Dept of Mathematics and Statistics
King Fahd University of Petroleum & Minerals
AS475: Survival Models for Actuaries
Dr. Mohammad H. Omar
Major 2 Exam Term 182 FORM A
Monday March 11 2018
6.30pm-8.30pm

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 exam time will be provided for the time spent outside the room.
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, financial calculators, or SOA approved calculators only. Write important steps to arrive at the solution of the exam problems.

The test is 2 parts each is 60 minutes, GOOD LUCK, and you may begin now!

Question	Total Marks	Marks Obtained	Comments
1	6+4+4=14		
2	6+4=10		
3	6		
4	3+4+2+2=11		
5	4+2+3+4=13		
6	6+4=10		
Output	6		
Total	70		

Extra blank page

1) (6+4+4=14 marks) For an anniversary to anniversary study, the values in the Table below were obtained.

d	u	x
25	26.0	
25	26.0	
25		25.3
25		26.7
25		25.4
25	27.0	
25	25.4	

d	u	x
25	25.8	
26	27.0	
26	27.0	
26	26.3	
26		26.2
26		26.4
26	26.9	

Estimate $q_{25}^{\prime(d)}$ and $q_{26}^{\prime(d)}$ using

a) the exact **Kaplan Meier** estimate,
b) **exact exposure**, and
c) **actuarial exposure**.

2) (6+4=10 marks) A mortality study is done from Jan 1, 2010 to Dec 31, 2014. You observe the history of the following 6 people who participated in the study:

Date of Birth (DOB)	Policy Issue Date	Date of Death (DOD)	Surrender Date, otherwise In study as of 12/31/2014
Apr 1, 1950	Mar 1, 2010	July 1, 2011	
July 1, 1950	Apr 1, 2009		
July 1, 1951	Apr 1, 2012	Jan 1, 2013	
Oct 1, 1952	July 1, 2010		Apr 1, 2013
Jan 1, 1953	Jan 1, 2011		
July 1, 1954	Mar 1, 2013		Oct 1, 2014

a) Assume **actual ages**. Find $\hat{q}_{61}$ using **exact exposure** (EE) and also **actuarial** exposure (AE).

b) Assume **age-last birthday**. Find $\hat{q}_{60}$ using EE and also AE.

3) (6 marks) You are given a data with 19 losses as follows:

i) 6 of these losses had a **deductible** of 250, 6 had a deductible of 500, and 7 had a deductible of 1000.

ii) 3 losses were paid at a **policy limit**, those values being 1000, 2750, and 5500 each.

iii) For the 16 losses **not paid at the limit**, the following table provides the frequency in each loss interval

Loss interval	(250, 500)	(500, 1000)	(1000, 2750)	(2750, 5500)	(5500, 6000)	(6000, 10000)
Frequency	1	2	4	7	1	1

Estimate the probability that a policy with a deductible of 500 will have a **claim payment in excess** of 5500.

Bonus Question

B1) (5 + 5=10 marks) The following table provides a summary of an observational study of a five-year term life insurance policy.

j	P_j	n_j^b	n_j^m	d_j	w_j^m	w_j^e
0	0	30	3	1	3	0
1	29	0	1	0	2	0
2	28	0	3	2	3	0
3	26	0	3	3	3	0
4	23	0	0	2	4	17

P_j = policy holders *at start* of interval
n_j^b = entrants entering policy at *beginning of* the interval
n_j^m = entrants entering policy *during* the interval
d_j = death *during* the interval
w_j^m = participants withdraw from policy *during* the interval
w_j^e = participants withdraw from policy at *end of* the interval

a) Using this summary table and the **actuarial method**, estimate single-decrement probabilities of survival from **death**, $p_j'^{(d)}$.
b) Using this summary table and the **actuarial method**, estimate single-decrement probabilities of survival from **withdrawals**, $p_j'^{(w)}$.

4) (3+4+2+2=11 marks) The *R* datafile "ovarian" from Edmunson et. al (1979) studies different chemotherapeutic sensitivities and host factors affecting prognosis in advanced ovarian carcinoma versus minimal residual disease. The variables in the "ovarian" file are as follows:

futime:	survival or censoring time
fustat:	censoring status (1= event, 0= censored)
age:	in years
resid.ds:	residual disease present (1=no,2=yes)
rx:	treatment group
ecog.ps:	ECOG performance status (1 is better)

