

# Subject CS1

## 2025 Study Guide

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## 1 Introduction

This Study Guide has been created to help you navigate your way through Subject CS1. It contains useful information you will need before starting to study Subject CS1 for the 2025 exams. You may also find it useful to refer to throughout your studies.

Further information on study skills can be found on our website at [ActEd.co.uk](https://www.acted.co.uk).

**Please read this Study Guide carefully before reading the Course Notes**, even if you have studied for some actuarial exams before.

### Before you start

When studying for the Institute and Faculty of Actuaries' exams, you may need:

- a copy of the **Formulae and Tables for Examinations of the Institute and Faculty of Actuaries, 2nd Edition (2002)** – these are referred to simply as the *Tables*
- a **scientific calculator** and/or **software package** to help with calculations.

The *Tables* are available from the Institute and Faculty of Actuaries' eShop. Please visit [actuaries.org.uk](https://www.actuaries.org.uk).

## 2 Subject sequencing and contents

### 2.1 Links to other subjects

#### Associateship Qualification

The principles introduced in Subject CS1 are further developed in Subject CS2 – Risk Modelling and Survival Analysis. Subject CM1 – Actuarial Mathematics and Subject CM2 – Economic Modelling apply the principles and techniques in Subject CS1 to the creation of actuarial and financial models.

### 2.2 Subject contents

There are four parts to the Subject CS1 course. The parts cover related topics and are broken down into chapters. At the end of each part there are assignments testing the material from that part.

The following table shows how the parts and chapters relate to each other. The final column shows how the chapters relate to the days of the regular tutorials. This table should help you plan your progress across the study session.

Part	Chapter	Title	No of pages	X Asst	Y Asst	Tutorial – 4 days
1	1	Data analysis	23	X1	Y1	1
	2	Probability distributions	63			
	3	Generating functions	30			
	4	Joint distributions	59			
	5	Conditional expectation	20			
2	6	Central Limit Theorem	27	X2		2
	7	Sampling and statistical inference	33			
	8	Point estimation	61			
	9	Confidence intervals and prediction intervals	53			
3	10	Hypothesis testing	89	X3		3
	11	Correlation	41			
	12	Linear regression	77			
4	13	Generalised linear models	74	X4	Y2	4
	14	Bayesian statistics	44			
	15	Credibility theory	32			
	16	Empirical Bayes credibility theory	54			

## 3 Syllabus

The Syllabus for each subject is produced by the Institute and Faculty of Actuaries. It includes information to support the study of this subject. The Syllabus will guide you through what you need to learn, the application of learning, as well as the skills that you need to develop.

Students can use the Syllabus as a guide for learning and development. We recommend that you use the Syllabus as an important part of your study.

### 3.1 Aim

The aim of Subject CS1 is to provide a grounding in mathematical and statistical techniques that are of particular relevance to actuarial work.

### 3.2 Topics and topic weightings

This subject covers the following topics:

- |    |                                    |       |
|----|------------------------------------|-------|
| 1. | Data analysis                      | (10%) |
| 2. | Random variables and distributions | (20%) |
| 3. | Statistical inference              | (25%) |
| 4. | Regression theory and applications | (30%) |
| 5. | Bayesian statistics                | (15%) |

The topic weighting percentage noted alongside the topics is indicative of the volume of content of a topic within the subject and therefore broadly aligned to the volume of marks allocated to this topic in the examination. For example, if a topic is 20% of the subject then you can expect that approximately 20% of the total marks available in the examination paper will be available on that topic.

Students should ensure that they are well prepared across the entire syllabus and have an understanding of the principal terms used within the course.

### 3.3 Objectives

The detailed syllabus objectives for Subject CS1 are given below. To the right of each objective are the chapter numbers in which the objective is covered in the ActEd course. The relevant individual syllabus objectives are also included at the start of each course chapter.

