CHAPTER 4

Quadratic Relations

This chapter introduces methods for analysing non-linear relations that can be characterized by an arch-shaped curve. This curve is seen in nature, art, and architecture. This type of non-linear relation is analysed by engineers to design bridges, by physicists to track the path of projectiles, and by analysts to maximize profit or predict trends in the consumer market.


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McDonald's


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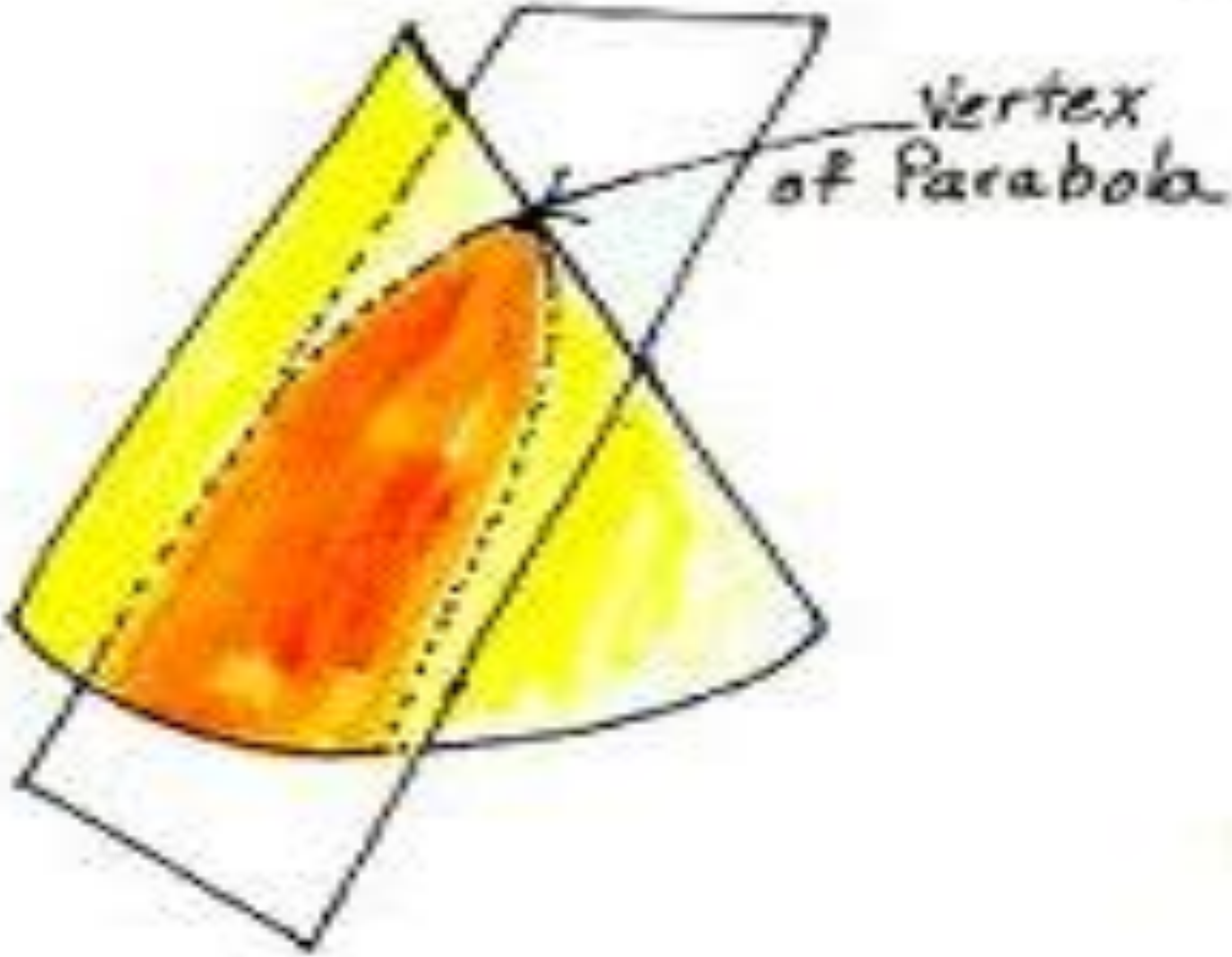

Vertex
of Parabola

Vocabulary

non-linear relation
curve of best fit
quadratic relation
parabola
vertex
axis of symmetry
finite differences
zero

Quadratic Relations of the Form $y = ax^2 + bx + c$

- Collect data that can be represented as a quadratic relation, graph the data, and draw a curve of best fit.
- Determine that a quadratic relation of the form $y = ax^2 + bx + c$ $(a \neq 0)$ can be graphically represented as a parabola, and that the table of values yields a constant second difference.
- Identify the effect on the graph of $y = x^2$ of transformations by considering separately each parameter a, h, and k.
- Explain the roles of a, h, and k in $y = a(x - h)^2 + k$, and identify the vertex and the equation of the axis of symmetry.
- Sketch the graph of $y = a(x - h)^2 + k$ by applying transformations to the graph of $y = x^2$.
- Determine the equation, in the form $y = a(x - h)^2 + k$, of a given graph of a parabola.
- Identify the key features of a graph of a parabola, and use the appropriate terminology to describe them.
- Compare the features of the graph of $y = x^2$ and the graph of $y = 2^x$, and determine the meaning of a negative exponent and of zero as an exponent.

