Dept of Mathematics and Statistics
King Fahd University of Petroleum & Minerals
AS476: Survival Models for Actuaries
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Major 1 Exam Term 231 FORM 001

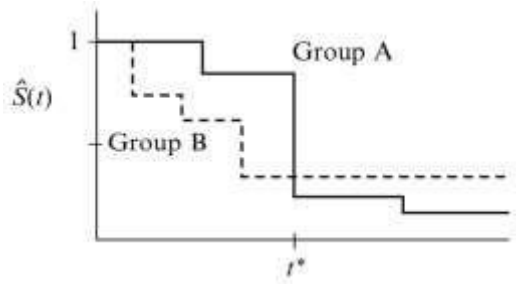
Name_____ID#:_____Serial #:___

Instructions.

1. Please turn off your cell phones and place them under your chair. Any student caught with mobile phones on during the exam will be considered under the cheating rules of the University.
2. You are, however. allowed **5 minutes** to **scan the OMR sheet** page **to upload** that to your class the class MS Teams account at the end of your test.
    a) Login to Microsoft Teams using portal login and password
    b) Go to the AS476 course teams
    c) Scan into your mobile phone your OMR and problem solving page using CamScanner/Adobe Scan
    d) Upload to AS476 class Teams for grading.
    e) Submit the scanned paper to your proctor
3. If you finish the test earlier and want to leave the room, please do so quietly so not to disturb others taking the test. No two person can leave the room at the same time. No extra time will be provided for the time missed outside the classroom.
4. Only materials provided by the instructor can be present on the table during the exam.
5. Do not spend too much time on any one question. If a question seems too difficult, leave it and go on.
6. Use the blank portions of each page for your work. Extra blank pages can be provided if necessary. If you use an extra page, indicate clearly what problem you are working on.
7. Only answers supported by work will be considered. Unsupported guesses will not be graded.
8. While every attempt is made to avoid defective questions, sometimes they do occur. In the rare event that you believe a question is defective, the instructor cannot give you any guidance beyond these instructions.
9. Mobile calculators, I-pad, or communicable devices are disallowed. Use regular scientific calculators or financial calculators only. Write important steps to arrive at the solution of the following problems.
10. Record your final answers to the multiple-choice questions on the OMR sheet. And write important steps to arrive at the solution of the last two problems.

The test is 120 minutes, GOOD LUCK, and you may begin now!

Use the following graph to answer the next 3 questions below.



Q1. Which group has a **poorer** survival prognosis before time *t**?

A) Group A B) Group B C) Neither group

Solution Q1: KK ch 1 practice Q18. Group B

Q2. Which group has a **poorer** survival prognosis after time *t**?

A) Group A B) Group B C) Neither group

Solution Q2: KK ch 1 practice Q19. Group A

Q3. Which group has a **shorter** median survival time?

A) Group A B) Group B C) Neither group

Solution Q3: KK ch1 practice Q20. Group B

Use the following information to answer the next 3 questions below

The following data are a sample from the 1967–1980 EV County study. Survival times (in years) are given for two study groups, each with 25 participants. Group 1 has **no history** of chronic disease (CHR = 0), and group 2 has a **positive history** of chronic disease (CHR = 1):

Group 1 (CHR = 0):	12.3+, 5.4, 8.2, 12.2+, 11.7, 10.0, 5.7, 9.8, 2.6, 11.0, 9.2, 12.1+, 6.6, 2.2, 1.8, 10.2, 10.7, 11.1, 5.3, 3.5, 9.2, 2.5, 8.7, 3.8, 3.0
Group 2 (CHR = 1):	5.8, 2.9, 8.4, 8.3, 9.1, 4.2, 4.1, 1.8, 3.1, 11.4, 2.4, 1.4, 5.9, 1.6, 2.8, 4.9, 3.5, 6.5, 9.9, 3.6, 5.2, 8.8, 7.8, 4.7, 3.9

Q4. **For group 1**, complete the following table involving ordered failure times.

$t_{(f)}$	m_f	q_f	$R_{(t(f))}$
0.0	0	0	25 persons survived > 0 years
1.8	1	0	25
2.2	1	0	24
2.5	1	0	**a**
2.6	1	0	22
3	**b**	0	21
3.5	1	0	20
3.8	1	0	19
5.3	1	0	18
5.4	1	0	17
5.7	1	0	16

$t_{(f)}$	m_f	q_f	$R_{(t(f))}$
6.6	1	**c**	15
8.2	1	0	14
8.7	1	0	13
9.2	2	0	12
9.8	1	0	10
10	1	0	9
10.2	1	0	**d**
10.7	1	0	7
11	1	0	6
11.1	1	0	5
11.7	1	3	4

Which of the following provides the missing values represented by (a), (b), (c), and (d) above?

A) a = 23, b = 1, c = 0, d = 8
B) a = 23, b = 0, c = 1, d = 8
C) a = 21, b = 1, c = 0, d = 9
D) a = 21, b = 1, c = 1, d = 9

Solution Q4: KK ch 1 Test ch 19. Answer is A

Q5. For the data of previous problem, the average survival time ($\bar{T}$) and the average hazard rate ($\bar{h}$) for each group are given as follows:

	$\bar{T}$	$\bar{h}$
Group 1:	7.5	0.1165
Group 2:	5.3	0.1894

Based on the above information, which group has a **better survival** prognosis and **why**?

