IES only

Reliability

(Not in Gate)

It is a ability of a product or device to perform its main function properly for the specified period under the given operating conditions. It simply means that the component will behave in the manner as expected it. This definition bring into account four important factor.

i) Probability

ii) function or Performance

iii) Time

iv) working condition.

Failure :— Variation of property of a product from a described condition is considered as failure. failure represent unreliability.

Causes of failure

1) Defective design
2) Improper selection of manufacturing technique
3) lack of knowledge and experiance.
4) Improper assembly.
5) Improper service condition.
6) Variation in operating conditions.
7) Human error.

Types of failure.

1) Catastropic failure (chance failure) :—
Normal operating product suddenly fails and becomes inoperative

2) Degradation (creeping failure).
It occurs gradually with time because change in some parameter.

3) Independent (Primary),
These are the failure which are not dependent on the failure of other

4) Dependent (secondary)
These are dependent upon primary failure

Phase of failure :— (Bath tub curve)

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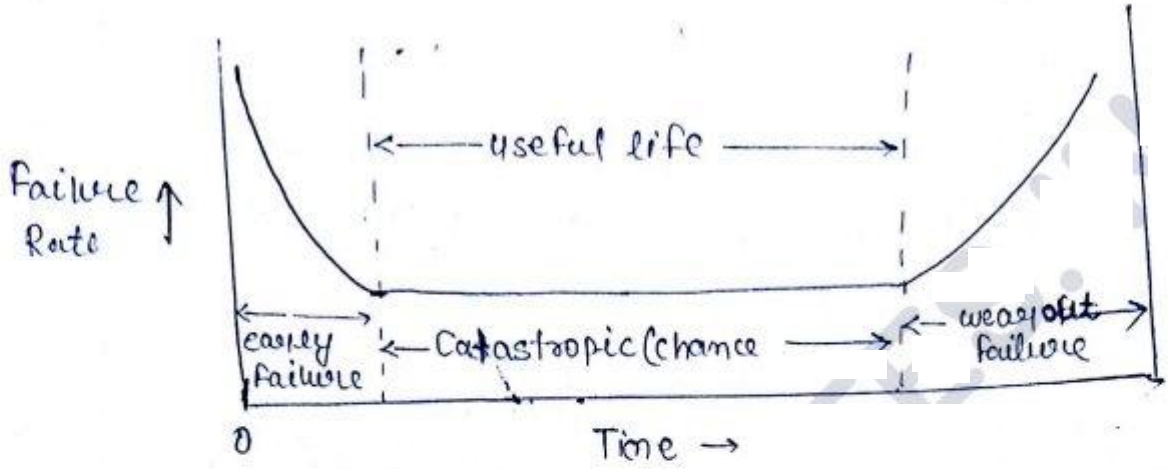


1) Early failure :- These failure occurs at begining due to the probability of defective design, manufacturing or assembling. warranty is the based on early failure the concept of

Catastropic :- These failure are normaly during the acatual working of product these occur randomly and unexpectdly. The failure rate is almost constant. These are caused due to sudden stress accumulation beyond the design limit.

③ Wear out failure :- Product is more likely to fail due to wear and tear and it is a ~~difficult~~ typical ageing problem. Proper care & maintenance can reduce failure at this stage.

Terms in Reliability

① Failure Rate :- (λ)

It is the number of failure per unit time and is normally prefered in terms of failure per 100 or per 1000 hours

$$\lambda = \frac{\text{No. of failure}}{\text{Time of study.}}$$

② Mean time between failure :- (MTBF)
(for repairable product)

$$MTBF = \frac{1}{\lambda}$$

it is the time gap between two successive failure and it is used for repairable product.

(3) Mean time to failure : (MTTF)
(for non repairable products)

$t_1, t_2, t_3 - - - , t_n$

$$MTTF = \frac{\sum_{i=1}^{n} t_i}{n}$$

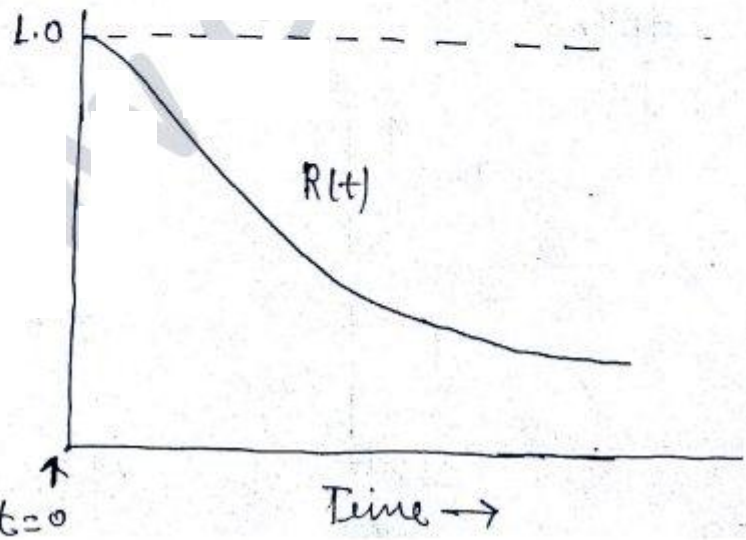
This is applied for non repairable product and it express as the average time a product is expected to function getting failed.