CHAPTER 4

Quadratic Relations

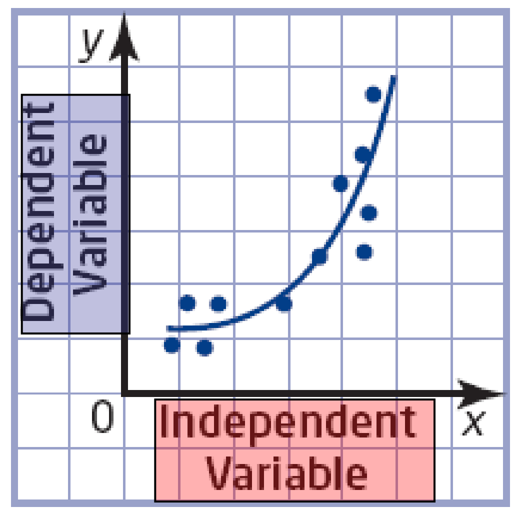
4.1 Investigate Non-Linear Relations

non-linear relation

- a relationship between two variables that does not follow a straight line when graphed

Key Concepts

- The independent variable is the one that you control before the trial begins. The dependent variable is the one that you measure during the trial. It is affected by a change in the independent variable.
- Look at the pattern of the points in a scatter plot when deciding if the relation is linear or non-linear. The points in a non-linear relation will not lie along a line, but will form a graph that is curved.



HWK:
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#1-7

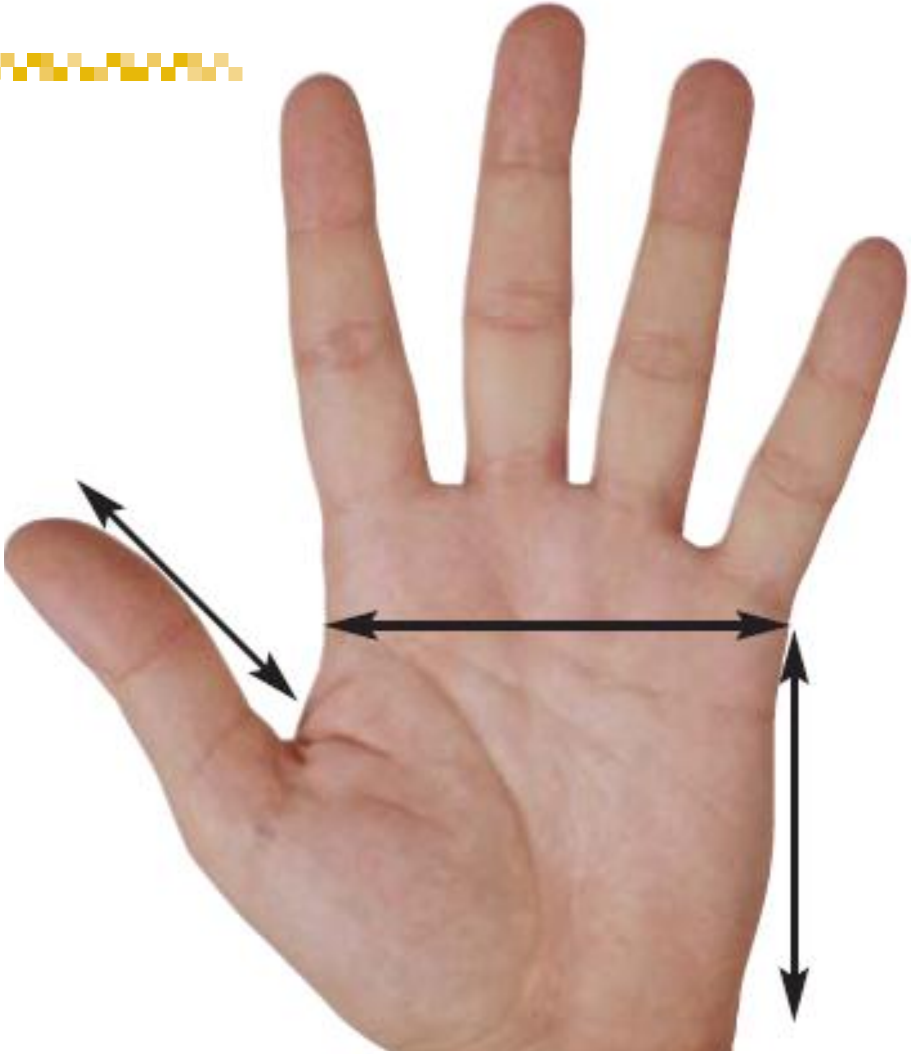
Investigate

A: Relate Thumb Length and Palm Area

Tools
- ruler
- grid paper

Work in small groups.

