

**KING FAHD UNIVERSITY OF PETROLEUM & MINERALS**  
**DEPARTMENT OF MATHEMATICS & STATISTICS**  
**DHAHRAN, SAUDI ARABIA**

**AS475: Survival Models for Actuaries - Term 152 (3-0-3)**

**Course Objectives:**

The statistical process of analyzing survival data, particularly for insurance applications. Techniques for estimating mortality rates; construction of mortality tables from the records of insured lives, employee benefit plans, and population statistics. Life tables, graph and related procedures. Graduation. Special attention to censoring and truncation. Single samples: complete or Type II censored data and Type I censored data for Exponential, Weibull, Gamma and other Distributions. Parametric regression for Exponential, Weibull and Gamma Distributions. Distribution-free methods for proportional hazard and related regression models.

**Prerequisites:** STAT302 and STAT310

We shall often refer to the description of SOA Exam C at:

<http://www.beanactuary.org/exams/preliminary/exams/syllabi/2013-02-exam-c.pdf>

**Textbook and Package:**

1. Kleinbaum, D. G. & Klein, M. (2012). *Survival Analysis: A Self-Learning Text 3<sup>rd</sup> edition*. New York, USA: Springer.
2. Chap 11 through 16 (except 15) of Klugman, S.A., Panjer, H.H. and Willmot, G.E. (2012). *Loss Models: From Data to Decisions* 4<sup>th</sup> Edition. Wiley and the Society of Actuaries: Hoboken, NJ.
3. Texas BAI Plus Calculator or Texas BAI Professional

**Reference:**

1. Hosmer, D. W. & Lemeshow, S. (2003). *Applied Survival Analysis: Regression Modeling of Time to Event Data*, 2nd ed., John Wiley and Son, New York.

**Instructor:** Dr. Mohammad H. Omar

**Office:** Bldg – 5, room – 508. **Phone:** 2471

**E-mail:** [omarmh@kfupm.edu.sa](mailto:omarmh@kfupm.edu.sa) (Not by WebCT/Blackboard email)

**Office Hours:** UTR: 11.00-11.55am and UT 12.30pm -1.45pm or by appointment.

Biweekly Optional lab: R 12.15-1.00pm

**Assessment**

Assessment for this course will be based on attendance, homework, term report, 3 major exams and a comprehensive final exam, as in the following:

Activity	Weight
Attendance and homework	(2%+5%)
Exam 1 (Chapters 1, 2, & KPW ch11 &12) <b>Wednesday (Feb 17 – week 5) , 6.00 pm (venue TBA)</b>	25%
Exam 2 (Chapters 3, 4, 5, & 6) <b>Monday (Mar 28- week 10), 7:00 pm (venue TBA)</b>	23%
Term Paper Report <b>Sunday (Apr 17 – week 13) due – in class</b>	15%
Final Exam (Comprehensive) <b>Saturday May 21 8am (as posted on registrar website)</b>	30%

**IMPORTANT NOTE on GRADES:** There is no quota on the number of students who can get an A+ grade.

- ✓ **Attendance** on time is *very* important. Mostly, attendance will be checked within the *first five minutes* of the class. Entering the class after that, is considered as late (**2 lates= 1 Absence**) and
- ✓ **More than 10 minutes late = Absence** (regardless of any excuse).

Letter grade	A+	A	B+	B	C+	C	D+	D	F	DN
Cut-off	90%	85%	80%	75%	67%	60%	55%	50%	<50%	≥ 9 absences

**General Notes:**

- Students are required to carry **pens, note-taking equipment** and a **calculator** to **EVERY lecture and exams**. It is strongly recommended to keep a **binder** for class-notes.
- Students are also expected to bring the book, take notes and organize their solved questions in a **binder** for easy retrieval to help them in study and review for class, exams, etc
  - It is to the student’s advantage to keep a binder for storing class notes, homework, and other graded assignments. Students who are **organized** will find it **easier** to find important materials when **studying for exams**.

