

Subject CS2

2021 Study Guide

Introduction

This Study Guide has been created to help you navigate your way through Subject CS2. It contains all the information you will need before starting to study Subject CS2 for the 2021 exams and you may also find it useful to refer to throughout your Subject CS2 journey.

The guide is split into two parts:

- Part 1 contains specific information about Subject CS2
- Part 2 contains general information about the Core Principles subjects.

Please read this Study Guide carefully before reading the Course Notes, even if you have studied for some actuarial exams before. While you may have already read (the majority of) the Part 2 material in previous subjects, the information in Part 1 is unique to this course.

Contents

Part 1	Section 1	Subject CS2 – background and contents	Page 2
	Section 2	Subject CS2 – Syllabus and Core Reading	Page 4
	Section 3	Subject CS2 – summary of ActEd products	Page 12
	Section 4	Subject CS2 – skills and assessment	Page 13
	Section 5	Subject CS2 – frequently asked questions	Page 14
Part 2	Section 1	Before you start	Page 15
	Section 2	Core study material	Page 16
	Section 3	ActEd study support	Page 18
	Section 4	Study skills and assessment	Page 24
	Section 5	Queries and feedback	Page 29

1.1 Subject CS2 – background and contents

History

The Actuarial Statistics subjects (Subjects CS1 and CS2) were introduced in the Institute and Faculty of Actuaries 2019 Curriculum.

Subject CS2 is *Risk Modelling and Survival Analysis*.

Predecessors

The topics in the Actuarial Statistics subjects cover content previously in Subjects CT3, CT4, CT6 and a small amount from Subject ST9:

- Subject CS1 contains material from Subjects CT3 and CT6.
- Subject CS2 contains material from Subjects CT4, CT6 and ST9.

Exemptions

In order to be eligible for a pass in Subject CS2, you will need:

- to have passed or been granted an exemption from Subjects CT4 and CT6 during the transfer process
- to have met the profession's requirements based on the current curriculum.

See the profession's website for further details:

www.actuaries.org.uk/studying/exam-exemptions

Links to other subjects

- This subject assumes that the student is competent with the material covered in CS1 – Actuarial Statistics – and the required knowledge for that subject.
- Subjects CM1 and CM2 – Actuarial Mathematics and Financial Engineering and Loss Reserving apply the material in this subject to actuarial and financial modelling.
- Topics in this subject are further built upon in SP1 – Health and Care Principles, SP7 – General Insurance Reserving and Capital Modelling Principles, SP8 – General Insurance Pricing Principles and SP9 – Enterprise Risk Management Principles.

Contents

There are five parts to the Subject CS2 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 – 5 days
1	1	Stochastic processes	37	X1	Y1	1
	2	Markov chains	72			
	3	The two-state Markov model and the Poisson model	41			
	4	Time-homogeneous Markov jump processes	71			
2	5	Time-inhomogeneous Markov jump processes	57	X2	Y1	2
	6	Survival models	38			
	7	Estimating the lifetime distribution	59			
3	8	Proportional hazards models	42	X3	Y1	3
	9	Exposed to risk	32			
	10	Graduation and statistical tests	64			
	11	Methods of graduation	31			
	12	Mortality projection	59			
4	13	Time Series 1	71	X4	Y2	4
	14	Time Series 2	67			
	15	Loss distributions	45			
	16	Extreme value theory	48			
5	17	Copulas	57	X5	Y2	5
	18	Reinsurance	45			
	19	Risk models 1	38			
	20	Risk models 2	43			
	21	Machine learning	83			

1.2 Subject CS2 – Syllabus and Core Reading

Syllabus

The Syllabus for Subject CS2 is given here. To the right of each objective are the chapter numbers in which the objective is covered in the ActEd course.

Aim

The aim of Subject CS2 is to provide a grounding in mathematical and statistical modelling techniques that are of particular relevance to actuarial work, including stochastic processes and survival models and their application.

Competences

On successful completion of this subject, a student will be able to:

1. describe and use statistical distributions for risk modelling
2. describe and apply the main concepts underlying the analysis of time series models
3. describe and apply Markov chains and processes
4. describe and apply techniques of survival analysis
5. describe and apply basic principles of machine learning.

Syllabus topics

1. Random variables and distributions for risk modelling (20%)
2. Time series (20%)
3. Stochastic processes (25%)
4. Survival models (25%)
5. Machine learning (10%)

The weightings are indicative of the approximate balance of the assessment of this subject between the main syllabus topics, averaged over a number of examination sessions.

The weightings also have a correspondence with the amount of learning material underlying each syllabus topic. However, this will also reflect aspects such as:

- the relative complexity of each topic, and hence the amount of explanation and support required for it
- the need to provide thorough foundation understanding on which to build the other objectives
- the extent of prior knowledge which is expected
- the degree to which each topic area is more knowledge or application based.