1. Measure the length of your thumb.
2. Measure the length and width of your palm. Calculate the approximate area of your palm.
3. Record the thumb length and palm area data for each group member.
4. Identify the independent and dependent variables.
5. Make a scatter plot of the data.
6. Describe the relationship between thumb length and palm area.
7. Draw a **curve of best fit**.
8. **Reflect** Why is a curve of best fit used for these data instead of a line of best fit?
9. Use your model to predict the area of a person's palm when that person's thumb is 8.1 cm long.



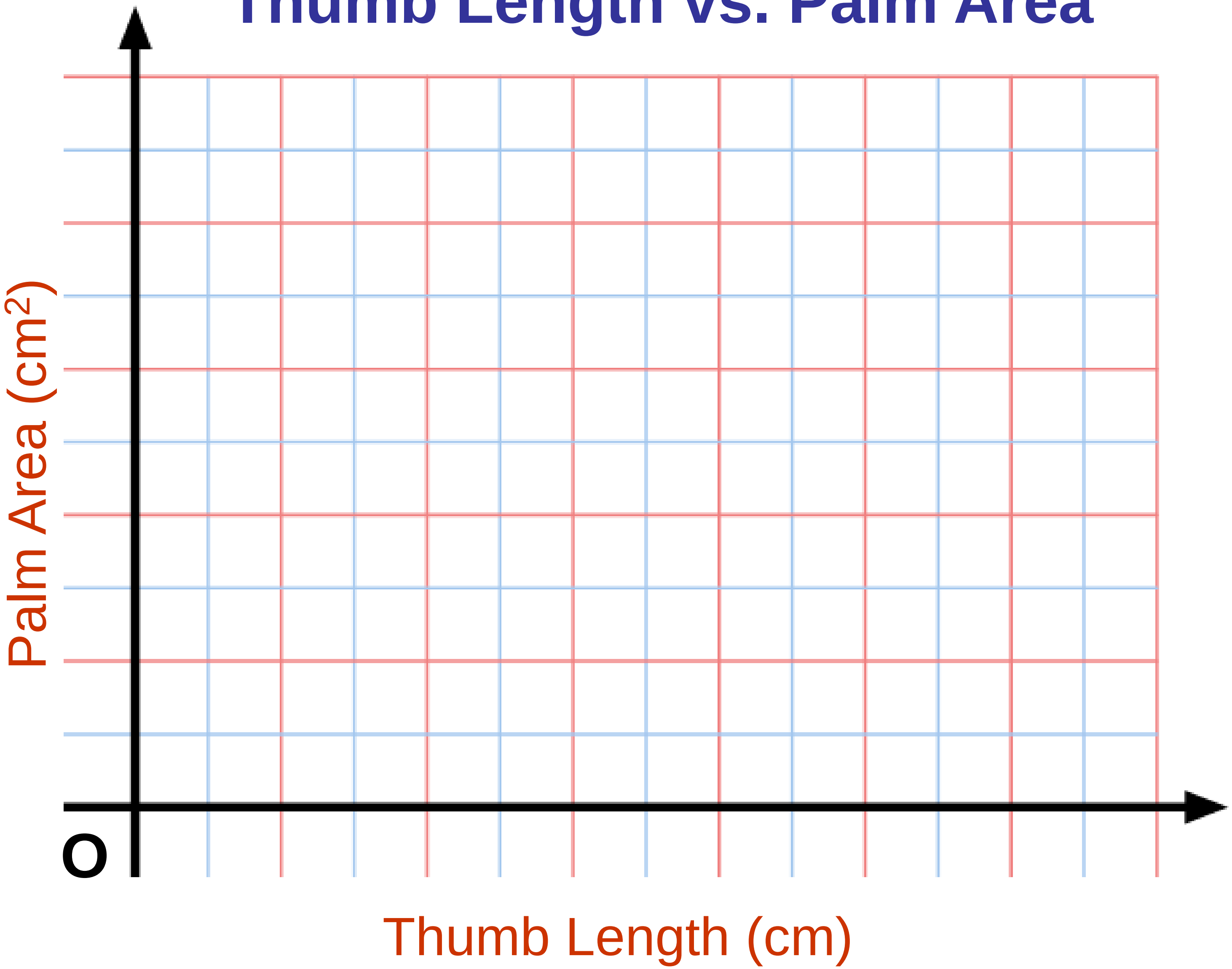
curve of best fit
- a smooth curve drawn to approximate the general path or trend in a scatter plot

Investigate 4.1

Investigate Non-Linear Relations

Thumb l	Palm L	$\times W$	$= A$

Thumb Length vs. Palm Area



3. An altimeter is attached to a model rocket before it is launched. The table shows the recorded data from the rocket's flight.

