UNSW Business School

School of Risk and Actuarial Studies

ACTL3141

Actuarial Models and Statistics

Course Outline

Semester 1, 2017

Part A: Course-Specific Information

Please consult Part B for key information on Business School policies (including those on plagiarism and special consideration), student responsibilities and student support services.

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Dear Students

Welcome to ACTL3141 Actuarial Models and Statistics.

This course corresponds to a major component of the CT4 course of the Institute of Actuaries/Faculty of Actuaries.

In this course outline, you will find the details of the course requirements, course aims and learning outcomes, content, teaching methods, assessment tasks, texts and readings, and expectations.

The way the course is taught is different to the traditional lecture. This teaching approach is often referred to as "flipped and blended".

The main rationale for this "flipped and blended" structure is twofold. First, it frees up class time which can now be used to do in–class exercises and learning-by-doing activities, which aim at enhancing students' long-lasting (deep) learning. Second, it brings a significant portion of the face-to-face time later in the learning process, when students are more comfortable with the materials, and more likely to interact and ask questions.

In this flipped and blended approach, the first conceptual encounter with the materials of a given module happens in class through a learn-by-doing activity to spark the students' interest in the topic and to provide a context for the subsequent video lectures. The second conceptual encounter with the materials happens at home when students watch video lectures. These video lectures are accompanied by Moodle forums which provide the students with an immediate opportunity for asking questions on their understanding of the material. Then, everyone gathers in the lecture room for a "lectorial". The word combines *lectures*—because they are run by the lecturer, and with the whole group, and *tutorial*—because their goal is not to "lecture" students. By contrast, in this lectorial, the lecturer first provides a high level summary of the key concepts of the module and then moves on to other activities (such as discussions, advanced exercises, guest lectures, real life applications) that aim to cement students' learning. Finally, the students move on to practicing their knowledge with tutorial exercises and computer exercises in R.

Please read this outline carefully and thoroughly, as it will be assumed that you are familiar with its contents.

If you have any questions about the course at any time, please contact me.

I look forward to guiding your learning for the duration of the course.

Andrés Villegas – Lecturer in charge

PART A: COURSE-SPECIFIC INFORMATION

1 STAFF CONTACT DETAILS

The Course Lecturer-in-charge is Dr Andrés Villegas. He is responsible for the teaching and assessment of the course. All administrative and academic (learning) enquiries to do with the course should be directed to Andrés.

Position	Name	Email	Room	Phone
Lecturer-in-charge	Andrés Villegas	a.villegas@unsw.edu.au	Business School 645	9385 2647

Consultation times are on Wednesdays from 11pm-12pm in Ritchie Th. Students are strongly encouraged to post their questions on the Moodle forums as well.

The Tutors for the course are:

Staff	E-mail	Consultation
Kelvin Duong	kelvin.duong@unsw.edu.au	***
Kane Hausfeld	k.hausfeld@unsw.edu.au	***
Alan Xian	a.xian@unsw.edu.au	***

*** Tutors will hold consultation once the week before any in-session assessment. The consultation times will be advertised on the course website.

2 COURSE DETAILS

2.1 Teaching Times and Locations

This Course consists of

- Self-study video recordings available on the course Moodle website and organised in 10 modules plus a module on ethics;
- 1 hour consultation every week (1 to 12);
- 1 hour tutorial every week **(**2 to 13); and
- 2 hour lectorials every week (1 to 12).

Lectorials

Lectorials will be held on **Tuesdays from 11am to 1pm in ChemScM17**, in weeks 1-7, 9-12 and on **Wednesday 26th April from 12pm to 1pm** (week 8) **in Ritchie Th**. You

must **remain available on the Wednesday slot of all other weeks** for additional activities should they be organised, but you do not need to come unless we announce you have to do so.

Timetables and locations are correct at time of editing. A full timetable of lectorials and topics is provided later in this Course outline. Any alterations to the lectorial times or locations will be advised in lectures and via the Course website.

