

How long is a 200 mm paver?

- An activity generating normally distributed data -

To some the above heading poses a silly question

– a 200 mm paver is 200 mm long – but is it?

If you have ever measured pavers or something similar you would have noticed that things that *aim* to be a certain size tend to be close to that size – but do *vary*, some a little too big, some a little too small.



If you don't believe this, find a group of pavers of the same type and measure their lengths. If you do you may find that the results you obtain look a little like those below, or may exhibit even greater variation, depending on your measurement techniques and the quality of the pavers measured.

The actual lengths of fifty 200 mm pavers (in mm)									
199.7	199.7	199.6	199.7	201.0	199.9	200.5	199.6	200.2	199.9
200.3	199.2	200.2	200.7	199.7	199.3	199.6	199.8	199.8	199.8
200.3	200.3	200.1	199.4	200.2	200.5	200.1	199.9	199.8	200.1
199.7	200.8	200.5	199.8	199.4	199.7	200.1	199.1	200.1	199.9
200.0	199.8	200.6	199.7	199.4	200.2	200.0	199.6	200.0	199.9

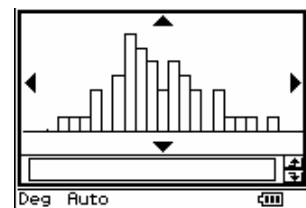
Activity 1 – Representing the lengths of a sample of pavers.

1. Draw a histogram of the lengths of the sample of pavers provided above (or use your own measurements if you have obtained them).
2. Describe the shape of the histogram that you have drawn.
3. Find the mean, median and standard deviation of the paver lengths.
4. Hence, answer the question “how long are these 200 mm pavers?”



Checkpoint

In your previous work with data you may have seen histograms with shapes similar to this one. Data with this characteristic *bell shape* is referred to as *normally distributed*. Many quantities that vary, like the height of your classmates, IQ (if a broad sample is taken), examination results and the measured quantities of manufactured goods



(like lengths, weights, volumes etc) are distributed in this way.

We will see, in the case of paver manufacture, that normal distributions occur because of the sum of the random errors that occur in the manufacturing process.


How long is a 200 mm paver?

Activity 2 – Making pavers without getting your hands dirty.

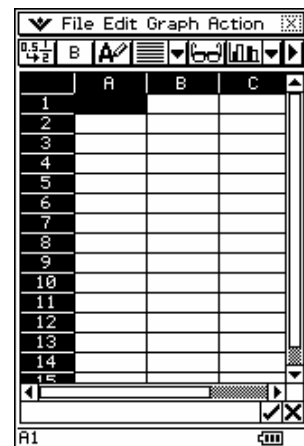
The making of pavers can be thought of in three main stages; the mixing of raw ingredients in a set ratio, the pouring of this mixture into a mold and its firing in a kiln. In each of these stages, errors can be introduced that cause the pavers' final length to deviate from the value intended. These can be human errors, mechanical inconsistencies or natural variations in materials and the environment. These three possible sources of errors act cumulatively, either cancelling each other out or combining to produce pavers that can differ markedly from their intended length.

Making paver by spreadsheet.




A. Open a spreadsheet in the  mode of a CASIO *ClassPad 300*.

Spreadsheet



This spreadsheet recognises three kinds of input,

- *Numbers*.
- *Text*, which can be entered using the abc .
- *Formulae*, which starts with an equals sign (=).

We are going to make 150 'virtual pavers' using this spreadsheet.

Clearly the intended length of the pavers is crucial, as is the size of the possible errors in manufacturing process

Note: In this spreadsheet we are going to use four columns.

To see these at once we can decrease the column width of columns A to C.

To do this, tap and slide over the heading row of columns A to C then tap **Edit : Column Width** and change the **Width** to 30, then tap **OK**.



B. In cell A1 enter the word **Aim**. In cell B1 enter the number **200**, as we will aim to produce pavers that are 200 mm in length.

In cell C1 enter the word **Error**.