Time (s)	1	2	3	4	5	6	7
Height (m)	230	310	350	360	350	300	220

a) Make a scatter plot of the data.

b) Describe the relation.

c) Draw a curve of best fit.

d) Use your model to predict the height of the rocket after 8 s.

3.

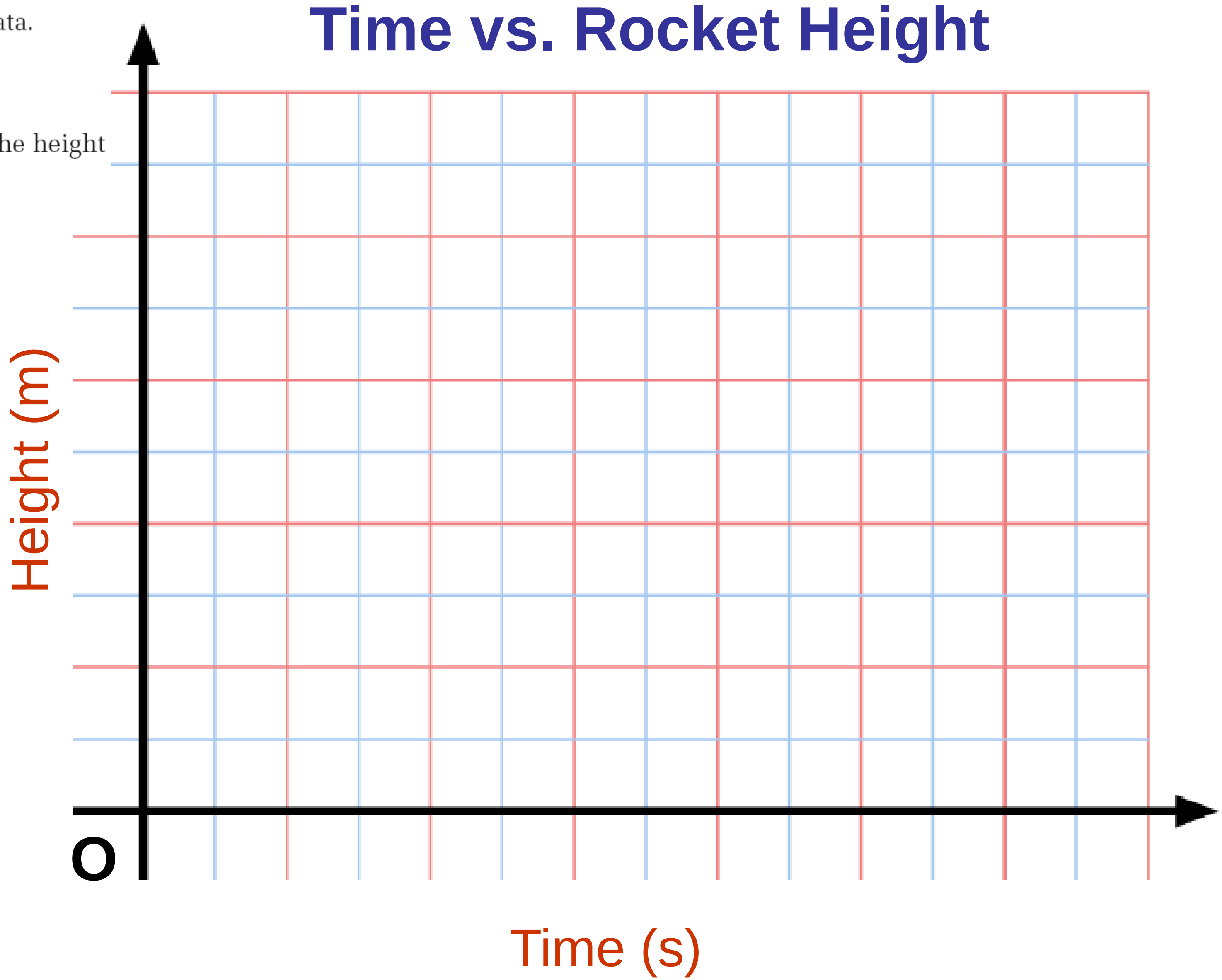
Time (s)	1	2	3	4	5	6	7
Height (m)	230	310	350	360	350	300	220

a) Make a scatter plot of the data.

b) Describe the relation.

c) Draw a curve of best fit.

d) Use your model to predict the height of the rocket after 8 s.

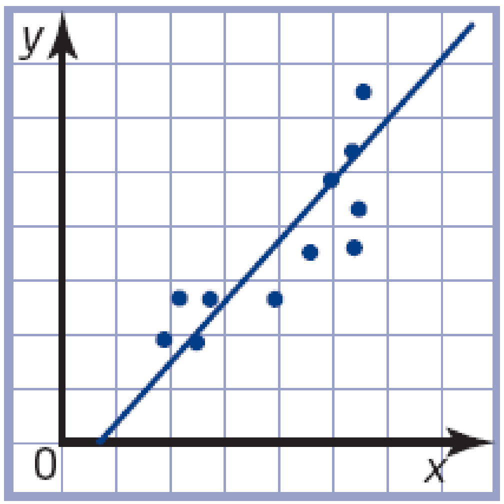


Communicate Your Understanding

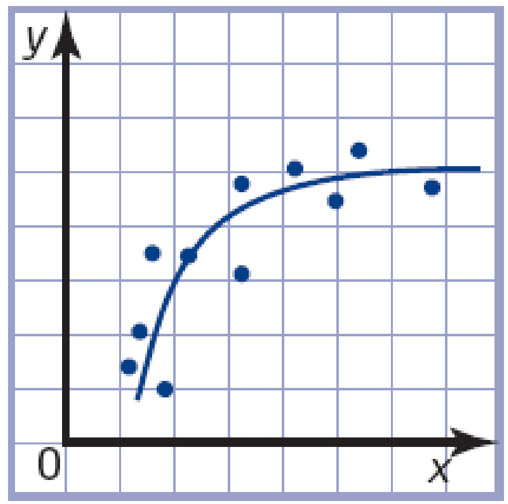
C1

State whether each line or curve of best fit is a good model for the data. Justify your answer.

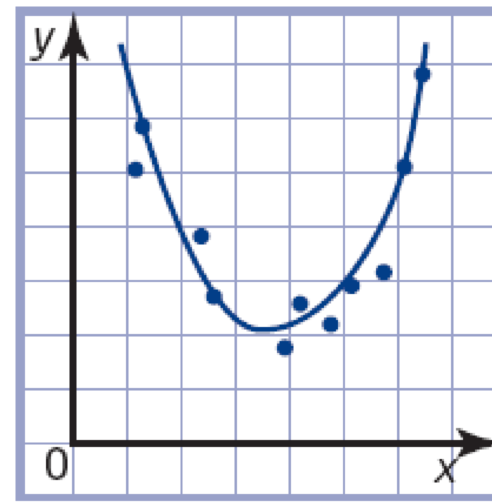
a)



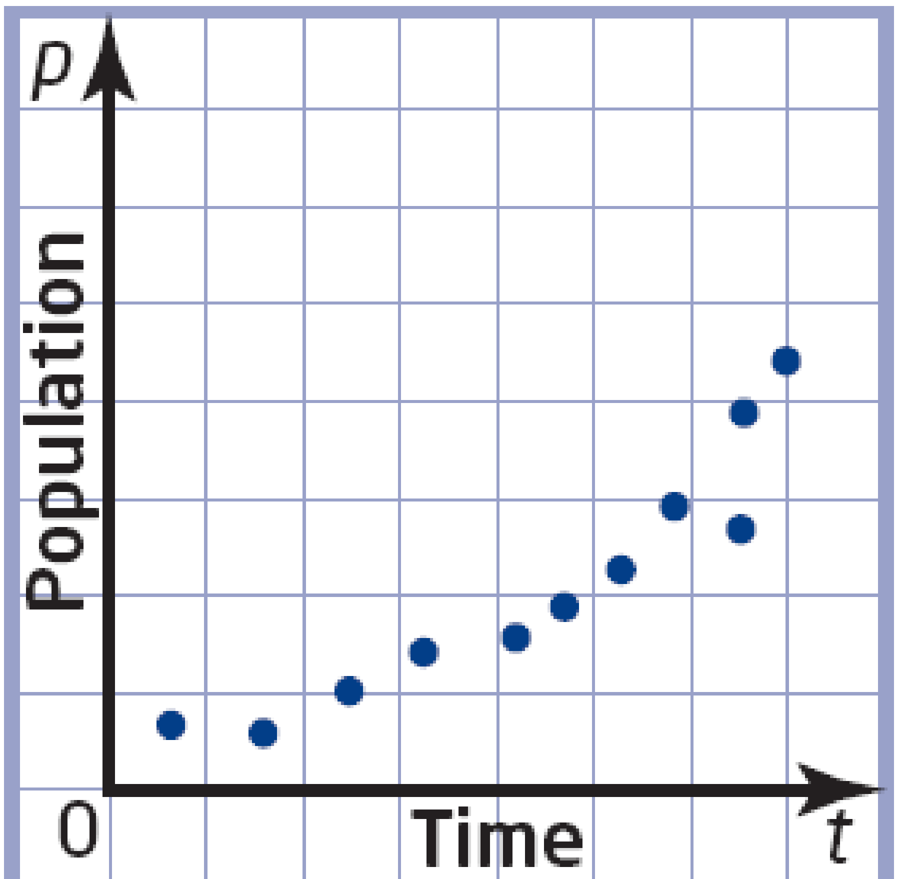
b)



c)



C2 The scatter plot shows the relationship between time, in 5-year intervals, and the population of a town. Explain why time was used as the independent variable.



HWK:
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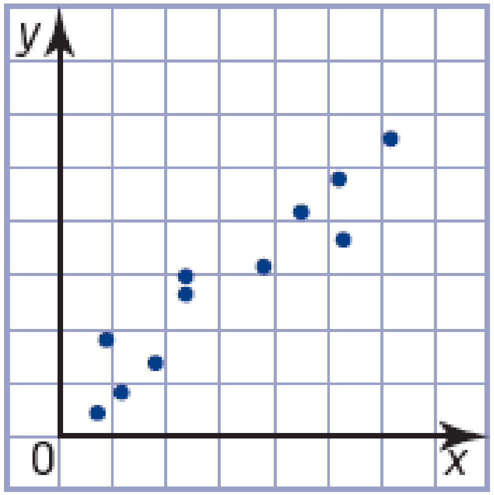
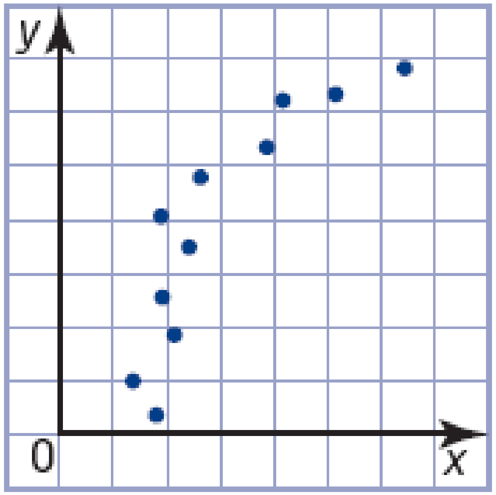
1. Which scatter plot(s) could be modelled using a curve instead of a line of best fit? Explain.

a)

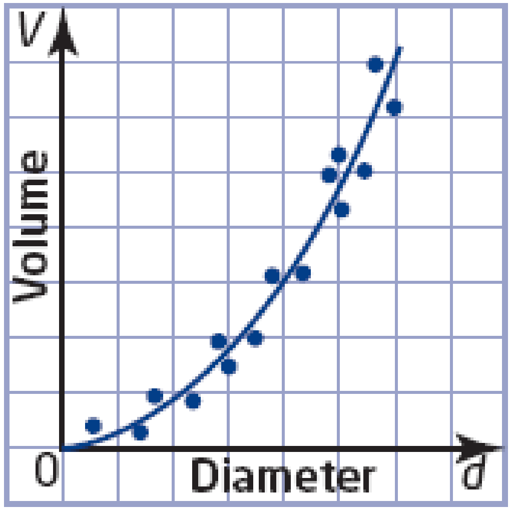


b)



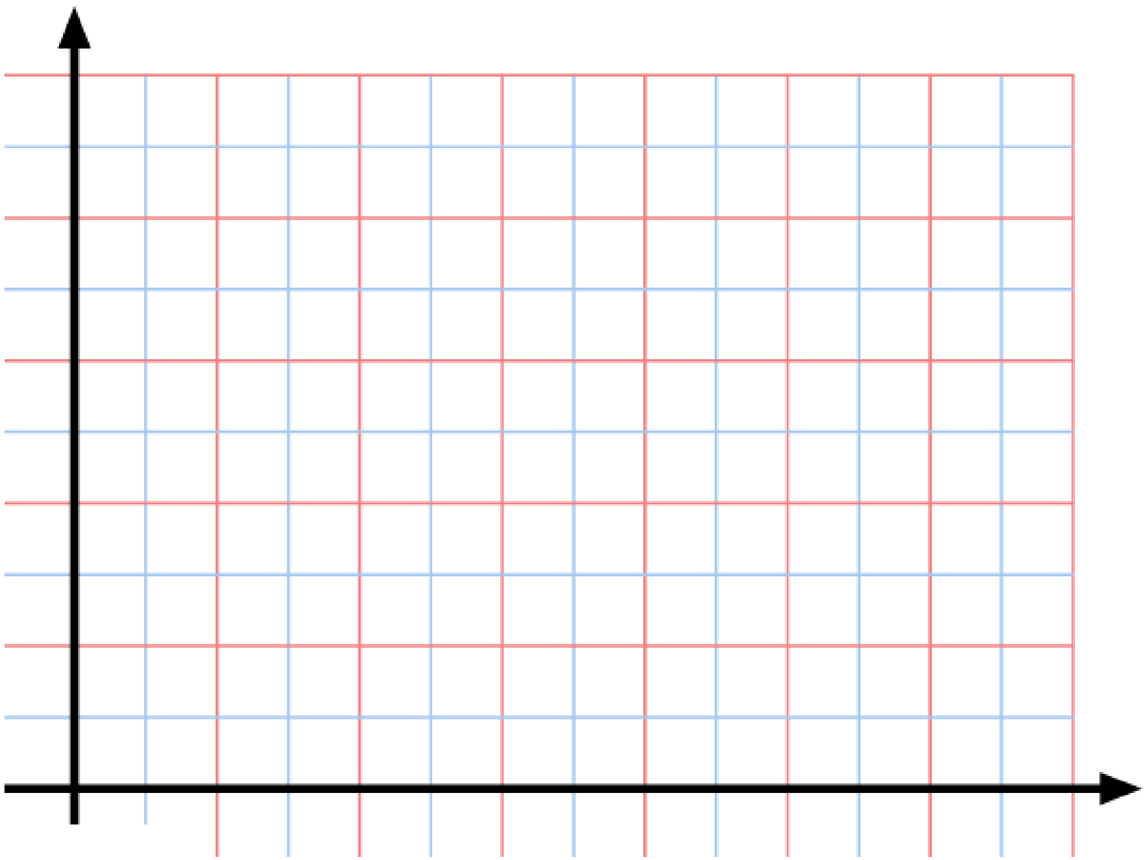
2. The scatter plot and curve of best fit show the relationship between the diameter of rain-collection barrels and the volume of water collected.

