Indian Statistical Institute, Bangalore
MS (QMS) First Year
First Semester - Reliability, Maintainability and Safety I

Final Exam | Date: November 15, 2019
Maximum marks: 100 | Duration: 3 hours

Answer as many questions as you can. But maximum you can score is 100

Question(1): Tick the most appropriate answer for the following questions with justification. Justification is not required for the questions with * mark

a) Assuming the life of a packaged magnetic disk exposed to corrosive gases has a Weibull Distribution with β =0.5 and the mean life is 600hrs. The chance that the packaged disk lasts at least 500hrs is
(i) 0.367 (ii) 1.095 (iii) 0.275 (iv) None of the above [6]

b) The life of a semiconductor laser at a constant power is Normally Distributed with mean of 7000hrs and standard deviation of 600hrs. What should be the mean life equal in order for 99% of the lasers to exceed 10000 hours before failure?
(i) 10000 hrs (ii) 11398 hrs (iii) 14047 hrs (iv)None of the above [6]

c) For the pdf $f(t) = 0.002\, e^{-0.002* t}$ for $t \geq 0$ with "t "is measured in hours for the random variable "T". Then the median of the random variable "T" is
(i) 555 hrs (ii) 457 hrs(iii) 347 hrs (iv) None of the above [5]

d) If a random variable (r.v) has an exponential density with parameter "θ", what is "a" such that the probability that the r.v a value greater than "a" is half
(i) $\ln 2\theta$ (ii) $\ln 2/\theta$ (iii) $\theta \ln 2$ (iv) None of the above [6]

e) An analysis of historic data indicates that the failure time for a particular product can be modeled with an Exponential Distribution The probability of surviving an operating time equal to twice the MTBF is
(i) practically zero (ii) about 14% (iii) about 36% (iv) None of the above [4]

*f) The flat portion of the bathtub curve is a region of chance failures; therefore the reliability equation $R = \exp(-t\lambda)$
(i) does not apply to this region (ii) only applies to this region (iii) applies to the wear out region as well as the flat region (iv) applies to the entire bathtub curve [2]

*g) From the definition of Reliability, it follows that in any reliability program there must be
(i) a quantification of reliability in terms of Probability (ii) a clear statement defining successful performance (iii) a definition of environment in which the equipment must operate (iv) a statement of the required operating times between failures (v) all of the above [2]

h) The lengths of a certain bushing are normally distributed with mean "μ". How many standard deviation units, symmetrical about "μ", will include 80% of the lengths
(i) ±1.04 (ii) ±0.52 (iii) ±1.28 (iv) ± 0.84? [3]

i) The consumption of electric power in a city can be approximated to having gamma distribution with η=2 and λ = 1/3 when expressed in 100 megawatts. What is the probability that power needed would be 1000 megawatts or more?

(i) 0.45 (ii)0.15 (iii) 0.30 (iv) None of the above [4]

Question(2): [4 + 6 + 6 = 16]

(i) Explain the difference between “Failure Rate” and “Hazard Rate”

(ii)Show that the hazard rate at time “t” equals the “Failure density function” divided by the “Reliability” with both of the latter evaluated at time “t”

(iii) Prove that a particular “Hazard rate” function will uniquely determine a “Reliability Function”

Question (3): [10]

A device has a failure rate characteristic which can be described by a Weibull failure model with Scale Parameter of 14142 hrs and a shape parameter of “2” Over what design life would the device have an average failure rate (AFR) $4*10^{-6}$ failures per hr.

Question (4): [4 + 6 = 10]

(i) Derive the expression for “Conditional Reliability” of the life of a component following “Three Parameter Weibull Distribution” for mission time “t” given that the component has survived up to age “T_0”

(ii) Assuming “Wear Out” of a given subsystem is normally distributed with a mean wear out time of 10000 hrs and standard deviation of 1000hrs, determine the reliability for an operating time of 400 hrs if the age of the component is 9000hrs.

Question (5): [10]

Derive the mean time between failures of a standby system having (n+1) identical components and all the components have equal and constant failure rate.

Question (6): [5 + 3 + 3 + 5 = 16]

Twenty bearings were tested in Design Laboratory. When the test was suspended at 6000 cycles, there were 7 failures. The cycles to failure were 6000,2000,4500,2700,1200,3500,5000

(i) What does the underlying Weibull Graph look like?
(ii) Where in the life cycle would these failures be placed?
(iii) What is the 63.2% Life Point?
(iv) Can “β” be manually calculated? If yes, what is the calculated value of “β”?

Question (7): [10]

Prove that for the Normal Density Function, the hazard rate is monotonically increasing.