4) Reliability function derivative :- (R(t))

It is define as the probability that a product or component will function over sum period of time 't'

$$R(t) = \text{Prob.}\{T \geq t\}$$

T is the time of failure.



At $t=0$, $R=1$

At t as $t \to \infty$, $R=0$

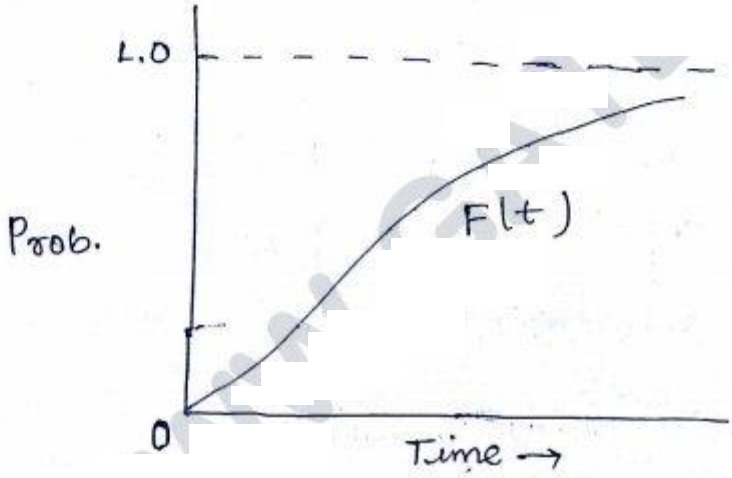
5. Cummulative distribution function :-

it is the probability that a failure occurs before time 't' and it is the distribution function for failure analysis

$$\boxed{F(t) = 1 - R(t)}$$

$$F(t) = \text{Prob.}\{t \geq T\}$$

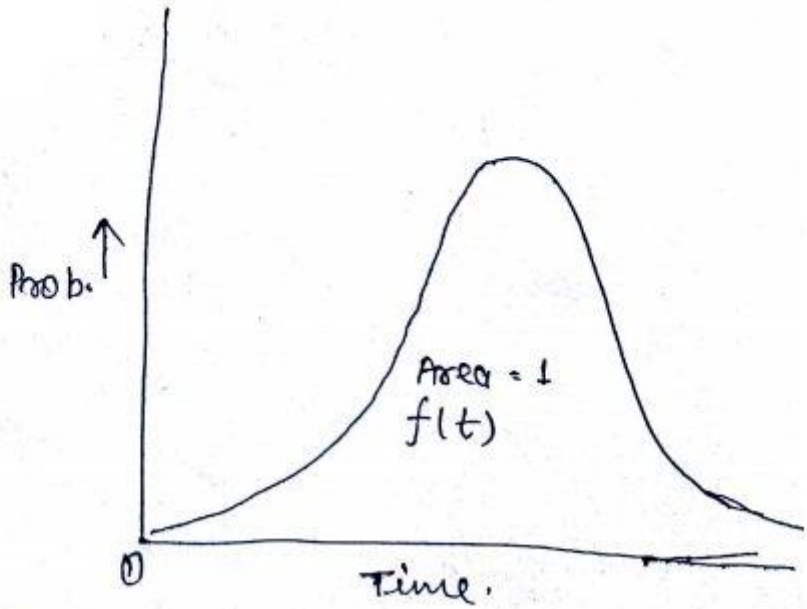
T time to failure.



6. Probability density function :-

This function describe the shape and area of failure distribution function

$$f(t) = \frac{dF(t)}{dt} = \frac{-dR(t)}{dt}$$



Relation between $R(t)$, $F(t)$, $f(t)$ and $\lambda(t) \rightarrow$

$$R(t) = 1 - F(t)$$

$$f(t) = \frac{dF(t)}{dt} = -\frac{dR(t)}{dt}$$

$$R(t) = \int_{t}^{\infty} f(t) \cdot dt$$

$$F(t) = \int_{-\infty}^{t} f(t) \cdot dt$$

$$MTTF = \int_{0}^{\infty} R(t) \cdot dt$$

$$\lambda(t) = \frac{f(t)}{R(t)}$$

Note:- In Reliability most of the time exponential distribution is widely used to compute the reliability.