Is this relation linear or non-linear? Justify your answer.



4. The table shows the average fuel economy of a car at a test track.

Speed (km/h)	Fuel Economy (L/100 km)
10	14.26
20	12.85
40	10.65
60	10.10
70	10.24
80	10.84
100	12.14
120	15.64
130	16.88
150	22.50



a) Make a scatter plot of the data.

b) Describe the relation.

c) Draw a curve of best fit.

d) Use your model to predict the fuel economy at 200 km/h.

e) This car does not get very good fuel economy. How would a graph of a car with better fuel economy look? Why?

5. The table shows the data for a bouncing ball.

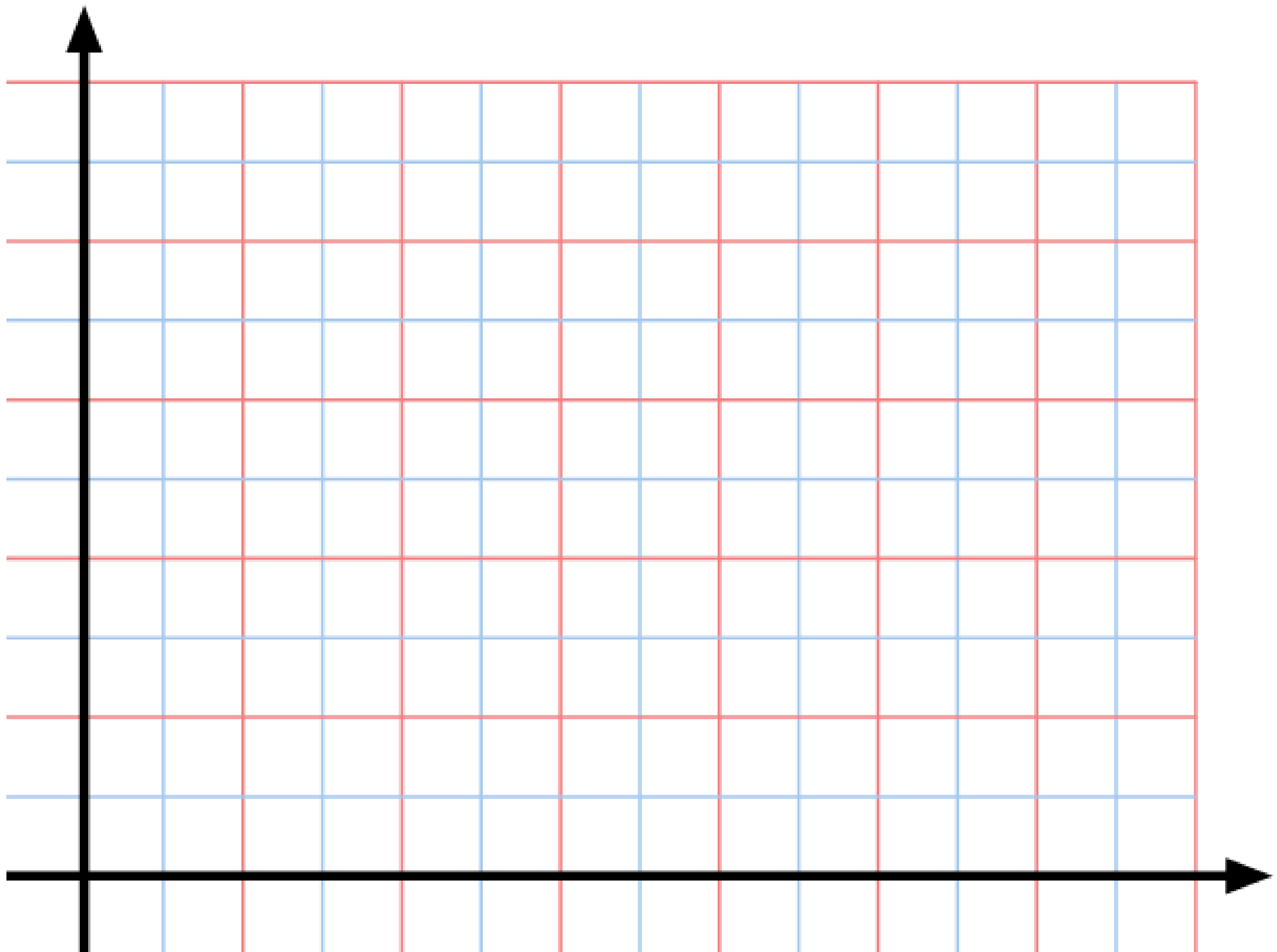
Bounce Number	1	2	3	4	5	6	7
Rebound Height (cm)	270	180	120	80	53	45	25

