**3.1 Use mathematical models in a variety of contexts**

You should be able to use linear models in a variety of contexts. This will include considering the limitations of the model and possible improvements for the model.

Examples

**Example 1** A student sows a seed and measures the growth of the plant after the seed germinates. On day 1 after germination the plant is 2.5 cm tall. On day 3 the plant is 5.5 cm tall and on day 5 the plant is 8.5 cm tall. The student decides to use a linear model to predict the size of the plant using *t* for the number of the day and *h* for the height in centimetres.

**(a)** Find an equation for *h* in terms of *t*.

**(b)** Use this equation to predict the height of the plant after 10 days.

**(c)** Comment on the suitability of the model.

**(d)** Suggest an improvement for the model.

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| (a) *h* = *mt* + *c*      So *h* = 1.5*t +* 1  (b) When *t* = 10,   *h* = 1.5× 10 *+* 1 = 16  The height is 16 cm.  (c) The model predicts unrestricted growth, which is impossible.  (d) State that *h* = 1.5 *t +* 1 is only valid for *t* < 20 | *m* is the gradient of the straight line and *c* is the intercept.  Substitute (1, 2.5).  Give your answer in context.  Another answer would be that plant growth slows down after a few days  Other improvements are possible. |

Exercise

**1.** In a new school there will be 120 students in each year group. School management wants to model the number of pupils in the school and will use *N* for the number of pupils in the school and *t* for time, such that *t* = 1 during the first year, *t* =2 for the second year, etc.

In the first year there will only be pupils in Y7, in the second year there will be pupils in Y7 and Y8, and the school continues to grow like this until there are 120 pupils in all the year groups from Y7 to Y13.

**(a)** Model this situation with an equation of the form where *m* and *c* are constants to be found.

**(b)** Use this equation to estimate the number of pupils in the fourth year after the school started.

**(c)** State a limitation of this model.

**2.** A sports car is bought new for £725 000. When the car has been used for 1 year the car is worth £600 000. The owner decides to use a linear model to predict the value of the car using *t* for the number of years she has owned the car and *V* for the value of the sports car.

**(a)** Find an equation for *V* in terms of *t*.

**(b)** Use this equation to predict the value of the car after 3.6 years.

**(c)** Comment on the suitability of the model.

**(d)** Suggest an improvement for the model.

Answers

**1. (a)** *N* = 120*t* (note *c*=0)

**(b)** *N* = 120 × 4 = 480; the model suggests there will be 480 pupils.

**(c)** One of the following:

* The model suggest the school population will continue to grow indefinitely**.**
* The model does not allow for pupils leaving**.**
* In some year groups there may be fewer than 120 students.

**2. (a)** *V* = –125 000*t* + 725 000

**(b)** *V* = –125 000× 3.6 + 725 000 = 275 000; the model suggests the value will be £275 000.

**(c)** The model suggests that the price will be negative after some years. This is not realistic.

**(d)** For example: the model is only valid for four years and the price will then remain constant

at £225 000.