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## LEVEL 3 CERTIFICATE

*Examiners' report*

# *QUANTITATIVE REASONING*

**H866**

For first teaching in 2015

# H866/02 Summer 2019 series

Version 1

www.ocr.org.uk/maths

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# Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

# Paper 2 series overview

The vast majority of candidates were well prepared for the examination, not just in terms of their knowledge and understanding but also in terms of their willingness to tackle problems in a variety of contexts.

Most candidates showed a good understanding of mathematical and statistical concepts, skills and techniques in their responses. Many were able to confidently apply mathematical and statistical thinking and reasoning to evaluate quantitative information and explain their answers to a wide range of real-life problems.

Most candidates set out their working in a way which made it clear what they had done. This is especially important in problem solving, or in questions where candidates are asked to show that a given answer is true.

Most candidates understood that there were questions where the use of rounded or approximate values was appropriate, and others where exact values were required throughout calculations.

## Question 1 (i)

1 **This question refers to the article "Share Indexes". This was given out as pre-release material and is available as an insert.**

A computer programmer conducts an experiment. He has 16 000 email addresses of people he does not know. The email addresses have been collected independently so the people are unlikely to know each other.

One Sunday, he sends half of the 16 000 people version 1 of the email below. The other half get version 2 at the same time.

| Version 1 | Version 2 |
| --- | --- |
| I have a system for predicting share prices. At 9 am tomorrow the FTSE 100 share index will be increasing. | I have a system for predicting share prices. At 9 am tomorrow the FTSE 100 share index will be decreasing. |

Throughout this question, you may assume that the FTSE 100 share index is always either decreasing or increasing. It is never constant.

**(i)** How many people receive an email on Sunday which correctly predicts the direction of change in the FTSE 100 share index on Monday? **[1]**

Nearly all candidates got this question correct.

## Question 1 (ii)

**(ii)** On each of Monday, Tuesday, Wednesday and Thursday evenings, the programmer divides the people who got a correct prediction the day before into two equal groups.
He sends one group version 1 of the email and the other group get version 2.
Those who got an incorrect prediction the day before get no further emails.

How many people get an email with a correct prediction of the change in Friday's FTSE 100 share index? **[3]**

Nearly all candidates used a correct method but some answered a slightly different question to the one asked, either finding the number of emails sent with any predictions for Friday (so getting 1 000) or the number of correct emails which would have been sent on Friday if the pattern had continued (250).

## Question 1 (iii) (a)

**(iii)** On Friday, the programmer sends those who have had five correct predictions an invitation to sign up for investment information at a cost.
28 women and 17 men respond.

(*A*) What percentage of those who received invitations respond? **[2]**

Most candidates were able to find the correct percentage.

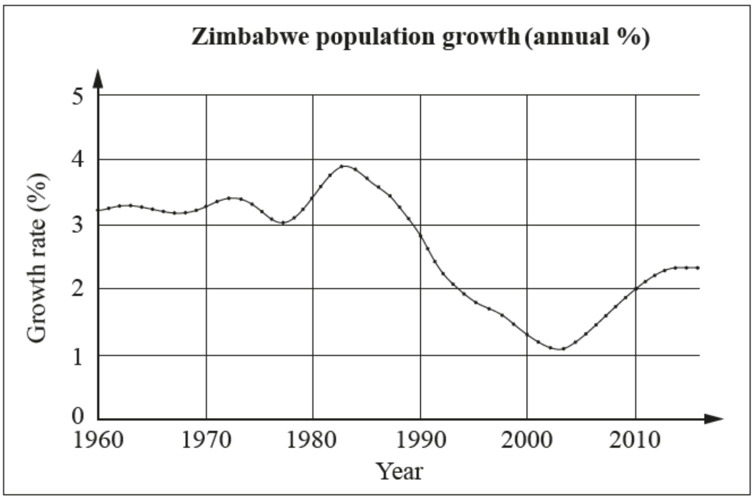
## Question 1 (iii) (b)

(*B*) Explain whether the data tell you that women are definitely more likely than men to respond to such invitations. **[1]**

Most candidates realised that it was not possible to be certain and identified a correct reason, such as not knowing whether there were equal numbers of men and women in the original sample.