In cell D1 enter the number **0.5**, signifying that the greatest single error in the manufacturing process will make a ± 0.5 mm contribution to paver length.

In cells A3, B3, C3 and D3 enter the labels **Ratio**, **Mold**, **Kiln** and **Length**

to indicate that columns A to C will contain the three error sources of the manufacturing process and column D will contain the resulting paver length.



How long is a 200 mm paver?

In the CASIO *ClassPad 300*, random numbers can be generated using the `Rand()` command. This generates a random number between 0 and 1.

To generate random numbers that range from $-max. error$ to $+max. error$, (i.e. ± 0.5 mm) we need to multiply the `Rand()` by twice the max. error and then subtract the max. error, using the max. error that is stored in `D1`.

Because of this, the command `=2* $\$D\1 *Rand()- $\$D\1` will be used.

The `$` is needed to lock the reference to cell `D1` when the formula is filled over a range of cells.



C. To fill columns A to C with this random number generating command,

- Tap **EDIT** : **Fill Range**.
- Enter the above command.
The colon and dollar sign are at screen top.
The command `rand()` is in the **cat** Keyboard.
- Enter the cell range as `A4:C153`.
- Tap **OK**.



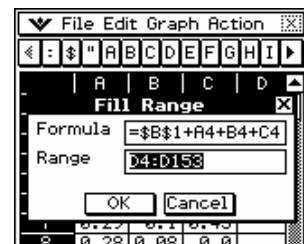
Look through the error values in columns A to C and answer these questions.

1. What is the largest error caused by the kiln in your 150 pavers?
2. Which of your 150 pavers will be the shortest? How short will it be?
3. Why won't you have any pavers that are 198.5 mm long?



D. To find the lengths of your 150 pavers you need to add to the intended length, in `B1`, the three error values in columns A to C.



- To do this,
- Tap **EDIT** : **Fill Range**.
 - Enter the command `=B1+A4+B4+C4`.
 - Enter the cell range as `D4:D153`.
 - Tap **OK**.

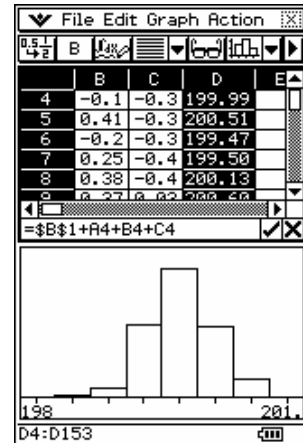


Checkpoint



How long is a 200 mm paver?

Activity 3 – How good are your 200 mm pavers?

The  mode of the CASIO *ClassPad 300* has many of the functions of  mode. The main difference is that the input is defined by a cell range, i.e. $D4:D153$, rather than as a list.



To draw a histogram of your paver lengths


- Tap Edit : Select Range and enter the range $D4:D153$.
- Tap Graph : Histogram (or tap the ▼ next to the  and tap on .


1. Draw a histogram of the lengths of your 150 pavers.
2. Describe the shape of the histogram that you have drawn.
3. Find the 'centre' of this data set.
4. By comparing these answers with your answers to Activity 1, describe the similarities and differences between the lengths of your pavers and the 50 pavers studied previously.



Checkpoint

For further analysis it is desirable to export the data into

 mode. To do this by tapping File : Export.

In  mode type the name of the newly created variable into the heading row of a list to call up the data set.



Activity 4 – Making more pavers.

If changes are made to the contents of cells in your spreadsheet the cells linked to these will be recalculated. This allows us to investigate this situation further.

1. Change the maximum error value to 0.25 mm and, by recalculating, generate the lengths of a new batch of 150 pavers.
2. Investigate the affect that this change has on the shape, centre and spread of the paver lengths.
3. Repeat Questions 1 and 2 for a maximum error value of 1 mm.
4. Change the Aim length of the paver to 170 mm (using a maximum error value used previously) and, by recalculating, generate the lengths of a new batch of 150 pavers.
5. Investigate the affect that this change has on the shape, centre and spread of the paver lengths.



Checkpoint