# Lecture 07 Software Reliability

- In the broad sense
  - S/w design will operate (execute ) well for a substantial time period.
- In a narrow sense
  - Reliability is a metric which is probability of operational success of the s/w
- Probabilistic and Deterministic Model
  - Example Winding of a motor bourns out
    - Due to temperature above melting point

( It will burns – it is certainly deterministic, But we are unable to predict when they will occur – it is probabilistic )

 Thus the model of failures become a probabilistic one and the random element (random variable ) is the time to failure

#### Failure Modes

- Hardware
- Software
- Skinware(Human)

#### Reliability Theory

- Modeling of failure and prediction of success probability
- Based on the concept of random/continuous variable, probability density function, probability distribution function

- Probability concept :
- Discrete random variable, X is a discrete random variable
  - 1) Probability Density Function: Probability of occurrence  $P(x_i) = f(x_i)$
  - 2) Distribution Function : Defined in term of the probability that  $X \le x$  :



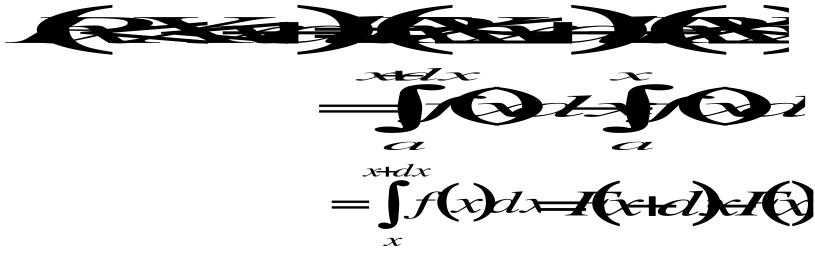
Continuous random variable,

The variable is continuous over some range of definition Density function,

- Distribution Function:  $F(x) = \int f(x) dx$ 
  - Let x take on all values between points a and b,



The Probability that X lies in an interval x < X <x+dx ,</li>



F(x) is a continuous,  $dx \rightarrow 0$ ; P(X=x) is zero

#### **Definition of Reliability**

• R(t) = Reliability is the mathematical probability is function of time t, is the success.

$$R(t) = P(x>t) = 1 - P(x where x is continuous  
=  $P(x>=t) = 1 - P(x<=t)$  where x is discrete$$

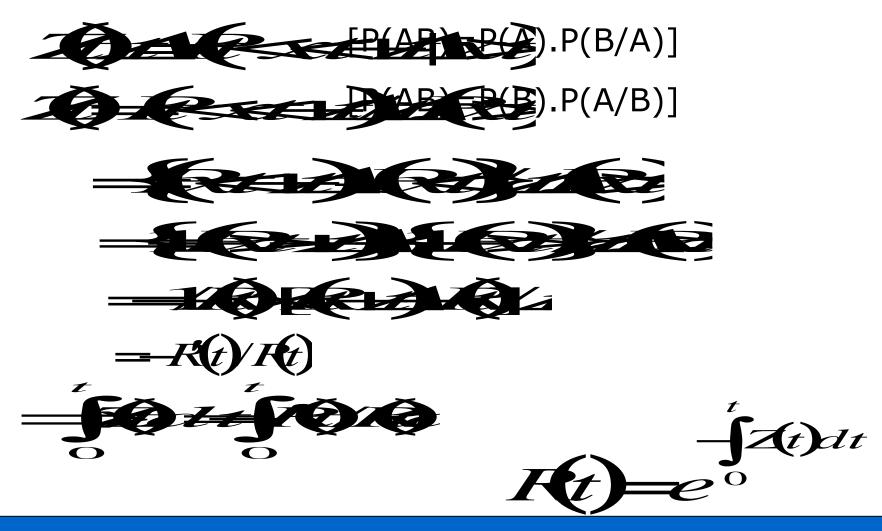
- Hazard rate (conitional failure rate), z(t)
  - Defined in term of the probability that a failure occurs in the same interval t to t+  $\Delta t$  , given that system has survival up to time t



We know, F(t)=1-R(t)

#### Relationship R(t) and Z(t)

We know, from definition of Hazard rate



#### Estimation theory:

- How one determines the parameters in a probabilistic model from statistical data taken on the items governed by the model
- Specifically, in reliability work we place a group of components on life test and observe the sequence of failure times t1,t2,...,tn
- On the basis of these data we compute time-to-failure models and hazard models
- Estimation theory provides guidelines for efficient and accurate components

- $n \le 5$  (few data)  $\rightarrow$  result must be questioned
- $n \ge 100 \rightarrow \text{result should be good}$
- $n \rightarrow \infty$   $\rightarrow$ many of the different computational scheme is need
- $10 \le n \le 50$  best for estimation theory
- A point estimation formula, MTTF=(10+20+25+35+40)/5
- = 26h
- It is often convenient to characterize a failure model using set of failure data by a single parameter (MTTF/MTBF)

 If we have life test information on a population of n items with failure times t1,t2,...tn

• MTTF= 
$$1/n\sum_{i=1}^{n} t_i$$

Expected value,



is discrete random variable



where x

is continuous random variable

 Using Hazard model, the MTTF for the probability distribution defined by the model is,

• MTTF= 
$$H(t) = \int_{0}^{\infty} t f(t) dt$$

• Let, 
$$I = \int t f(t) dt$$

$$= t \int t f(t) dt$$

$$= d(1-R(t))/dt$$

$$= -dR(t)/dt$$

- Case I : Constant hazard,  $R(t) = e^{-\lambda t}$
- Case II: Linearly increasing hazard,  $R(t) = e^{-kt^2/2}$
- Case III: Weibull distribution,