Problem 45:- The Reliability of a Cutting assembly is as given below determine
i) failure rate ii) does failure rate ↓ or ↑ with time
iii) Determine MTTM.

$$R(t) = \begin{cases} \left(1 - t/t_0\right)^2 & 0 \le t \le t_0 \\ 0 & t \ge t_0 \end{cases}$$

Sol:

(i) Failure rate $\lambda = \frac{f(t)}{R(t)}$

$$f(t) = -\frac{dR(t)}{dt}$$

$$f(t) = -2\left(1-\frac{t}{t_0}\right)\left(0-\frac{1}{t_0}\right)$$

$$f(t) = \frac{2}{t_0}\left(1-\frac{t}{t_0}\right)$$

$$\lambda(t) = \frac{\left(1-\frac{t}{t_0}\right)\cdot\frac{2}{t_0}}{\left(1-\frac{t}{t_0}\right)^2} \Rightarrow \lambda(t) = \frac{2}{t_0}\cdot\frac{t_0}{(t_0-t)}$$

$$\lambda(t) = \frac{2}{(t_0-t)}$$

(ii) at $t = 0$ $\quad \lambda(0) = \frac{2}{t_0}$

$t = t_0 \quad \lambda(t) \Rightarrow \infty$

it mean it increasing with time.

(iii) $$MTTF = \int_0^\infty R(t)\cdot dt = \int_0^\infty \left(1-\frac{t}{t_0}\right)^2 \cdot dt$$

$$MTTF = \frac{t_0}{3}$$

Problem 46:-

The probability density function is given by

$$f(t) = \begin{cases} 0.002\, e^{-0.002t} & t \geq 0 \\ 0 & \text{otherwise} \end{cases}$$

where t is in hours determine R(t), MTTF and also find meadion time to failure.

Soln

$$f(t) = 0.002\, e^{-0.002t}$$

$$\int_0^{R(t)} dR(t) = \int_0^{t} f(t)\, dt$$

$$R(t) = 0.002 \int_0^{t} e^{-0.002t}\, dt$$

$$R(t) = \frac{0.002}{(-)0.002} \left[e^{-0.002t} \right]_t^{\infty}$$

$$R(t) = -1 \left(0 - e^{-0.002t} \right)$$

$$R(t) = e^{-0.002t}$$

$$MTTF = \int_0^{\infty} R(t)\, dt = \int_0^{\infty} e^{-0.002t}\, dt$$

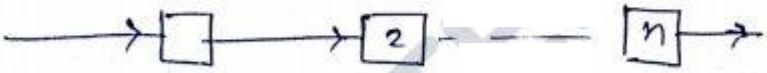
$$MTTF = \left[\frac{e^{-0.002t}}{-0.002} \right]_0^{\infty} = \frac{1000}{2} = 500 \text{ hr.}$$

3) $R = 0.5 = e^{-0.003t}$

$t = 346.5 \text{ hr}$

Reliability of System Component :—

(1) when the Component are in series:—

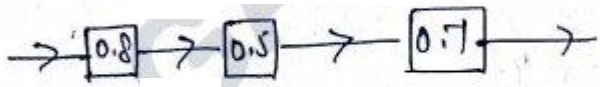


In these Condition for the succesfull operation of system depends on operation of all the Component in series.

Reliability of System

$$R_S = R_1 \cdot R_2 \cdot R_3 \cdots R_n$$

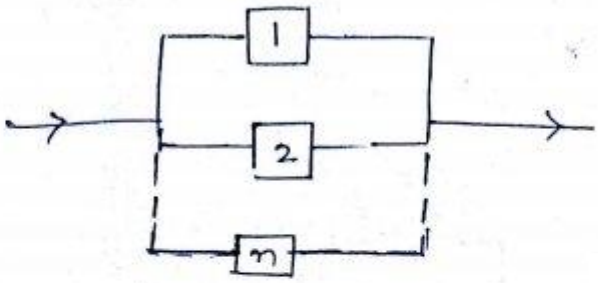
$$R_S \leq \text{Min}\{R_i\}$$

e.g. 

$R_S = 0.8 \times 0.5 \times 0.7$

$R_S = 0.28$

(2) When the Component are in Parallel :-



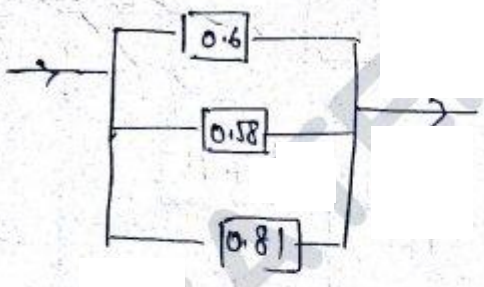
In these condition system fail when all the Component connected in parallel get failed that is system keep on working if atleast one component is working.

$$R_S = 1 - (1-R_1).(1-R_2)\ldots(1-R_n)$$

Reliability of system.

$$R_S \geq \text{Max.}\{R_i\}$$

e.g.