Tutorials

Tutorials will be held from week 2 to week 13. They will cover topics covered in the current module. A maximum of 9 tutorials groups are planned for the course. Scheduled Tutorial Session times and locations are as follows:

M14A	Monday	2pm-3pm	MorvB G5	Xian
M15A	Monday	3pm-4pm	MorvB G5	Xian
M16A	Monday	4pm-5pm	MorvB G5	Xian
T10A	Tuesday	10am-11am	BUS 216	Duong
T11A	Tuesday	11am-12pm	BUS 216	Duong
T15A	Tuesday	3pm-4pm	BUS 232	Duong
T16A	Tuesday	4pm-5pm	BUS 232	Hausfeld
H10A	Thursday	10am-11am	BUS 205	Hausfeld
H11A	Thursday	11am-12am	BUS 205	Hausfeld

Tutorials falling on Public Holidays will not be replaced. Students must attend the tutorial for which they are enrolled. Attendance will be recorded and counts towards meeting the requirements to pass the course; for more information, see Part B of the Course Outline. If you wish to change your tutorial, then you must lodge an application to change your tutorial time with the Student Centre.

In tutorials, we will implement interactive learning where participation is highly encouraged. To get the most out of the tutorials, students should cover the lectures' contents and complete assigned homework problems in advance of the tutorials.

2.2 Units of Credit

The course is worth 6 units of credit.

There is no parallel teaching in this course.

2.3 Summary of Course

This course covers survival models and their estimation as well as applications in insurance and finance. Specific topics include: the concept of survival models and actuarial notation; estimation of lifetime distributions; multiple state models; maximum likelihood estimation of transition intensities; the binomial model of mortality and its estimation; models with transition intensities depending on age and duration; the census approximation and formulae; statistical comparison of crude rates with a standard table; graduation of crude estimates and tests of fidelity and smoothness; analysis of mortality/morbidity and the main forms of selection; models for projection of mortality. The analysis of data using numerical computer packages developed during the course will form part of the course assessment.

This course covers material in the Subject CT4 Models of the Institute of Actuaries, covering Units 5-13 of CT4.

2.4 Course Aims and Relationship to Other Courses

At the end of the course students should be able to:

A. Assess the properties of a model involving survival or transition intensities and apply to real-life data for insurance and finance applications.

B. Use actuarial statistics techniques to assess probability models and data.

C. Understand and discuss ethical issues and implications of the modelling introduced in the course.

This course covers the development and application of statistical techniques to practical actuarial problems. Examples will be drawn from the insurance and financial markets. Students are assumed to have a good knowledge of ACTL2131 and ACTL2102.

Particularly important is the material on statistical estimation and regression techniques covered in ACTL2131. If your knowledge on this topic area requires revision it is important that you revise this material as soon as possible. The assumed knowledge of the course includes a good understanding of mathematics in calculus and linear algebra.

2.5 Student Learning Outcomes

The Course Learning Outcomes are what you should be able to DO by the end of this course if you participate fully in learning activities and successfully complete the assessment items. These are:

1. Explain the concept of survival models

2. Describe estimation procedures for lifetime distributions

3. Describe statistical models of transfers between multiple states, including processes with single or multiple decrements, and derive relationships between probabilities of transfer and transition intensities

4. Derive maximum likelihood estimators for the transition intensities in models of transfers between states with piecewise constant transition intensities

5. Describe the Binomial model of mortality, derive a maximum likelihood estimator for the probability of death and compare the Binomial model with the multiple state models

6. Describe how to estimate transition intensities depending on age, exactly or using the census approximation.

7. Describe how to test crude estimates for consistency with a standard table or a set of graduated estimates, and describe the process of graduation.

8. Describe the principal forms of mortality and morbidity heterogeneity in a population and the main forms of selection

9. Describe the main methods of projecting/forecasting mortality rates.

10 Understand and discuss the ethical dimensions and implications of the modelling introduced in the course

The course covers the following aims and syllabus items of the Institute of Actuaries courses:

Course Learning Outcome	Institute of Actuaries Syllabus aim
1	Survival Models v 1-8 (Chapter 7 CT4 notes)
2	Estimating the lifetime distribution function and Proportional hazards models vi 1-5 (Chapter 8 and 9 CT4 notes)
3	Markov processes and survival models iv 5-7 (Chapters 5 and 6 CT4 notes)
4	MLE estimation for transition intensities vii 1-4 (Chapter 5 CT4 notes)
5	Binomial model viii 1-3 (Chapter 10 CT4 notes)
6	Exposed to risk ix 1-9 (Chapter 11 CT4 notes)
7	Graduation and statistical tests x 1-3 (Chapter 12 CT4 notes) and Methods of graduation x 4-7 (Chapter 13 CT4 notes)
8	CT5 ix 1-9
9	Current topics
10	Ethical issues

The Learning Outcomes in this course also help you to achieve some of the overall Program Learning Goals and Outcomes for all undergraduate coursework students in the Business School. Program Learning Goals are what we want you to BE or HAVE by the time you successfully complete your degree (e.g. 'be an effective team player'). You demonstrate this by achieving specific Program Learning Outcomes - what you are able to DO by the end of your degree (e.g. 'participate collaboratively and responsibly in teams').

