POSTAL Book Package 2021

Mechanical Engineering

Conventional Practice Sets

Production and Maintenance Engineering

Contents

MADE EASY Publications

8 CHAPTER
Practices & Principles of Maintenance Engineering

Practice Questions : Level-I

Q.1 The reliability of an equipment for a time to failure exceeding (t) hours to given by $R(t) = \exp(-0.005t)$. Determine the mean time to failure of this component in hours.

Solution:

$$R(t) = \exp^{(-0.005t)}$$

$$\lambda = 0.005 \text{ (failure rate)}$$

$$MTTF = \frac{1}{\lambda} = \frac{1}{0.005} = 200 \text{ hours}$$

Q.2 The reliability of a repairable product by exponential distribution is given by $R(t) = e^{-0.004t}$ and mean time to repair is 20 hours. Determine the MTTF for the product in hours.

Solution:

$$R(t) = \exp^{-0.00t} = e^{-\lambda t}$$

$$\lambda = 0.004 = \frac{1}{MTBF} \qquad [\because \text{In this case MTTR is given}]$$

$$MTBF = 250$$

$$MTBF = MTTF + MTTR$$

$$250 = MTTF + 20$$

$$MTTF = 230$$

Q.3 For a system, λ is 4% per 2000 hours, then find the value of failure rate per hours.

Solution:

$$\lambda = \frac{0.04}{2000} = 2 \times 10^{-5} \text{ per hour}$$

Q.4 5 units are connected in series to form a module, λ for each is 0.005 per hour, then find the mean time to failure of module.

Solution:

MTTF for module is series connection

$$= \frac{1}{n\lambda} = \frac{1}{5 \times 0.005} = 40 \text{ hours}$$

Q.5 The power generator provide electricity of the facility i.e., main and backup generator. If the main generator has reliability of 0.90 and the reliability of the system is 0.98. Then what is the reliability of backup generator?

Solution:

$$R = R_1 + R_2(1 - R_1)$$
$$0.98 = 0.9 + R_2(1 - 0.9)$$
$$0.08 = R_2 \times 0.1$$
$$R_2 = 0.8$$

Q.6 A system has two component in series with mean time between failure (MTBF) of 20, 10 hours respectively. What is the 400 hours system reliability.

Solution:

$$R = e^{-\lambda_1 t} \times e^{-\lambda_2 t} = e^{-(\lambda_1 + \lambda_2)t}$$
$$\lambda_1 = \frac{1}{20}$$
$$\lambda_2 = \frac{1}{10}$$
$$R = e^{-\left(\frac{1}{20} + \frac{1}{10}\right) \times 400} = e^{-\frac{30}{200} \times 400} = e^{-60}$$

Q.7 Twenty two air-conditioners designed for use in a space shuttle were operated for 1100 hours in a test facility, two of the air-conditioner failed. During the test one after 200 hours and other after 600 hours. Then find the failure rate?

Solution:

$$\text{Failure rate } (\lambda) = \frac{\text{Number of failure}}{\text{Total unit operating hours}}$$

Total time of operation = 1100 hours × 22 units = 24200 hours

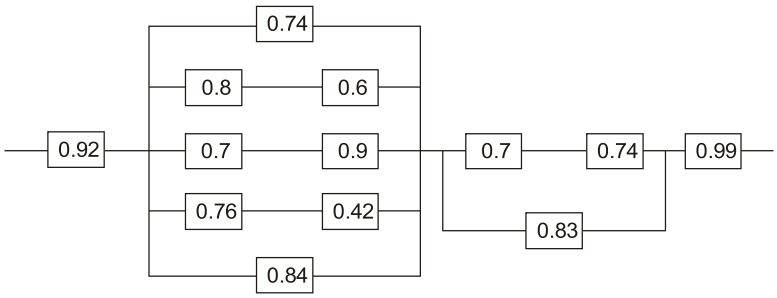
Non operating time = 900 hours for first units + 500 hours for second unit = 1400 hours

Operating time = Total time – Non operating time = 24200 – 1400 = 22800 hours

$$\text{Failure rate } (\lambda) = \frac{2}{22800} = \frac{1}{11400}$$

Practice Questions : Level-II

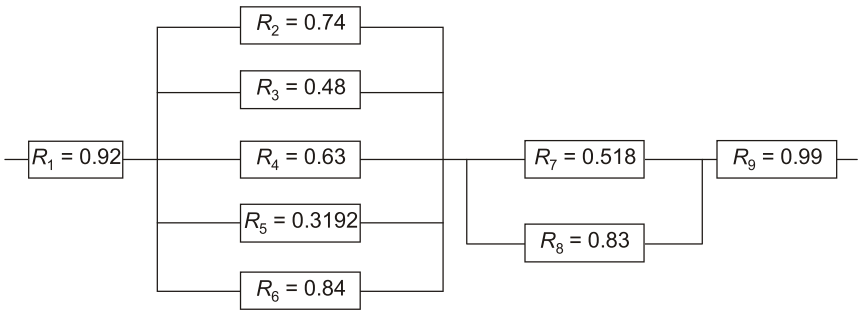
Q.8 Reliability of individual component is shown in figure.



