



Institute
and Faculty
of Actuaries

Guidance for Candidates Sitting the CS2 Exams in September 2020

July 2020

Introduction

In September 2020, as a change to previous practice, the CS2A examination will be an open-book, online exam where candidates will be expected to submit their typed solutions in Word documents. There will be no change to the format of the CS2B examination.

Due to the limitations of typing in Word and also the open-book nature of the exam, the question format for the September 2020 CS2A exam must differ from that of previous exam papers. The purpose of this document is to provide guidance to prospective candidates on the expected format of the September 2020 CS2A paper.

This document provides a commentary on each question in the September 2019 CS2A exam paper with reference to its feasibility for open-book, online delivery. This document should therefore be read in conjunction with the September 2019 CS2A exam paper and Examiners' Report, both of which can be found on the IFoA website using the following link:

<https://www.actuaries.org.uk/studying/prepare-your-exams/past-exam-papers-and-examiners-reports>

The questions in the September 2019 CS2A exam paper broadly fall into one of the following three categories:

	<i>Category</i>	<i>Category Description</i>
1	Likely to be excluded	This refers to questions that would not be suitable for open-book, online delivery. This could be because they are purely Knowledge skill type questions or they require diagrams / graphs / charts as part of the solution or because they contain a very high degree of complex mathematical notation.
2	Likely to be included with appropriate modification	This refers to questions that would be suitable for open-book, online delivery after some appropriate modification e.g. the number of marks allocated is increased to account for the volume of typing required or the scope of the question is reduced to exclude unsuitable elements or the question is converted into multiple-choice format.
3	Likely to be included without any modification	This refers to questions that would be suitable for open-book, online delivery as they currently stand. Questions falling into this category would be expected to be included in the exam without any modification.

Due to the open-book nature of the September 2020 CS2A exam, candidates should expect very few pure Knowledge skill type questions. The approximate split of assessment across the two remaining skill types is 75% Application and 25% Higher Order skills.

Question 7 of the September 2019 CS2A exam falls into category 2 in the table above. For the purposes of providing further guidance to prospective candidates, we have included, in the Appendix, a modified version of this question, to make it suitable for open-book, online delivery. Updated solutions for this question have also been included in the Appendix.

Commentary on the Online Feasibility of the September 2019 CS2A Exam Paper

Question 1

Category 3 – Likely to be included without any modification.

The solution should be relatively straightforward to type in Word using standard keyboard notation. The “Equation Editor” functionality in Word would not be required.

Please refer to the [IFoA Notation Guide](#) for suggested notation that could be used in this question.

Question 2

Parts (i) and (ii) would both fall into Category 3 – Likely to be included without any modification.

Parts (i) and (ii) require no mathematical notation.

Question 3

Part (i) – Category 3 – Likely to be included without any modification.

Part (i) requires no mathematical notation if candidates use the first alternative solution for both the state space and time domain. The second alternative solution for both the state space and time domain should be relatively straightforward to type in Word using standard keyboard notation.

Part (ii) – Category 2 – Likely to be included with appropriate modification.

In part (ii), the formula in the second alternative solution could be suitable for online delivery if candidates use the suggested notation in the [IFoA Notation Guide](#). The first alternative solution could also be suitable but there is a lot to type for 3 marks. As most candidates are likely to opt for the first alternative solution, this question would probably be modified by increasing the number of marks available, reducing the scope of the question to $t = 1$ and 2 only or by converting it into a multiple-choice question.

Part (iii) – Category 3 – Likely to be included without any modification.

Part (iii) requires no mathematical notation.

Please refer to the [IFoA Notation Guide](#) for suggested notation that could be used in this question.

Question 4

Part (i) – Category 1 – Likely to be excluded.

Part (i) is a straightforward Knowledge type question and is therefore likely to be excluded due to the open-book nature of the exam.

Part (ii) – Category 3 – Likely to be included without any modification.

Part (ii) requires no mathematical notation.

Part (iii) – Category 2 – Likely to be included with appropriate modification.

In part (iii), the formulae in the solutions for matrix III would not be suitable for online delivery as they currently stand. However, candidates could use the notation set out in the [IFoA Notation Guide](#) to speed up their typing. This part, therefore, could be modified by increasing the number of marks available, reducing the scope of the question to I and II only (with a corresponding reduction in marks allocated) or by converting it into a multiple-choice question.

Please refer to the [IFoA Notation Guide](#) for suggested notation that could be used in this question.