- |       |   |              |
|-------|---|--------------|
| 1     | <b>Data analysis</b>  | <b>(10%)</b> |
|       | Production of simple visualisations and statistics from a data set.                     |              |
| 1.1   | Describe the purpose and function of data analysis:                                     | (Chapter 1)  |
| 1.1.1 | Aims of a data analysis (eg descriptive, inferential and predictive).                   |              |
| 1.1.2 | Stages and suitable tools used to conduct a data analysis to solve real-world problems. |              |

- 1.1.3 Sources of data and their characteristics, including extremely large data sets.
- 1.1.4 Meaning and value of reproducible research and the elements required to ensure a data analysis is reproducible.
- 1.2 Complete exploratory data analysis: (Chapter 11)
  - 1.2.1 Appropriate tools to calculate suitable summary statistics and undertake exploratory data visualisations.
  - 1.2.2 Interpret and make statistical inferences using Pearson's, Spearman's and Kendall's measures of correlation for bivariate data.
  - 1.2.3 Principal components analysis to reduce the dimensionality of a complex data set.
- 2 **Random variables and distributions** (20%)
 

The basic properties and uses of commonly used probability distributions and the statistical properties of data generated by randomly sampling from a known distribution.

  - 2.1 Understand the characteristics of basic univariate distributions and how to generate samples from them: (Chapter 2)
    - 2.1.1 Geometric, binomial, negative binomial, hypergeometric, Poisson and uniform discrete distributions on a finite set.
    - 2.1.2 Normal, lognormal, exponential, gamma, chi-square,  $t$ ,  $F$ , beta and uniform continuous distributions on an interval.
    - 2.1.3 Evaluation of probabilities and quantiles associated with these distributions (by calculation or using statistical software as appropriate).
    - 2.1.4 Poisson process and the connection between the Poisson process and the Poisson distribution.
    - 2.1.5 Generation of basic discrete and continuous random variables using the inverse transform method.
    - 2.1.6 Generation of discrete and continuous random variables using statistical software.
  - 2.2 Determine the characteristics of jointly distributed random variables: (Chapter 4)
    - 2.2.1 Probability function or density function for marginal and conditional distributions of jointly distributed random variables.
    - 2.2.2 The conditions under which random variables are independent.
    - 2.2.3 Covariance, the correlation and expected value of a function of two jointly distributed random variables.
    - 2.2.4 Mean and variance of linear combinations of random variables.
  - 2.3 Evaluate expectations and conditional expectations: (Chapter 5)
    - 2.3.1 Conditional expectation of one random variable given the value of another random variable.
    - 2.3.2 Mean and variance of a random variable as an expectation of conditional expected values.

- 2.4 Evaluate and apply generating functions: (Chapter 3)
- 2.4.1 Moment and cumulant generating functions of a random variable.
  - 2.4.2 Moment calculation via series expansion or differentiation of a generating function.
- 2.5 State and apply the Central Limit Theorem: (Chapter 6)
- 2.5.1 Central Limit Theorem for a sequence of independent, identically distributed random variables.
  - 2.5.2. Comparison of simulated samples from a given distribution with the normal distribution.
- 2.6 Describe random sampling and sampling distributions of statistics commonly used in statistical inference: (Chapter 7)
- 2.6.1 Random samples from a population.
  - 2.6.2 The sampling distribution of a statistic.
  - 2.6.3 The mean and variance of a sample mean and the mean of a sample variance in terms of the population mean, variance and the sample size.
  - 2.6.4 Basic sampling distributions for the sample mean and variance for random samples from a normal distribution.
  - 2.6.5 The distribution of the  $t$ -statistic for random samples from a normal distribution.
  - 2.6.6 The  $F$  distribution for the ratio of two sample variances from independent samples taken from normal distributions.
- 3 Statistical inference (25%)**
- Uses of statistics to make inferences about the process underlying a data set.
- 3.1 Construct estimators and discuss their properties: (Chapter 8)
- 3.1.1 Method of moments for constructing estimators of population parameters.
  - 3.1.2 Method of maximum likelihood for constructing estimators of population parameters.
  - 3.1.3 Efficiency, bias, consistency and mean square error of an estimator.
  - 3.1.4 Comparison of estimators using their mean square error and bias or unbiasedness.
  - 3.1.5 Asymptotic distribution of maximum likelihood estimators.
  - 3.1.6 Bootstrap method to estimating properties of an estimator.
- 3.2 Calculate confidence intervals and prediction intervals: (Chapter 9)
- 3.2.1 Confidence interval for an unknown parameter of a distribution based on a random sample.
  - 3.2.2 Prediction interval for a future observation based on a model fitted to a random sample.

