Use of Calculators in MEI Statistics Examinations

Doing statistics involves using data to solve problems. Doing a statistics examination has a slightly different purpose; the candidate needs to demonstrate to the examiners that the necessary techniques have been acquired and can be used appropriately and accurately. In some cases this can be done by simply recording the correct answer to a question or a part question. However, that can only succeed if the candidate has ended up with the correct answer, and records it to a suitable degree of accuracy.

Although statistical and graphical calculators are allowed in all AS and A Level statistics examinations, different exam boards may have different expectations of how much working candidates need to show in order to gain marks. The advice in this document comes from MEI and relates to the MEI AS and A Level Statistics modules.

In an examination, marks can only be awarded for clear evidence of a correct method – an unsupported, wrong answer scores no marks, however close it may be to the right answer. When candidates use calculators in examinations they should make their method clear.

Scientific Calculators
A typical S1 question could ask students to find the sample mean and sample variance, s^2, of these data:

9   13   15   15   16   16   17   19   19   21   25   25

There are three ways in which candidates might use their calculators in answering this question:

Using basic calculator functions only	Entering data and using summary statistics	Entering data and using calculator functions
9+13+15+15+16+16+17+19+ 19+21+25+25=210 mean = 210/12 = 17.5 9²+13²+15²+15²+16²+16²+17²+ 19²+19²+21²+25²+25²=3914 $S_{xx} = \sum x^2 - \dfrac{\left(\sum x\right)^2}{n}$ $= 3914 - \dfrac{(210)^2}{12} = 239$ Variance = $\dfrac{S_{xx}}{n-1} = \dfrac{239}{11} = 21.73$	$\sum x = 210$; mean = 210/12 = 17.5 $\sum x^2 = 3914$ $S_{xx} = \sum x^2 - \dfrac{\left(\sum x\right)^2}{n}$ $= 3914 - \dfrac{(210)^2}{12} = 239$ Variance = $\dfrac{S_{xx}}{n-1} = \dfrac{239}{11} = 21.73$ [**Check** that calculator does give mean = 17.5, variance = 21.73]	Mean = 17.5 Variance = 21.73

Using only basic calculator functions means that each data item has to be typed in twice and that increases the likelihood of entering a number incorrectly. Just writing down the mean and variance means that no credit can be given if these are incorrect, even if the candidate has understood the process. Using summary statistics allows some working to be shown which is likely to receive some marks, even if the final answers are incorrect. It is sensible to use the calculator to check that the mean and variance it gives are the same as those calculated from the summary statistics. This is quick to do if the data have been entered in.

Graphical calculators

Finding probabilities

For a question which involves finding $P(X < 22)$ for $X \sim N(24, \ 3.2^2)$ candidates can either standardise and use tables or they can use the functions available on some graphical calculators. However, there are usually several marks available for such questions and candidates who write down only an answer from their graphical calculator will get no marks if this answer is incorrect. To avoid this, candidates could standardise and use tables and just use the graphical calculator to check their answers. At the very least, candidates who are using their graphical calculators should write down the numbers they are inputting for such a question. For the above example,

Lower bound = -1000, upper bound = 22, $\mu = 24$, $\sigma = 3.2$ gives $P(X < 22) \approx 0.2660$.

Candidates who do this will be eligible for all the method marks even if the final answer is incorrect.

Note that a question asking candidates to show that $P(X < 22) = 0.2660$, for $X \sim N(24, \ 3.2^2)$, requires them to standardise and use tables, showing all stages in the working. It is not sufficient for candidates to check that their calculator does indeed give the stated answer. So students do need to be able to use statistical tables.

Conducting hypothesis tests

If candidates are using graphical calculators to perform hypothesis tests, they must write down sufficient detail to gain the available marks in the examination. For example, in a chi-squared test, marks are likely to be available for stating the contributions to the test statistic; this is partly because correct contributions indicate that a correct method is being used, but more importantly because these contributions are useful in interpreting the result of the test – they identify and highlight where any important discrepancies are. More generally, marks will be available for finding, with suitable justification, a critical region for a hypothesis test. Any statement of critical regions or values needs to display the corresponding probability, so that examiners can tell that a correct method is being used. Students will find it easier to show sufficient detail of their working if they do ***not*** simply use the hypothesis testing facilities on their calculators.