Question 5

Part (i) – Category 1 – Likely to be excluded.

Part (i) is a straightforward Knowledge type question and is therefore likely to be excluded due to the open-book nature of the exam.

Part (ii) – Category 3 – Likely to be included without any modification.

Part (ii) requires no mathematical notation.

Part (iii) – Category 3 – Likely to be included without any modification.

Part (iii) requires no mathematical notation.

Question 6

Part (i) – Category 3 – Likely to be included without any modification.

Note that candidates would not be expected to use the mathematical notation that is given in the solution in the Examiners' Report as this would require the use of Equation Editor. Instead, candidates could use the suggested notation in the [IFoA Notation Guide](#). For example:

$z_x = \frac{d_x - d_x^e}{\sqrt{d_x^e}}$ could be written as $z_x = (d_x - d_x(e)) / \text{sqrt}(d_x(e))$ and;

$\frac{(d_x - d_x^e)^2}{d_x^e}$ could be written as z^2 and;

$\sum_x (z_x^2)$ could be written as Sum over x((z_x)^2).

Part (ii) – Category 3 – Likely to be included without any modification.

Part (ii) requires no mathematical notation.

Part (iii) – Category 3 – Likely to be included without any modification.

As candidates can decide for themselves which test to perform in this question it would probably be in their best interests to perform one which is most conducive to online delivery e.g. Grouping of Signs Test or the Individual Standardised Deviations Test. Note that the Signs Test would also be conducive to online delivery but in this case only receives partial credit as it does not test the key feature of the data.

Part (iv) – Category 3 – Likely to be included without any modification.

Part (iv) requires no mathematical notation.

Please refer to the [IFoA Notation Guide](#) for suggested notation that could be used in this question.

Question 7

Part (i) – Category 3 – Likely to be included without any modification.

The mathematical notation in this part is fairly straightforward. We have slightly adjusted the notation in the first line of sub-part (b) in the re-worked solution in the Appendix to be consistent with the suggested notation in the [IFoA Notation Guide](#).

Part (ii) – Category 2 – Likely to be included with appropriate modification.

The solution to part (ii) contains a significant amount of mathematical notation. It would be possible, however, to answer this question using the suggested notation in the [IFoA Notation Guide](#). However, it is likely that the number of marks available would have to be increased to allow for the extra time required to type the solution. Another appropriate modification might be to convert it into a series of multiple-choice questions. Note that the re-worked question in the Appendix splits this part into two multiple choice questions.

*Candidates **DO NOT** need to include any workings for multiple-choice questions. One, and only one, answer option should be included in the Word document for each multiple-choice question. Partial marks will **NOT** be awarded for candidates' workings.*

Correctly carried forward errors from the first multiple-choice question should receive full marks in the second multiple-choice question.

Part (iii) – Category 3 – Likely to be included without any modification.

The mathematical notation in this part is reasonably straightforward. We have adjusted the notation in the re-worked solution in the Appendix to make it easier to type and to be consistent with the suggested notation in the [IFoA Notation Guide](#). Note that in the question in the Appendix, the original part (iii) is now part (iv) due to the splitting of the original part (ii) into two multiple choice questions.

Please refer to the Appendix for an example of the potential modifications that could be made to this question and its solutions. Additionally, please refer to the [IFoA Notation Guide](#) for suggested notation that could be used in this question.

Question 8

Parts (i), (ii), (iii), (iv) and (v) – Category 2 – Likely to be included with appropriate modification.

The solutions to the first five parts of this question all contain complex mathematical notation. It would be possible, however, to answer these questions using the suggested notation in the [IFoA Notation Guide](#). However, it is likely that the number of marks available would have to be increased to allow for the extra time required to type the solutions. Another appropriate modification might be to convert them into multiple-choice questions with part (iv) likely to be converted into two multiple-choice questions; one for α and one for σ^2 .

Part (vi) – Category 3 – Likely to be included without any modification.

Part (vi) requires no mathematical notation.

Please refer to the [IFoA Notation Guide](#) for suggested notation that could be used in this question.

Question 9

Part (i) – Category 1 – Likely to be excluded.

Part (i) requires a sketch and is therefore very likely to be excluded.

Part (ii) – Category 1 – Likely to be excluded.

Part (ii) is a straightforward Knowledge type question and is therefore likely to be excluded due to the open-book nature of the exam.

Part (iii) – Category 2 – Likely to be included with appropriate modification.

