SECTION 9.3 REVIEW

TECHNIQUES

- Compute the output string for a given finite-state machine and a given input string.
- Draw a state graph from a state table and vice versa.
- Construct a finite-state machine to act as a recognizer for a certain type of input.
- Find a regular expression given the description of a regular set.
- Decide whether a given string belongs to a given regular set.
- Minimize finite-state machines.
- Construct sequential networks for finite-state machines.

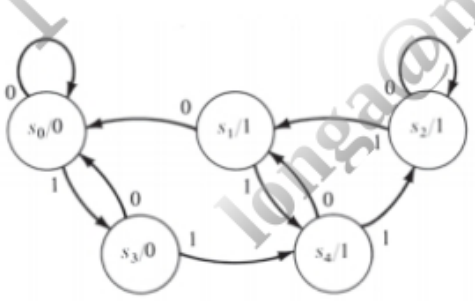
MAIN IDEAS

- Finite-state machines have a synchronous, deterministic mode of operation and limited memory capabilities.
- The class of sets that finite-state machines can recognize is the class of all regular sets; hence, their recognition capabilities are limited.
- Unreachable states can be removed from a machine.
- After unreachable states have been removed from a machine, a minimized version of that machine can be found that produces the same output strings for all input strings.
- Any finite-state machine can be built using a network of AND gates, OR gates, inverters, and delay elements.

EXERCISES 9.3

1. For each input sequence and machine given, compute the corresponding output sequence (starting state is always s_0).

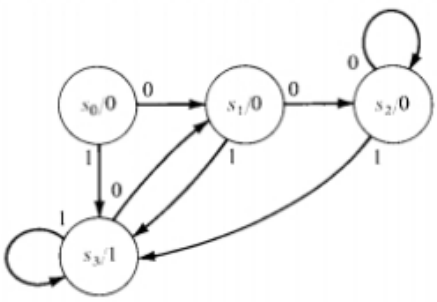
   a. 011011010



   b. *abccaab*

Present state	Next state			Output
	Present input			
	a	*b*	*c*	
s_0	s_2	s_0	s_3	*a*
s_1	s_0	s_2	s_3	*b*
s_2	s_2	s_0	s_1	*a*
s_3	s_1	s_2	s_0	*c*

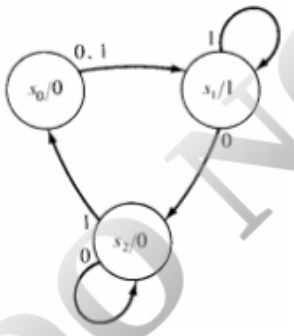
c. 0100110



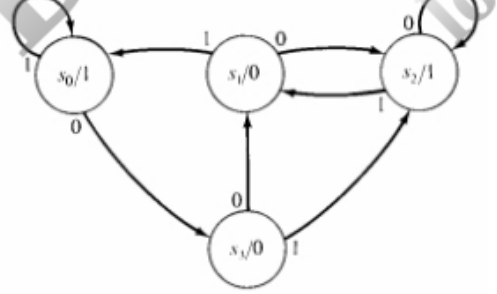
2. a. For the machine described in Exercise 1a, find all input sequences yielding an output sequence of 0011110.
   b. For the machine described in Exercise 1b, find all input sequences yielding an output sequence of *abaaca*.
   c. For the machine described in Exercise 1c, what will be the output for an input sequence $a_1a_2a_3a_4a_5$ where $a_i \in \{0, 1\}$, $1 \le i \le 5$?

In Exercises 3–6, write the state table for the machine, and compute the output sequence for the given input sequence.

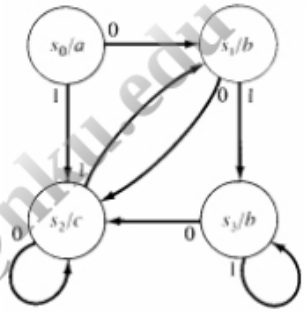
3. 00110



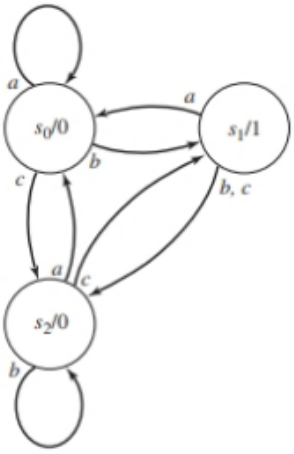
4. 1101100



5. 01011



6. *acbabc*



In Exercises 7–10, draw the state graph for the machine, and compute the output sequence for the given input sequence.

