M1 Maths

A1-4 Discrete vs Continuous Relations

- distinguish discrete and continuous relations and present them as tables and graphs appropriately

Summary Learn Solve Revise Answers

Summary

In a discrete relation, the independent variable takes on a number of separate values with no values in between these.

Relations that are not discrete are continuous. In a continuous relation, the independent variable can take on any of a continuous range of values.

A continuous relation has an infinite number of value pairs. As a table or set of ordered pairs, only a sample of the value pairs can be given. As a graph, all the value pairs can be given by using a line graph.

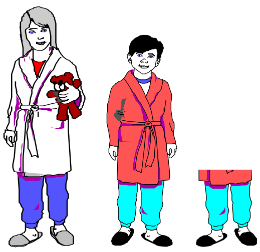
A discrete relation must be graphed as separate points.

Learn

Discrete relations

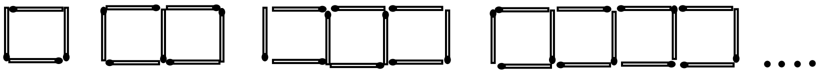
Most of the relations you have examined so far have been **discrete**. This is because their independent variables have been discrete. A discrete variable is one that can take on only certain values, with the values in between these not being allowed.

To understand this better, consider the Matrix Adventure Club example. The independent variable is the number of children. This variable can take the values 0, 1, 2, 3, 4, 5 and 6, but it cannot take values in between these, for instance 4½ or 2.3. This is because a family must have a whole number of children. There is no prescribed joining fee for a family with 2.3 children.



Consider a relation between day of the month and maximum temperature. Here the independent variable is the day of the month. This takes the values 1, 2, 3 etc., but it cannot take a value between 1 and 2.

Consider these squares made from matches:



The independent variable is the number of squares. There must be a whole number of squares: 1, 2, 3, 4, 5, 6, etc. The relation is not designed to give the number of matches for 4½ squares or for any other fractional number of squares.

The word 'discrete' means 'separate' and signifies that the independent variable takes on a number of separate (or discrete) values with no values in between these.

In a discrete relation, the independent variable takes on a number of separate values with no values in between these.

Note that **it is the independent variable that has to be discrete** for the relation to be discrete.

The graph of a discrete relation consists of a set of separate points with spaces in between. The table of a discrete relation contains all the value pairs of the relation. Likewise for a set of ordered pairs.

Continuous relations

Relations that are not discrete are continuous. In a continuous relation, the independent variable can take on any of a continuous range of values.

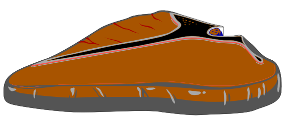
As an example of a continuous relation, consider the relation between the mass of a pack of T-bone steaks and its price.

Suppose T-bone steak costs $20 per kilogram.

a 1 kg pack will cost $20

a 2 kg pack will cost $40

a 3 kg pack will cost $60 etc.



Here, the mass of the pack is the independent variable. Because the relation is continuous, not discrete, it is quite meaningful to consider masses in between these values. For example,

a 1.5 kg pack would cost $30

a 1.1 kg pack would cost $22

a 2.574 kg pack would cost $51.48

a 2.2395061 kg pack would cost $44.79 (even though most butcher's scales would not measure this accurately).

How many different values can the mass take in this relation? It can take an infinite number of different values, and for each value for the mass, there will be a price. So there will be an infinite number of value pairs.

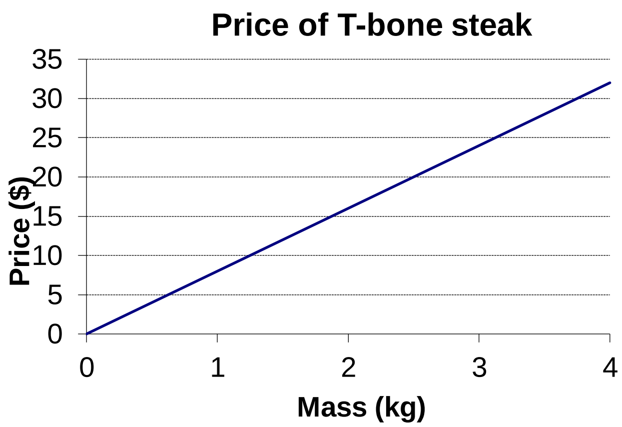
Obviously, we can't put all the value pairs into a table. The best we can do is to write a sample table containing a sample of value pairs, like this one:

Mass (kg)	1	2	3	4	5
Price ($)	20	40	60	80	120

The same will go if we try to write the relation as a set of ordered pairs. There are an infinite number of ordered pairs, so the best we can do is to write a sample set.

However, a continuous relation can be expressed fully as a graph or a formula. The graph for the T-bone relation will look like the one to the right. The formula will be

$$price = mass \times 20$$

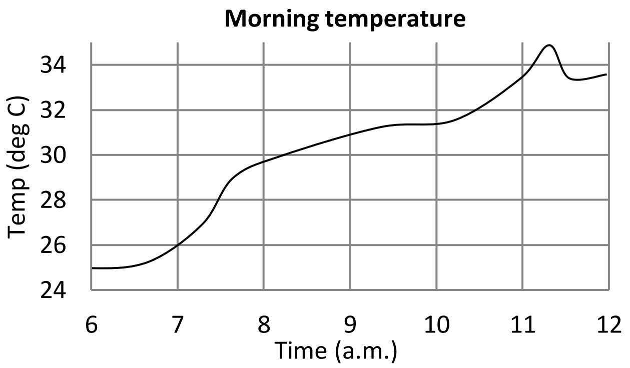


Unlike the graphs of discrete relations you met in earlier modules, this graph is a line graph rather than a set of separate (discrete) points. It is possible to think of the line as consisting of the infinite number of points which represent the infinite number of value pairs of the relation.