The solution to part (iii) contains a reasonable amount of mathematical notation. It would be possible, however, to answer this question using the suggested notation in the [IFoA Notation Guide](#). However, it is likely that the number of marks available would have to be increased to allow for the extra time required to type the solution. Another possible modification would be to convert it into a multiple-choice question. However, if presented as a multiple-choice question it would become a straightforward Knowledge type question and would therefore not be appropriate for an open-book exam.

Part (iv) – Category 3 – Likely to be included without any modification.

The solution to part (iv) contains a little mathematical notation but it would be quite possible to answer this question using the suggested notation in the [IFoA Notation Guide](#).

Part (v) – Category 2 – Likely to be included with appropriate modification.

The solution to part (v) contains a reasonable amount of mathematical notation. It would be possible, however, to answer this question using the suggested notation in the [IFoA Notation Guide](#). However, it is likely that the number of marks available would have to be increased to allow for the extra time required to type the solution. Another possible modification would be to convert it into two separate parts: one multiple-choice question and one standard question. The multiple choice question could cover the calculation of the value of the test statistic and the standard question could cover the result of the hypothesis test.

Please refer to the [IFoA Notation Guide](#) for suggested notation that could be used in this question.

Question 10

Part (i) – Category 2 – Likely to be included with appropriate modification.

Note that candidates would be expected to be able to use tables in Word. Additionally, candidates could use notation such as t_j , n_j , d_j , and c_j in place of t_j , n_j , d_j and c_j .

However, due to volume of typing required for two Kaplan-Meier estimates, part (i) would likely be modified by increasing the number of marks available.

Part (ii) – Category 1 – Likely to be excluded.

Part (ii) requires a graph and is therefore very likely to be excluded.

Part (iii) – Category 3 – Likely to be included without any modification.

Part (iii) requires no mathematical notation. However, it is acknowledged that excluding part (ii) may make it harder to answer part (iii).

APPENDIX – MODIFIED VERSION OF QUESTION 7

Question 7

An insurance company has a portfolio of policies. Let X denote an individual claim amount, with probability density function $f_X(x)$ for $x > 0$.

The insurance company has an individual excess of loss reinsurance arrangement with a retention of M . Let Y be the amount paid by the insurance company net of reinsurance.

- (i) (a) Express Y in terms of X .
(b) Derive an expression for the probability density function of Y in terms of X . [3]

An actuary believes that X follows a Weibull distribution with density function $f_X(x) = 0.6cx^{-0.4}e^{-cx^{0.6}}$ where c is an unknown constant.

The insurance company has an excess of loss reinsurance arrangement with retention \$1,000. The following claims are observed:

Claims below retention: \$156, \$208, \$232, \$270, \$378, \$486, \$540, \$700, \$822, \$982

Number of claims above retention: 5

Total number of claims: 15

- (ii) Which **one** of the following options represents, up to a multiplicative constant, the correct likelihood function? [3]
- A $c^{10}e^{-c\sum x_i^{0.6}}$
B $c^{10}e^{-0.6c\sum x_i}e^{-3000c}$
C $c^{10}e^{-0.6c\sum x_i}$
D $c^{10}e^{-c\sum x_i^{0.6}}e^{-5c*1000^{0.6}}$
- (iii) Which **one** of the following options represents the correct estimate of c by the method of maximum likelihood? [4]
- A 0.00171
B 0.00349
C 0.01419
D 0.02568
- (iv) Estimate c applying the method of percentiles to the median. [4]

[Total 14]

Solutions for Question 7

Notes:

1. Candidates **DO NOT** need to include any workings for multiple-choice questions. One, and only one, answer option should be included in the Word document for each multiple-choice question. Partial marks will **NOT** be awarded for candidates' workings.
2. Candidates **MUST** include workings for all numerical questions that are not multiple-choice. A correct answer will **NOT** score full marks unless workings are also shown.
3. Candidates should type their workings and answers into the Word document using standard keyboard typing. Candidates **DO NOT** need to use notation that requires specialised equation editing e.g. the "Equation Editor" functionality in Word.
4. Candidates **MUST** type all their workings and answers into the Word document. Calculations pasted in from another application (e.g. Excel or R) will **NOT** be accepted.

$$7 \quad (i) \quad (a) \quad Y = X \quad \text{if } X \leq M, \\ Y = M \quad \text{if } X > M \quad [1]$$

