

11. Let $L_1 = \{aaa\}^*$, $L_2 = \{a, b\}\{a, b\}\{a, b\}\{a, b\}$, and $L_3 = L_2^*$. Describe the strings that are in the languages L_2 , L_3 , and $L_1 \cap L_3$.

For Exercises 12 through 37, give a regular expression that represents the described set.

12. The set of strings over $\{a, b, c\}$ in which all the a 's precede the b 's, which in turn precede the c 's. It is possible that there are no a 's, b 's, or c 's.
13. The same set as Exercise 12 without the null string.
14. The set of strings of length two or more over $\{a, b\}$ in which all the a 's precede the b 's.
15. The set of strings over $\{a, b\}$ that contain the substring aa and the substring bb .
16. The set of strings over $\{a, b\}$ in which the substring aa occurs at least twice. *Hint:* Beware of the substring aaa .
17. The set of strings over $\{a, b, c\}$ that do not contain the substring aa .
18. The set of strings over $\{a, b\}$ that do not begin with the substring aaa .
19. The set of strings over $\{a, b\}$ that do not contain the substring aaa .
20. The set of strings over $\{a, b\}$ that do not contain the substring aba .
21. The set of strings over $\{a, b\}$ in which the substring aa occurs exactly once.
22. The set of strings over $\{a, b, c\}$ that begin with a , contain exactly two b 's, and end with cc .
23. The set of strings over $\{a, b\}$ that contain the substring ab and the substring ba .
24. The set of strings over $\{a, b, c\}$ that contain the substrings aa , bb , and cc .
25. The set of strings over $\{a, b, c\}$ in which every b is immediately followed by at least one c .
26. The set of strings over $\{a, b, c\}$ with length three.
27. The set of strings over $\{a, b, c\}$ with length less than three.
28. The set of strings over $\{a, b, c\}$ with length greater than three.
29. The set of strings over $\{a, b\}$ in which the number of a 's is divisible by three.
30. The set of strings over $\{a, b, c\}$ in which the total number of b 's and c 's is three.
31. The set of strings over $\{a, b\}$ in which every a is either immediately preceded or immediately followed by b , for example, $baab$, aba , and b .
32. The set of strings of odd length over $\{a, b\}$ that contain the substring bb .
33. The set of strings of even length over $\{a, b, c\}$ that contain exactly one a .
34. The set of strings over $\{a, b, c\}$ with an odd number of occurrences of the substring ab .
35. The set of strings of odd length over $\{a, b\}$ that contain exactly two b 's.
36. The set of strings over $\{a, b\}$ with an even number of a 's or an odd number of b 's.