Discrete relations are always graphed as separate points.
Continuous relations are graphed as lines.

Continuous relations with and without patterns

The relation between mass and price for T-bone steak above has an obvious pattern (and therefore a formula) and so a sample table or sample set of ordered pairs is adequate because we can work out what the value pairs in between will be.



But consider the graph to the right which shows the relation between time and air temperature between 6 a.m. and noon one day at Popple Peak Weather Station.

This relation has no pattern, so a sample table or sample set of ordered pairs won't give us all the information, as we have no way of working out the value pairs in between. As there is no pattern, the relation can't be written as a formula either. So the graph is the only complete way of expressing it. A sample table would give some indication of the relation, but not a complete one. For example, the sample table below

Time (a.m.)	6	7	8	9	10	11	12
Temperature (°C)	24.8	25.8	29.5	30.8	31.2	33.2	33.3

gives a general picture of the temperature variation during this time, but gives no indication that the temperature got above 34° just after 11 a.m.

Practice

Q1 For each of the following variables, say whether it is discrete or continuous:

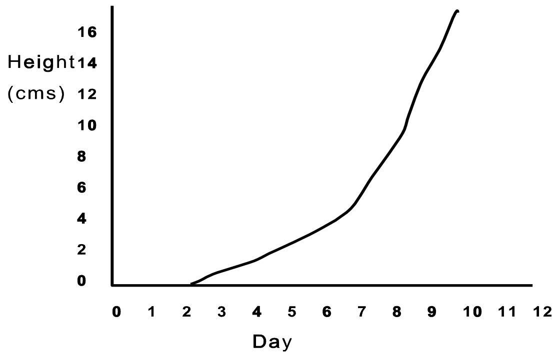
(a) the number of people at a meeting
(b) the number of chairs in the room
(c) the heights of the people at the meeting
(d) how long the meeting goes for
(e) the number of agenda items successfully dealt with
(f) the number of litres of coffee drunk
(g) the year in which the chairperson was born
(h) the date of the meeting
(i) the advertised starting time
(j) the actual starting time
(k) the number of hours the meeting goes for

Q2 For each of the following relations, state whether it is discrete or continuous.

(a) The results of rolling a die 50 times:

Result	1	2	3	4	5	6
Frequency	10	7	9	5	10	9

(b)



Q3 Present the relation in Q2b above as a sample table and as a sample set of ordered pairs.

Q4 You should never join points on a graph by lines when plotting a discrete relation. Explain why.

Solve

Q51 In Australia, pizzas a generally sold whole. The number of pizzas you can buy is a discrete variable. In the US they are often sold in eighths. Is the number of pizzas you can buy there a discrete or continuous variable?

Q52 The price to send a package by post is $12 per kilogram or part thereof. So the price can be $12, $24, $36 etc., but not $18 or $31.20. A graph on the post office wall shows the relation with mass on the horizontal axis and price on the vertical axis. Is this relation discrete or continuous?

Q53 When you buy something in the supermarket, the price is a discrete variable. However, when dealing with large amounts of money, like a person's annual income, the possible values are so close together that we often treat it as a continuous variable. List some other variables which, strictly speaking, are discrete, but which might be thought of as continuous.

Revise

Revision Set 1

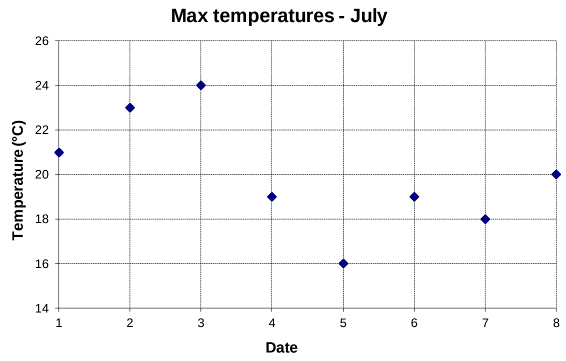
Q61 For each of the following variables, say whether it is discrete or continuous:
(a) the number or people at a party

(b) the number of pizzas ordered for the party
(c) the number of pizzas eaten
(d) the number of songs chosen
(e) the number of hours spent dancing

Q62 For each of the following relations, state whether it is discrete or continuous.

(a) The relation between age and mass for the first six weeks of a baby's life

(b)



Q63 Is it possible to produce a table showing all the value pairs for a continuous relation? Explain why. What do we do instead if we want to present the relation as a table?

Q64 How is the graph of a continuous relation different from that of a discrete relation?

Answers

Q1 (a) discrete (b) discrete (c) continuous (d) continuous (e) discrete (f) continuous (g) discrete (h) discrete (i) discrete (j) continuous (k) continuous

Q2 (a) discrete (b) continuous

Q3 (2, 0), (3, 1), (4, 2), (5, 3), (6, 4), (7, 6), (8, 9), (9, 14), where the first number is the day and the second number is the height in centimetres

Day	2	3	4	5	6	7	8	9
Height (cm)	0	1	2	3	4	6	9	14

Q4 This is because there are gaps between the value pairs

Q51 discrete (because you can't buy 0.361 of a pizza)

Q52 continuous (because the mass is a continuous variable)

Q53 the number of molecules in a glass of water, the numbers of stars in different galaxies

Q71 (a) discrete (b) discrete (c) continuous (d) discrete (e) continuous

Q72 (a) continuous (b) discrete

Q73 No, because there are an infinite number of them. Instead we present a sample table.

Q74 It is a curve rather that separate points