- To successfully prepare for the SOA exams, students MUST **solve problems** regularly and with discipline. The selected assigned problems are specifically designed to prepare you for major and final exams. So, it is expected that you complete these problems **step-by-step** and **with comprehension**.
    - If you happen to stumble upon a solution manual somewhere, remember 2 important points. (1) Due to publishing costs and deadlines, these solutions are brief and may have mistakes and (2) in your career as an actuary and your exams and quizzes in this class, you are expected to know every step to a problem and to know if a solution is incorrect. Thus, the best way to solve problem is without these brief solutions.
  - Never round** your intermediate results to problems when doing your calculations. This will cause you to lose calculation accuracy. Your answers may then be different from the SOA exam key even when you use the right procedure.
  - For every exam, so you need to bring with you **pens, pencils, a sharpener, an eraser**, and a **SOA approved calculator**.
  - Students should wait until completion of the next course AS482 before they attempt to take the professional exam MLC.
- Academic Integrity:** All KFUPM policies regarding **ethics** and **academic honesty** apply to this course.

### Syllabus (Tentative)

Week	Dates	Sections	Topic	Notes
1	17-Jan - 21-Jan	Ch 1 KK	Introduction to Survival Analysis (2-1/2 class).	
2	24-Jan - 28-Jan	Ch 11 KPW	KPW11 Estimation of Modified Data	
3	31-Jan - 4-Feb	Ch 12 KPW	Estimation of Actuarial Survival Data Nelson-Aalen Estimate.	
4	7-Feb - 11-Feb	Ch 2 KK	Kaplan-Meier Survival Curves and the Log-Rank Test	Declare your Term paper topic: Sun
5	14-Feb - 18-Feb	Ch 3 KK	The Cox Proportional Hazards Model and its Characteristics,	(2 wks): Midterm grade reports starts
<b>Wednesday, Feb 17 – 1st Major Exam (chapters 1, 2, KPW ch11, &amp; KPW ch12)</b>				
6	21-Feb - 25-Feb	Ch 4 KK Ch 5 KK	Evaluating the PH Model assumptions The Stratified Cox Procedure	
7	28-Feb - 3-Mar	Ch 5 KK Ch 6 KK	The Stratified Cox Procedure (cont.) Extension of the Cox PH Model for Time-Dependent Variables	
8	6-Mar - 10-Mar	Ch 6 KK Ch 13 KPW	Extension of the Cox PH Model for Time-Dependent Variables (cont.) Parametric Survival Models	
	13-Mar - 17-Mar	Midterm Break		
9	20-Mar - 24-Mar	Ch 13 KPW	Parametric Survival Models (continued)	
<b>Monday, Mar 28 – 2nd Major Exam (chapters 3, 4, 5 &amp; 6)</b>				
10	27-Mar - 31-Mar	Ch 16 KPW Ch 7 KK	Model Selection	
11	3-Apr - 7-Apr	Ch 7 KK	Model Selection (continued)	
12	10-Apr - 14-Apr	Ch 8 KK	Recurrent Event Survival Analysis	
13	17-Apr - 21-Apr	Ch 9 KK	Competing Risks Survival Analysis	<b>Sun Apr 17:</b> Term Paper Report due to instructor
14	24-Apr - 28-Apr	C review if time permits	Practice format from SOA C professional exam	
15	1-May - 5-May	Review	Review	
16	Sat 21-May 8am	<b>"Comprehensive" Final Exam</b>		

**Student Learning Outcomes:** (From the Society of Actuaries Exam C) May change in 2016

**a) Post-2014 Outcomes with SOA weights of 45-55%**

<b>SOA Learning Outcomes</b>		<b>Weights</b>	<b>Course</b>
<b>F. Construction of Empirical Models</b>		<b>20-25%</b>	
1.	Estimate failure time and loss distributions using: a) Kaplan-Meier estimator, b) Nelson-Åalen estimator, c) Kernel density estimators		AS475
2.	Estimate the variance of estimators and confidence intervals for failure time and loss distributions.		AS475
3.	Apply the following concepts in estimating failure time and loss distribution: a) Unbiasedness, b) Consistency, c) Mean squared error		AS475 & STAT302
<b>G. Estimation of decrement probabilities from large samples</b>			
1.	Estimate decrement probabilities using both parametric and nonparametric approaches for both individual and interval data		AS475
2.	Approximate the variance of the estimators	AS475	
<b>H. Construction and Selection of Parametric Models</b>		<b>25-30%</b>	
1.	Estimate the parameters of failure time and loss distributions using: a) Maximum likelihood, b) Method of moments, c) Percentile matching, d) Bayesian procedures		AS475 & AS483
2.	Estimate the parameters of failure time and loss distributions with censored and/or truncated data using maximum likelihood.		AS475
3.	Estimate the variance of estimators and the confidence intervals for the parameters and functions of parameters of failure time and loss distributions.		AS475
4.	Apply the following concepts in estimating failure time and loss distributions: a) Unbiasedness, b) Asymptotic unbiasedness, c) Consistency, d) Mean squared error, e) Uniform minimum variance estimator		AS475 & STAT302
5.	Determine the acceptability of a fitted model and/or compare models using: a) Graphical procedures, b) Kolmogorov-Smirnov test, c) Anderson-Darling test, d) Chi-square goodness-of-fit test, e) Likelihood ratio test, f) Schwarz Bayesian Criterion	AS475	