a) Make a scatter plot of the data.

b) Describe the relation.

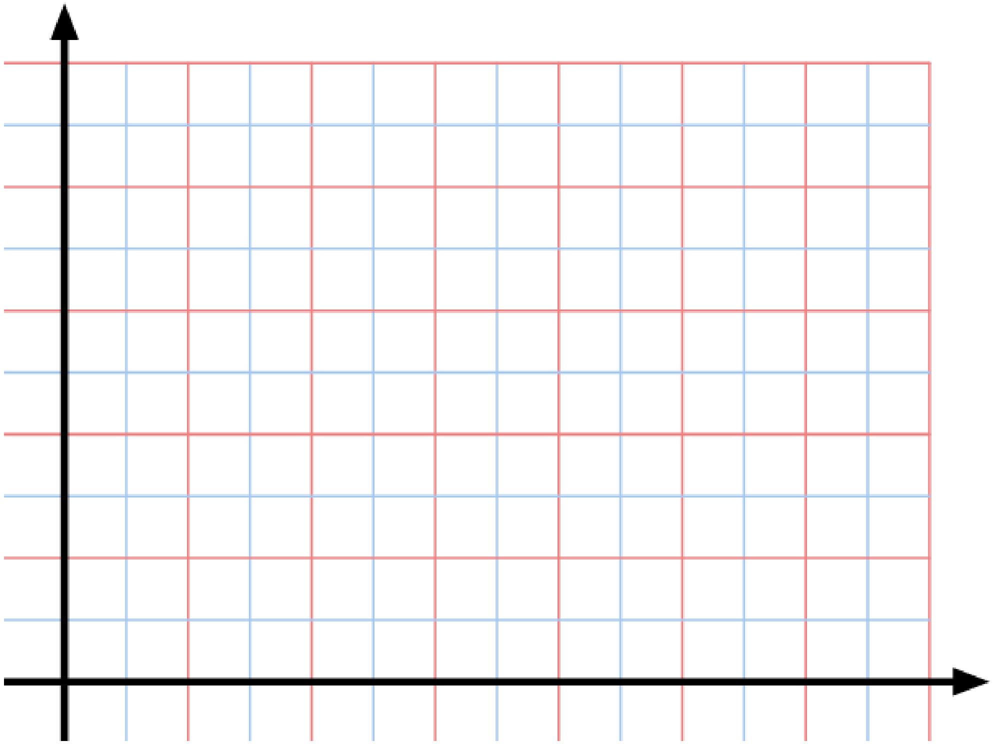
c) Draw a curve of best fit.

d) How would the relationship change for a ball that was bouncier?



6. **Chapter Problem** A city opened a new landfill site in 2000. The table shows how much garbage was added to the landfill in each year from 2000 to 2007.

Year	Garbage Added (1000s of tonnes)
2000	200
2001	230
2002	258
2003	287
2004	317
2005	347
2006	376
2007	406



a) Determine the total mass of garbage in the landfill at the end of each year.

b) Make a scatter plot of the total mass of garbage versus the year. Draw a curve of best fit.

c) What problems do you predict if growth continues at its current rate?

7. A rectangle has a width of x centimetres, and its length is double its width.

a) Create a table comparing the length and area of a rectangle for widths up to 8 cm.

b) Make a scatter plot of the data.

c) Draw a curve of best fit.

d) Explain why the graph of this relation is non-linear.

width	length	area
x	$2x$	$2x^2$