Engineering Economics & Management

Reliability & Total Quality Management

30th May 16

Measuring Reliability of Items

30th May 16

Engineering Reliability

'The probability that an item will perform its required function in the desired manner under all relevant conditions and on the occasions, or during the time intervals, when it is required to perform'

Definition of Item

- A component – the smallest part that can be replaced or repaired on failure (a bolt)
- A unit – comprising a number of components (a pump)
- A system – comprising many units (a process line)

Types of Reliability

- Time-independent
  - The item functions only on demand t
  - Reliability measured by the probability of successful function, P_S; its complement is the probability of failure on demand, P_F.

- Time-dependent
  - The item functions continuously
  - Reliability measured by the probability R(t) that it will run successfully for some specified time t.

Statistical Analysis of Item Lifetime

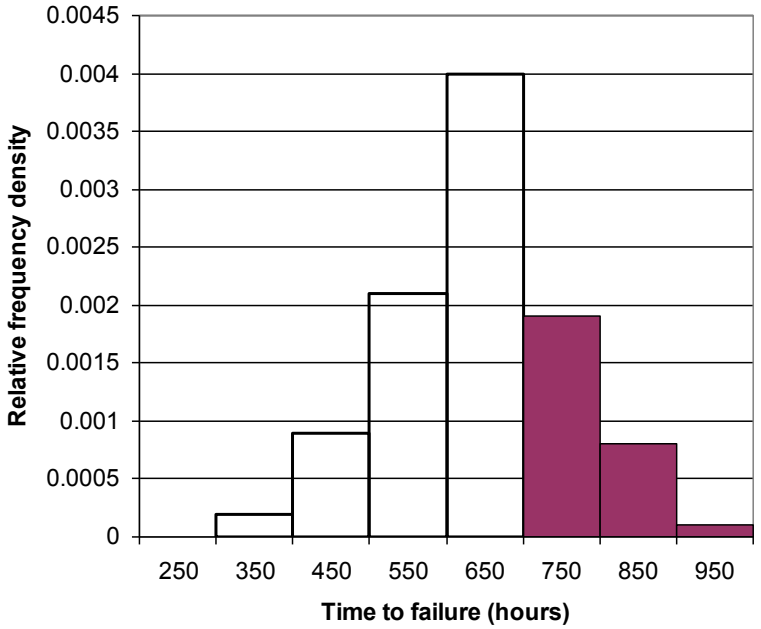
- Mean, variance and standard deviation
- Grouped distribution
  - class interval, class mark, frequency, relative frequency and relative frequency density
  - histograms
- Probability density function, pdf - f(t)
- Cumulative distribution function, cdf - F(t)

Example of Pump Failure

Class interval	Frequency	Relative frequency	Rel. freq. density
Time to Failure (hours)	No. of Pumps failing	Fraction failing	Fraction failing per hour
300 – 400	2	0.02	0.0002
400 – 500	9	0.09	0.0009
500 – 600	21	0.21	0.0021
600 – 700	40	0.4	0.004
700 – 800	19	0.19	0.0019
800 – 900	8	0.08	0.0008
900 – 1000	1	0.01	0.0001
Totals	100	1	0.01