7. 10001

Present state	Next state		Output
	Present input		
	0	1	
s_0	s_0	s_2	1
s_1	s_1	s_0	0
s_2	s_0	s_1	0

8. 0011

Present state	Next state		Output
	Present input		
	0	1	
s_0	s_2	s_3	0
s_1	s_0	s_1	1
s_2	s_1	s_3	0
s_3	s_1	s_2	1

9. *acbbca*

Present state	Next state			Output
	Present input			
	a	*b*	*c*	
s_0	s_1	s_1	s_1	0
s_1	s_2	s_2	s_1	0
s_2	s_0	s_2	s_1	1

10. 21021

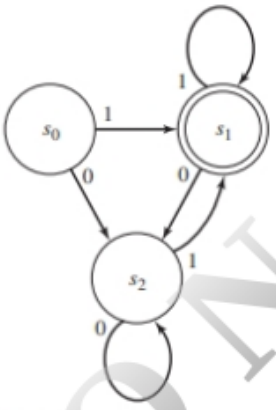
Present state	Next state			Output
	Present input			
	0	1	2	
s_0	s_3	s_1	s_2	1
s_1	s_3	s_0	s_1	2
s_2	s_2	s_1	s_1	0
s_3	s_1	s_4	s_0	0
s_4	s_1	s_4	s_2	2

11. a. Construct a finite-state machine that complements each bit of the binary input string (read left to right).
    b. Write the output for the input sequence 01011.
12. a. Construct a finite-state machine that will compute $x + 1$ where x is the input given in binary form, least significant digit first (in this case, read the input right to left). You could use the binary adder of Figure 9.5 by writing 1 as 00…01 with the correct number of leading 0*s*, but that's much too complicated.
    b. Write the output for $x = 1101$.
13. a. Construct a finite-state machine that will compute the bitwise AND of two binary input strings.
    b. Write the output for the input sequence consisting of the strings 11011 and 10010 (read left to right).
14. a. Construct a finite-state machine that will compute the bitwise OR of two binary input strings.
    b. Write the output for the input sequence consisting of the strings 11011 and 10010 (read left to right).
15. a. Construct a delay machine having input and output alphabet {0, 1} that, for any input sequence $a_1a_2a_3\ldots$ produces an output sequence of $00a_1a_2a_3\ldots$.
    b. Explain (intuitively) why a finite-state machine cannot be built that, for any input sequence $a_1a_2a_3\ldots$, produces the output sequence $0a_10a_20a_3\ldots$.
16. a. Construct a finite-state machine that will compute the 2's complement of p where p is a binary number input with the least significant digit first. (See Exercise 27, Section 8.2.) (In this case, read the input right to left.)
    b. Use the machine of part (a) to find the 2's complement of 1100 and of 1011.
17. You are designing a Windows-based, event-driven program to handle customers for a small business. You design the user interface with three screens. The opening screen contains an exit button to quit the program and displays a list box of customer names. Double-clicking on one of the entries in the list box brings up a second screen showing complete data for that customer. This screen contains a button to get back to the opening screen. The opening screen also contains a button that brings up a form to enter the data for a new customer. Draw the state graph for a finite-state machine that describes the high-level user interaction with the program.

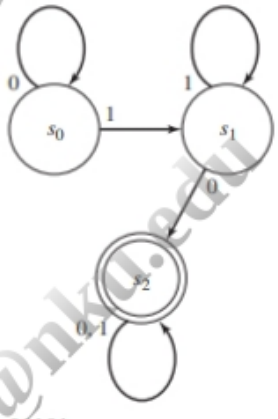
18. Whenever a video disk is inserted into a DVR, the machine automatically turns on and plays the disk. At the end of the recorded part of the disk, the machine turns off. To program the DVR, you must manually turn it on and then select the menu function; when you are finished, you turn the machine off, but its timer is set. At the appropriate time, the machine records, then at the appropriate time it turns itself completely off. Draw the state graph for a finite-state machine that describes the behavior of the DVR.
19. You have an account at First National Usury Trust (FNUT) and a card to operate their ATM (automated teller machine). Once you have inserted your card, the ATM will allow you to process a transaction only if you enter your correct code number, which is 417. Draw the state graph for a finite-state machine designed to recognize this code number. The output alphabet should have three symbols: "bingo" (correct code), "wait" (correct code so far), and "dead" (incorrect code). The input alphabet is $\{0, 1, 2, \ldots, 9\}$. To simplify notation, you may designate an arc by $I-\{3\}$, for example, meaning that the machine will take this path for an input symbol that is any digit except 3. (At FNUT, you get only one chance to enter the code correctly.)
20. An elevator in a three-story building services floors 1, 2, and 3. Input consists of a signal to the elevator of an up-or-down request (U or D) together with the floor from which the signal originates. The elevator responds to an input signal by moving to the correct floor. For example, when the elevator is on floor 1 and receives a D-3 signal, it moves to floor 3. Draw a state graph for a finite-state machine that describes the elevator behavior.

For Exercises 21–24, determine whether the given machine recognizes the given input string.

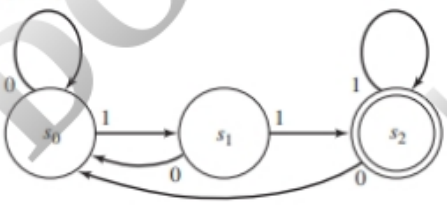
21. 11010



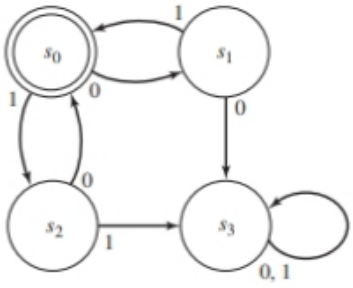
23. 0101



22. 01110111



24. 01101



For Exercises 25–28, construct finite-state machines that act as recognizers for the input described by producing an output of 1 exactly when the input received to that point matches the description. The input and output alphabet in each case is $\{0, 1\}$.