For more information on the Undergraduate Coursework Program Learning Goals and Outcomes, see Part B of the course outline.

Business Undergraduate Program Learning Goals and Outcomes

1. Knowledge: **Our graduates will have in-depth disciplinary knowledge applicable in local and global contexts.**

You should be able to select and apply disciplinary knowledge to business situations in a local and global environment**.**

2. Critical thinking and problem solving: Our graduates will be critical thinkers and effective problem solvers.

You should be able to identify and research issues in business situations, analyse the issues, and propose appropriate and well-justified solutions.

3. Communication: Our graduates will be effective professional communicators.

You should be able to:

- **a.** Prepare written documents that are clear and concise, using appropriate style and presentation for the intended audience, purpose and context, and
- **b.** Prepare and deliver oral presentations that are clear, focused, well-structured, and delivered in a professional manner.

4. Teamwork: Our graduates will be effective team participants.

You should be able to participate collaboratively and responsibly in teams, and reflect on your own teamwork, and on the team's processes and ability to achieve outcomes.

5. Ethical, social and environmental responsibility: Our graduates will have a sound awareness of the ethical, social, cultural and environmental implications of business practice.

You should be able to:

a. Identify and assess ethical, environmental and/or sustainability considerations in business decision-making and practice, and
b. Identify social and cultural implications of business situations.

The following table shows how your Course Learning Outcomes relate to the overall Program Learning Goals and Outcomes, and indicates where these are assessed (they may also be developed in tutorials and other activities):

Program Learning Goals and Outcomes	Course Learning Outcomes	Course Assessment Item
This course helps you to achieve the following learning goals for all	*On successful completion of the course, you should be able to:*	*This learning outcome will be*

Business undergraduate students:			*assessed in the following items:*
1	Knowledge	Learning Outcomes 1-9	• Tutorial Problems • R Assignments • Mid-session exam • Final Exam
2	Critical thinking and problem solving	Learning Outcomes 1-9	• Tutorial Problems • R Assignments • Mid-session exam • Final Exam
3a	Written communication	Learning Outcomes 1-9	• Assignment • Mid-session exam • Final exam
3b	Oral communication	Communicate ideas in a succinct and clear manner.	• Part of tutorial participation but not specifically assessed.
4	Teamwork	Work collaboratively to complete a task.	• Part of tutorial participation but not specifically assessed.
5a.	Ethical, environmental and sustainability responsibility	Identify and assess ethical, environmental and/or sustainability considerations in business decision-making and practice.(Learning Outcome 10)	• Assignment • Final exam
5b.	Social and cultural awareness	Consider social and cultural implications of business and /or management practice. (Learning Outcome 10)	• Assignment • Final exam

3 LEARNING AND TEACHING ACTIVITIES

3.1 Approach to Learning and Teaching in the Course

The approach adopted in this course is one of assisted self-study. **The approach adopted in this course is called "flipped and blended" classroom.** While reading this subsection, please refer to the schedule given in Section 7.

The main rationale for this "flipped and blended" structure is twofold. First, it frees up class time which can now be used to do in–class exercises and learning-by-doing activities, which aim at enhancing students' long-lasting (deep) learning. Second, it brings a significant portion of the face-to-face time later in the learning process, when students are more comfortable with the materials, and more likely to interact and ask questions.

In this flipped and blended approach, the first conceptual encounter with the materials of a given module happens in class through a learn-by-doing activity to spark the students' interest in the topic and to provide a context for the subsequent video lectures. The second conceptual encounter with the materials happens at home when students watch video lectures. These video lectures are accompanied by Moodle forums which provide the students with an immediate opportunity for asking questions on their understanding of the material. Consultation is also available. Then, everyone gathers in the lecture room for a "lectorial". The word combines *lectures*—because they are run by the lecturer, and with the whole group, and *tutorial*—because their goal is not to "lecture" students. By contrast, in this lectorial, the lecturer first provides a high level summary of the key concepts of the module and then moves on to other activities (such as discussions, advanced exercises, guest lectures, real life applications) that aim to cement students' learning. Finally, the students move on to practicing their knowledge with tutorial exercises and computer exercises in R. Tutorial sessions aim to provide some additional face-to-face and personalised help.