- 3.2.3 Confidence interval for an unknown parameter using a given sampling distribution.
- 3.2.4 Confidence intervals for the mean and the variance of a normal distribution.
- 3.2.5 Confidence intervals for a binomial probability and a Poisson mean, including the use of the normal approximation in both cases.
- 3.2.6 Confidence intervals for two-sample situations involving the normal distribution, and the binomial and Poisson distributions using the normal approximation.
- 3.2.7 Confidence intervals for a difference between two means from paired data.
- 3.2.8 Bootstrap method to obtain confidence intervals.
- 3.3 Apply the concepts of hypothesis testing and goodness of fit: (Chapter 10)
  - 3.3.1 Understand the concepts of null and alternative hypotheses, simple and composite hypotheses, type I and type II errors, sensitivity, specificity, test statistic, likelihood ratio, critical region, level of significance, probability value and power of a test.
  - 3.3.2 Use of basic tests for the one-sample and two-sample situations involving the normal, binomial and Poisson distributions, and apply basic tests for paired data.
  - 3.3.3 The permutation approach to non-parametric hypothesis tests.
  - 3.3.4 Chi-square test to test the hypothesis that a random sample is from a particular distribution, including cases where parameters are unknown.
  - 3.3.5 A contingency (or two-way) table, and use a chi-square test to test the independence of two classification criteria.
- 4 **Regression theory and applications** (30%)
 

Use of statistics to examine and make inferences about the relationships between two or more data sets.

  - 4.1 Understand and use linear regression models: (Chapter 12)
    - 4.1.1 Response and explanatory variables.
    - 4.1.2 Simple regression model (with a single explanatory variable) and multiple linear regression model (with several explanatory variables).
    - 4.1.3 Least squares estimates of the slope and intercept parameters in a simple linear regression model.

- 4.1.4 Use of appropriate software to fit a linear regression model to a data set and interpret the output:
- Perform statistical inference on the slope parameter.
  - Describe the use of measures of goodness of fit of a linear regression model.
  - Use a fitted linear relationship to predict a mean response or an individual response with confidence limits.
  - Use residuals to check the suitability and validity of a linear regression model.
- 4.1.5 Measures of model fit to select an appropriate set of explanatory variables.
- 4.2 Understand and use generalised linear models: (Chapter 13)
- 4.2.1 Binomial, Poisson, exponential, gamma and normal distributions as an exponential family.
- 4.2.2 Mean, variance, variance function and scale parameter for a GLM for the binomial, Poisson, exponential, gamma and normal distributions. Evaluate these quantities for these distributions.
- 4.2.3 The link function and the canonical link function, referring to the distributions in 4.2.1.
- 4.2.4 Variables, factors taking categorical values and interaction terms.
- 4.2.5 Definition of the linear predictor, its form for simple models, including polynomial models and models involving factors.
- 4.2.6 Deviance, scaled deviance and estimation of the parameters of a GLM.
- 4.2.7 Choice of a suitable model using an analysis of deviance and examination of the significance of the parameters.
- 4.2.8 Pearson and deviance residuals and their use.
- 4.2.9 Statistical tests to determine the acceptability of a fitted model: Pearson's chi-square test and the likelihood-ratio test.
- 4.2.10 Fit a GLM to a data set and interpret the output.
- 5 Bayesian statistics (15%)**  
(Chapters 14, 15 and 16)
- Use of Bayesian statistics to update prior beliefs about a data generating process.
- 5.1 Explain fundamental concepts of Bayesian statistics and use these concepts to calculate Bayesian estimators:
- 5.1.1 Use of Bayes' theorem to calculate simple conditional probabilities.
- 5.1.2 Prior distribution, posterior distribution and conjugate prior distribution.

