Indian Statistical Institute, Bangalore

M.S (QMS) First Year

First Semester -Reliability, Maintainability and Safety-I

Final Examination

Time: 3 hrs.   Date: 16/11/2022   Maximum marks :50

Instruction: This paper has six questions. Answer any five questions. Each question carries 10 marks. Try to answer all parts of a question on the same place.

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1. Thickness (X) and length (Y) of a particular item are jointly distributed and vary from item to item. The dimensions X and Y are measured in mm. Assume that the joint probability density function of X and Y is given by
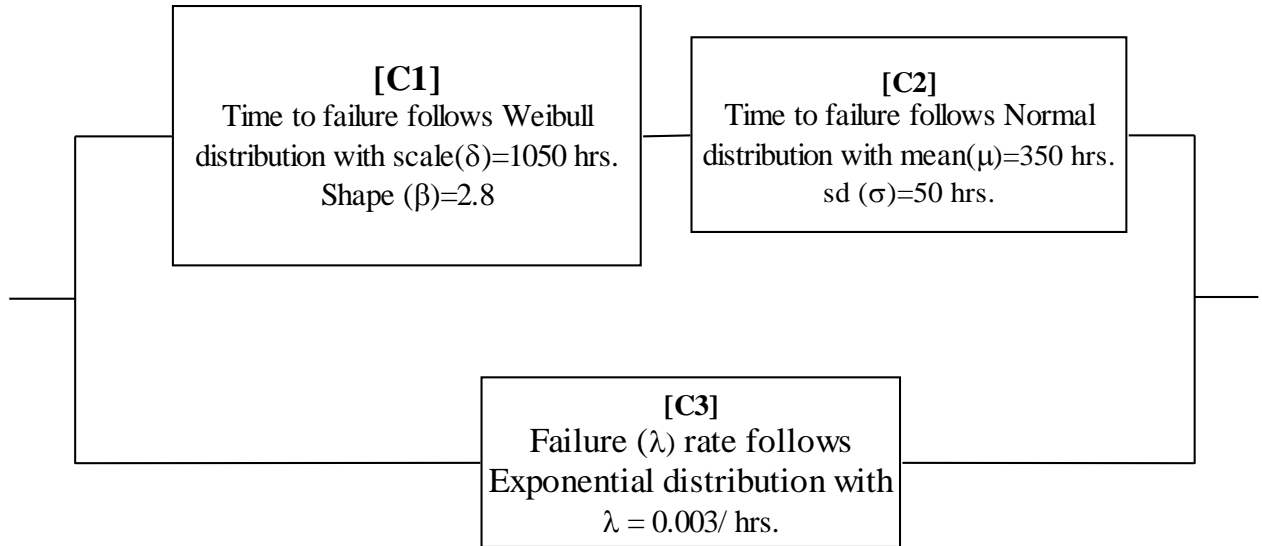
$$f(x, y) = \begin{cases} (x + 6y^2) & if \ 1 \le x \le 4 \ and \ 5 \le y \le 8 \\ 0 & Otherwise \end{cases}$$

   a) Find the probability that a randomly chosen item has a thickness between 2.0 mm to 3.0 mm and length between 6.0 mm to 7.0 mm.
   b) Find the marginal probability density function of Y.   **[5+5=10]**

2. A municipal bond service has three rating categories (A, B and C). Suppose in the past year, of the municipal bonds issued throughout the country 70% were rated A, 20% were rated B, and 10% were rated C. Of the municipal bonds rated A ,50% were issued by cities, 40% by suburbs, and 10% by rural areas. Of the municipal bonds rated B ,60% were issued by cities, 20% by suburbs, and 20% by rural areas. Of the municipal bonds rated C ,90% were issued by cities, 5% by suburbs, and 5% by rural areas.
   a) If a new municipals bond is to be issued by a city, what is the probability that it will receive an A rating?
   b) What proportion of municipal bonds are issued by cities?
   c) What proportion of municipal bonds are issued by suburbs?
                    [4+3+3=10]

3. Five samples of an electronic component were placed on a life-testing. The components survived for 80 hrs., 100 hrs., 120 hrs., 140 hrs., and 120 hrs. respectively. Assuming constant failure rate, calculate the reliability of the component at 200 hrs. Also calculate the median time to failure.
                    [5 +5=10]

4. Calculate the system reliability of the given series-parallel system below for the first 150 hrs. In the system, time to failure of components C1 and C2 follows Weibull and Normal distribution respectively, and component C3 has a constant failure rate. The parameters of the distributions are provided within the component in the figure.

[C1]
Time to failure follows Weibull distribution with scale(δ)=1050 hrs.
Shape (β)=2.8

[C2]
Time to failure follows Normal distribution with mean(μ)=350 hrs.
sd (σ)=50 hrs.

[C3]
Failure (λ) rate follows Exponential distribution with $\lambda = 0.003/$ hrs.

[10]

5. a) Explain the 'Bathtub curve'.
   b) 'Weibull distribution is one of the most flexible reliability models'- Explain.

[5+5=10]

6. a) The reliability function of a component is given by

$$R(t) = 1 - \frac{t^2}{a^2} \quad for\ 0 \le t \le a$$

Where a is a parameter of the distribution representing the component's maximum life. Determine the mean time to failure (MTTF) of the component.

b) Define *maintainability* and *availability*.

[6+4=10]

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