Strathmore
UNIVERSITY

INSTITUTE OF MATHEMATICAL SCIENCES
MSC (STATISTICAL SCIENCE)
END OF SEMESTER EXAMINATION
STA 8103: SURVIVAL ANALYSIS

DATE **TIME 2.5 Hours**

Instruction:
1. This examination consists of **FOUR** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

Question 1 (20 marks)

(a) Define the following terminologies as used in survival analysis giving example in each case
   i. Time origin (2 marks)
   ii. Time scale (2 marks)
   iii. Censoring (2 marks)

(b) State three (3) reasons why an observation might be censored (3 points)

(c) The survival function of the three-parameter Weibull distribution is given by $S(t) = \exp[-\lambda(t-\gamma)^{\alpha}]$. Find the hazard rate and the density function of the three- parameter Weibull distribution (4 marks)

(d) List assumption that must hold in order for a Cox PH model to be valid? (3 marks)

(e) Explain how you would use Martingale residuals to find the best functional form a covariate on survival, adjusting for other covariates. (4 marks)

Question 2 (20 marks)

(a) Differentiate between Type I and Type II censoring **(4 marks)**

(b) The lifetime of light bulbs follows an exponential distribution with a hazard rate of 0.001 failures per hour of use.
   i. Derive an expression of a survival function of an exponential distribution give that $h(t) = \lambda$ **(4 marks)**
   ii. Find the median lifetime of a randomly selected light bulb. **(4 marks)**
   iii. What is the probability a light bulb will still function after 2,000 hours of use? **(4 marks)**

(c) State the test statistics for the following tests of the hypothesis H0 : $\beta = 0$ in the Cox regression model.

i) Likelihood ration test ***(2 marks)***
ii) Wald test ***(2 marks)***

Question 3 (20 marks)

Sixteen patients with advanced stomach carcinoma were randomized to receive one of two chemotherapies (Group A or Group B). The survival times from treatment (in weeks) are (+ denotes a censored observation): Group A: 63+, 59+, 57+, 40, 37, 33, 21+, 11 Group B: 57+, 51+, 44+, 32, 27, 27+, 10+, 6

i. Calculate the Kaplan -Meier estimate of the survival function for Group B, presenting the results in a table then sketch a graph of the estimated function. ***(6 marks)***
ii. Calculate a linear 95% confidence interval for S(27) using Group B. ***(4 marks)***
iii. Test the hypothesis that there is no difference in survival between the two groups using the log-rank test. ***(10 marks)***

Question 4 (20 marks)

a) Describe the Cox regression model. Write up the partial likelihood function. How is the partial likelihood function used to get estimates of the parameters β? ***(5 marks)***

b) The models below were generated from a dataset which represents the death times in days for patients with advanced lung cancer. Also recorded are the patient's age in years, weight loss after 6 months and sex.

```
Call:
coxph(formula = Surv(time, status) ~ age + sex + wt.loss, data = lung)

             coef exp(coef) se(coef)     z       p
age       0.02009   1.02029  0.00966     a       0.0377
sex      -0.52103   0.59391  0.17435   -2.99       0.0028
wt.loss   0.00076   1.00076  0.00619    0.12       0.9024

Likelihood ratio test=14.67  on 3 df, p=0.002
n= 214, number of events= 152

> #Test for the proportional-hazards (PH) assumption
> test.ph <- cox.zph(res.cox)
> test.ph
             rho chisq     p
age      -0.0483 0.378 0.538
sex       0.1265 2.349 0.125
wt.loss   0.0126 0.024 0.877
GLOBAL        NA 2.846 0.416
```

i. Compute the value **a** (**3 marks)**
ii. How many individuals in the study were right-censored? (**2 marks)**

iii. Interpret the exp(coef) for age **(2 marks)**

iv. Find 95% confidence interval for the "coef" for age **(3 marks)**

v. Find the hazard ratio between an individual who is 60 years old and one who is 50 years old and interpret your results. **(3 marks)**

vi. Find 95% confidence interval for this hazard ratio calculated in **v** above. **(2 marks)**