- 5.1.3 Posterior distribution for a parameter in simple cases.
- 5.1.4 Use of simple loss functions to derive Bayesian estimates of parameters.
- 5.1.5 Credible intervals in simple cases.
- 5.1.6 Credibility premium formula and the role played by the credibility factor.
- 5.1.7 Bayesian approach to credibility theory and its use for calculating credibility premiums in simple cases.
- 5.1.8 Empirical Bayes approach to credibility theory and its use for deriving credibility premiums in simple cases.
- 5.1.9 Understanding the differences between the two approaches (Bayes v Empirical Bayes) and the assumptions underlying each of them.



## 4 Core Reading

This section explains the role of the Core Reading and how it links to the Syllabus, supplementary ActEd text and the examination.

### 4.1 Core Reading

The Core Reading has been produced by the Institute and Faculty of Actuaries. It supports students in their learning and development of this subject by providing information and explanation of the topics and objectives in the Syllabus.

The Core Reading is updated annually to reflect any changes to the Syllabus and current practice, as well as for continuous improvement.

The current version of the Core Reading is up-to-date as of 31 May 2024. It references the version of any legislation, standards, professional guidance, *etc* as of this date. Any known upcoming changes to the references are noted where relevant in the Core Reading.

### Accreditation

The Institute and Faculty of Actuaries would like to thank the numerous people who have helped in the development of the material contained in the Core Reading.

### Further reading

A list of additional resources to support candidate learning and development for this subject can be found on the Module pages on the Institute and Faculty of Actuaries' website:

[actuaries.org.uk/curriculum/](https://actuaries.org.uk/curriculum/)

### 4.2 Links to the Syllabus

Each part of the Core Reading relates directly to the Syllabus.

The relevant syllabus objectives are included at the start of each chapter for reference.

The Core Reading supports coverage of the Syllabus in helping to ensure that both depth and breadth are re-enforced.

### 4.3 Links to the examination

Examiners can set questions based on any area of the Syllabus within any examination sitting and will consider and draw from the Core Reading when setting examinations questions.

Students will be expected to apply the Core Reading to scenarios and questions proposed by the examiners.

The exams in April and September 2025 will be based on the Syllabus and Core Reading as at 31 May 2024. We recommend that you always use the up-to-date Core Reading to prepare for the exams.

Past papers indicate to students how the examiners apply the Core Reading. The Examiners' Reports provide further insight as to how students answered the questions and how marks were awarded.

#### 4.4 ActEd text

The Core Reading deals with each syllabus objective and covers what is needed to pass the exam, and the Subject CS1 Course Notes include the Core Reading in full, integrated throughout the course.

However, the tuition material that has been written by ActEd enhances it by giving examples and further explanation of key points. Here is an excerpt from some ActEd Course Notes to show you how to identify Core Reading and the ActEd material. **Core Reading is shown in this bold font.**

In the example given above, the index *will* fall if the actual share price goes below the theoretical ex-rights share price. Again, this is consistent with what would happen to an underlying portfolio.

**After allowing for chain-linking, the formula for the investment index then becomes:**

$$I(t) = \frac{\sum_i N_{i,t} P_{i,t}}{B(t)}$$

where  $N_{i,t}$  is the number of shares issued for the  $i$ th constituent at time  $t$ ;

$B(t)$  is the base value, or divisor, at time  $t$ .

This is  
ActEd  
text

This is Core  
Reading

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These conditions remain in force after you have finished using the course.

## 5 Skills and assessment

### 5.1 Technical skills

Subjects CS1 and CS2 are very mathematical and have relatively few questions requiring wordy answers.

