Total No. of printed pages = 6

EE 1818OE41

18/61M

Roll No. of candidate

2022

B.Tech. 8th Semester End-Term Examination

RELIABILITY ENGINEERING

(New Regulation)

Full Marks – 70

Time – Three hours

The figures in the margin indicate full marks for the questions.

Answer question No. 1 and any *four* from the rest.

1. Choose the correct answer from the following : (10 × 1 = 10)

(i) If an event A depends on another event B then $P(A \mid B)$ equal to

(a) $P(A) \cdot P(B)$

(b) $P(A \cup B) / P(B)$

(c) $P(A \cap B) / P(A)$

(d) $P(A \cap B) / P(B)$

(ii) The mean value of a continuous density function $f(x)$ is

(a) $E(x) = \int_{-\infty}^{\infty} f(x)\, dx$

(b) $E(x) = \int_{-\infty}^{\infty} x f(x)\, dx$

(c) $E(x) = \int_{-\infty}^{\infty} x^2 f(x)\, dx$

(d) $E(x) = \sum_{-\infty}^{\infty} x f(x)$

(iii) The main reason for the failure of different light bulbs at different times is due to

(a) random life of bulbs

(b) infant mortality of bulbs

(c) poor quality of bulbs

(d) wear-out of bulbs.

(iv) If the overall reliability of a sys tem is the product of individual reliabilities of components then the system is a

(a) series system

(b) parallel system

(c) series-parallel system

(d) parallel-series system.

(v) If the number of components that fail in time t is N_f out of N, the hazard rate is given by

(a) $\frac{dN_f}{dt}$

(b) $\frac{d(N - N_f)}{dt}$

(c) $-\frac{dN_f}{dt}$

(d) $\frac{1}{N - N_f}\frac{dN_f}{dt}$

(vi) The hazard rate function for an exponential failure density function

(a) increases with time

(b) decreases with time

(c) is constant with time

(d) none of the above

(vii) The mean time to failure (MTTF) of a two-component parallel system with identical failure rate λ is

(a) 2λ

(b) $2/\lambda$

(c) $1/2\lambda$

(d) $3/2\lambda$

(viii) In case of Weibull distribution if the shape parameter $\beta = 1$ the density function becomes

(a) Exponential

(b) Rayleigh

(c) Normal

(d) Uniform distribution

(ix) In Markov process the failure rate of a component is assumed as

(a) time dependent

(b) constant

(c) both (a) and (b)

(d) none of the above

(x) If the constant failure and repair rate of a component/system are λ and μ respectively then the steady-state availability is

(a) $\frac{\lambda}{\lambda+\mu}$

(b) $\frac{\mu}{\lambda+\mu}$

(c) $\frac{1}{\lambda}+\frac{1}{\mu}$

(d) $\lambda+\mu$

2. (a) Define reliability. Identify the key elements in the definition. (3)

(b) What is bath-tub curve? Draw a typical bath-tub curve and identify the regions. (4)

(c) State the differences between mission oriented systems and continuously operated systems. (4)

(d) What do you mean by failure of engineering system? State few causes of failure of such system. (4)

3. (a) State and explain total probability theorem. (5)

(b) The cumulative distribution function for a random variable T is given by $F(t) = 1 - e^{-0.001t}$. (5)

Determine probability density function f(t) and its mean. Also roughly sketch $F(t)$ and $f(t)$.

