6.2 Linear Relations

Describe and represent linear relations, using:

- words
- ordered pairs
- tables of values
- graphs
- equations.

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Relations
A relation can be presented in a variety of ways. For example,

Words
Three times the length of your ear, *e*, is equal to the length of your face, *f*, (from chin to hairline).

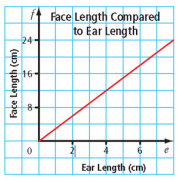
Equation
$f = 3e$

Ordered Pairs
(4, 12), (4.5, 13.5), (5, 15), (5.5, 16.5), (6, 18), (6.5, 19.5)

Table of Values

Ear Length, e (cm)	Face Length, f (cm)
4	12
4.5	13.5
5	15
5.5	16.5
6	18
6.5	19.5

Graph



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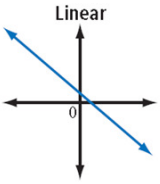
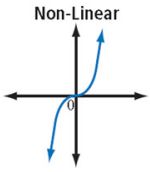
Linear and Non-Linear Relations

There are a number of ways to determine whether a relation is a **linear relation** or a **non-linear relation.**



linear relation
- a relation that forms a straight line when the data are plotted on a graph

non-linear relation
- a relation that does not form a straight line when the data are plotted on a graph



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You can determine whether a relation is linear or non-linear from a table of values. In linear relations, values of y increase or decrease by a constant amount as values of x increase or decrease by a constant amount. Horizontal and vertical lines are exceptions.

Linear Relation

	x	y	
	2	8	
+1	3	11	+3
+1	4	14	+3
+1	5	17	+3

Non-Linear Relation

	x	y	
	2	8	
+1	3	27	+19
+1	4	64	+37
+1	5	125	+61

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When a linear relation is written as an equation, it will contain one or two variables and its degree will be 1.

Linear Relations

$x = 7$

$3m + 2n = -12$

$y = -\frac{2}{3}x + 5$

Non-Linear Relations

$2x + y^2 = 6$ ← degree of 2

$h = k^3$ ← degree of 3

$xy = 3$ ← degree of 2

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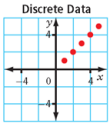
Discrete or Continuous Data

A graph of **discrete data** can only show points because the values in between them have no meaning. A graph of **continuous data** is a solid line or curve.

discrete data
- data values on a graph that are not connected

continuous data
- data values on a graph that are connected

Discrete Data



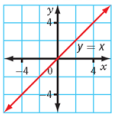
For example, a relation is defined by the set of ordered pairs {(1, 1), (2, 2), (3, 3), (4, 4), (5, 5)}.
There are only five data points in the relation. These are discrete data. The graph has five unconnected points.

For the relation defined by the equation $y = x$, there are an infinite number of possible ordered pairs.

The points (1, 1), (2, 2), (3, 3), (4, 4), and(5, 5) satisfy this relation.

So do many other points such as $\left(\frac{3}{2}, \frac{3}{2}\right)$ and (-3.6, -3.6). These represent continuous data. On a graph, you show an infinite set with an unbroken, or continuous, line.

Continuous Data



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Independent and Dependent Variables

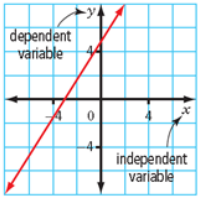
In a relation with two variables, one is the **independent variable** and the other is the **dependent variable**.

independent variable
- the variable for which values are selected (The manipulated variable)

dependent variable
- the variable whose values depend on those of the independent variable (The responding variable)

When a relation is expressed as a table of values, the values of the independent variable are listed in the first column. The values of the dependent variable are listed in the second column.

x	$y = 3x + 5$
−1	2
0	5
1	8
2	11



When a relation is expressed as a graph, the values of the dependent variable are plotted along the vertical axis. The values of the independent variable are plotted along the horizontal axis.

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Example 1 Describe a Relation in a Variety of Ways

The Canadian National Frog Jumping Championship is part of Les Folies Grenouilles. This annual festival is in St-Pierre-Jolys, MB. The first champion, a frog named Georges, jumped a distance of just over 2 m in a single leap. Assume that Georges could maintain a distance of 2 m on every jump and that the total distance travelled from the start is measured after every jump. Consider the relationship between the number of jumps Georges takes and the total distance the frog travels.

a) Identify the relationship as linear or a non-linear. Explain how you know.
b) Create a variable to represent each quantity in the relation. Which is the dependent variable? Which is the independent variable?
c) Create a table of values for this relation. What are appropriate values for the independent variable?
d) Create a graph for the relation. Are the data discrete or continuous?

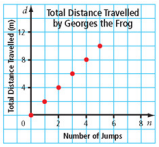
Solution

a) Since the distance that Georges covers on each leap is the same, the relation is linear.
b) The total distance travelled depends on how many jumps the frog takes. Let n represent the independent variable, the number of jumps. Let d represent the dependent variable, the distance travelled.
c) Choose a realistic number of consecutive jumps that Georges might make. For example, the frog could make five jumps.

why can the values of n only be whole numbers?

n	d
0	0
1	2
2	4
3	6
4	8
5	10

d) Display the independent variable, n, on the horizontal axis and the dependent variable, d, on the vertical axis. The data are discrete because there are only six possible values in the relation.
Georges does not take partial jumps, so values for n such as 1.5 or 2.8 cannot be used.



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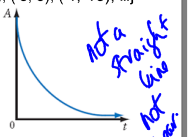
Example 2 Determine Whether a Relation Is Linear or Non-linear

Consider each relation. Determine whether the relation is linear. Explain why or why not.

a) the relation described by {..., (-9, -10), (-7, -5), (-5, 0), (-3, 5), (-1, 10), ...}

Linear.

b) The graph shows the relationship between the amount, A, of a radioactive isotope present and the age of a rock sample over time, t, in years



Not a straight line

Not linear.

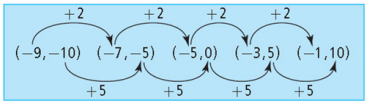
c) the relation described by the equation $m - 17 = 0.8n$

Linear.

Solution

a) Method 1: Compare Changes in the Independent and Dependent Variables

Check to see if the independent variable increases or decreases at a constant rate and if, at the same time, the dependent variable increases or decreases at a constant rate.



Method 2: Use a Table of Values to Compare Changes in Each Variable

	x	y	
+2	−9	−10	+5
+2	−7	−5	+5
+2	−5	0	+5
+2	−3	5	+5
	−1	10	

The relation is linear. Values of x (the independent variable) increase each time by 2. Values of y (the dependent variable) increase each time by 5.

b) The relation is not linear. The graph is not a straight line.

c) The degree is 1. The relation is linear.

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