**1.4** Each of the following languages is the intersection of two simpler languages. In each part, construct DFAs for the simpler languages, then combine them using the construction discussed in footnote 3 (page 46) to give the state diagram of a DFA for the language given. In all parts, $\Sigma = \{\mathtt{a}, \mathtt{b}\}$.

**a.** $\{w \mid w$ has at least three a's and at least two b's$\}$

**A b.** $\{w \mid w$ has exactly two a's and at least two b's$\}$

**c.** $\{w \mid w$ has an even number of a's and one or two b's$\}$

**A d.** $\{w \mid w$ has an even number of a's and each a is followed by at least one b$\}$

**e.** $\{w \mid w$ starts with an a and has at most one b$\}$

**f.** $\{w \mid w$ has an odd number of a's and ends with a b$\}$

**g.** $\{w \mid w$ has even length and an odd number of a's$\}$

**1.5** Each of the following languages is the complement of a simpler language. In each part, construct a DFA for the simpler language, then use it to give the state diagram of a DFA for the language given. In all parts, $\Sigma = \{\mathtt{a}, \mathtt{b}\}$.

**[A]a.** $\{w \mid w$ does not contain the substring $\mathtt{ab}\}$

**[A]b.** $\{w \mid w$ does not contain the substring $\mathtt{baba}\}$

**c.** $\{w \mid w$ contains neither the substrings $\mathtt{ab}$ nor $\mathtt{ba}\}$

**d.** $\{w \mid w$ is any string not in $\mathtt{a}^*\mathtt{b}^*\}$

**e.** $\{w \mid w$ is any string not in $(\mathtt{ab}^+)^*\}$

**f.** $\{w \mid w$ is any string not in $\mathtt{a}^* \cup \mathtt{b}^*\}$

**g.** $\{w \mid w$ is any string that doesn't contain exactly two $\mathtt{a}$'s$\}$

**h.** $\{w \mid w$ is any string except $\mathtt{a}$ and $\mathtt{b}\}$

**1.6** Give state diagrams of DFAs recognizing the following languages. In all parts, the alphabet is $\{0,1\}$.

**a.** $\{w \mid w$ begins with a 1 and ends with a $0\}$

**b.** $\{w \mid w$ contains at least three 1s$\}$

**c.** $\{w \mid w$ contains the substring 0101 (i.e., $w = x0101y$ for some $x$ and $y$)$\}$

**d.** $\{w \mid w$ has length at least 3 and its third symbol is a $0\}$

**e.** $\{w \mid w$ starts with 0 and has odd length, or starts with 1 and has even length$\}$

**f.** $\{w \mid w$ doesn't contain the substring $110\}$

**g.** $\{w \mid$ the length of $w$ is at most $5\}$

**h.** $\{w \mid w$ is any string except 11 and $111\}$

**i.** $\{w \mid$ every odd position of $w$ is a $1\}$

**j.** $\{w \mid w$ contains at least two 0s and at most one $1\}$

**k.** $\{\varepsilon, 0\}$

**l.** $\{w \mid w$ contains an even number of 0s, or contains exactly two 1s$\}$

**m.** The empty set

**n.** All strings except the empty string

**1.7** Give state diagrams of NFAs with the specified number of states recognizing each of the following languages. In all parts, the alphabet is $\{0,1\}$.

**[A]a.** The language $\{w \mid w$ ends with $00\}$ with three states

**b.** The language of Exercise 1.6c with five states

**c.** The language of Exercise 1.6l with six states

**d.** The language $\{0\}$ with two states

**e.** The language $0^*1^*0^+$ with three states

**[A]f.** The language $1^*(001^+)^*$ with three states

**g.** The language $\{\varepsilon\}$ with one state

**h.** The language $0^*$ with one state

**1.8** Use the