What will be the reliability of the system?

Solution:

The system can be replaced by an equivalent diagram as shown in figure.

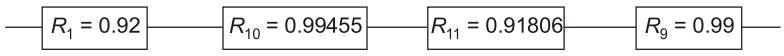


Now,

$$R_3 = 0.8 \times 0.6 = 0.48$$
$$R_4 = 0.7 \times 0.9 = 0.63$$
$$R_5 = 0.76 \times 0.42 = 0.3192$$
$$R_7 = 0.7 \times 0.74 = 0.518$$

This system can be replace by an equivalent diagram.

$$(1 - R_{10}) = (1 - R_2)(1 - R_3)(1 - R_4)(1 - R_5)(1 - R_6)$$
$$= (1 - 0.74)(1 - 0.48)(1 - 0.63)(1 - 0.3192)(1 - 0.84)$$
$$(1 - R_{10}) = 5.45 \times 10^{-3}$$
$$R_{10} = 0.99455$$
$$(1 - R_{11}) = (1 - R_7)(1 - R_8)$$
$$(1 - R_{11}) = (1 - 0.518)(1 - 0.83)$$
$$(1 - R_{11}) = 0.08194$$
$$R_{11} = 0.91806$$



Hence, reliability of system, $R_S = R_1 \times R_{10} \times R_{11} \times R_9$

$$= 0.92 \times 0.99455 \times 0.91806 \times 0.99$$

Reliability of system, $R_S = 0.831612$

Q.9 **Define reliability engineering, reliability science and reliability management.**

Solution:

Reliability engineering deals with the design and construction of systems and products, taking into account the unreliability of their parts and components. It also includes testing and programs to improve reliability. Good engineering results in a more reliable end product.

Reliability science is concerned with the properties of materials and the causes for deterioration leading to part and component failures. It also deals with the effect of manufacturing processes (for example, casting, annealing) on the reliability of the part of component product.

Reliability management deals with the various management issues in the context of managing the design, manufacture, and/or operation of reliable products and systems. Here, the emphasis is on the business viewpoint, since unreliability has consequences in terms of cost, time wasted and, in certain cases, the welfare of an individual or even the security of a nation.

Q.10 A machine is to be designed to have a minimum reliability of 0.9 and minimum availability of 0.97 over a period of 5000 hour. Calculate the following:

1. Mean time to repair.
2. Probability that machine will fail after 9000 hour.

Solution:

(1) Given: Time, $t = 5000$ hour; Reliability, $R = 0.9$; Availability, $A = 0.97$

We know that, Reliability is exponential function of time.

$$R = e^{-\lambda t}$$
$$0.9 = e^{-\lambda \times 500}$$
$$0.9 = e^{-5000\lambda}$$
$$\ln 0.9 = -5000\lambda$$
$$\text{Failure rate, } \lambda = 2.1072 \times 10^{-5} \text{ per hour}$$

$$\text{Mean time between failure, MTBF} = \frac{1}{\lambda} = \frac{1}{2.1072 \times 10^{-5}} = 47456.34 \text{ hour}$$

$$\text{We know that, Availability, } A = \frac{MTBF}{MTBF + MTTR}$$

$$0.97 = \frac{47456.34}{47456.34 + MTTR}$$
$$0.97(\text{MTTR}) = 47456.34 - 0.97 \times 47456.34$$
$$\text{MTTR} = 1467.722 \text{ hour}$$

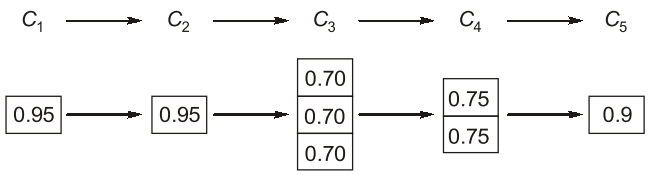
2. Reliability that machine will run for 9000 hour,

$$R(t) = e^{-\lambda t}$$
$$R(9000) = e^{-2.1072 \times 10^{-5} \times 9000} = 0.82725 = 82.725\%$$

Q.11 Consider a system with 5 kinds of component, with reliabilities.

- Component 1 : 0.95
- Component 2 : 0.95
- Component 3 : 0.70
- Component 4 : 0.75
- Component 5 : 0.90

What is the system reliability?



Because of the low reliability of the third and fourth components, they are replicated, the system now contains 3 of the third component and 2 of the fourth component. What is overall system reliability?

Solution: