When it is not convenient to write each side of an exponential equation using the same base, you can solve the equation by taking a logarithm of each side.

EXAMPLE 2 Take a logarithm of each side

ANOTHER WAY
For an alternative method for solving the problem in Example 2, turn to page 523 for the **Problem Solving Workshop**.

Solve $4^x = 11$.

$4^x = 11$	Write original equation.
$\log_4 4^x = \log_4 11$	Take $\log_4$ of each side.
$x = \log_4 11$	$\log_b b^x = x$
$x = \frac{\log 11}{\log 4}$	Change-of-base formula
$x \approx 1.73$	Use a calculator.

▸ The solution is about 1.73. Check this in the original equation.

NEWTON'S LAW OF COOLING An important application of exponential equations is *Newton's law of cooling*. This law states that for a cooling substance with initial temperature T_0, the temperature T after t minutes can be modeled by

$$T = (T_0 - T_R)e^{-rt} + T_R$$

where T_R is the surrounding temperature and r is the substance's cooling rate.

EXAMPLE 3 Use an exponential model

CARS You are driving on a hot day when your car overheats and stops running. It overheats at 280°F and can be driven again at 230°F. If $r = 0.0048$ and it is 80°F outside, how long (in minutes) do you have to wait until you can continue driving?

Solution

$T = (T_0 - T_R)e^{-rt} + T_R$	Newton's law of cooling
$230 = (280 - 80)e^{-0.0048t} + 80$	Substitute for T, T_0, T_R, and r.
$150 = 200e^{-0.0048t}$	Subtract 80 from each side.
$0.75 = e^{-0.0048t}$	Divide each side by 200.
$\ln 0.75 = \ln e^{-0.0048t}$	Take natural log of each side.
$-0.2877 \approx -0.0048t$	$\ln e^x = \log_e e^x = x$
$60 \approx t$	Divide each side by -0.0048.

▸ You have to wait about 60 minutes until you can continue driving.

✓ GUIDED PRACTICE for Examples 2 and 3

Solve the equation.

4. $2^x = 5$ **5.** $7^{9x} = 15$ **6.** $4e^{-0.3x} - 7 = 13$