Detailed syllabus objectives

1. Random variables and distributions for risk modelling (20%)
 - 1.1 Loss distributions, with and without risk sharing (Chapters 15 and 18)
 - 1.1.1 Describe the properties of the statistical distributions that are suitable for modelling individual and aggregate losses.
 - 1.1.2 Explain the concepts of excesses (deductibles), and retention limits.
 - 1.1.3 Describe the operation of simple forms of proportional and excess of loss reinsurance.
 - 1.1.4 Derive the distribution and corresponding moments of the claim amounts paid by the insurer and the reinsurer in the presence of excesses (deductibles) and reinsurance.
 - 1.1.5 Estimate the parameters of a failure time or loss distribution when the data is complete, or when it is incomplete, using maximum likelihood and the method of moments.
 - 1.1.6 Fit a statistical distribution to a data set and calculate appropriate goodness-of-fit measures.
 - 1.2 Compound distributions and their applications in risk modelling (Chapters 19 and 20)
 - 1.2.1 Construct models appropriate for short term insurance contracts in terms of the numbers of claims and the amounts of individual claims.
 - 1.2.2 Describe the major simplifying assumptions underlying the models in 1.2.1.
 - 1.2.3 Define a compound Poisson distribution and show that the sum of independent random variables, each having a compound Poisson distribution, also has a compound Poisson distribution.
 - 1.2.4 Derive the mean, variance and coefficient of skewness for compound binomial, compound Poisson and compound negative binomial random variables.
 - 1.2.5 Repeat 1.2.4 for both the insurer and the reinsurer after the operation of simple forms of proportional and excess of loss reinsurance.
 - 1.3 Introduction to copulas (Chapter 17)
 - 1.3.1 Describe how a copula can be characterised as a multivariate distribution function that is a function of the marginal distribution functions of its variates, and explain how this allows the marginal distributions to be investigated separately from the dependency between them.
 - 1.3.2 Explain the meaning of the terms 'dependence or concordance', 'upper and lower tail dependence', and state in general terms how tail dependence can be used to help select a copula suitable for modelling particular types of risk.

- 1.3.3 Describe the form and characteristics of the Gaussian copula and the Archimedean family of copulas.
- 1.4 Introduction to extreme value theory (Chapter 16)
 - 1.4.1 Recognise extreme value distributions, suitable for modelling the distribution of severity of loss and their relationships
 - 1.4.2 Calculate various measures of tail weight and interpret the results to compare the tail weights.
- 2 Time series (20%)
 - 2.1 Concepts underlying time series models (Chapters 13 and 14)
 - 2.1.1 Explain the concept and general properties of stationary, $I(0)$, and integrated, $I(1)$, univariate time series.
 - 2.1.2 Explain the concept of a stationary random series.
 - 2.1.3 Explain the concept of a filter applied to a stationary random series.
 - 2.1.4 Know the notation for backwards shift operator, backwards difference operator, and the concept of roots of the characteristic equation of time series.
 - 2.1.5 Explain the concepts and basic properties of autoregressive (AR), moving average (MA), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) time series.
 - 2.1.6 Explain the concept and properties of discrete random walks and random walks with normally distributed increments, both with and without drift.
 - 2.1.7 Explain the basic concept of a multivariate autoregressive model.
 - 2.1.8 Explain the concept of cointegrated time series.
 - 2.1.9 Show that certain univariate time series models have the Markov property and describe how to rearrange a univariate time series model as a multivariate Markov model.
 - 2.2 Applications of time series models (Chapters 13 and 14)
 - 2.2.1 Outline the processes of identification, estimation and diagnosis of a time series, the criteria for choosing between models, and the diagnostic tests that may be applied to the residuals of a time series after estimation.
 - 2.2.2 Describe briefly other non-stationary, non-linear time series models.
 - 2.2.3 Describe simple applications of a time series model, including random walk, autoregressive and cointegrated models as applied to security prices and other economic variables.

- 2.2.4 Develop deterministic forecasts from time series data, using simple extrapolation and moving average models, applying smoothing techniques and seasonal adjustment when appropriate.
- 3 Stochastic processes (25%)
- 3.1 Describe and classify stochastic processes. (Chapter 1)
- 3.1.1 Define in general terms a stochastic process and in particular a counting process.
- 3.1.2 Classify a stochastic process according to whether it:
- operates in continuous or discrete time
 - has a continuous or a discrete state space
 - is a mixed type
- and give examples of each type of process.
- 3.1.3 Describe possible applications of mixed processes.
- 3.1.4 Explain what is meant by the Markov property in the context of a stochastic process and in terms of filtrations.
- 3.2 Define and apply a Markov chain. (Chapter 2)
- 3.2.1 State the essential features of a Markov chain model.
- 3.2.2 State the Chapman-Kolmogorov equations that represent a Markov chain.
- 3.2.3 Calculate the stationary distribution for a Markov chain in simple cases.
- 3.2.4 Describe a system of frequency based experience rating in terms of a Markov chain and describe other simple applications.
- 3.2.5 Describe a time-inhomogeneous Markov chain model and describe simple applications.
- 3.2.6 Demonstrate how Markov chains can be used as a tool for modelling and how they can be simulated.
- 3.3 Define and apply a Markov process. (Chapters 4 and 5)
- 3.3.1 State the essential features of a Markov process model.
- 3.3.2 Define a Poisson process, derive the distribution of the number of events in a given time interval, derive the distribution of inter-event times, and apply these results.
- 3.3.3 Derive the Kolmogorov equations for a Markov process with time-independent and time/age-dependent transition intensities.