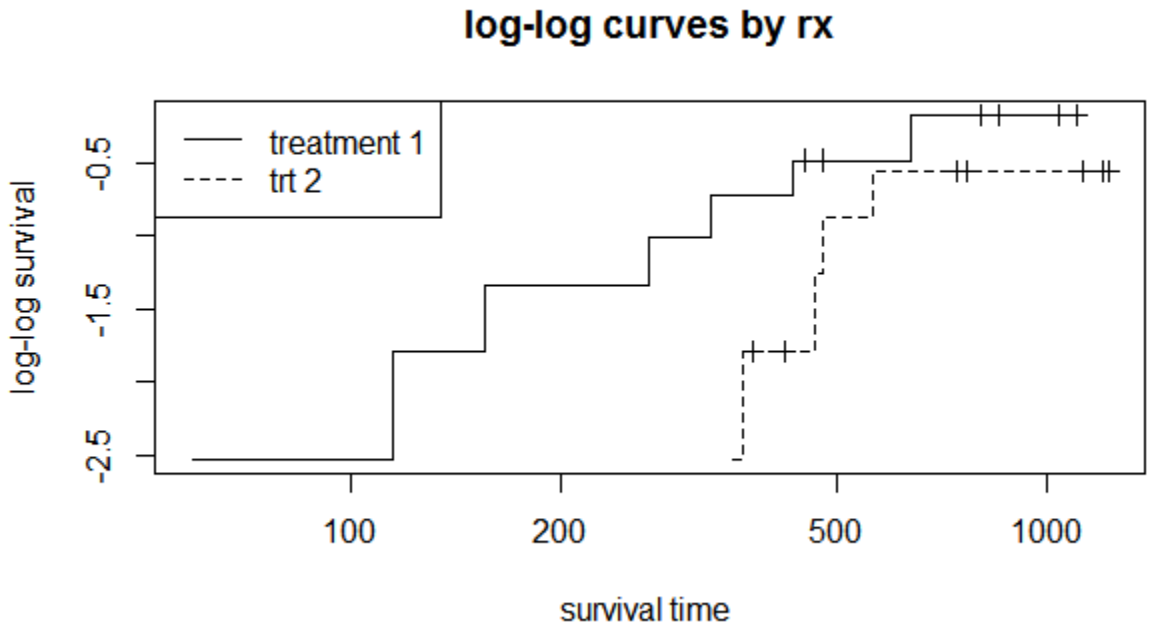
Using this data in an *R* analysis with futime as the dependent survival time, answer the following question parts:

a) Complete the blank parts of the output below:

```
             rho  chisq     p
rx        0.1457 [     ] [     ]
age      -0.0528 0.0459 0.830
resid.ds -0.1239 0.1883 0.664
ecog.ps  [     ] 1.8903 0.169
GLOBAL        NA 3.3540 0.500
```

b) Based on the output in (a), what conclusion can you make?

c) Provide the *R* command that produces the following output.



d) Does the graphical output in (c) above provide support for the PH assumption in the Cox model?

5) (4+2+3+4=13 marks) Use the *R* datafile "ovarian" to fit a Cox proportional hazards model on futime as the dependent survival time. Some partial results are given below:

```
           coef exp(coef) se(coef)      z      p
rx       -0.914          0.6533 -1.400 0.1600
age                1.133 0.0469  2.662 0.0078
resid.ds  0.826          0.7896  1.046 0.3000
ecog.ps                  0.6439  0.522 0.6000

Likelihood ratio test=17  on 4 df, p=0.0019  n= 26, number of events= 12
```

a. Complete the **missing information** in the output above
b. State an **initial PH model** that can be used to assess the relationship of interest.
c. For your model in part (b), give an **expression for the hazard ratio** that compares a person with age = 40 to a person with age=20 when all other predictors **are controlled**.
d. Test for the **significance of the treatment** (rx)

6) (6+4=10 marks) Use the *R* datafile "ovarian" to fit Cox proportional hazards models on futime as the dependent survival time. The edited output of computer results for this analysis are given as follows:

Model 1

```
      coef exp(coef) se(coef)    z      p
age 0.162      1.18   0.0497   3.25 0.0012

Likelihood ratio test=14.3  on 1 df, p=0.000156  n= 26, number of events= 12
```

Model 2

```
     coef exp(coef) se(coef)     z      p
rx  [      ]      [     ]   0.6320 -1.27 [      ]
age  0.147     1.159   0.0461  3.19 0.0014

Likelihood ratio test=15.9  on 2 df, p=0.000355  n= 26, number of events= 12
```

a) Using **model 2**, give an **expression for the estimated survival curve** for persons with rx = 1, adjusted for AGE. Also, give an expression for the estimated survival curve for persons with rx=2, adjusted for AGE.

b) What is your overall conclusion about the **effect of rx** on survival time based on the computer results provided from this study?