# Dept of Mathematics and Statistics
# King Fahd University of Petroleum & Minerals

## AS475: Survival Models for Actuaries
## Dr. Mohammad H. Omar
## Major 1 Exam Term 132 FORM A
## Sunday March 2 2014
## 6.00pm-7.15pm

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. If you need 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.
3. Only materials provided by the instructor can be present on the table during the exam.
4. Do not spend too much time on any one question. If a question seems too difficult, leave it and go on.
5. 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.
6. Only answers supported by work will be considered. Unsupported guesses will not be graded.
7. 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.
8. Mobile calculators, I-pad, or communicable devices are disallowed. Use regular scientific calculators or financail calculators only. Write important steps to arrive at the solution of the following problems.

The test is 90 minutes, GOOD LUCK, and you may begin now!

| Question | Total Marks | Marks Obtained | Comments |
|---|---|---|---|
| 1 | 4+4=8 | | |
| 2 | 6 | | |
| 3 | 6+3=9 | | |
| 4 | 1+4=5 | | |
| 5 | 3+3+3=9 | | |
| 6 | 4+3+3+3=13 | | |
| Total | 50 | | |

Extra blank page

1. (4+4=8 points) For the time-to- event data below

   0.5, 1.3, 1.5, 1.5, 2.1, 2.1, 2.1, 2.8,

   a) Determine the **empirical** cumulative distribution function $F_n(x)$ and

   b) Determine the **Nelson-Åalen** estimate.

2. (6 points) Determine the Kaplan-Meier estimate for the Time-to-accident Dataset below.

| $j$ | $y_j$ | $s_j$ | Risk set $r_j$ |
|---|---|---|---|
| 1 | 0.8 | 1 | 30 |
| 2 | 2.9 | 2 | 26 |
| 3 | 3.1 | 1 | 26 |
| 4 | 4.0 | 2 | 26 |
| 5 | 4.1 | 1 | 23 |
| 6 | 4.8 | 1 | 21 |

.

3. (6+3=9 points) Suppose that the following remission durations are observed from 10 patients ($n = 10$) with solid tumors.

   Six patients relapse at 3.0, 6.5, 6.5, 10, 12, and 15 months;

   1 patient is lost to follow-up at 8.4 months; and

   3 patients are still in remission at the end of the study after 4.0, 5.7, and 10 months.

   (a) Determine the survivorship function $\widehat{S}(t)$ and

   (b) Estimate (by linear interpolation) the median remission time

4. (1+4=5 points). From a population having distribution function $F$, you are given the following sample:

2.0, 3.3, 3.3, 4.0, 4.0, 4.7, 4.7, 4.7

Calculate the kernel density estimate of $F(4)$, using the uniform kernel with bandwidth 1.4.

a) 0.31
b) 0.41
c) 0.50
d) 0.53
e) 0.63

Work Shown (4 points):

The answer is (  ).

5. (3+3+3=9 points) A mortality study is based on observations during the period January 1, 2010 through December 31, 2012. Five policies were observed, with the following information recorded.

(i) Born 4-1977, purchased insurance policy on 8-2009, was an active policyholder on 1-2013.
(ii) Born 6-1977, purchased insurance policy on 7-2009, died 9-2011.
(iii) Born 8-1977, purchased insurance policy on 2-2011, surrendered policy on 2-2012.
(iv) Born 5-1977, purchased insurance policy on 6-2010, died 3-2011.
(v) Born 7-1977, purchased insurance policy on 3-2010, surrendered policy on 5-2012.

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 occurence. Furthermore, all months are treated as being one-twelfth of a year in length.

a) Summarize the information in a manner that is sufficient for estimating mortality probabilities. (i.e. create a reasonable data layout for this estimation purpose)

b) Estimate all possible mortality rates at integral ages to the above data using both (1) *Exact exposure* and (2) *Actuarial exposure* method.

6. (4+3+3+3=13 points) Consider the Remission data below and the hypothesis of equivalent survival curves,

| | | **# failures** | | **# in risk set** | | **# expected** | | **Observed - expected** | |
|---|---|---|---|---|---|---|---|---|---|
| $j$ | $t_{(j)}$ | $m_{(1j)}$ | $m_{(2j)}$ | $n_{(1j)}$ | $n_{(2j)}$ | $e_{(1j)}$ | $e_{(2j)}$ | $m_{(1j)} - e_{(1j)}$ | $m_{(2j)} - e_{(2j)}$ |
| 1 | 1 | 0 | 2 | 21 | 21 | 1 | 1 | $-1.00$ | 1.00 |
| 2 | 2 | 0 | 2 | 21 | 19 | 1 | 19/20 | $-1.05$ | 1.05 |
| 3 | 3 | 0 | 1 | 21 | 17 | | 17/38 | | 0.55 |
| 4 | 4 | 0 | 2 | 21 | 16 | 42/37 | 32/37 | $-1.14$ | 1.14 |
| 5 | 5 | 0 | 2 | 21 | 14 | 42/35 | | $-1.20$ | |
| 6 | 6 | 3 | 0 | 21 | 12 | 21/11 | 12/11 | 1.09 | $-1.09$ |
| 7 | 7 | 1 | 0 | 17 | 12 | 17/29 | 12/29 | 0.41 | $-0.41$ |
| 8 | 8 | 0 | 4 | 16 | 12 | 16/7 | 12/7 | $-2.29$ | 2.29 |
| 9 | 10 | 1 | 0 | 15 | 8 | | 8/23 | | $-0.35$ |
| 10 | 11 | 0 | 2 | 13 | 8 | 13/7 | 16/21 | $-1.24$ | 1.24 |
| 11 | 12 | 0 | 2 | 12 | 6 | 12/9 | | $-1.33$ | |
| 12 | 13 | 1 | 0 | 12 | 4 | 3/4 | 1/4 | 0.25 | $-0.25$ |
| 13 | 15 | 0 | 1 | 11 | 4 | 11/15 | 4/15 | $-0.73$ | 0.73 |
| 14 | 16 | 1 | 0 | 11 | 3 | 11/14 | 3/14 | 0.21 | $-0.21$ |
| 15 | 17 | 0 | 1 | 10 | 3 | 10/13 | 3/13 | $-0.77$ | 0.77 |
| 16 | 22 | 1 | 1 | 7 | 2 | 14/9 | 4/9 | $-0.56$ | 0.56 |
| 17 | 23 | 1 | 1 | 6 | 1 | 12/7 | 2/7 | $-0.71$ | 0.71 |
| **Totals** | | 9 | 21 | | | 19.26 | 10.74 | | |

(a) complete the blank spaces (provide sample calculation below)

(b) calculate the approximate chi-square statistics.

(c) calculate the log rank statistic.

(d) decide at $\alpha = 0.05$, if the two groups have equal survival curves

END OF TEST PAPER