### 5.2 Exam skills

In each examination, students will be expected to demonstrate, through their answers, that they have knowledge of, can apply and use higher order skills in this subject:

- Knowledge will be demonstrated through answering questions that assess understanding of that knowledge as well as through questions that ask for the application of relevant knowledge to scenarios.
- Application will be demonstrated through answering questions that assess the ability to identify and apply relevant concepts and skills to solve problems (both numerical and non-numerical).
- Higher order skills will be demonstrated through questions that will assess the ability to use relevant knowledge, concepts and skills to solve problems, draw appropriate conclusions, and make meaningful and appropriate comments on those conclusions.

In the CS subjects, the approximate split of assessment across the three skill types is:

- Knowledge – 20%
- Application – 65%
- Higher Order skills – 15%.

The Institute and Faculty of Actuaries use command verbs (such as 'Define', 'Discuss' and 'Explain') to help students to identify what the question requires. The examination can be composed of questions drawing from any part of the syllabus and using any command verb.

The Institute and Faculty of Actuaries has produced guidance on 'Command verbs used in the Associate and Fellowship examinations', to help students to understand what each command verb is asking them to do.

You can find the relevant document on the Institute and Faculty of Actuaries' website at:

**[actuaries.org.uk/qualify/prepare-for-your-exams](https://www.actuaries.org.uk/qualify/prepare-for-your-exams)**

### 5.3 Assessment

Assessment is in the form of two timed, online examinations:

- Paper A is 3 hours and 20 minutes and consists of a number of questions of varying marks, for which the answers must be constructed and typed in Microsoft Word
- Paper B is 1 hour and 50 minutes and consists of a number of questions of varying marks, for which the answers must typically be constructed using R and typed using Microsoft Word.

This includes reading time, as well as the time taken for students to download and/or print the question paper.

In order to pass this subject, both Paper A and Paper B must be sat within the same sitting, and a combined mark of a pass achieved.

### 5.4 Further information

The Institute and Faculty of Actuaries has produced a number of documents, which it advises students to read and understand. In particular, the:

- Qualification Handbook, which contains information on studying and preparing for exams, as well as available support and resources
- Examinations Handbook, which contains practical assistance on how to sit an Institute and Faculty of Actuaries' examination
- Assessment Regulations document, which includes rules on eligibility, entry and conduct during an online assessment.

The Qualification Handbook can be found at:

**[actuaries.org.uk/qualify/student-and-associate-exam-news/qualification-handbook](https://actuaries.org.uk/qualify/student-and-associate-exam-news/qualification-handbook)**

The Examinations Handbook and Assessment Regulations document can be found at:

**[actuaries.org.uk/qualify/my-exams/ifo-exams](https://actuaries.org.uk/qualify/my-exams/ifo-exams)**

**IMPORTANT NOTE: These documents may be updated and re-published in the weeks leading up to each exam session. It is important that you keep up-to-date with any changes and developments.**

## 6 ActEd study support

An overview of ActEd's products and services, and guidance on how to choose the best ones for you, can be found on our website at [ActEd.co.uk/productguide](https://www.acted.co.uk/productguide).

### 6.1 Summary of ActEd products and services

Detailed descriptions of all ActEd's products and services can be found on our website at [ActEd.co.uk](https://www.acted.co.uk). However, the specific products and services available for Subject CS1 include:

- Course Notes
- Paper B Online Resources (PBOR), including the Y Assignments
- X Assignments – four assignments:
  - X1, X2: 80-mark tests (you are allowed 2¾ hours to complete these)
  - X3, X4: 100-mark tests (you are allowed 3¾ hours to complete these)
- Y Assignments – two assignments:
  - Y1, Y2: 100-mark tests (you are allowed 1¾ hours to complete these)
- Series X Marking
- Series Y Marking
- Online Classroom – over 150 tutorial units
- Flashcards
- Revision Notes – seven A5 booklets
- ASET (2020-23 papers) – four years of exam papers, covering the period April 2020 to September 2023
- Mini-ASET – covering the April 2024 exam paper
- Mock Exam – one 100-mark test for the Paper A examination and a separate 100-mark test for the practical Paper B exam
- Additional Mock Pack (AMP) – two additional 100-mark Paper A tests and two additional 100-mark Paper B tests
- Mock Exam Marking
- Marking Vouchers.