A) Group 1 because it has lower average survival time and a higher average hazard rate
B) Group 2 because it has lower average survival time and a higher average hazard rate
C) Group 1 because it has higher average survival time and a lower average hazard rate
D) Group 2 because it has higher average survival time and a lower average hazard rate
E) Neither group

Solution Q5: KK ch 1 Test ch 19. Answer C.

Group 1 has a better survival prognosis than group 2 because group 1 has a higher average survival time and a correspondingly lower average hazard rate than group 2.

Q6. Which of the following **best describes** how a comparison of survivor curves provide **additional information** to what is provided in the table in Q5?

A) No additional information is provided by the survivor curves
B) The average survival time and average hazard rates describe overall central tendencies while the survivor curves provide information about spread of the two data distributions.
C) The survivor curves additionally provide information about the skewness of the two data distributions.
D) The survivor curves additionally provide information about the kurtosis of the two data distributions.
E) The average survival time and average hazard rates give overall descriptive statistics. The survivor curves allow comparisons over time.

Solution Q6: KK ch 1 Test ch 19. Answer E.

The following summary is obtained for a mortality study data over a 5-year period. Answer the next two questions.

j	y_j	s_j	r_j
1	0.8	1	30
2	2.9	2	29
3	3.1	1	27
4	4.0	1	26
5	4.8	2	25

Note: s_j = frequency of death event and r_j = risk set.

Q7. Which of the following is the **correct value** of the **Nelson-Aelen estimator** for $H(2.9)$?

A) 0.1023 B) 0.9028 C) 0.9667 D) 0.9000 E) 0.1103

Solution Q7: KPW ch 11 Example 11.4. Answer is A.

Q8. Which of the following is the **correct value** of the **Kaplan-Meier estimator** for $S(2.9)$?

A) 0.1023 B) 0.1103 C) 0.9000 D) 0.9028 E) 0.9310

Solution Q8: KPW ch 12. Answer is C

Compare to example 12.2

$$\hat{S}(2.9) = \frac{30-1}{30}\left(\frac{29-2}{29}\right) = \frac{27}{30} = 0.9$$

Q9. A mortality study is based on observations during the period January 1, 2009, through December 31, 2011. Five policies were observed, with the following information recorded. For simplicity, a date of 3-1995 is interpreted as March 1, 1995, and all events are treated as occurring on the first day of the month of occurrence. Furthermore, all months are treated as being one-twelfth of a year in length. Summarize the information in a manner that is sufficient for estimating mortality probabilities.

1. Born 5-1976, purchased insurance policy on 8-2008, was an active policyholder on 1-2012.
2. Born 6-1976, purchased insurance policy on 7-2008, died 9-2010.
3. Born 8-1976, purchased insurance policy on 2-2010, surrendered policy on 2-2011.
4. Born 5-1976, purchased insurance policy on 6-2009, died 3-2010.
5. Born 7-1976, purchased insurance policy on 3-2009, surrendered policy on 5-2011.

A partial summary is given below.

policy holder	actual age at start	actual age at end	age group 32-33	33-34	34-35	35-36
1	a	b	c	12	12	d
2	32-7	34-3	5		3	
3	33-6		0	6		0
4	33-1	33-10	0	9	0	
5		34-10		12		0

Using the exact exposure method:
i) Which of the following **is correct**?

A) a = 32-5, b = 35-5, c = 7 months, d = 5 months, and under exact exposure $e_{32} = 16$
B) a = 32-6, b = 35-6, c = 6 months, d = 6 months, and under exact exposure $e_{32} = 15$
C) a = 32-7, b = 35-7, c = 5 months, d = 7 months, and under exact exposure $e_{32} = 14$
D) a = 32-8, b = 35-8, c = 4 months, d = 8 months, and under exact exposure $e_{32} = 13$
E) a = 32-9, b = 35-9, c = 3 months, d = 9 months, and under exact exposure $e_{32} = 12$

Solution Q9: See KPW ch12 examples 12.14 and 12.15. Answer D. $e_{32 = c+5+0+0+4}$

ii) Estimate all mortality rates at integral ages, i.e., estimate e_{32}, e_{33}, e_{34}, e_{35}, $\hat{q}_{33}$, and $\hat{q}_{34}$, where e_j is a measure of exposure and $\hat{q}_j$ is the probability of death.

SOLUTION:

$$q_j = 1 - \exp(-d_j/e_j).$$

32-33: $e_{32} = 3 + 5 + 0 + 0 + 4 = 12.$
33-34: $e_{33} = 12 + 12 + 6 + 9 + 12 = 51.$
34-35: $e_{34} = 12 + 3 + 6 + 0 + 10 = 31.$
35-36: $e_{35} = 9 + 0 + 0 + 0 + 0 = 9.$

$$\hat{q}_{33} = 1 - \exp[-1/(51/12)] = 0.20966$$
$$\hat{q}_{34} = 1 - \exp[-1/(31/12)] = 0.32097.$$