

Formal Languages and Automata Theory
Homework # 3

For each of the following, give a DFA that accepts the specified language. Exercises to be handed in from Part I include 1,3 and 28. Exercises to be handed in from Part II include 4 and 6.

Part I

1. The set of strings over $\{a, b, c\}$ in which all a 's preceded the b 's, which in turn precede the c 's.
2. The same as in 1 except for the null string.
3. The set of strings over $\{a, b\}$ in which the substring aa occurs exactly once.
4. The set of strings over $\{a, b\}$ that do not contain the substring aaa .
5. The set of strings over $\{a, b, c\}$ that do not contain the substring aa .
6. The set of strings over $\{a, b, c\}$ that begin with an a , contain exactly two b 's, and end with cc .
7. The set of strings over $\{a, b, c\}$ in which the total number of b 's and c 's is three.
8. The set of strings over $\{a, b, c\}$ in which every b is followed by at least one c .
9. The set of strings over $\{a, b\}$ that contain the substring aa and the substring bb .
10. The set of strings over $\{a, b, c\}$ that contain the substrings aa , bb , and cc .
11. The set of strings over $\{a, b, c\}$ with length three.
12. The set of strings over $\{a, b, c\}$ with length less than three.
13. The set of strings over $\{a, b, c\}$ with length greater than three.
14. The set of strings over $\{a, b\}$ in which the number of a 's is divisible by three.
15. The set of strings over $\{a, b\}$ in which every a is either preceded or followed by a b , for example, $baab$, aba , and b .
16. The set of strings over $\{a, b\}$ with an even number of a 's or an odd number of b 's.
17. The set of strings over $\{a, b\}$ with an even number of a 's and an even number of b 's.
18. The set of strings over $\{a, b\}$ that have odd length and contain exactly two b 's.
19. The set of strings over $\{a, b, c\}$ that have odd length and contain exactly one a .
20. The set of strings over $\{a, b, c\}$ with an odd number of occurrences of the substring ab .

21. The set of strings over $\{a, b\}$ ending with the substring $abba$.
22. The set of strings over $\{1, 2, 3\}$ the sum of whose elements is divisible by 6.
23. The set of strings over $\{a, b, c\}$ in which the number of a's plus the number of b's plus twice the number of c's is divisible by six.
24. The set of strings over $\{a, b\}$ in which every substring of length four has exactly one b.
25. The set of strings over $\{a, b\}$ that contain an even number of substrings ba .
26. The set of strings over $\{0, 1\}$ in which every consecutive sequence of 3 symbols contains at least two zeros.

Part II

For problems 1-6, give an NFA that accepts the specified language. Note that in many cases it may be possible to simply give a DFA, which by definition is an NFA. However, in all cases you should try to exploit non-determinism in the construction of your NFA. For an extra exercise you might also try and come up with a DFA as well.

1. The set of strings over $\{a, b\}$ whose third to the last symbol is b .
2. The set of strings over $\{a, b\}$ that have both or neither aa and bb as substrings.
3. The set of strings over $\{a, b\}$ in which the substring aa occurs at least once.
4. The set of strings over $\{a, b\}$ in which the substring aa occurs at least twice.
5. The set of strings over $\{a, b\}$ ending with the substring $abba$.
6. The set of strings over $\{a, b\}$ containing an even number of occurrences of the substring ba .