## Question 2 (i)

**2** The graph below shows the annual percentage population growth rate in Zimbabwe from 1960 to 2016.




**(i)** A newspaper claims that the graph shows that the population of Zimbabwe decreased in the 1990s before rising again.
Does the graph show this? Justify your answer. **[2]**

Most candidates realised that the graph showed growth rate rather than population. The best responses concluded that the population was always growing because the growth rate was always positive. Some candidates incorrectly assumed that a drop in the growth rate meant a drop in the population.

## Question 2 (ii) (a)

**(ii)** (*A*) Use the graph to estimate the average population growth rate between 1960 and 2016. **[2]**

Successful approaches to estimating the average population growth rate involved either estimating by eye from the graph (perhaps with the help of a horizontal "average line") or taking several readings and finding the mean. Most candidates were successful, but a small number took two readings and found the difference. Some candidates did not realise that the average must be somewhere between the maximum and minimum values.

## Question 2 (ii) (b)

(*B*) The population of Zimbabwe in 1960 was 3.75 million.
Use your answer to (*A*) to calculate an estimate of the population in 2016. **[3]**

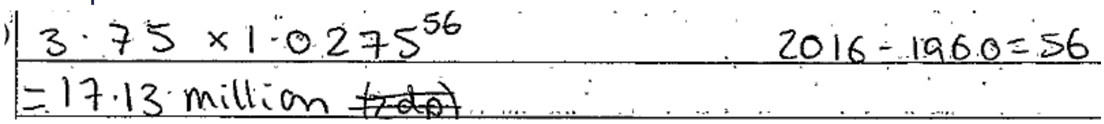
Many candidates were able to use their average growth rate to estimate the population in 2016, using an efficient decimal multiplier method for the 56 year period. Exemplar 1 shows 3.75 million with a growth rate of 2.75% per year for 56 years.

As can be seen in Exemplar 2, a small number wrongly assumed that the number the population went up by in the first year would also apply for subsequent years, i.e. they took a "simple interest" approach. This is seen in the wrong workings below for 2.6% growth per year:

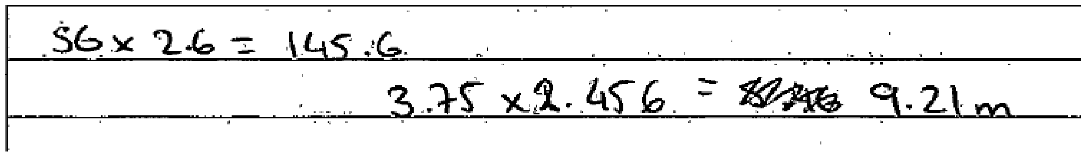
Some found the increase in population over just one year, rather than the whole period as in Exemplar 3.

Nearly all candidates gave the final answer as a whole number of people, which was appropriate.

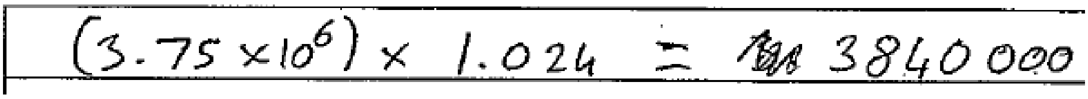
### Exemplar 1


$3.75 \times 1.0275^{56}$ $2016 - 1960 = 56$
$= 17.13$ million

### Exemplar 2


$56 \times 2.6 = 145.6$
$3.75 \times 2.456 = 9.21$m

### Exemplar 3


$(3.75 \times 10^6) \times 1.024 = 3840000$

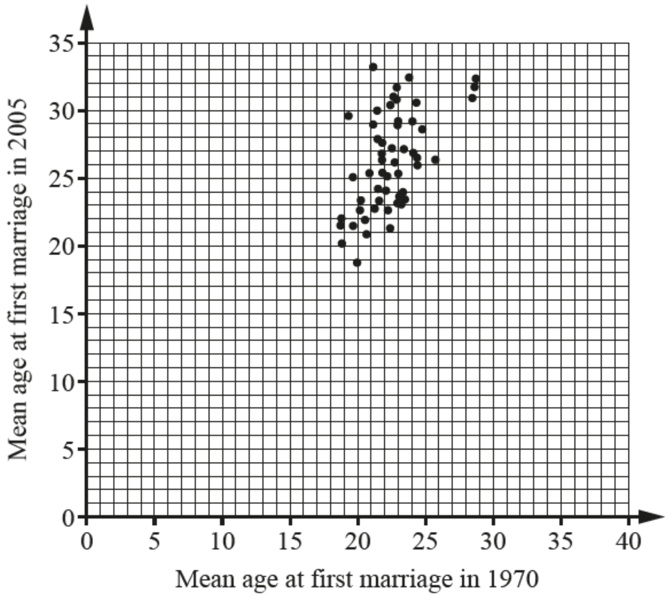
## Question 2 (iii)

**(iii)** The actual population of Zimbabwe in 2016 was 16.15 million.
What does this tell you about your answer to **(ii)** (*A*)? **[1]**

Nearly all candidates were able to compare their estimate to the actual population and come to a suitable conclusion about their average growth rate.

## Question 3 (i)

**3** The scatter diagram below shows the mean age at first marriage for women who were married in the years 1970 and 2005.
Each dot in the scatter diagram represents a different country.
The data are not available for other countries for both years.




**(i)** Circle the point which represents the country with the highest mean age of first marriage in 2005. **[1]**

Nearly all candidates got this correct. The most common error was to circle the point furthest right.

## Question 3 (ii)

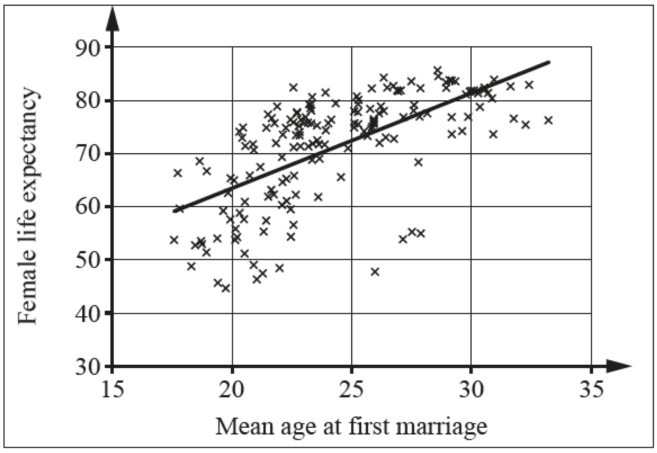
**(ii)** Write T in the box for the statements which must be true and F for the statements which could possibly be false. **[2]**

| | | |
|---|---|---|
| **3(ii)** | ☐ | There is positive correlation in the scatter diagram. |
| | | |
| | ☐ | The three points close together at the top right of the diagram must be due to an error in plotting. |
| | | |
| | ☐ | The graph shows that females below age 18 do not marry in any of the countries shown. |
| | | |
| | ☐ | For the countries shown in the graph, mean age at first marriage in 2005 is generally higher than in 1970. |

Few candidates got this completely correct. Common errors were not recognising the (weak) positive correlation and thinking that the graph showed that females do not marry below the age of 18 in any of the countries shown. None of the mean ages were below 18, but it is possible that some of the ages which contributed to the mean could be below 18.

## Question 3 (iii) (a)

**(iii)** The scatter diagram below shows 2005 data plotted against female life expectancy. A spreadsheet has been used to draw the line of best fit.




(*A*) Sam says 'The graph shows that getting married later makes you live longer'. Is Sam correct? Justify your answer. **[1]**

Candidates who answered simply that correlation did not imply causation got full credit. Longer responses which implied other factors might be relevant also got full credit. Some candidates wrongly referred to the positive correlation as evidence in favour of Sam's statement.

## Question 3 (iii) (b)

(*B*) The mean age at first marriage in a country, not included on the diagram, was 27.8 in 2005.
Sam uses the line of best fit to estimate the female life expectancy in that country in 2005.
Will this give a good estimate of the female life expectancy? Justify your answer. **[1]**

Most correct answers referred to the large amount of scatter or to the outliers. Some candidates claimed that the line of best fit would give a good estimate, with some stating that most points were on the line, which is clearly not the case. It seems that some candidates had not previously considered whether an estimate from a line of best fit was likely to be a good estimate.

## Question 4

**4** A developer is planning a new tourist attraction.
The initial plan has a rectangular area measuring 40 metres by 30 metres set aside for the car park.

Estimate the number of cars which could be parked in the car park. Show all your reasoning. **[6]**

There were many good answers to this question with candidates making good estimates of the typical size of a car parking space and taking into account the need for manoeuvring space in the car park. All candidates were able to gain some marks on this question. A few candidates presented solutions where it was difficult to follow their reasoning but most candidates showed their reasoning clearly, making good use of diagrams in some cases. A common error was to completely misjudge the dimensions of a typical car, with some candidates' work based on vehicles far smaller than a micro-car.

In Exemplar 4 the candidate makes good progress but falls short of a completely correct solution by not taking into account that not all the space would be available for parking as vehicles need to drive and manoeuvre within the car park.

Candidates found various ways of dealing with the space reduction needed for vehicle manoeuvring, as can be seen in Exemplar 5.

## Exemplar 4

Area of the rectangle = 40×30 = 1200 metres²

length of a car = 5 metres (Avg estimate

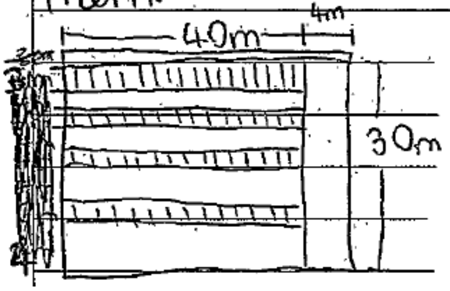
width of a car = 2.5 metres (Avg estimate.

5×2.5 = 12.5m² area of a car.

1200 ÷ 12.5 = 96 cars

## Exemplar 5

The car park is 40m x 30m, but it will not be jam packed with cars, as the cars need space to get in and out, with no othercars obstructing them.




## Question 5

**5** A journalist writes the headline below.

**No public toilets by 2050**

The journalist used the following data about the number of public toilets in England and Wales.

| Year | Number of toilets |
|---|---|
| 2000 | 6087 |
| 2008 | 5084 |

Show that the headline is consistent with a constant rate of change in the number of toilets. **[3]**

Nearly all candidates realised that about 1 000 toilets were lost in 8 years, with many able to complete the question by providing a convincing demonstration that the headline was consistent with this constant rate of change up to the year 2050 or thereabouts. Most realised that to answer the question fully, they should give a short concluding statement as in Exemplar 6 below.

It was disappointing that some candidates who finished with a negative number of toilets in 2050, did not go on to indicate in just a few words that in the modelling context this was consistent with there being no toilets remaining. Exemplar 7 below demonstrates this and could have earned full marks with just a simple worded conclusion.

A few candidates who identified the percentage reduction of 16.5% over the first 8 years, mistakenly went on to use a compound interest model for depreciation which was not appropriate in this context.

## Exemplar 6

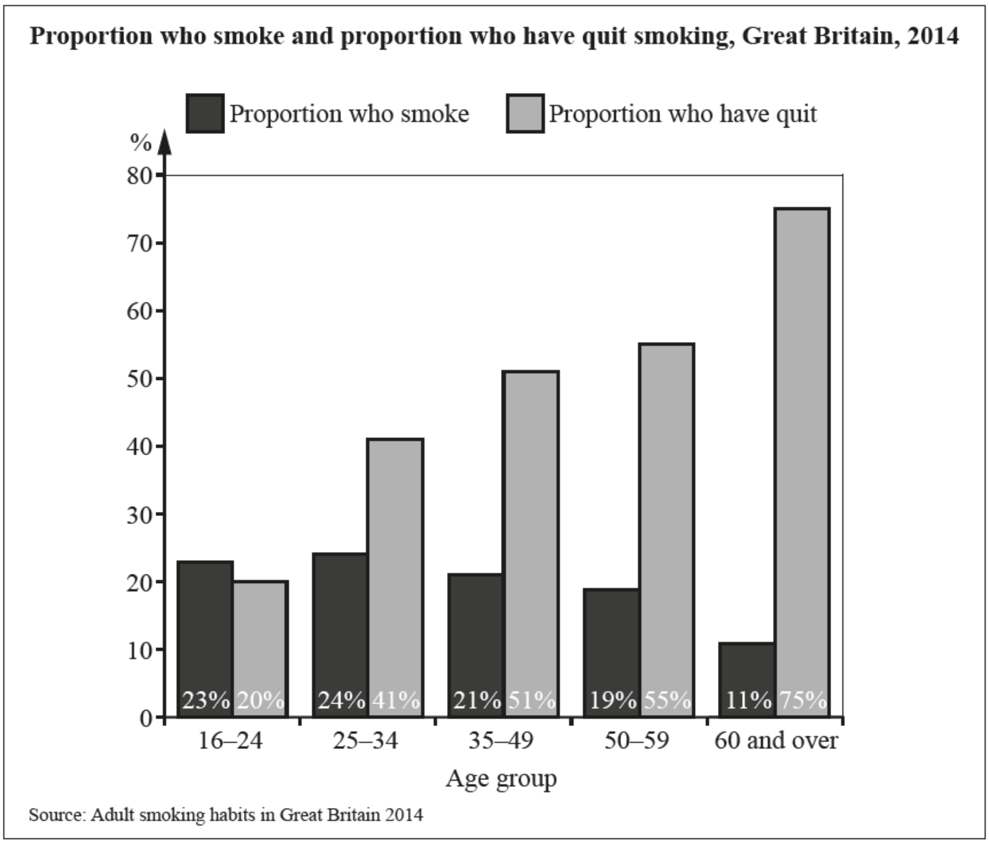
This is consitant as by 2048 there would be 69 toilets left by 2050 there would be 0. However, this would rely on there being a decrease by 1003 toilets every 8 years.

## Exemplar 7

6087 - 6250 = -163 toilets by 2050.

## Question 6 (i) (a)

**6** The chart below shows the percentages of people who smoke and who have quit smoking in different age groups in Great Britain in 2014.




Use the chart to answer the following questions about Great Britain in 2014.

**(i) For the age group 60 and over:**

(*A*) Write down the percentage point difference between the proportion who smoke and the proportion who have quit smoking. **[1]**

Most candidates got this correct. The main error was not focusing on the intended age group, instead attempting to combine data for all age groups. A very small number of candidates did not seem to know what was meant by "percentage point difference" and used division rather than subtraction.

## Question 6 (i) (b)

(*B*) For each person who smokes, roughly how many people have quit smoking? **[2]**

Most candidates got this correct; the main error was not rounding their answer to an integer.

## Question 6 (ii) (a)

**(ii)** (*A*) Which age group has the highest percentage of people who have **never** smoked?
Explain how you know. **[2]**

Most candidates correctly identified the 16 to 24 age group, but some were unable to clearly show why this was the case. The most common error was to say that the group had the lowest percentage of those who had quit. The most commonly chosen wrong age group was 60 and over, "because they have the lowest percentage of smokers" but this did not take account of the fact that people who have quit must have smoked once.

## Question 6 (ii) (b)

(*B*) For that age group, what percentage of people have never smoked? **[2]**

Most candidates got this correct, often by stating the value they had correctly worked out to justify their answer in (ii)(a).