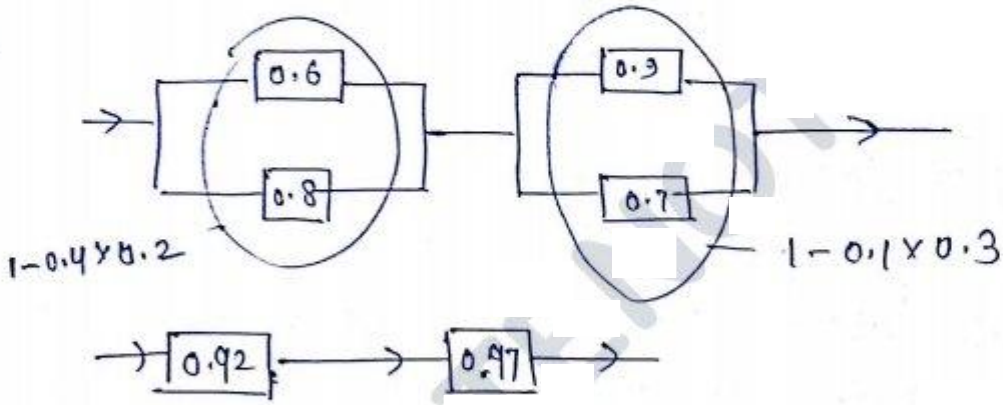
$$R_S = 1 - (1-0.6)(1-0.58)(1-0.81)$$

$$R_S = 0.96$$

③ Combined series Parallel System:—

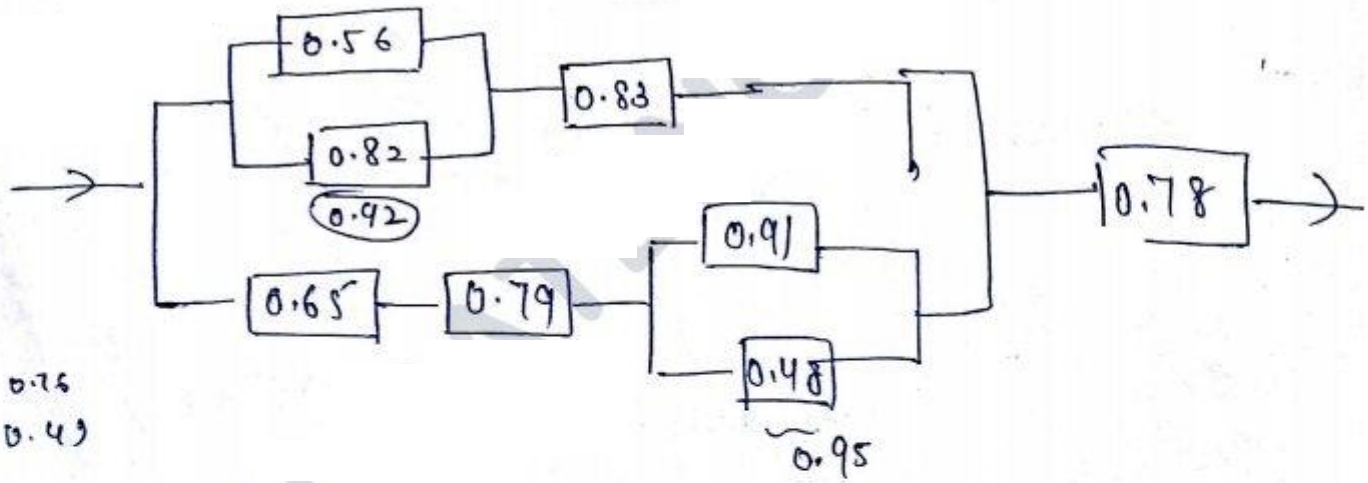
In these condition we can analyse the reliability of the system by converting them into equivalent sub system

e.g.



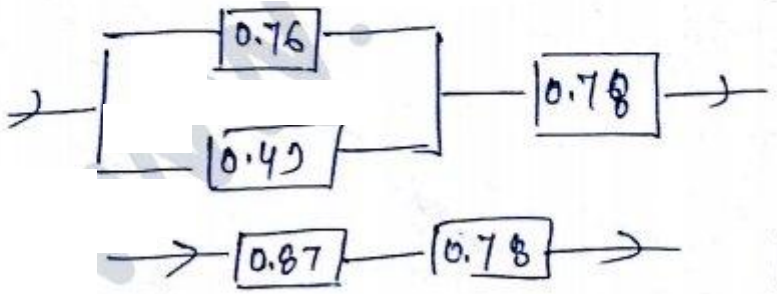
$R_S = 0.92 \times 0.97 = 0.892$

Problem: 46 find the Reliability of the system as given below.



0.76
0.49

Soln



$R_S = 0.6861$

Reliability