(d) \( \{a, ab, abc\}\{d, cd\} \) and \( \{a, ab\}\{c, cd, d\} \). [2 marks]

(e) \((ab)^* \cup (aba)^* a \) and \( a((ba)^* \cup (baa)^*) \). [2 marks]
2. (a) Consider the nondeterministic finite automata with states 1, 2 and 3, where state 1 is the initial state and state 2 is the only accepting state. The transition function is given by the following table.

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>{2,3}</td>
<td>∅</td>
</tr>
<tr>
<td>2</td>
<td>∅</td>
<td>{3}</td>
</tr>
<tr>
<td>3</td>
<td>∅</td>
<td>{1}</td>
</tr>
</tbody>
</table>

Draw a diagram of this NFA, and write down an accepting path (i.e. sequence of states visited, ending in accepting state) for the input ababba. [5 marks]
2. (b) Draw a diagram of a DFA that is equivalent to the NFA in part (a). The DFA should either be the one obtained by the standard method, or else explain briefly why your DFA is equivalent. [5 marks]
3(a) Recall that the language represented by the concatenation of 2 regular expressions $E$ and $F$ is the set of all words $w$ that can be written as $w = w_1w_2$, where $w_1$ is in the language of $E$ and $w_2$ is in the language of $F$.

Suppose that $E$, $F$ and $G$ are regular expressions. Explain why the concatenation $(EF)G$ represents the same language as $E(FG)$. (That is, it makes no difference whether we concatenate $E$ with $F$ first (then concatenate $EF$ with $G$), or concatenate $F$ with $G$ first (then concatenate $E$ with $FG$).) [4 marks]

3(b) If you were given a finite automaton, how could you tell whether it accepts an infinite number of distinct words? (Try to describe an algorithm that tests for this.) [4 marks]