OR:

$$Y = \min(X, M) \quad [1]$$

$$(b) \quad f_Y(y) = f_X(y) \quad \text{for } Y < M, \quad [1] \\ P(X > M) \quad \text{for } Y = M \quad [1]$$

$$(ii) \quad \text{Answer: D} \quad [3]$$

Candidates **DO NOT** need to include any workings for multiple-choice questions. For completeness, the correct solution is given below:

$$L = \left(\prod_{i=1}^{10} 0.6cx_i^{-0.4} e^{-cx_i^{0.6}} \right) (P(X > 1000))^5 \\ = 0.6^{10} c^{10} \prod_{i=1}^{10} (x_i^{-0.4}) e^{-c \sum x_i^{0.6}} (e^{-c \cdot 1000^{0.6}})^5 \\ \propto c^{10} e^{-c \sum x_i^{0.6}} e^{-5c \cdot 1000^{0.6}}$$

Answer A is incorrectly obtained if the claims above the retention are omitted. Answer B is incorrectly obtained if $x_i^{0.6}$ and $1000^{0.6}$ are replaced by $0.6x_i$ and $0.6 \cdot 1000$ respectively. Answer C contains the errors in both answers A and B.

$$(iii) \quad \text{Answer: C}$$

Mark allocation

In view of the calculations set out below, candidates answering consistently with the following table would be awarded **FULL** marks for part (iii):

Answer to part (ii)	Answer to part (iii)
A	D
B	A
C	B
D	C

Candidates providing no answer to part (ii) and correctly answering C to part (iii) will also be awarded **FULL** marks for part (iii). Such candidates would be assumed to have derived the answer to part (iii) by a valid method independent of part (ii).

[4]

OR:

Candidates incorrectly answering A, B or C to part (ii) and correctly answering C to part (iii) would be awarded **HALF** marks for part (iii). For such candidates it would not be known whether the answer to part (iii) had been derived by a valid method independent of part (ii) or whether a further error had been made in follow-through. Since candidates' workings receive no credit in multiple-choice questions, any workings offered in the Word documents will be strictly ignored.

[2]

Candidates giving any other combination of answers to parts (ii) and (iii) would be awarded no marks for part (iii).

Candidates **DO NOT** need to include any workings for multiple-choice questions. For completeness, the correct solution is given below:

Using the likelihood function from part (ii):

$$\ln L = 10 \ln c - c \sum x_i^{0.6} - 5c * 1000^{0.6} + \text{const}$$

$$\frac{d \ln L}{dc} = \frac{10}{c} - \sum x_i^{0.6} - 5 * 1000^{0.6}$$

$$c = \frac{10}{\sum x_i^{0.6} + 5 * 1000^{0.6}} = \frac{10}{389.474 + 315.479} = 0.01419$$

$$\frac{d^2 \ln L}{dc^2} = \frac{-10}{c^2} < 0$$

Answer A follows from answer B in part (ii):

$$\ln L = 10 \ln c - 0.6c \sum x_i - 3000c + \text{const}$$

$$\frac{d \ln L}{dc} = \frac{10}{c} - 0.6 \sum x_i - 3000$$

$$c = \frac{10}{0.6 \sum x_i + 3000} = \frac{10}{2864.4 + 3000} = 0.00171$$

$$\frac{d^2 \ln L}{dc^2} = \frac{-10}{c^2} < 0$$

Answer B follows from answer C in part (ii):

$$\ln L = 10 \ln c - 0.6c \sum x_i + \text{const}$$

$$\frac{d \ln L}{dc} = \frac{10}{c} - 0.6 \sum x_i$$

$$c = \frac{10}{0.6 \sum x_i} = \frac{10}{2864.4} = 0.00349$$

$$\frac{d^2 \ln L}{dc^2} = \frac{-10}{c^2} < 0$$

Answer D follows from answer A in part (ii):

$$\ln L = 10 \ln c - c \sum x_i^{0.6} + \text{const}$$

$$\frac{d \ln L}{dc} = \frac{10}{c} - \sum x_i^{0.6}$$

$$c = \frac{10}{\sum x_i^{0.6}} = \frac{10}{389.474} = 0.02568$$

$$\frac{d^2 \ln L}{dc^2} = \frac{-10}{c^2} < 0$$

(iv) Median is 700. [1]

$$F(m) = 1 - \exp(-cm^{0.6}) = 0.5 \quad [1]$$

$$-c * 700^{0.6} = \ln 0.5 \quad [1]$$

$$c = 0.01361 \quad [1]$$

[Total 14]

END OF GUIDANCE