3.4 Quadratic and Power Models

Recall that we are able to write an equation for a line if we know **two points** on the line.

We are able to write an equation for a parabola if we know **three points** on the parabola.

Problem: Find the function for a parabola if three points on its graph are

(- 2, - 4), (3, 1) and (2, 4).

$y = ax^2 + bx + c$

① $-4 = a(-2)^2 + b(-2) + c$

$-4 = 4a - 2b + c$

② $1 = a(3)^2 + b(3) + c$

$1 = 9a + 3b + c$

$4 = a(2)^2 + b(2) + c$

③ $4 = 4a + 2b + c$

$-1① + ②$

$4 = -4a + 2b - c$

$1 = 9a + 3b + c$

$5 = 5a + 5b$

$-1③ + ②$

$-4 = -4a - 2b - c$

$1 = 9a + 3b + c$

$-3 = 5a + b$

$y = ax^2 + bx + c$

$\boxed{y = -1x^2 + 2x + 4}$

$-1(5 = 5a + 5b)(-1)$

$-3 = 5a + b$

$-5 = -5a - 5b$

$-3 = 5a + b$

$-8 = -4b$

$2 = b$

$-3 = 5a + 2$

$-5 = 5a$

$-1 = a$

$c = 4$

If the graph of a set of data has a pattern that ***approximates*** the shape of a parabola or a part of a parabola, a *quadratic function* may be appropriate to model the data.

Also, for equally spaced input values, if ***second differences*** (the differences of *first differences*) are constant, the data may be modeled ***exactly*** by a *quadratic function*.

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The table has inputs, *x*, and outputs for three functions, *f*, *g*, and *h*. Use second differences to determine which function is exactly quadratic, which is approximately quadratic, and which is not quadratic.

X	*f(x)*	First difference	Second difference
0	0	—	—
2	399	399	—
4	1601	1202	803
6	3600	1999	797
8	6402	2802	803
10	9998	3596	794

f is approximately quadratic.

X	$g(x)$	First difference	Second difference
0	2	—	—
2	0.8	-1.2	—
4	1.2	.4	1.6
6	3.2	2	1.6
8	6.8	3.6	1.6
10	12	5.2	1.6

g is exactly quadratic.

X	$h(x)$	First difference	Second difference
0	0	—	—
2	110	110	—
4	300	190	80
6	195	-105	-295
8	230	35	140
10	290	60	25

h is not quadratic.

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Remember the **four parts of a model**:

- an equation for the curve that fits the data;
- a statement of what the input variable, usually x, represents along with the measurement units;
- a statement of what the output variable, usually y or f(x), represents along with the measurement units; and
- a statement about the interval of the input values so that a user of the model will know whether he/she is using *interpolation* or *extrapolation*.

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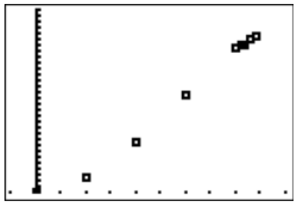
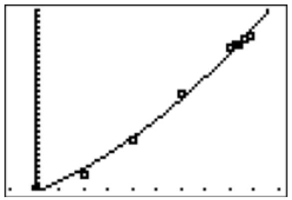
a) x= number of years since 1960

y = median annual income for U.S. males (in dollars)

$y = 6.829x^2 + 329.198x + 3550.236$

X is in [0, 44] or data collected for years from 1960 to 2004.





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b) In 1997 (x = 37) the model estimates the median annual income of males was $25,080.
We interpolated to find this estimate.

In 2010 (x = 50) the model estimates the median annual income of males was $37,083.
We extrapolated to find this estimate.

c) We are fairly confident about the 1997 figure, but extrapolating will not always give accurate predictions.

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b) In 1997 (x = 37) the model estimates the median annual income of males was $25,080.
We interpolated to find this estimate.

In 2010 (x = 50) the model estimates the median annual income of males was $37,083.
We extrapolated to find this estimate.

c) We are fairly confident about the 1997 figure, but extrapolating will not always give accurate predictions.

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Sometimes a *power function* is an appropriate fit for a set of data points.

If *(log x, log y)* is *linear*, a *power function* is an appropriate model for the data points.

For now, we will follow directions given or try both a quadratic and a power function and visually determine the better fitting function.

There are statistical measurements to measure *goodness of fit* of models to data, but *care must be used in interpreting these measures.*

For example, we can use *r* to measure the goodness of fit for a linear function, but **not** for a quadratic function.

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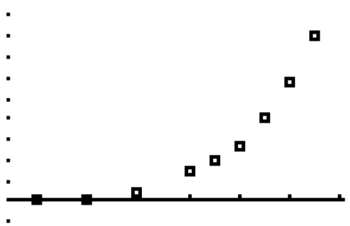
a)



A model with some curvature is appropriate, perhaps a quadratic function.

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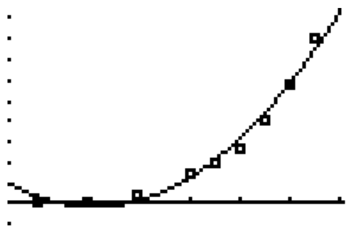
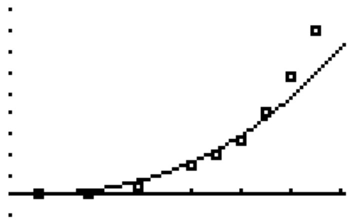
b) For both the power model and the quadratic model,

x = the number of years since 1950
y = national health care expenditures in the US in billions of dollars
$x \in [10, 65]$



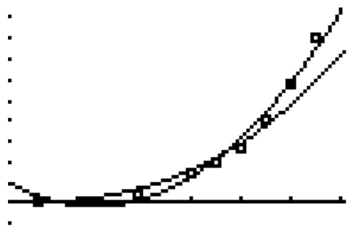
```
Plot1 Plot2 Plot3
\Y1=2.0253988961
366X^2+-86.72191
670849X+853.8904
49908
\Y2=
\Y3=
\Y4=
```

quadratic model



```
Plot1 Plot2 Plot3
\Y1=
\Y2=.03240716023
755X^2.737490901
8414
\Y3=
\Y4=
\Y5=
```

power model



c) The quadratic model gives an expenditure value for 2010 that is closer to the value given in the table than does the power model.

d) $4707.8 billion

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