Course materials are organised in 10 modules plus a module on ethics. Students are responsible to learn topics with the following materials:

- Prescribed books (and recommended books for additional support)
- Topic video lectures available on the course website
- Tutorial exercises with solutions
- Self-study R tutorials
- Past quizzes and exams for advanced exercises

It is expected the students will take a pro-active approach to learning. On average, students have one week to cover the contents of a given module. It is recommended to have read all prescribed readings, watched the associated videos, attempted the tutorial exercises and gone through the self-study R tutorials prior to the associated module's lectorial.

It is expected that you will spend at least ten hours per week studying this course. In periods where you need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment (to extra-curricular activities) has been a cause of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities. In the past, students have found the amount of contents particularly challenging. **Don't allow yourself to fall behind the schedule!**

3.2 Learning Activities and Teaching Strategies

It is expected that the students will take a pro-active approach to learning. The course is organised in the following learning activities.

Video lectures and Self-study

During the time periods of self-study, students should cover the readings, video lectures and tutorials for the associated module. A required learning strategy for this course is to have read all prescribed readings, watched the associated video lectures and attempted the tutorial exercises before lectorials.

Lectorials

Weekly lectorials are there to wrap up modules, to solve advanced exercises and to answer the students' questions. Students should have read the prescribed books, watched the videos and done the tutorial exercises **prior to the lectures**. No course contents will be taught during the lectures. Students are encouraged to prepare questions and communicate them to the lecturer in advance via the Moodle forums.

Tutorials

The more you read the more you know, **but the more you practice the more you learn and understand**. So the key to the understanding of this course is problem solving.

Tutorials are planned throughout the time allocated to a module's learning. Tutorials are for students to ask questions on aspects of the course that need further clarification and to interact with other students in the course. Students need to attempt the tutorial exercises prior to the tutorial classes and identify problems that require closer review during tutorials. They are an opportunity to learn from other students and to develop team skills by working on problems with other students.

The purpose of tutorials is to enable you to raise questions about difficult topics or problems encountered in their studies. *Students must not expect another lecture – they and their questions should drive what is discussed during a tutorial.*

A good learning strategy for the tutorials is:

- Prior to make an attempt of the exercises, review your lecture notes and videos.
- Prior to the tutorial, make an attempt to the exercises you should make before the tutorial (see Section 7: Course Schedule).
- During the tutorial, make an attempt to the exercises you should make in the tutorial (see Section 7: Course Schedule).
- After the tutorial, make an attempt to the exercises you should make after the tutorial (see Section 7: Course Schedule).
- If you have questions about the tutorial exercises, ask them to your tutor. If you think you have a good understanding of the material, you should try and answer the questions of your peers. This will give you feedback on your ability to explain the material and hence how well you know the material.
- Check your answer using the tutorial solution.

Self-Study R tutorials

For some of the modules in the course there will be an associated self-study R tutorial to develop your skills in implementing the course content using R. You are required to go through each of the R tutorials on your own time and raise any questions during the face-to-face tutorials and/or on the Moodle forums. The slides of the ACTL R tutorials and "R U Ready?" module available in the Moodle ACTL all students website are useful resources in case you are unfamiliar with R or need to refresh your knowledge of this software.

4 ASSESSMENT

4.1 Formal Requirements

In order to pass this course, you must:

- achieve a composite mark of at least 50; and
- make a satisfactory attempt at all assessment tasks (see below).

Students must complete and submit all components of assessment at or before the due times. It is important that students be punctual and reliable when submitting assessment. This is an important workplace requirement and students need to ensure they meet deadlines.

Your regular and punctual attendance at lectures and tutorials is expected in this course; see Part B of the Course Outline for details.

A professional CT4 exemption is determined by a weighted average of ACTL2102 (1/3rd) and 3141 (2/3rds) marks. This average must be 65% or higher in order to be recommended for exemptions. If you do not achieve this exemption grade then you can still gain the exemption by successfully completing the Institute of Actuaries equivalent examination as soon as practical after the UNSW course

4.2 Assessment Details

Assessment Task	**Weighting**	**Modules Assessed**	**Length**	**Date**
Mid-Session Exam	15%	1 to 5	1 hour	Wednesday 5 April 11.00am-1.00pm.
Ethics Assignment	20%	Ethics		Wednesday 3 May 11.55am.
Final Exam	65%	1 to 10	2 hours	University Exam Period

Mid-term exam

There will be one written answer mid-session exam in week 6 of 1 hour duration, plus 5 minutes reading time. **The mid-term exam will take place on Wednesday 5th April, from 11am to 1pm.** The exam venue will be advertised later. The mid-session exam will be closed book. Students will only be allowed to bring the text "Formulae and Tables for Actuarial Examinations".