(c) In an experiment, 10 components are tested. If the failure probability of each component is 0.02, what is the probability that (i) exactly 10 components are in operating condition and (ii) at least 5 components are in failed condition? (5)

4. (a) Derive expressions for reliability of the system shown in Fig. 1 for the given conditions (i) and (ii) R_A, R_B and R_C are the reliabilities of components. (8)

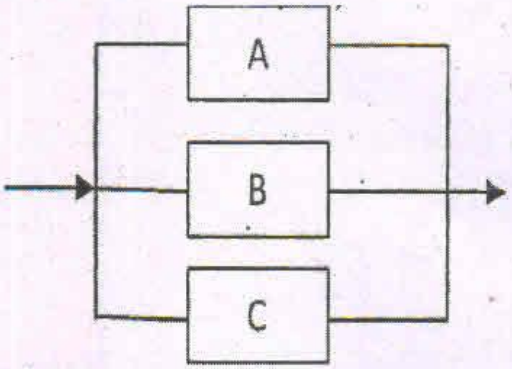

Fig. 1

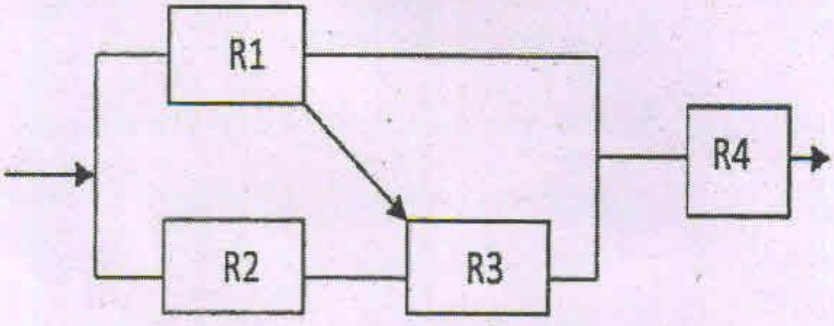

Fig. 2

(i) Components A, Band C are non-identical and at least one component of this group must be available for system success.

(ii) Components A, Band C are identical and at least two out of the three components functions satisfactorily for system success.

(b) Evaluate reliability of the complex system shown in Fig. 2 using anyone of the following methods. R1 , R2, R3 and R4 are the reliabilities of components where R1 = 0.90, R2 = 0.85 and R3 = 0.92 and R4 =0.95

(i) Decomposition method (conditional probability approach)

(ii) Cut set method. (7)

5. (a) What is meant by hazard rate? How it is different from failure rate? (2)

(b) The hazard rate of a system is given by $\lambda(t)) = 0.004 + 0.0016t$ where t is in hours. (i) Derive reliability function, $R(t)$ and failure density function, $f(t)$. (ii) Evaluate reliability of the system at 10 hours and the design life to maintain a reliability of 0.90. (5)

(c) The life of a bearing is normally distributed with a mean value of 2000 hours and a standard deviation of 100 hours. What is the probability that the bearing fails before 1850 hours? (3)

(d) An electronic circuit consists of 6 transistors each having a failure rate of 10.6 f/hr, 4 diodes each having a failure rate of 0.5×10^{-6} f/hr, 3 capacitors each having a failure rate of 0.2×10^{-6} f/hr, 10 resistors each having a failure rate of 5×10^{-6} f/hr and 2 switches each having a failure rate of 2×10^{-6} f/hr. Assuming connections and wiring are 100% reliable. evaluate the equivalent failure rate of the system and the probability of the system surviving 1000 hour if all components must operate for system success. (5)

6. (a) What is a fault tree? Draw fault tree for a series system having three non identical components. (3)

(b) A system consists of a primary unit and a standby unit with identical failure rate λ. Derive the reliability expression for the system assuming 100% reliable switches. Also derive expression for Mean-Time-To-Failure (MTTF) of standby system. (6)

(c) Develop state-space diagram and stochastic transitional probability matrix for a repairable system having two non-identical components with failure rates λ_1, λ_2 and repair rates μ_1 and μ_2. (6)

7. (a) Define availability and maintainability. (2)

(b) State the difference between preventive and corrective maintenance. (2)

(c) A system is maintained at equal time interval T. Develop a maintenance based reliability model for the system. (7)

(d) A system is maintained at equal time interval of 1 year. If the failure characteristic of the system is exponentially distributed with constant failure rate of 0.1 f/yr then find the reliability of the system after 5 years with and without maintenance. (4)