9-6 Modeling Real-World Data

Example 1 Identifying Models by Using Constant Differences or Ratios

Use constant differences or ratios to determine which parent function would best model the given data set.

A.

Time (yr)	5	10	15	20	25
Height (in).	58	93	128	163	198

Notice that the time data are evenly spaced. Check the first differences between the heights to see if the data set is linear.

Height (in).	58	93	128	163	198

First differences 35 35 35 35

Because the first differences are a constant 35, a linear model will best model the data.

B.

Time (yr)	4	8	12	16	20
Population	10,000	9,600	9,216	8,847	8,493

Notice that the time data are evenly spaced. Check the first differences between the populations.

Population	10,000	9,600	9,216	8,847	8,493

First differences –400 –384 –369 –354

Second differences 16 15 15

Neither the first nor second differences are constant. Check ratios between the volumes.

$$\frac{9{,}600}{10{,}000} = 0.96, \frac{9216}{9600} = 0.96, \frac{8847}{9216} \approx 0.96, \text{ and } \frac{8493}{8847} \approx 0.96$$

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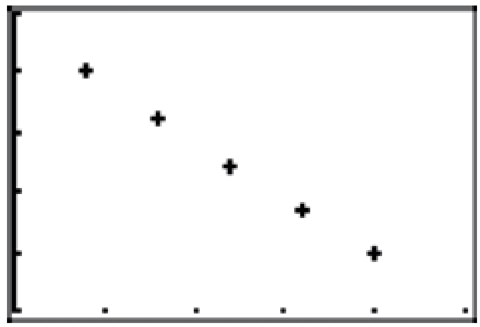
Example 1 Identifying Models by Using Constant Differences or Ratios (continued)

Because the ratios between the values of the dependent variable are constant, an exponential function would best model the data.



Check A scatter plot reveals a shape similar to an exponential decay function.

C.

Time (s)	1	2	3	4	5
Height (m)	132	165	154	99	0

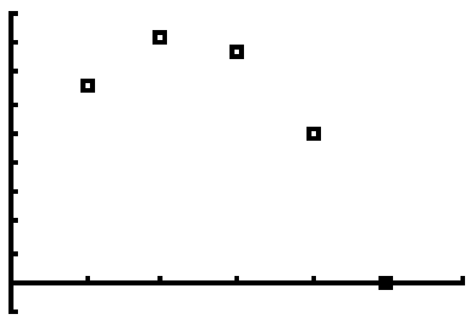
Notice that the time data are evenly spaced. Check the first differences between the heights.

Height (m)	132	165	154	99	0

First differences 33 −11 −55 −99

Second differences −44 −44 −44

Because the second differences of the independent variable are constant when the dependent variables are evenly spaced, a quadratic function will best model the data.



Check A scatter plot reveals a shape similar to a quadratic parent function $f(x) = x^2$.

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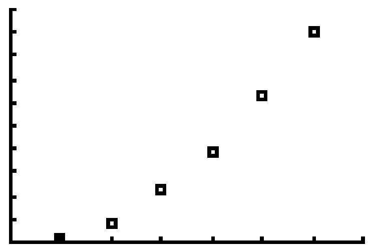
Example 2 Economic Application

A printing company prints advertising flyers and tracks its profits. Write a function that models the given data.

Flyers Printed	100	200	300	400	500	600
Profit ($)	10	70	175	312	500	720

Step 1 Make a scatter plot of the data. The data appear to form a quadratic or an exponential pattern.



Step 2 Analyze differences.

Profit ($)	10	70	175	312	500	720

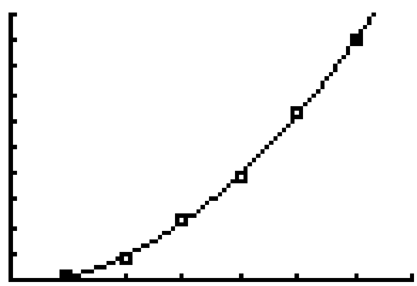
First differences 60 105 137 188 220

Second differences 45 32 51 32

Because the second differences of the independent variable are close to constant when the dependent variables are evenly spaced, a quadratic function will best model the data.

Step 3 Use your graphing calculator to perform a quadratic regression.

```
QuadReg
 y=ax²+bx+c
 a=.0020214286
 b=.007
 c=-11.2
 R²=.9999428789
```



A quadratic function that models the data is $f(x) = 0.002x^2 - 0.015x - 8.7$. The correlation coefficient r is very close to 1, which indicates a good fit.

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Example 3 Application

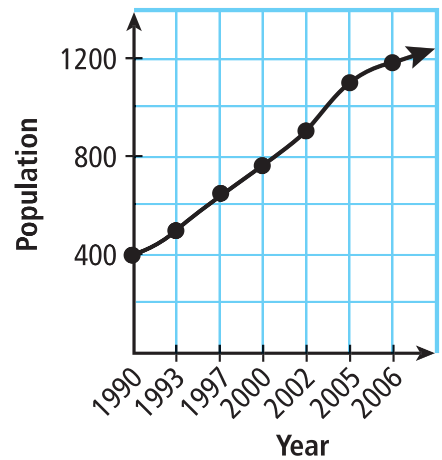
The data set shows the population of a small town since 1990. Using 1990 as a reference year, write a function that models the data.

Year	1990	1993	1997	2000	2002	2005	2006
Population	400	490	642	787	901	1104	1181

The data are not evenly spaced, so you cannot analyze differences or ratios.

Create a scatter plot of the data. Use 1990 as year 0. The data appear to be quadratic, cubic, or exponential.

Use the calculator to perform each type of regression.




```
QuadReg
 y=ax^2+bx+c
 a=1.63434496
 b=22.22609746
 c=403.5805366
 R^2=.9998397932
```

```
CubicReg
 y=ax^3+bx^2+cx+d
 a=.0352679345
 b=.7708935191
 c=27.44604368
 d=399.934689
 R^2=.9999996578
```

```
ExpReg
 y=a*b^x
 a=399.9367777
 b=1.07002316
 r^2=.9999996828
 r=.9999998414
```

Compare the values of r^2 . The exponential model seems to be the best fit. The function $f(x) \approx 399.94(1.07)^x$ models the data.