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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	INDUSTRIAL RELIABILITY
COURSE CODE	:	BWB 32003
PROGRAMME	:	3 BWB
EXAMINATION DATE	:	JUNE 2015 / JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS EXAMINATION PAPER CONSISTS OF **SIX (6)** PAGES

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Q1 (a) State and describe the five elements of reliability.

(5 marks)

(b) Describe two differences between censoring Type I and censoring Type II.

(2 marks)

(c) Explain two effects of data censoring.

(2 marks)

Q2 A population of capacitors is known to fail according to Weibull distribution with characteristic life, $\alpha = 20,000$ power-on hours and the CDF is given as:

$$F(t) = 1 - e^{-(t/\alpha)^{\beta}}$$

(a) State the scale parameter of the above distribution.

(3 marks)

(b) Calculate the cumulative percent fallout at 10,000 hours, given that the shape parameter of three.

(2 marks)

(c) If it is known that the probability that a new capacitor will fail by 30,000 hours is 0.706, compose the value of the shape parameter.

(5 marks)

(d) At what time will 15% of these capacitors expected to fail, if given that the shape parameter of 0.8?

(4 marks)

(e) Show that the exponential model is nested within the Weibull distribution. Then, sketch the hazard function for the exponential distribution.

(4 marks)

Q3 (a) A manufacturer produces parts with a mean width of 2.5 cm. The population distribution about this average value is normal with a variance of 0.1 cm. The specification for the part is 2.0 cm to 3.0 cm.

(i) What fraction of the parts produced end up being scrapped?

(4 marks)

(ii) If random sample of 3 parts were selected, calculate the probability that mean sample is larger than the width specification for the part.

(4 marks)

(iii) Derive lognormal distribution for the above normal distribution.

(5 marks)

(b) A population of devices is known to fail according to a lognormal distribution. Compose the median life necessary for 1.5% failures by 100 hours, given a shape parameter of three.

(7 marks)

Q4 Twenty electric generators were placed on test until failure, where the failure times are as follows:

121	121	279	711	848	1051	1051
1425	1657	1883	1883	2951	5296	5637
6054	6303	6853	7201	9068	10,609	

(a) Compose the estimate for the survivor function of 6,000 hours by using the following approach:

(i) Empirical survivor function

(3 marks)

(ii) Kaplan-Meier or product-limit estimate

(5 marks)

(b) By using your answer in (a)(i), construct a 95% confidence interval for the probability that a generator will survive to 6,000 hours.

(4 marks)

(c) By using maximum likelihood estimate, produce the estimated of conditional probability of failure, $\hat{h}(y_i)$ for $i = 7$ and 8.

(4 marks)

Q5 (a) A gamma prior with $a = 1$ and $b = 2300$ was chosen for a system with assumed exponential interarrivals times for repair having mean time between failure (MTBF) of 2300. A new test was run for 2500 hours when a repair action was needed.

(i) Compute the Bayes point estimator for λ and MTBF.

(4 marks)

(ii) Compute the 95% lower bound for the system MTBF.

(4 marks)

(b) A group of engineers investigating the reliability of a new piece of equipment. They want to determine the minimum test time that can confirm a MTBF of 500 with 95% confidence. Assumed that the prior parameters a and b are known to be 2 and 1400 respectively.

(i) Calculate the minimum test time by using Bayesian Test Time if they decide to allow up to two failures,

(4 marks)

(ii) Compare your answer in (b)(i) if you use classical minimum test time to solve the problem. Then, conclude your answer.

(5 marks)

Q6 (a) Given the linear acceleration relationship between a random time to failure at use conditions, t_U and time at which the failure would happen at a set higher stress conditions, t_S is given as the following equation:

$$t_U = AF \times t_S \text{ ; AF is acceleration factor.}$$

By using the above equation, derive the relationship of the following function:

(i) Cumulative failure probability at use condition, F_U and cumulative failure probability at a set higher stress conditions, F_S.

(2 marks)

(ii) Density function at use condition, f_U and density function at a set higher stress conditions, f_S.

(3 marks)

(iii) Instantaneous failure rate, h_U and instantaneous failure rate at a set higher stress conditions, h_S.

(3 marks)

(b) A component was tested at $335^{\circ}C$ in a laboratory has an exponential distribution with a mean time to fail (MTTF) of 5500 hours. Typical use temperature for the component is $30^{\circ}C$ and the acceleration factor between the two temperatures is 28. Solve the following questions for typical use temperature:

(i) Compute the failure rate of 10,000 hours.

(4 marks)

(ii) Calculate the percentage of these components will fail before the end of the expected useful life period of 20,000 hours.

(4 marks)

(iii) At what time will 10% of these components are expected to fail?

(4 marks)

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Appendix

Test Length Guide

Number of Failures	Confidence Level						
	50%	60%	75%	80%	90%	95%	97.5%
0	0.693	0.916	1.39	1.61	2.30	3.00	3.69
1	1.68	2.02	2.69	2.99	3.89	4.74	5.57
2	2.67	3.11	3.92	4.28	5.32	6.30	7.22
3	3.67	4.18	5.11	5.52	6.68	7.75	8.77
4	4.67	5.24	6.27	6.72	7.99	9.15	10.24
5	5.67	6.29	7.42	7.91	9.27	10.51	11.67
6	6.67	7.34	8.56	9.08	10.53	11.84	13.06
7	7.67	8.39	9.68	10.23	11.77	13.15	14.42
8	8.67	9.43	10.80	11.38	12.99	14.43	15.76
9	9.67	10.48	11.91	12.52	14.21	15.71	17.08
10	10.67	11.52	13.02	13.65	15.41	16.96	18.39
15	15.67	16.69	18.49	19.23	21.29	23.10	24.74
20	20.67	21.84	23.88	24.73	27.05	29.06	30.89
30	30.67	32.09	34.55	35.56	38.32	40.69	42.83
50	50.67	52.49	55.62	56.89	60.34	63.29	65.92
100	100.67	103.23	107.58	109.35	114.07	118.08	121.63

Note: Multiply desired MBTF by factor to determine test time needed to demonstrate desired MTBF at a given confidence level, if *k* failures occur.

GAMMAINV(0.95, 2, 0.0002) = 0.0009

GAMMAINV(0.95, 2, 2) = 7.7794

GAMMAINV(0.95, 4, 2) =15.5073

GAMMAINV(0.05, 2, 2) = 0.7107