## Question 6 (iii)

**(iii)** In order to answer this question you will need to make an assumption, which you should state, about the population.
21% of people aged 35 to 49 smoke; 24% of people aged 25 to 34 smoke.
Show that there are more smokers aged 35 to 49 than smokers aged 25 to 34. **[3]**

Most candidates realised that there were more people aged 35 to 49 than 25 to 34, as the first group includes a wider age range. Those who did not realise this were unable to make progress. Many candidates made reasonable assumptions for population in each group, and then went on to calculate the numbers of smokers in each group using the 21% and 24% as required for completion.

A few candidates explained that there were more people in the older age range, but then did not offer further calculations. Candidates should have expected to offer more justification than this, given that 3 marks were allocated to this part of the question.

## Question 7 (i)

**7** A football team asks its fans to name their new mascot.
80 people vote by putting four names in order of preference from 1 as the highest to 4 as the lowest.
The numbers of people voting for each option are shown in the table below.

| | **Order of preference (1 highest to 4 lowest)** | | | |
|---|---|---|---|---|
| **Name** | **1** | **2** | **3** | **4** |
| Endeavour | 10 | 26 | 19 | 25 |
| Victor | 35 | 2 | 8 | 35 |
| Lucky | 28 | 12 | 37 | |
| Warrior | 7 | 40 | 16 | 17 |

**(i)** The number is missing from the shaded cell. What should it be? **[2]**

Most candidates got this correct but a small number incorrectly thought that the total number of votes should be 100 rather than 80.

## Question 7 (ii)

**(ii)** Someone suggests that the winning name should be Victor because that had the greatest number of highest preferences.
Give a reason why the votes suggest that Victor should **not** be the winning name. **[1]**

Nearly all candidates gave a reasonable explanation.

## Question 7 (iii)

**(iii)** Describe a **different** possible rule for finding the winning name.
Use your rule to find the winning name. **[4]**

There were many clear and well-explained solutions which scored full marks. Candidates who lost marks often chose a method which had problems similar to the "first past the post" method which had already been dismissed. A small number of candidates suggested abandoning the first vote and voting again with a different voting system; this did not gain credit as it did not address the issue of how to select a winner from the votes that had already been cast.

A popular approach was to assign points to each ranking position, and these were generally completed appropriately to choose a winning name as in Exemplar 8 below.

A few of those who effectively did a 'weighted mean' approach, assigning points 1, 2, 3, 4, did not realise that their winner would have the lowest mean.

## Exemplar 8

Endeavour = (10x4) + (26x3) + (19x2) + (25x1)
= 181 points

Victor = (35x4) + (2x3) + (8x2) + (35x1)
= 197 points

Lucky = (28x4) + (12x3) + (37x2) + (3x1)
= 225 points

Warrior = (7x4) + (40x3) + (16x2) + (17x1)
= 197 points

## Question 8 (i) (a)

**8** A researcher carries out a trial to investigate whether a new medication is effective at preventing a particular illness.
Those taking part are allocated to one of two groups: those who get the medication or a control group.

**(i)** Megan is taking part in the trial. She does not know which group she is in, nor do those conducting the trial.

(*A*) Explain briefly why it is important for the trial to be set up in this way. **[1]**

Most candidates were successful in referring to bias. A common error was to try and explain the placebo effect but not indicate that this might cause bias in the trial.

## Question 8 (i) (b)

(*B*) Which one of the following terms gives the fullest description of the trial?

Blind, Random, Placebo, Experiment, Double blind. **[1]**

Most candidates got this correct.

## Question 8 (ii) (a)

**(ii)** 500 people take part in the trial; they are randomly allocated either to the group taking medication or the control group, such that there are 250 in each group.

The makers of the medication claim that the probability of someone who does not take the medication catching the illness is 0.1 and the probability of someone who takes the medication catching the illness is 0.04.