Normal examination rules apply to the conduct of mid-term exams. Calculators will be allowed in the mid-term and final examination but a clear indication of all of the steps involved in your calculations must be shown. The University will not supply calculators to students for use in examinations where the provision of calculators has not been requested by the course examiner. It is the student's responsibility to be familiar with the rules governing the conduct of examinations. The course exams require written responses, with students earning marks for correct mathematical working as well as partial marks for incorrect responses with correct method and reasoning. They test not only their knowledge of the material, but also the depth of their understanding of it.

Ethics Assignment

There will be one major (non-quantitative) assignment for this course focussing particularly on the ethical dimension of the course materials.

Full information about the major assignment will be released early in the session.

Final examination

The final examination will assess students understanding of the concepts covered in the course and readings and their ability to apply them to practical problems. The final examination will be a two hour written paper. The final examination will be closed book. Students will only be allowed to bring the text "Formulae and Tables for Actuarial Examinations" into the exam. This must not be annotated.

Quality Assurance

The Business School is actively monitoring student learning and quality of the student experience in all its programs. A random selection of completed assessment tasks may be used for quality assurance, such as to determine the extent to which program learning goals are being achieved. The information is required for accreditation purposes, and aggregated findings will be used to inform changes aimed at improving the quality of Business School programs. All material used for such processes will be treated as confidential.

5 COURSE RESOURCES

The **prescribed textbook** for the course is:

- *Core Reading for Subject CT4 Models* published by The Institute of Actuaries.
- *ActEd Course Notes for Subject CT4 Models.*

Additional, **recommended references** are:

- Klein, J. P., and Moeschberger, M. L. *Survival Analysis: Techniques for Censored and Truncated Data*, Springer-Verlag, New York, 1997 (2nd edition 2003).
    - Chapter 2 Basic Quantities and Models, Chapter 3 Censoring and Truncation, Chapter 4 Nonparametric estimation, Chapter 8 Semi-parametric proportional hazards regression and Chapter 9 Refinements of Semi-parametric proportional hazards.
- Benjamin, B., and Pollard, J.H., *The Analysis of Mortality and Other Actuarial Statistics*, The Institute of Actuaries, 1993.
    - Chapter 1 on Mortality Measures, Chapters 11, 12, 14, 15 and 16 on Graduation topics, Chapter 19 on Social and Economic Factors Affecting Mortality, and Chapter 9 on Trend and Forecasting.
- Pitacco, E., Denuit, M., Haberman, S., and Olivieri, A.. *Modelling longevity dynamics for pensions and annuity business*, Oxford University Press, Oxford, 2009.
    - Chapters 4 and 5 on forecasting mortality.
- Zuur, I., and Meesters, *A Beginner's Guide to R*, Springer, 2009.
- Charpentier, A. *Computational actuarial science with R*, CRC Press/Taylor and Francis Group, Boca Raton, FL, 2014.

The course draws on and further develops concepts covered in ACTL2131 (Estimation, Regression) and ACTL2102 (Markov Chains). Students are encouraged to review these concepts as required early in the course.

Formulae & Tables

The only text students are allowed to bring into the examinations for the actuarial courses is the text "Formulae and Tables for Actuarial Examinations". It must not be annotated. All students in the actuarial courses should purchase a copy of this text if they wish to use it in tutorials, mid-session exams and the final examinations. The text is available from the UNSW Bookstore, the UK Institute of Actuaries or from ActEd. Visit the ActEd website at http://www.acted.co.uk

Course website

The course Moodle website is available from the UNSW TELT platform:

http://elearning.unsw.edu.au/

To access the Moodle online support site for students, follow the links from that website to UNSW Moodle Support/Support for Students. Additional technical support can be obtained from itservicecentre@unsw.edu.au (02 9385 1333). All course contents will be available from the course website (except for the ACTL R tutorials and the module "R U Ready?" which are available on the Moodle ACTL all students website). **It is essential that you visit the site regularly (at least weekly) to see any notices posted there by the course coordinator.**

The Actuaries Institute

The Actuaries Institute allows students to become University Subscribers free of charge. Full time undergraduates studying at an Institute accredited university who are members of a university student actuarial society are eligible. To sign up, go to

http://www.actuaries.asn.au/becoming-an-actuary/becoming-a-university-subscriber

6 COURSE EVALUATION AND DEVELOPMENT

Each year feedback is sought from students and other stakeholders about the courses offered in the School and continual improvements are made based on this feedback. UNSW's Course and Teaching Evaluation and Improvement (CATEI) Process is one of the ways in which student evaluative feedback is gathered. In this course, we will seek your feedback at least at the end of semester.