- 3.3.4 Solve the Kolmogorov equations in simple cases.
- 3.3.5 Describe simple survival models, sickness models and marriage models in terms of Markov processes and describe other simple applications.
- 3.3.6 State the Kolmogorov equations for a model where the transition intensities depend not only on age/time, but also on the duration of stay in one or more states.
- 3.3.7 Describe sickness and marriage models in terms of duration-dependent Markov processes and describe other simple applications.
- 3.3.8 Demonstrate how Markov jump processes can be used as a tool for modelling and how they can be simulated.
- 4 Survival models (25%)
- 4.1 Explain the concept of survival models.
- 4.1.1 Describe the model of lifetime or failure time from age x as a random variable. (Chapter 6)
- 4.1.2 State the consistency condition between the random variable representing lifetimes from different ages. (Chapter 6)
- 4.1.3 Define the distribution and density functions of the random future lifetime, the survival function, the force of mortality or hazard rate, and derive relationships between them. (Chapter 6)
- 4.1.4 Define the actuarial symbols ${}_t p_x$ and ${}_t q_x$ and derive integral formulae for them. (Chapter 6)
- 4.1.5 State the Gompertz and Makeham laws of mortality. (Chapter 6)
- 4.1.6 Define the curtate future lifetime from age x and state its probability function. (Chapter 6)
- 4.1.7 Define the symbols e_x and $\overset{\circ}{e}_x$ and derive an approximate relation between them. Define the expected value and variance of the complete and curtate future lifetimes and derive expressions for them. (Chapter 6)
- 4.1.8 Describe the two-state model of a single decrement and compare its assumptions with those of the random lifetime model. (Chapter 3)
- 4.2 Describe estimation procedures for lifetime distributions.
- 4.2.1 Describe the various ways in which lifetime data may be censored. (Chapter 7)
- 4.2.2 Describe the estimation of the empirical survival function in the absence of censoring, and what problems are introduced by censoring. (Chapter 7)

- 4.2.3 Describe the Kaplan-Meier (or product-limit) estimator of the survival function in the presence of censoring, compute it from typical data and estimate its variance. (Chapter 7)
- 4.2.4 Describe the Nelson-Aalen estimator of the cumulative hazard rate in the presence of censoring, compute it from typical data and estimate its variance. (Chapter 7)
- 4.2.5 Describe models for proportional hazards and how these models can be used to estimate the impact of covariates on the hazard. (Chapter 8)
- 4.2.6 Describe the Cox model for proportional hazards, derive the partial likelihood estimate in the absence of ties, and state the asymptotic distribution of the partial likelihood estimator. (Chapter 8)
- 4.3 Derive maximum likelihood estimators for transition intensities. (Chapters 3 and 4)
 - 4.3.1 Describe an observational plan in respect of a finite number of individuals observed during a finite period of time, and define the resulting statistics, including the waiting times.
 - 4.3.2 Derive the likelihood function for constant transition intensities in a Markov model of transfers between states given the statistics in 4.3.1.
 - 4.3.3 Derive maximum likelihood estimators for the transition intensities in 4.3.2 and state their asymptotic joint distribution.
 - 4.3.4 State the Poisson approximation to the estimator in 4.3.3 in the case of a single decrement.
- 4.4 Estimate transition intensities dependent on age (exact or census). (Chapter 9)
 - 4.4.1 Explain the importance of dividing the data into homogeneous classes, including subdivision by age and sex.
 - 4.4.2 Describe the principle of correspondence and explain its fundamental importance in the estimation procedure.
 - 4.4.3 Specify the data needed for the exact calculation of a central exposed to risk (waiting time) depending on age and sex.
 - 4.4.4 Calculate a central exposed to risk given the data in 4.4.3.
 - 4.4.5 Explain how to obtain estimates of transition probabilities, including in the single decrement model the actuarial estimate based on the simple adjustment to the central exposed to risk.
 - 4.4.6 Explain the assumptions underlying the census approximation of waiting times.
 - 4.4.7 Explain the concept of the rate interval.

- 4.4.8 Develop census formulae given age at birthday where the age may be classified as next, last, or nearest relative to the birthday as appropriate, and the deaths and census data may use different definitions of age.
- 4.4.9 Specify the age to which estimates of transition intensities or probabilities in 4.4.8 apply.
- 4.5 Graduation and graduation tests (Chapters 10 and 11)
- 4.5.1 Describe and apply statistical tests of the comparison of crude estimates with a standard mortality table testing for:
- the overall fit
 - the presence of consistent bias
 - the presence of individual ages where the fit is poor
 - the consistency of the 'shape' of the crude estimates and the standard table.
- For each test describe:
- the formulation of the hypothesis
 - the test statistic
 - the distribution of the test statistic using approximations where appropriate
 - the application of the test statistic.
- 4.5.2 Describe the reasons for graduating crude estimates of transition intensities or probabilities, and state the desirable properties of a set of graduated estimates.
- 4.5.3 Describe a test for smoothness of a set of graduated estimates.
- 4.5.4 Describe the process of graduation by the following methods, and state the advantages and disadvantages of each:
- parametric formula
 - standard table
 - spline functions
- (The student will not be required to carry out a graduation.)
- 4.5.5 Describe how the tests in 4.5.1 should be amended to compare crude and graduated sets of estimates.
- 4.5.6 Describe how the tests in 4.5.1 should be amended to allow for the presence of duplicate policies.
- 4.5.7 Carry out a comparison of a set of crude estimates and a standard table, or of a set of crude estimates and a set of graduated estimates.

