

**CPSC 4083/5210**  
**Homework # 4**

For problems 1-26, give a regular expression that accepts the specified language. Note that these are the same problems from homework #3. Exercises to be handed in include 1,3, and 10.

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. Use the regular expression identities discussed in class to prove each of the following identities.
- (a)  $ba(ba)^*(a^*b^* + a^*) = (ba)^*baa^*(b^* + \epsilon)$
- (b)  $bb^*(a^*b^* + \epsilon)b = b(b^*a^* + \epsilon)bb^*$
- (c)  $(a + b)^* = (a + b)^*b^*$
- (d)  $(a + b)^* = (a^* + ba^*)^*$
- (e)  $(a + b)^* = (b^*(a + \epsilon)b^*)^*$
27. The set of strings over  $\{0, 1\}$  in which every consecutive sequence of 3 symbols contains at least two zeros.