Following on the positive feedback received last year on the use of "flipped and blended" approach, such a learning and teaching strategy has been maintained for the delivery of the course this year. However, upon reflection on the student's feedback on the "flipped and blended" approach a number of adjustments will be implemented. This include:

- Weekly rather than fortnightly lectorials to provide more contact hours and support to students.
- Enhanced technological facilities within Moodle that allow students to provide comments and ask questions as the videos are watched.

These two adjustments should enable students to get prompter feedback on their understanding of the material.

Furthermore, as result of student feedback, industry feedback, and the school L&T strategic plan, the software R is now incorporated throughout the course with a new set of self-study R tutorials.

7 COURSE SCHEDULE

The course is organised according to the following model:

Week…	***1***	***2***	***3***	***4***	***5***	***6***	***7***		***8***	***9***	***10***	***11***	***12***	***13***
…starting	***27-Feb***	***6-Mar***	***13-Mar***	***20-Mar***	***27-Mar***	***3-Apr***	***10-Apr***	***17-Apr***	***24-Apr***	***1-May***	***8-May***	***15-May***	***22-May***	***29-May***
Self-study	**Mod. 1**	**Mod. 2**	**Mod. 3**	**Mod. 4-5**	**Mod. 6**	**Mod. 7**		***Break***	**Mod. 8**		**Mod. 9**	**Mod. 10**		
Lectorials	**Intro**	**1**	**2**	**E, 3**	**4-5**	**6**	**7**		**7**	**8**	**8**	**9**	**10-Rev**	
Tutorials	**No tute**	**1**	**2**	**3**	**4-5**	**6**	**7**		**7**	**8**	**8**	**9**	**10**	**Rev**
Mid-term						**1-5**								
Ethics Assignment										**E**				

Note: Numbers specify the associated modules

Self-study
During the time periods indicated in pink, students should cover the readings, videos and tutorials for the associated module (details are given in the following pages).

Lectorials
Lectorials will wrap up modules and provide an opportunity (during normal contact hours) to ask questions about the associated module. See Section 3.

Tutorials
Tutorials provide support during the learning of the associated module. See Section 3.

Mid-term
The mid-term provides formal assessment of the associated module(s). See Section 4.2.

Ethics assignment
The assignment will cover the ethical dimension of the course material and is a formal assessment. See Sections 4.2

This timetable may be altered. Students will be advised of any changes in lectures and via the course web site.
Detailed information about the modules' contents and their associated readings is given in the following pages.

School of Risk and Actuarial Studies

Module	Topic	References
E	Ethics	Lecture notes
1	Survival Models and The Life Table	Core Reading CT4 Unit 5 CT4 ActEd Course Notes Chapter 7 Klein, J. P. and M. L. Moeschberger, Chapter 2 - 2.1-2.4 Charpentier, A., Chapter 7.3
2	Non-parametric models: Kaplan-Meier, Nelson-Aalen and the comparison of survival functions	Core Reading CT4 Unit 6 CT4 ActEd Course Notes Chapter 8 Klein, J. P. and M. L. Moeschberger, Chapters 3 and 4.
3	Semi-parametric models: The Cox regression model	Core Reading CT4 Unit 7 CT4 ActEd Course Notes Chapter 9 Klein, J. P. and M. L. Moeschberger, Chapter 2 -2.5, Chapters 8, 11.2
4	Parametric models: Introduction	Klein, J. P. and M. L. Moeschberger, Chapter 12
5	Parametric models: Binomial and Poisson Models	Core Reading CT4 Unit 9 CT4 ActEd Course Notes Chapter 10

6	Parametric models: Markov models	Core Reading CT4 Unit 8 CT4 ActEd Course Notes Chapter 3, 4, 5 and 6
7	Exposed to risk	Core Reading CT4 Unit 10 CT4 ActEd Course Notes Chapter 11

8	Graduation methods	Core Reading CT4 Unit 11 and 12 CT4 ActEd Course Notes Chapter 12 and 13 Benjamin and Pollard, Chapter 11, 12, 14, 15 and 16
9	Mortality projection models	Pitacco et al., Chapter 4 and 5 Charpentier, A., Chapter 8
10	Mortality, Selection and Standardisation	Benjamin and Pollard, Chapter 19