- 4.6 Mortality projection (Chapter 12)
- 4.6.1 Describe the approaches to the forecasting of future mortality rates based on extrapolation, explanation and expectation, as well as their advantages and disadvantages.
 - 4.6.2 Describe the Lee-Carter, age-period-cohort, and p -spline regression models for forecasting mortality.
 - 4.6.3 Use an appropriate computer package to apply the models in 4.6.2 to a suitable mortality data set.
 - 4.6.4 List the main sources of error in mortality forecasts.
- 5 Machine learning (10%)
- 5.1 Explain and apply elementary principles of machine learning. (Chapter 21)
- 5.1.1 Explain the main branches of machine learning and describe examples of the types of problems typically addressed by machine learning.
 - 5.1.2 Explain and apply high-level concepts relevant to learning from data.
 - 5.1.3 Describe and give examples of key supervised and unsupervised machine learning techniques, explaining the difference between regression and classification and between generative and discriminative models.
 - 5.1.4 Explain in detail and use appropriate software to apply machine learning techniques (*eg* penalised regression and decision trees) to simple problems.
 - 5.1.5 Demonstrate an understanding of the perspectives of statisticians, data scientists, and other quantitative researchers from non-actuarial backgrounds.

Core Reading

The Subject CS2 Course Notes include the Core Reading in full, integrated throughout the course.

Further reading

The exam will be based on the relevant Syllabus and Core Reading and the ActEd course material will be the main source of tuition for students.

1.3 Subject CS2 – summary of ActEd products

The following products are available for Subject CS2:

- Course Notes
- Paper B Online Resource (PBOR), including the Y Assignments
- X Assignments – five assignments:
 - X1, X2, X3: 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
- ASET (2014-17 papers) – four years of exam papers, *ie* eight sittings, covering the period April 2014 to September 2017
- ASET (2019-20 papers) – two years of exam papers, covering the period April 2019 to September 2020
- Mock Exam – one 100-mark test for the written Paper A examination and a separate 100-mark test for the computer-based 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 www.ActEd.co.uk for full details about available eBooks, software requirements and restrictions.

The following tutorials are typically available for Subject CS2:

- Regular Tutorials (five days)
- Block Tutorials (five days)
- a Preparation Day for the computer-based exam.

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

1.4 Subject CS2 – skills and assessment

Technical skills

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

Exam skills

Exam question skill levels

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

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

Assessment

Assessment consists of a combination of a 3¼-hour written examination and a 1¾-hour computer-based data analysis and statistical modelling examination.

1.5 Subject CS2 – frequently asked questions

Q: *What knowledge of earlier subjects should I have?*

A: Knowledge of Subject CS1, Actuarial Statistics, is assumed.

Q: *What level of mathematics is required?*

A: Good mathematical skills are essential for Subject CS2. Calculus and algebra (including matrices) are used extensively in this course.

If your maths is a little rusty you may wish to consider purchasing additional material to help you get up to speed. The course 'Pure Maths and Statistics for Actuarial Studies' is available from ActEd and it covers the mathematical techniques that are required for the Core Principles subjects, some of which are beyond A-Level (or Higher) standard. You do not need to work through the whole course in order – you can just refer to it when you need help on a particular topic. An initial assessment to test your mathematical skills and further details regarding the course can be found on our website.

Q: *What should I do if I discover an error in the course?*

A: If you find an error in the course, please check our website at:

www.ActEd.co.uk/paper_corrections.html

to see if the correction has already been dealt with. Otherwise please send details via email to **CS2@bpp.com**.

Q: *Who should I send feedback to?*

A: We are always happy to receive feedback from students, particularly details concerning any errors, contradictions or unclear statements in the courses.

If you have any comments on this course in general, please email to **CS2@bpp.com**.

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

2.1 Before you start

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

- a copy of the **Formulae and Tables for Examinations of the Faculty of Actuaries and the Institute of Actuaries, 2nd Edition (2002)** – these are referred to simply as the *Tables*
- an 'authorised' **scientific calculator** – you will find the list of permitted calculators on the profession's website. Please check the list carefully, since it is reviewed each year.

These are both available from the Institute and Faculty of Actuaries' eShop. Please visit www.actuaries.org.uk.

2.2 Core study material

This section explains the role of the Syllabus, Core Reading and supplementary ActEd text. It also gives guidance on how to use these materials most effectively in order to pass the exam.

Some of the information below is also contained in the introduction to the Core Reading produced by the Institute and Faculty of Actuaries.

Syllabus

The Syllabus for Subject CS2 has been produced by the Institute and Faculty of Actuaries. The relevant individual syllabus objectives are included at the start of each course chapter and a complete copy of the Syllabus is included in Section 1.2 of this Study Guide. We recommend that you use the Syllabus as an important part of your study.

Core Reading

The Core Reading has been produced by the Institute and Faculty of Actuaries. The purpose of the Core Reading is to assist in ensuring that tutors, students and examiners have clear shared appreciation of the requirements of the Syllabus for the qualification examinations for Fellowship of the Institute and Faculty of Actuaries.

The Core Reading supports coverage of the Syllabus in helping to ensure that both depth and breadth are re-enforced. It is therefore important that students have a good understanding of the concepts covered by the Core Reading.

The examinations require students to demonstrate their understanding of the concepts given in the Syllabus and described in the Core Reading; this will be based on the legislation, professional guidance *etc* that are in force when the Core Reading is published, *ie* on 31 May in the year preceding the examinations.

