Total No. of printed pages = 4

EE 1818 OE 41

13/6/23

Roll No. of candidate | | | | | | | | | | |

2023

B.Tech. 8th Semester End-Term Examination

RELIABILITY ENGINEERING

(New Regulation w.e.f. 2017-18 & New Syllabus w.e.f. 2018-19)

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 appropriate answer from the followings : $(10 \times 1 = 10)$

(i) Two events A and B are independent and mutually exclusive. The probability of occurrence of either A or B or both will be

(a) $P(A).P(B)$ (b) $P(A)+P(B)$

(c) $P(A)+P(B)-P(A \cup B)$ (d) $P(A)+P(B)-P(A \cap B)$

(ii) The occurrence of an event A depends on two mutually exclusive events S and F. The probability $P(A)$ is equal to

(a) $P(A \mid S)+P(A \mid F)$ (b) $P(S \mid A)P(S)+P(F \mid A)P(F)$

(c) $P(A \mid S)P(S)+P(A \mid F)P(F)$ (d) $P(S \mid A)P(A)+P(F \mid A)P(A)$

(iii) The life of a system during the infant mortality period has

(a) increasing failure rate

(b) decreasing failure rate

(c) constant failure rate

(d) either increasing or decreasing failure rate

(iv) The reliability of a parallel system is always _____ the reliability of any of the components of the system

(a) greater than (b) smaller than

(c) equal to (d) none of the above

[Turn over

(v) If the overall failure probability of a system is the product of individual failure probabilities of components then the system is a

(a) series system (b) parallel system

(c) series-parallel system (d) parallel-series system

(vi) If the number of components that fail in time t is F out of N, the reliability of the component is

(a) $\frac{F}{N}$ (b) $\frac{N}{F}$

(c) $1-\frac{F}{N}$ (d) $\frac{F}{N-F}$

(vii) The reliability function $R(t)$ relates to hazard rate function $\lambda(t)$ by the expression

(a) $R(t)=\int_{-\infty}^{\infty}\lambda(t)dt$ (b) $R(t)=\int_{0}^{\infty}\lambda(t)dt$

(c) $R(t)=e^{-\int_{0}^{\infty}\lambda(t)dt}$ (d) $R(t)=e^{-\int_{0}^{t}\lambda(t)dt}$

(viii) The Mean-Time-To-Failure (MTTF) of a one-component standby system considering identical failure rate λ for main and standby unit with perfect switching is

(a) 2λ (b) $2/\lambda$

(c) $1/2\lambda$ (d) $3/2\lambda$

(ix) The failure rate of a series system composed of n components, with constant failure rate λ for each component, is given by

(a) $\sum_{i=1}^{n}\lambda_i$ (b) $\prod_{i=1}^{n}\lambda_i$

(c) $\frac{1}{\sum_{i=1}^{n}\lambda_i}$ (d) $\max(\lambda_i)$

(x) The corrective maintenance is performed

(a) after failure (b) must before failure

(c) just before failure (d) none of the above

2. (a) The probability of two events A and B are such that $P(A) = 0.4$, $P(A\cup B)=0.8$, $P(A\cap B)=0.2$. Determine (i) $P(B)$, (ii) $P(B^c)$, (iii) $P(A\mid B)$ (iv) $P(B\mid A)$. (5)

(b) The probability of failure of an engine is 0.10 under certain environmental conditions. Ten engines are put under test. What is the probability that (i) exactly 5 engines fail? (ii) more than half will fail? (5)

(c) A system consists of five identical components, each with a reliability R, in parallel. The system requires at least three components for successful operation of the system. Determine the reliability of the system. (5)

3. (a) The total number of hours that a family runs a vacuum cleaner over a period of one year is a continuous random variable T that has the density function

$$f(t) = t, \quad 0 < t < 100$$
$$= 2 - t, \quad 100 \le t < 200$$
$$= 0, \quad \textit{otherwise}$$

Find the probability that over a period of one year, a family runs their vacuum cleaner (i) Less than 120 hours and (ii) between 50 and 100 hours. (5)

(b) Explain the need of reliability program for an engineering system. (5)

(c) A failure density function for an appliance is assumed to be a normal distribution with mean μ = 1000 hours and standard deviation σ = 200 hours. What is the probability that the appliance will fail (i) within 800 and 1200 hours and (ii) before 700 hours? (5)

4. (a) Evaluate the reliability of the system shown in Fig. 1 using decomposition method (conditional probability approach). (8)

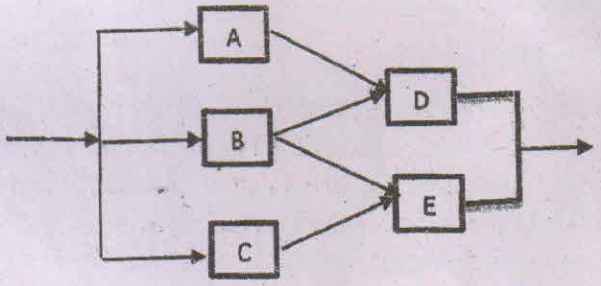

Fig. 1

(b) What is meant by minimal cut sets? Determine minimal cut sets for the system shown in Fig. 1. Estimate the approximate reliability of the system using minimal cut sets. (7)

5. (a) Derive a reliability expression for a system for an operating period of t, under the condition that it has already operated for a period of T_0. (5)

(b) An electromechanical system has a constant failure rate of λ = 0.01/hour. Determine (i) the probability that the system will fail within first 25 hours of operation (ii) reliability after 100 hours of operation (iii) what is the design life if a reliability of 0.95 is desired? (5)

(c) Derive reliability function, $R(t)$ and failure density function, $f(t)$ for a hazard rate function $\lambda(t) = ae^{t}$ where 'a' is a constant and $a > 0$. (5)

6. (a) A system consists of three sub-systems A, B, and C in series with failure rate model as shown: $\lambda_A(t) = 0.95 \times 10^{-5}$, $\lambda_B(t) = 0.06 \times 10^{-5}$ and $\lambda_C(t) = 0.05 \times 10^{-5}$. Determine the reliability for an operating time of 1000 hours and its mean-time-to-failure (MTTF). (5)

(b) Calculate MTTF and reliability of a 2-component parallel system for an operating period of 10 hours. The failure rate of each component is 0.02 failures per hour. In the system, if any one of the components is considered as standby to the other component and the switches used for standby system are assumed to be 100% reliable, what is the reliability and MTTF of the system after 10 hours of operation? (5)

(c) How minimal cut sets are deduced from a fault tree diagram? Illustrate with the help of a typical fault tree diagram. (5)

7. (a) A system is maintained at equal time interval T. Develop a maintenance based reliability model for the system. (5)

(b) A repairable system can reside in three different states:

State 1 : Full output

State 2 : Derated output

State 3 : No output

The probability of making transition from state 1 to 2,2 to 3 and 1 to 3 is 0.01 in each case. Similarly, the probability of making transition from state 2 to 1 and 3 to 1 is 0.50. There is no transition from state 3 to 2, Develop a state space diagram and stochastic transitional probability matrix and using these, evaluate limiting state probabilities of each state. What is the probability of giving full output by the system? (10)