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MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

SEVENTH SEMESTER B.TECH. (INSTRUMENTATION AND CONTROL ENGG.)

END SEMESTER DEGREE EXAMINATION, MARCH - 2021

RELIABILITY AND SAFETY ENGINEERING [ICE 4029]

22-03-2021

TIME: 3 HOURS MAX. MARKS: 50

Instructions to candidates :*Answer ALL questions and missing data may be suitably assumed.*

1A. Derive the expression for hazard rate of a continuous random variable.

1B. A semiconductor fabrication plant has an average output of 10 million devices per week. It has been found that over the past year 100,000 devices were rejected in the final test. Find the following
(i) What is the unreliability of semiconductor devices according to the conducted tests?
(ii) If the tests reject 99% of all defective devices, what is the chance that any device a customer receives will be defective?

1C. The probability density function for the life of a device is given by

$$f(t) = \frac{1}{4}e^{-t} + \frac{3}{3}e^{-2t}, t \geq 0$$

(a) Prove that the above function is a valid pdf.
(b) Find the probability that a device will last at least 3 hours.
(c) Find the expected life or the MTBF of the device.

(4+3+3)

2A In designing a computer-based control system, two computers are being considered to obtain higher reliability. Each computer contains four sub systems namely motherboard (MB), hard disk (HD), power supply (PS), and processor (CPU). Designer suggested redundancy at the component level. The reliabilities of four subsystems are 0.98, 0.95, 0.91, and 0.99 respectively. What is the overall system reliability for a mission of 1000 h?

2B A two component parallel system uses both identical components each with $\lambda=10^{-5}$/hr and $\mu=10^{-2}$/hr. Calculate the percentage increase in mean time to failure, with the repair facilities, if the system uses:
(i) Active Parallel Redundancy
(ii) Standby Redundancy.

2C The failure time (T) of an electronic circuit board follows an exponential distribution with failure rate $\lambda = 10^{-4}$ /h. What is the probability that (i) it will fail before 1000 h; (ii) it will survive at least 10,000 h; (iii) it will fail between 1000 h and 10,000 h? Determine (iv) the mean time to failure (v) the median time failure.

(3+3+4)

3A Draw fault tree for the emergency power system shown in Fig Q3A

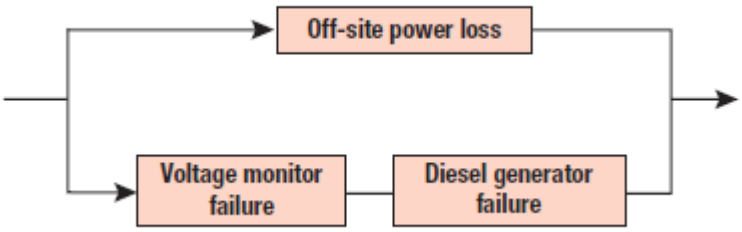

Fig Q3A

3B The stress (X) and the strength (Y) for a given failure mode of a component follow a normal distribution with the following information about their coefficient of variation (CV):

$CV_X = 0.25$ and $CV_Y = 0.17$.

The customer wants a reliability of 0.99990 for the above failure mode. What is the safety factor that the designer must use to meet the requirements of the customer?

3C Prove that Mean Time To Failure (MTTF) of an exponential distribution is inversely proportional to the failure rate.

(2+4+4)

4A Explain the importance of forced inputs, voluntary inputs in the design of safety and liabilities.

4B Describe the Reliability centred maintenance life cycle cost.

4C Given the following 20 failure times: 100.84, 580.24, 1210.14, 1630.24, 2410.89, 6310.56, 3832.12, 3340.34, 1420.76, 830.24, 680.35, 195.68, 130.72, 298.76, 756.86, 270.39, 130.0, 30.12, 270.38, 720.12. Estimate R(t), F(t), f(t), and $\lambda(t)$.

(3+3+4)

5A List the benefits of Probabilistic Safety Assessment.

5B Illustrate influence of the human behaviours and errors in the safety engineering.

5C The three units A, B and C are connected in parallel. Their failure rate and repair rates are given in Table Q5C.

Table Q5C

Unit	Failure/rate hr	Repair rate/hr
A	0.004	0.10
B	0.005	0.15
C	0.003	0.06

Find the following:

i) System availability
ii) Frequency of system failure
iii) Mean down time
iv) Mean up time

(3+3+4)

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