Therefore the exams in April and September 2021 will be based on the Syllabus and Core Reading as at 31 May 2020. We recommend that you always use the up-to-date Core Reading to prepare for the exams.

Examiners will have this Core Reading when setting the papers. In preparing for examinations, students are advised to work through past examination questions and will find additional tuition helpful. The Core Reading will be updated each year to reflect changes in the Syllabus, to reflect current practice, and in the interest of clarity.

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 this Core Reading.

ActEd text

Core Reading deals with each syllabus objective and covers what is needed to pass the exam. 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

Here is an excerpt from some ActEd Course Notes to show you how to identify Core Reading for R code.



The R code to draw a scatterplot for a bivariate data frame, <data>, is:

```
plot (<data>)
```

Further explanation on the use of R will not be provided in the Course Notes, but instead be picked up in the Paper B Online Resources (PBOR). We recommend that you refer to and use PBOR at the end of each chapter, or couple of chapters, that contains a significant number of R references.

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Legal action will be taken if these terms are infringed. In addition, we may seek to take disciplinary action through the Institute and Faculty of Actuaries or through your employer.

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

2.3 ActEd study support

This section gives a description of the products offered by ActEd.

Successful students tend to undertake three main study activities:

1. *Learning* – initial study and understanding of subject material
2. *Revision* – learning subject material and preparing to tackle exam-style questions
3. *Rehearsal* – answering exam-style questions, culminating in answering questions at exam speed without notes.

Different approaches suit different people. For example, you may like to revise material gradually over the months running up to the exams or you may do your revision in a shorter period just before the exams. Also, these three activities will almost certainly overlap.

We offer a flexible range of products to suit you and let you control your own learning and exam preparation. The following table shows the products that we produce. Not all products are available for all subjects.

LEARNING	LEARNING & REVISION	REVISION	REVISION & REHEARSAL	REHEARSAL
Course Notes	Assignments Combined Materials Pack (CMP) Assignment Marking Tutorials Online Classroom	Flashcards	Revision Notes ASET	Mock Exam Additional Mock Pack (AMP) Mock Marking

The products and services are described in more detail below.

‘Learning’ products

Course Notes

The Course Notes will help you develop the basic knowledge and understanding of principles needed to pass the exam. They incorporate the complete Core Reading and include full explanation of all the syllabus objectives, with worked examples and questions (including some past exam questions) to test your understanding.

Each chapter includes:

- the relevant syllabus objectives
- a chapter summary
- a page of important formulae or definitions (where appropriate)
- practice questions with full solutions.

Paper B Online Resources (PBOR)

The Paper B Online Resources (PBOR) will help you prepare for the computer-based paper. Delivered through a virtual learning environment (VLE), you will have access to worked examples and practice questions. PBOR will also include the Y Assignments, which are two exam-style assessments.

‘Learning & revision’ products

X Assignments

The Series X Assignments are written assessments that cover the material in each part of the course in turn. They can be used to develop and test your understanding of the material.

Y Assignments

The Series Y Assignments are exam-style assessments that cover material across the whole course.

Combined Materials Pack (CMP)

The Combined Materials Pack (CMP) comprises the Course Notes, PBOR and the Series X Assignments.

CMP Upgrade

The purpose of the CMP Upgrade is to enable you to amend last year’s study material to make it suitable for study for this year.

Wherever possible, it lists the changes to the syllabus objectives, Core Reading, the Course Notes and the X / Y Assignments since last year that might realistically affect your chance of success in the exam. It is produced so that you can manually amend your notes. The upgrade includes replacement pages and additional pages where appropriate.

However, if a large number of changes have been made to the Course Notes and X / Y Assignments, it is not practical to produce a full upgrade, and the upgrade will only *outline* the most significant changes. In this case, we recommend that you purchase a replacement CMP (printed copy or eBook) or Course Notes at a significantly reduced price.

The CMP Upgrade can be downloaded free of charge on our website at **www.ActEd.co.uk**.

A separate upgrade for eBooks is not produced but a significant discount is available for retakers wishing to re-purchase the latest eBook.

X / Y Assignment Marking

We are happy to mark your attempts at the X and/or Y assignments. Marking is not included with the Assignments or the CMP and you need to order both Series X and Series Y Marking separately. You should submit your script as an attachment to an email, in the format detailed in your assignment instructions. You will be able to download your marker's feedback via a secure link.

Don't underestimate the benefits of doing and submitting assignments:

- Question practice during this phase of your study gives an early focus on the end goal of answering exam-style questions.
- You're incentivised to keep up with your study plan and get a regular, realistic assessment of your progress.
- Objective, personalised feedback from a high quality marker will highlight areas on which to work and help with exam technique.

In a recent study, we found that students who attempt more than half the assignments have significantly higher pass rates.

There are two different types of marking product: Series Marking and Marking Vouchers.

Series Marking

Series Marking applies to a specified subject, session and student. If you purchase Series Marking, you will **not** be able to defer the marking to a future exam sitting or transfer it to a different subject or student.

We typically provide full solutions with the Series Assignments. However, if you order Series Marking at the same time as you order the Series Assignments, you can choose whether or not to receive a copy of the solutions in advance. If you choose not to receive them with the study material, you will be able to download the solutions via a secure link when your marked script is returned (or following the final deadline date if you do not submit a script).