Products are generally available in both paper and eBook format. Visit [ActEd.co.uk](https://www.acted.co.uk) for full details about available eBooks, software requirements and restrictions.

## 6.2 Tuition

The following tutorials are typically available for Subject CS1:

- Regular Tutorials (four full days / eight half days)
- Block Tutorials (four days)
- a Preparation Day for the practical exam.

Tutorials are typically available both face-to-face and live online.

Full details are set out in our *Tuition Bulletin*, which is available on our website at **ActEd.co.uk**.

## 6.3 Questions and queries

From time to time you may come across something in the study material that is unclear to you.

Our online discussion forum at **ActEd.co.uk/forums** (or use the link from our home page at **ActEd.co.uk**) is dedicated to actuarial students so that you can get help from fellow students on any aspect of your studies from technical issues to study advice. ActEd tutors visit the site regularly to ensure that you are not being led astray and we also post other frequently asked questions from students on the forum as they arise.

If you are still stuck, then you can send queries by email to the Subject CS1 email address **CS1@bpp.com**, but we recommend that you try the forum first. We will endeavour to contact you as soon as possible after receiving your query but you should be aware that it may take some time to reply to queries, particularly when tutors are running tutorials. At the busiest teaching times of year, it may take us more than a week to get back to you.

If you have many queries on the course material, you should raise them at a tutorial or book a personal tuition session with an ActEd tutor. Please email **ActEd@bpp.com** for more details.

## 6.4 Feedback

If you find an error in the course, please check the corrections page of our website (**ActEd.co.uk/paper\_corrections.html**) to see if the correction has already been dealt with. Otherwise, please send the details via email to the Subject CS1 email address **CS1@bpp.com**. Our tutors work hard to ensure that the courses are as clear as possible and free from errors.

ActEd also works with the Institute and Faculty of Actuaries to suggest developments and improvements to the Syllabus and Core Reading. If you have any comments or concerns about the Syllabus or Core Reading, these can be passed on via ActEd. Alternatively, you can send them directly to the Institute and Faculty of Actuaries' Examination Team by email to **memberservices@actuaries.org.uk**.

## 7 General information and support

### 7.1 Safeguarding

We want you to feel comfortable within our learning environment and safe in the knowledge that if you ever needed support, you know where to go.

If you need support, please contact BPP's Safeguarding team at [safeguarding@bpp.com](mailto:safeguarding@bpp.com) or for urgent concerns call 07464 542 636.

Additional information can be found at [ActEd.co.uk/learningsupport](https://ActEd.co.uk/learningsupport).

### 7.2 BPP learning support

BPP's Learning Support team offers a wide range of support for all students who disclose a learning difficulty or disability. This support is accessible to all ActEd students free of charge.

Please contact BPP's Learning Support team at [LearningSupport@bpp.com](mailto:LearningSupport@bpp.com) for more information.

Additional information can be found at [ActEd.co.uk/learningsupport](https://ActEd.co.uk/learningsupport).

### 7.3 The Prevent Duty

The Prevent Duty is to protect people from radicalisation and being drawn into extremist views and terrorism. As a Government-regulated training provider, ActEd has a duty to ensure that our learners are well informed and stay safe, and to empower our students to know what to look for and when to report concerns.

Please report any concerns to a tutor or email [safeguarding@bpp.com](mailto:safeguarding@bpp.com) or for urgent concerns call 07464 542 636.

More information is available at:

- [ActEd.co.uk/learningsupport](https://ActEd.co.uk/learningsupport)
- [officeforstudents.org.uk/advice-and-guidance/student-wellbeing-and-protection/counter-terrorism-the-prevent-duty/](https://officeforstudents.org.uk/advice-and-guidance/student-wellbeing-and-protection/counter-terrorism-the-prevent-duty/)

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