NAND Gate

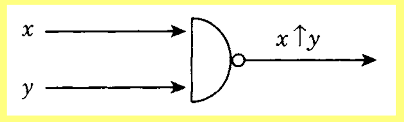
A **NAND gate** receives two bits x and y as input signals and produces a unique output denoted by $x \uparrow y$, where

$$x \uparrow y = \begin{cases} 0 & \text{if } x = 1 = y \\ 1 & \text{otherwise} \end{cases}$$

Figure 12.10 displays a NAND gate.

Figure 12.10

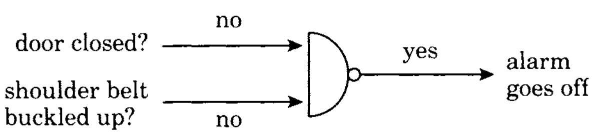
A NAND gate.



The next example provides an interesting instance of a NAND gate from everyday life.

EXAMPLE 12.18 Modern cars are equipped with alarms to warn forgetful drivers. Assume the car key is in the ignition. If the door on the driver's side is not closed or if her shoulder belt is not buckled up, a sound alarm will go off automatically. (See Figure 12.11.)

Figure 12.11



■

NOR Gate

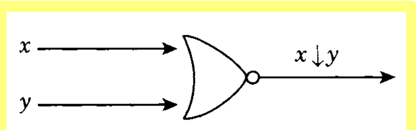
A **NOR gate** receives two input signals x and y and produces a unique output denoted by $x \downarrow y$, where

$$x \downarrow y = \begin{cases} 1 & \text{if } x = 0 = y \\ 0 & \text{otherwise} \end{cases}$$

A NOR gate is pictured in Figure 12.12.

Figure 12.12

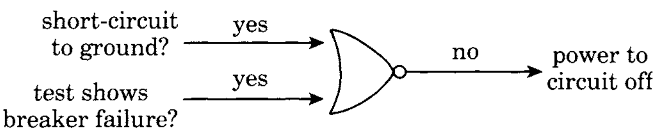
A NOR gate.



The next example presents a real-world application of a NOR gate.

EXAMPLE 12.19 Modern bathroom circuits are required for safety reasons to have "ground fault interrupt" circuit breakers to terminate the flow of electricity. These circuit breakers turn power off automatically if they detect a short-circuit. Circuit breakers carry test buttons, so the user can confirm that the breaker is working. Power is on unless a short-circuit is detected or a test indicates a dead breaker. This situation can be represented by a NOR gate, as Figure 12.13 shows.

Figure 12.13



■

The five logic gates introduced carry out basic operations of easy practical value, yielding predictable output from known input. AND gates yield products, OR sums, and NOT complements. NAND and NOR gates produce exactly the opposite outputs of AND and OR gates.

Exercises 12.3

Find the output, if the bits 1, 1, and 0 are input into each gate.

1. AND gate 0 ✓ 1×1×0=0 **2.** OR gate 1 ✓ 1+1+0=1

Compute the NAND gate output from inputing each pair of bits.

3. 0,0 = ~~0~~ 1 **4.** 0,1 = ~~0~~ 1 **5.** 1,0 = ~~0~~ 1 **6.** 1,1 = ~~1~~ 0

7–10. Redo Exercises 3–6 with a NOR gate. 0,0 = 1 ✓, 0,1 = 1,0 = 1,1 = 0. ✓

Construct a logic table for each gate.

11. $x \uparrow y$ **12.** $x \downarrow y$

Find the DNF of each boolean function.

13. $f(x,y) = x \uparrow y$ **14.** $f(x,y) = x \downarrow y$

15. $f(x,y,z) = x \uparrow (y \uparrow z)$ **16.** $f(x,y,z) = (x \uparrow y) \uparrow z$

17. Suppose the bits x, y, and z are input into a NAND gate. List the possible output in a logic table.

18. Redo Exercise 17 for a NOR gate.

Mark each statement as true or false.

19. $x \uparrow y = y \uparrow x$ **20.** $x \downarrow y = y \downarrow x$

21. $x \uparrow (y \uparrow z) = (x \uparrow y) \uparrow z$ **22.** $x \downarrow (y \downarrow z) = (x \downarrow y) \downarrow z$