If you are having your attempts at the assignments marked by ActEd, you should submit your scripts regularly throughout the session, in accordance with the schedule of recommended dates set out on our website at **www.ActEd.co.uk**. This will help you to pace your study throughout the session and leave an adequate amount of time for revision and question practice.

The recommended submission dates are realistic targets for the majority of students. Your scripts will be returned more quickly if you submit them well before the final deadline dates.

Any script submitted *after* the relevant final deadline date will not be marked. It is your responsibility to ensure that we receive scripts in good time.

Marking Vouchers

Marking Vouchers give the holder the right to submit a script for marking at any time, irrespective of the individual assignment deadlines, study session, subject or person.

Marking Vouchers can be used for any assignment. They are valid for four years from the date of purchase and can be refunded at any time up to the expiry date.

Although you may submit your script with a Marking Voucher at any time, you will need to adhere to the explicit Marking Voucher deadline dates to ensure that your script is returned before the date of the exam. The deadline dates are provided on our website at **www.ActEd.co.uk**.

Tutorials

Our tutorials are specifically designed to develop the knowledge that you will acquire from the course material into the higher-level understanding that is needed to pass the exam.

We run a range of different tutorials including face-to-face tutorials at various locations, and Live Online tutorials. Full details are set out in our *Tuition Bulletin*, which is available on our website at **www.ActEd.co.uk**.

Regular and Block Tutorials

In preparation for these tutorials, we expect you to have read the relevant part(s) of the Course Notes before attending the tutorial so that the group can spend time on exam questions and discussion to develop understanding rather than basic bookwork.

You can choose **one** of the following types of tutorial:

- **Regular Tutorials** spread over the session
- a **Block Tutorial** held two to eight weeks before the exam.

The tutorials outlined above will focus on and develop the skills required for the written Paper A examination. Students wishing for some additional tutor support working through exam-style questions for Paper B may wish to attend a Preparation Day. These will be available Live Online or face-to-face, where students will need to provide their own device capable of running R.

Online Classroom

The Online Classroom acts as either a valuable add-on or a great alternative to a face-to-face or Live Online tutorial, focussing on the written Paper A examination.

At the heart of the Online Classroom in each subject is a comprehensive, easily-searched collection of tutorial units. These are a mix of:

- teaching units, helping you to really get to grips with the course material, and
- guided questions, enabling you to learn the most efficient ways to answer questions and avoid common exam pitfalls.

The best way to discover the Online Classroom is to see it in action. You can watch a sample of the Online Classroom tutorial units on our website at www.ActEd.co.uk.

'Revision' products

Flashcards

For most subjects, there is **a lot of material** to revise. Finding a way to fit revision into your routine as painlessly as possible has got to be a good strategy. Flashcards are a relatively inexpensive option that can provide a massive boost. They can also provide a variation in activities during a study day, and so help you to maintain concentration and effectiveness.

Flashcards are a set of A6-sized cards that cover the key points of the subject that most students want to commit to memory. Each flashcard has questions on one side and the answers on the reverse. We recommend that you use the cards actively and test yourself as you go.

The following questions and comments might help you to decide if flashcards are suitable for you:

- Do you have a regular train or bus journey?
Flashcards are ideal for regular bursts of revision on the move.
- Do you want to fit more study into your routine?
Flashcards are a good option for 'dead time', eg using flashcards on your phone or sticking them on the wall in your study.
- Do you find yourself cramming for exams (even if that's not your original plan)?
Flashcards are an extremely efficient way to do your pre-exam memorising.

If you are retaking a subject, then you might consider using flashcards if you didn't use them on a previous attempt.

'Revision & rehearsal' products

Revision Notes

Our Revision Notes have been designed with input from students to help you revise efficiently. They are suitable for first-time sitters who have worked through the ActEd Course Notes or for retakers (who should find them much more useful and challenging than simply reading through the course again).

The Revision Notes are a set of A5 booklets – perfect for revising on the train or tube to work. Each booklet covers one main theme or a set of related topics from the course and includes:

- Core Reading to develop your bookwork knowledge
- relevant past exam questions with concise solutions from the last ten years
- other useful revision aids.

ActEd Solutions with Exam Technique (ASET)

The ActEd Solutions with Exam Technique (ASET) contains our solutions to a number of past exam papers, plus comment and explanation. In particular, it highlights how questions might have been analysed and interpreted so as to produce a good solution with a wide range of relevant points. This will be valuable in approaching questions in subsequent examinations.

‘Rehearsal’ products

Mock Exam

The Mock Exam consists of two papers. There is a 100-mark mock exam for the written Paper A examination and a separate mock exam for the computer-based Paper B exam. These provide a realistic test of your exam readiness.

It is based on the Mock Exam from last year but it has been updated to reflect any changes to the Syllabus and Core Reading.

Additional Mock Pack (AMP)

The Additional Mock Pack (AMP) consists of four further 100-mark mock exam papers – Mock Exam 2 (Papers A and B) and Mock Exam 3 (Papers A and B). This is ideal if you are retaking and have already sat the Mock Exam, or if you just want some extra question practice.