(*A*) Assuming that the makers' claims about probability are correct, fill in the missing numbers in the table on page 15. **[3]**

| | **Expected numbers taking medication** | **Expected numbers not taking medication** | **Total** |
|---|---|---|---|
| **Catch illness** | | | |
| **Do not catch illness** | | | 465 |
| **Total** | 250 | 250 | 500 |

Most candidates gained full marks here.

## Question 8 (ii) (b)

(*B*) Calculate the probability that someone who catches the illness was taking the medication. **[2]**

Candidates who used their answer to part (A) were more likely to be successful than those who began again using a probability tree approach. Some candidates misunderstood what probability was being asked for.

## Question 9 (i)

**9** 50% of smartphone users will experience a cracked screen.
A local mobile phone shop displays this advert.

**Smartphone protection plan**

Make an additional one-off payment of £40 when you get your phone and we'll replace a cracked screen at any time

The manager of the shop thinks he will sell the protection plan to 400 smartphone users.
A Normal distribution can be used to model the number of people with the protection plan who get a cracked smartphone screen.

Assuming that each person has a 50-50 chance of getting a cracked smartphone screen and 400 users buy the protection plan, work out the following.

**(i)** The mean of the Normal distribution. **[1]**

Most candidates got this part correct.

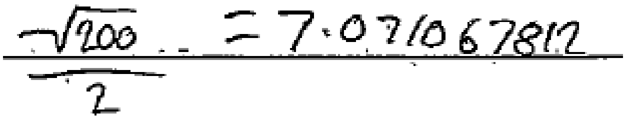
## Question 9 (ii)

**(ii)** The standard deviation of the Normal distribution. **[2]**

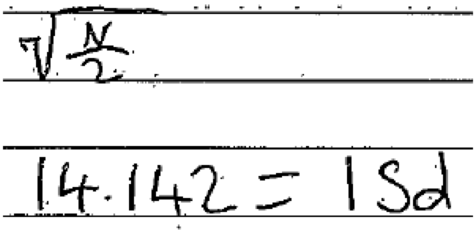
Familiarity with this part of the specification seems to be increasing. However, some of those who quoted the standard formula did not know what *n* stands for and so they were unable to use it appropriately. An example of this, where 200 has been used wrongly instead of 400, is shown in Exemplar 9 below.

A common misquote of the formula was $\sqrt{\frac{n}{2}}$ as shown in Exemplar 10.

### Exemplar 9




### Exemplar 10




## Question 9 (iii)

**(iii)** It will cost the shop, on average, £70 to replace a cracked smartphone screen.
Work out whether the shop is certain to make a profit on the smartphone protection plan.
Explain your reasoning. **[4]**

Most candidates gained a mark for finding the income gained from the protection plan. A common answer that earned a further mark was to calculate the profit and explain in context that this profit would fall if more screens than expected had to be repaired.

A small number of candidates were able to use their answer from 9(ii), to examine the situation where the number of phones with cracked screens might exceed 2 or 3 standard deviations from the mean. Complete solutions based on correct analysis using standard deviation were seen occasionally as in Exemplar 11 below.

## Exemplar 11

~~DD~~ 400 x 40 = Ƶ16000 Profit Ƶ2000

200 x 70 = Ƶ14000

if it is ~~with +Sc~~ up 1 standard deviation the 210 people crack their screens

210 x 70 = Ƶ14700 Profit Ƶ1300

+2 standard deviations

220 x 70 = Ƶ15400 Profit = Ƶ600

+3 Standard deviations

230 x 70 Ƶ16100 Loss Ƶ100

## Copyright information

Question 3(i)-(ii)

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Question 3(iii)

Adapted from 'Life Expectancy (years)', www.gapminder.org, Gapminder. Free material from www.gapminder.org. Reproduced under the terms of the Creative Commons Attribution 3.0 Unported license.

Question 6

40 years of smoking in Great Britain', Office for National Statistics, www.ons.gov.uk/, 9 March 2016. Reproduced under the terms of the Open Government Licence v3.0.

 

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