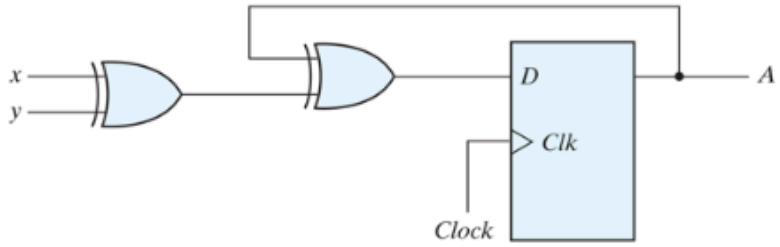
Analysis with *D* Flip-Flops

We will summarize the procedure for analyzing a clocked sequential circuit with *D* flip-flops by means of a simple example. The circuit we want to analyze is described by the input equation

$$D_A = A \oplus x \oplus y$$

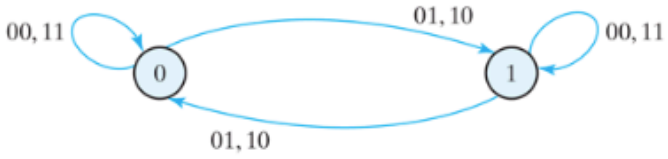
The D_A symbol implies a *D* flip-flop with output *A*. The *x* and *y* variables are the inputs to the circuit. No output equations are given, which implies that the output comes from the output of the flip-flop. The logic diagram is obtained from the input equation and is drawn in **Fig. 5.17(a)**.



(a) Circuit diagram

Present state	Inputs		Next state
A	*x*	*y*	*A*
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

(b) State table



(c) State diagram

FIGURE 5.17
Sequential circuit with *D* flip-flop

The state table has one column for the present state of flip-flop *A*, two columns for the two inputs, and one column for the next state of *A*. The binary numbers under *Axy* are listed from 000 through 111 as shown in **Fig. 5.17(b)**. The next-state values are obtained from the state equation

$$A(t+1) = A \oplus x \oplus y$$

The expression specifies an odd function and is equal to 1 when only one variable is 1 or when all three variables are 1. This is indicated in the column for the next state of *A*.

The circuit has one flip-flop and two states. The state diagram consists of two circles, one for each state as shown in **Fig. 5.17(c)**. The present state and the output can be either 0 or 1, as indicated by the number inside the circles. A slash on the directed lines is not needed, because there is no output from a combinational circuit. The two inputs can have four possible combinations for each state. Two input combinations during each state transition are separated by a comma to simplify the notation.

Practice Exercise 5.6

What determines the next state of a *D*-type flip-flop?

Answer: The next state of a *D*-type flip-flop is the value of *D* at the synchronizing edge of the clock.