Mock Marking

We are happy to mark your attempts at the mock exams. The same general principles apply as for the Assignment Marking. In particular:

- Mock Exam Marking applies to a specified subject, session and student. In this subject it covers the marking of both Paper A and Paper B.
- Marking Vouchers can be used for each mock exam paper. You will need two marking vouchers in order to have both Paper A and Paper B marked. Marking vouchers have to be used for marking the AMP mocks and can be used for marking the Mock Exam.

Recall that:

- marking is not included with the products themselves and you need to order it separately
- you should submit your script via email in the format detailed in the mock exam instructions
- you will be able to download the feedback on your marked script via a secure link.

2.4 Study skills and assessment

Technical skills

The Core Reading and exam papers for these subjects tend to be very technical. The exams themselves have many calculation and manipulation questions. The emphasis in the exam will therefore be on *understanding* the mathematical techniques and applying them to various, frequently unfamiliar, situations. It is important to have a feel for what the numerical answer should be by having a deep understanding of the material and by doing reasonableness checks.

As a high level of pure mathematics and statistics is generally required for the Core Principles subjects, it is important that your mathematical skills are extremely good. If you are a little rusty you may wish to consider purchasing additional material to help you get up to speed. The course 'Pure Maths and Statistics for Actuarial Studies' is available from ActEd and it covers the mathematical techniques that are required for the Core Principles subjects, some of which are beyond A-Level (or Higher) standard. You do not need to work through the whole course in order – you can just refer to it when you need help on a particular topic. An initial assessment to test your mathematical skills and further details regarding the course can be found on our website at www.ActEd.co.uk.

Study skills

Overall study plan

We suggest that you develop a realistic study plan, building in time for relaxation and allowing some time for contingencies. Be aware of busy times at work, when you may not be able to take as much study leave as you would like. Once you have set your plan, be determined to stick to it. You don't have to be too prescriptive at this stage about what precisely you do on each study day. The main thing is to be clear that you will cover all the important activities in an appropriate manner and leave plenty of time for revision and question practice.

Aim to manage your study so as to allow plenty of time for the concepts you meet in these courses to 'bed down' in your mind. Most successful students will probably aim to complete the courses at least a month before the exam, thereby leaving a sufficient amount of time for revision. By finishing the courses as quickly as possible, you will have a much clearer view of the big picture. It will also allow you to structure your revision so that you can concentrate on the important and difficult areas.

You can also try looking at our discussion forum, which can be accessed at www.ActEd.co.uk/forums (or use the link from our home page at www.ActEd.co.uk). There are some good suggestions from students on how to study.

Study sessions

Only do activities that will increase your chance of passing. Try to avoid including activities for the sake of it and don't spend time reviewing material that you already understand. You will only improve your chances of passing the exam by getting on top of the material that you currently find difficult.

Ideally, each study session should have a specific purpose and be based on a specific task, eg *'Finish reading Chapter 3 and attempt Practice Questions 3.4, 3.7 and 3.12'*, as opposed to a specific amount of time, eg *'Three hours studying the material in Chapter 3'*.

Try to study somewhere quiet and free from distractions (eg a library or a desk at home dedicated to study). Find out when you operate at your peak, and endeavour to study at those times of the day. This might be between 8am and 10am or could be in the evening. Take short breaks during your study to remain focused – it's definitely time for a short break if you find that your brain is tired and that your concentration has started to drift from the information in front of you.

Order of study

We suggest that you work through each of the chapters in turn. To get the maximum benefit from each chapter you should proceed in the following order:

1. Read the syllabus objectives. These are set out in the box at the start of each chapter.
2. Read the Chapter Summary at the end of each chapter. This will give you a useful overview of the material that you are about to study and help you to appreciate the context of the ideas that you meet.
3. Study the Course Notes in detail, annotating them and possibly making your own notes. Try the self-assessment questions as you come to them. As you study, pay particular attention to the listing of the syllabus Objectives and to the Core Reading.
4. Read the Chapter Summary again carefully. If there are any ideas that you can't remember covering in the Course Notes, read the relevant section of the notes again to refresh your memory.
5. Attempt (at least some of) the Practice Questions that appear at the end of the chapter.
6. Where relevant, work through the relevant Paper B Online Resources for the chapter(s). You will need to have a good understanding of the relevant section of the paper-based course before you attempt the corresponding section of PBOR.

It's a fact that people are more likely to remember something if they review it several times. So, do look over the chapters you have studied so far from time to time. It is useful to re-read the Chapter Summaries or to try the Practice Questions again a few days after reading the chapter itself. It's a good idea to annotate the questions with details of when you attempted each one. This makes it easier to ensure that you try all of the questions as part of your revision without repeating any that you got right first time.

Once you've read the relevant part of the notes and tried a selection of questions from the Practice Questions (and attended a tutorial, if appropriate) you should attempt the corresponding assignment. If you submit your assignment for marking, spend some time looking through it carefully when it is returned. It can seem a bit depressing to analyse the errors you made, but you will increase your chances of passing the exam by learning from your mistakes. The markers will try their best to provide practical comments to help you to improve.

To be really prepared for the exam, you should not only know and understand the Core Reading but also be aware of what the examiners will expect. Your revision programme should include plenty of question practice so that you are aware of the typical style, content and marking structure of exam questions. You should attempt as many past exam questions as you can.

Active study

Here are some techniques that may help you to study actively.