Other SOA C learning outcomes are discussed in AS483 Actuarial Risk Theory and Credibility.

As a summary, the number of SOA C learning outcomes per KFUPM course is as follows:

Course	# SOA C Learning Outcomes
STAT301	3
STAT302	4
AS475	23
AS483	34
AS475/AS483	1
<b>Total</b>	<b>65</b>

Interesting links on the internet:

<http://www.statsoft.com/Textbook/Survival-Failure-Time-Analysis/button/2>

**Extra topics** (if time permits & if not already covered in AS483)

**KleinBaum's topics**

**Ch 1. Introduction to Survival Analysis**

**KPW11 Estimation of Complete Data**

**KPW12 Estimation of Modified Data**

**Ch 2. Kaplan-Meier Survival Curves and the Log-Rank Test**

Major 1

**Ch 3. The Cox Proportional Hazards Model and its Characteristics**

**Ch 4. Evaluating the PH Model assumptions**

**Ch 5. The Stratified Cox procedure**

**Ch 6. Extension of the Cox PH Model for Time-Dependent Variables**

Major 2

**KPW13 Frequentist Estimation for Discrete Distributions**

**KPW16 Model Selection**

Ch 7. Parametric Survival Models

Ch 8. Recurrent Event Survival Analysis

Ch 9. Competing Risks Survival Analysis

- The statistical process of analyzing survival data, particularly for insurance applications.
- Techniques for estimating mortality rates;
  - construction of mortality tables from the records of insured lives,
  - employee benefit plans, and population statistics.
  - Life tables, graph and related procedures.
  - Graduation.
- Special attention to censoring and truncation.
- Single samples: complete or Type II censored data and Type I censored data for Exponential, Weibull, Gamma and other Distributions.
- Parametric regression for Exponential, Weibull and Gamma Distributions.
- Distribution-free methods for proportional hazard and related regression models.

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2	24-Jan - 28-Jan	Ch 11 KPW	KPW11 Estimation of Modified Data	Hwk 1: KPW Q11.1, Q11.2, Q11.6
3	31-Jan - 4-Feb	Ch 12 KPW	Estimation of Actuarial Survival Data Nelson-Aalen Estimate.	Hwk 2: KPW Q12.2, Q12.3, Q12.33
4	7-Feb - 11-Feb	Ch 2 KK	Kaplan-Meier Survival Curves and the Log-Rank Test	
5	14-Feb - 18-Feb	Ch 3 KK	The Cox Proportional Hazards Model and its Characteristics,	
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8	6-Mar - 10-Mar	Ch 6 KK Ch 13 KPW	Extension of the Cox PH Model for Time-Dependent Variables (cont.) Parametric Survival Models	Hwk 3: KPW Q13.4, Q13.32
	13-Mar - 17-Mar		Midterm Break	
9	20-Mar - 24-Mar	Ch 13 KPW	Parametric Survival Models (continued)	
<b>Monday, Mar 28 – 2nd Major Exam (chapters 3, 4, 5 &amp; 6)</b>				
10	27-Mar - 31-Mar	Ch 16 KPW Ch 7 KK	Model Selection	Hwk 4: KPW Q16.1, Q16.4, Q16.9, Q16.13
11	3-Apr - 7-Apr	Ch 7 KK	Model Selection (continued)	
12	10-Apr - 14-Apr	Ch 8 KK	Recurrent Event Survival Analysis	
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