1. Don't believe everything you read. Good students tend to question everything that they read. They will ask 'why, how, what for, when?' when confronted with a new concept, and they will apply their own judgement. This contrasts with those who unquestioningly believe what they are told, learn it thoroughly, and reproduce it (unquestioningly?) in response to exam questions.
2. Another useful technique as you read the Course Notes is to think of possible questions that the examiners could ask. This will help you to understand the examiners' point of view and should mean that there are fewer nasty surprises in the exam room. Use the Syllabus to help you make up questions.
3. Annotate your notes with your own ideas and questions. This will make you study more actively and will help when you come to review and revise the material. Do not simply copy out the notes without thinking about the issues.
4. Attempt the questions in the notes as you work through the course. Write down your answer before you refer to the solution.
5. Attempt other questions and assignments on a similar basis, *ie* write down your answer before looking at the solution provided. Attempting the assignments under exam conditions has some particular benefits:
 - It forces you to think and act in a way that is similar to how you will behave in the exam.
 - When you have your assignments marked it is *much* more useful if the marker's comments can show you how to improve your performance under exam conditions than your performance when you have access to the notes and are under no time pressure.
 - The knowledge that you are going to do an assignment under exam conditions and then submit it (however good or bad) for marking can act as a powerful incentive to make you study each part as well as possible.
 - It is also quicker than trying to write perfect answers.
6. Sit a mock exam four to six weeks before the real exam to identify your weaknesses and work to improve them. You could use a mock exam written by ActEd or a past exam paper.

You can find further information on how to study in the profession's Student Handbook, which you can download from their website at:

www.actuaries.org.uk/studying

Revision and exam skills

Revision skills

You will have sat many exams before and will have mastered the exam and revision techniques that suit you. However it is important to note that due to the high volume of work involved in the Core Principles subjects it is not possible to leave all your revision to the last minute. Students who prepare well in advance have a better chance of passing their exams on the first sitting.

Unprepared students find that they are under time pressure in the exam. Therefore it is important to find ways of maximising your score in the shortest possible time. Part of your preparation should be to practise a large number of exam-style questions under timed exam conditions as soon as possible. This will:

- help you to develop the necessary understanding of the techniques required
- highlight the key topics, which crop up regularly in many different contexts and questions
- help you to practise the specific skills that you will need to pass the exam.

There are many sources of exam-style questions. You can use past exam papers, the Practice Questions at the end of each chapter (which include many past exam questions), assignments, mock exams, the Revision Notes and ASET.

Exam question skill levels

Exam questions are not designed to be of similar difficulty. The Institute and Faculty of Actuaries specifies different skill levels at which questions may be set.

Questions may be set at any skill level:

- Knowledge – demonstration of a detailed knowledge and understanding of the topic
- Application – demonstration of an ability to apply the principles underlying the topic within a given context
- Higher Order – demonstration of an ability to perform deeper analysis and assessment of situations, including forming judgements, taking into account different points of view, comparing and contrasting situations, suggesting possible solutions and actions, and making recommendations.

Command verbs

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 profession has produced a document, 'Command verbs used in the Associate and Fellowship examinations', to help students to understand what each command verb is asking them to do.

It also gives the following advice:

- The use of a specific command verb within a syllabus objective does not indicate that this is the only form of question which can be asked on the topic covered by that objective.
- The examiners may ask a question on any syllabus topic using any of the agreed command verbs, as are defined in the document.

You can find the relevant document on the profession's website at:

www.actuaries.org.uk/studying/prepare-your-exams

Past exam papers

You can download some past exam papers and Examiners' Reports from the profession's website at **www.actuaries.org.uk**. However, please be aware that the majority of these exam papers are for the pre-2019 syllabus and so not all questions will be relevant.

The examination

IMPORTANT NOTE: The following information was correct at the time of printing, however it is important to keep up-to-date with any changes. See the profession's website for the latest guidance.

For the written exams the examination room will be equipped with:

- the question paper
- an answer booklet
- rough paper
- a copy of the *Tables*.

Remember to take with you:

- black pens
- an authorised scientific calculator – please refer to **www.actuaries.org.uk** for the latest advice.

Please also refer to the profession's website and your examination instructions for details about what you will need for the computer-based Paper B exam.

2.5 Queries and feedback

Questions and queries

From time to time you may come across something in the study material that is unclear to you. The easiest way to solve such problems is often through discussion with friends, colleagues and peers – they will probably have had similar experiences whilst studying. If there's no-one at work to talk to then use our discussion forum at www.ActEd.co.uk/forums (or use the link from our home page at www.ActEd.co.uk).

Our online forum 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. You could also use it to get ideas for revision or for further reading around the subject that you are studying. ActEd tutors will visit the site from time to time 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 relevant subject email address (see Section 1.5), 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 away from the office 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. Information about personal tuition is set out in our current brochure. Please email ActEd@bpp.com for more details.

Feedback

If you find an error in the course, please check the corrections page of our website (www.ActEd.co.uk/paper_corrections.html) to see if the correction has already been dealt with. Otherwise please send details via email to the relevant subject email address (see Section 1.5).

Each year our tutors work hard to improve the quality of the study material and to ensure that the courses are as clear as possible and free from errors. We are always happy to receive feedback from students, particularly details concerning any errors, contradictions or unclear statements in the courses. If you have any comments on this course please email them to the relevant subject email address (see Section 1.5).

Our tutors also work with the profession 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 education.services@actuaries.org.uk.

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