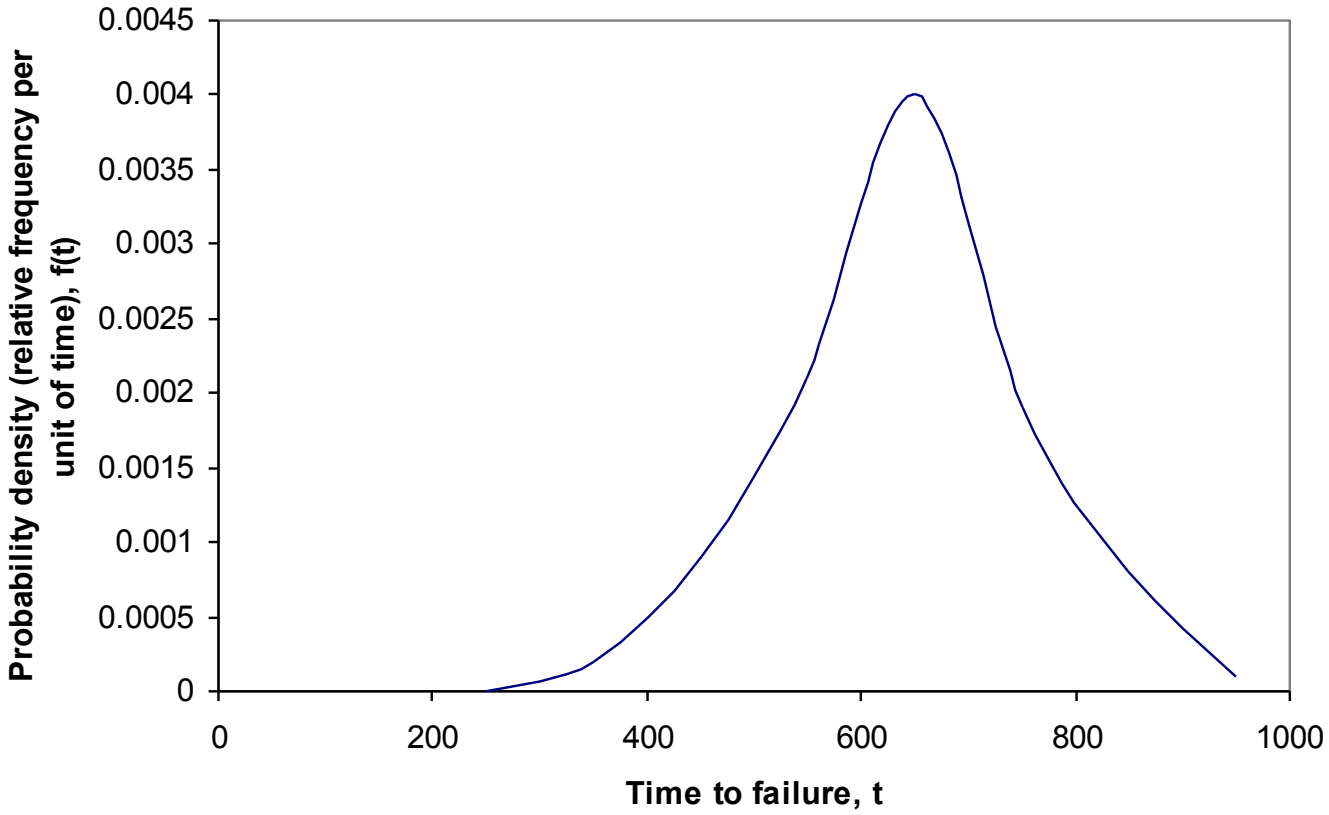
Table 1. Pump failure data

Figure 1. Histogram of pump failure data

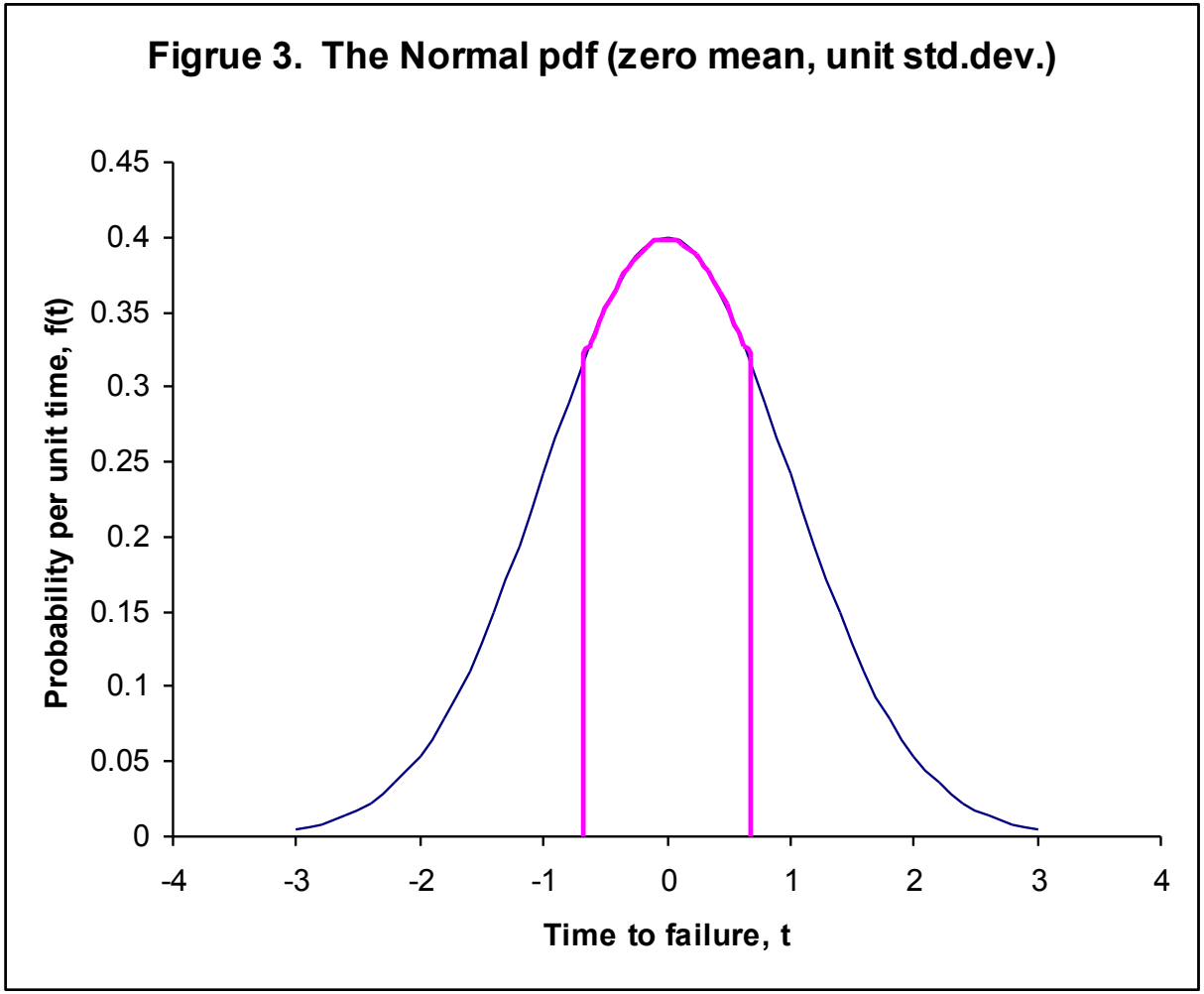


Probability Density Function

Figure 2. Continuous probability density distribution

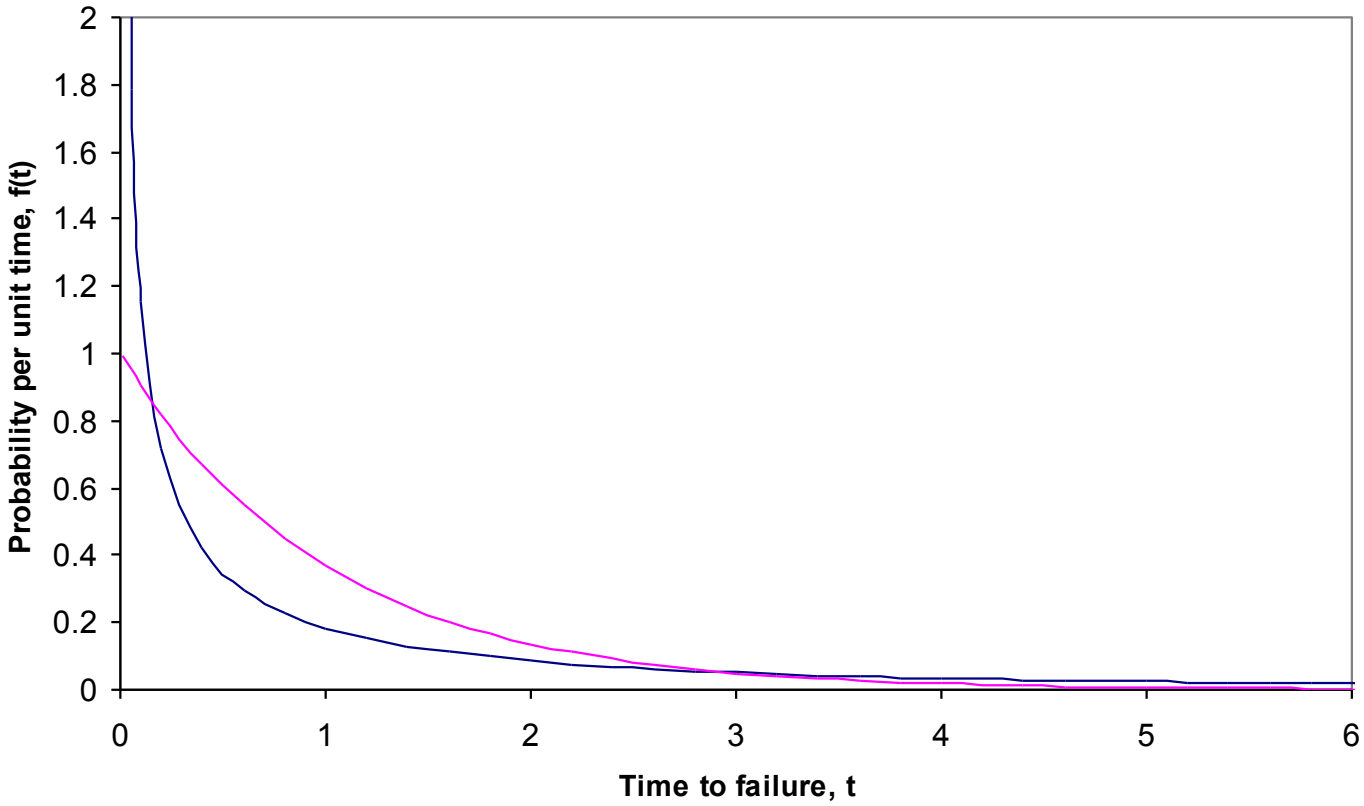


Wear-out pdf


Figrue 3. The Normal pdf (zero mean, unit std.dev.)
Probability per unit time, f(t)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-4
-3
-2
-1
0
1
2
3
4
Time to failure, t

Random failure and Running-in pdf

Figure 4. Hyper-exponential and exponential pdf's



Measures of item reliability

Failure probability F(t)

Reliability R(t)

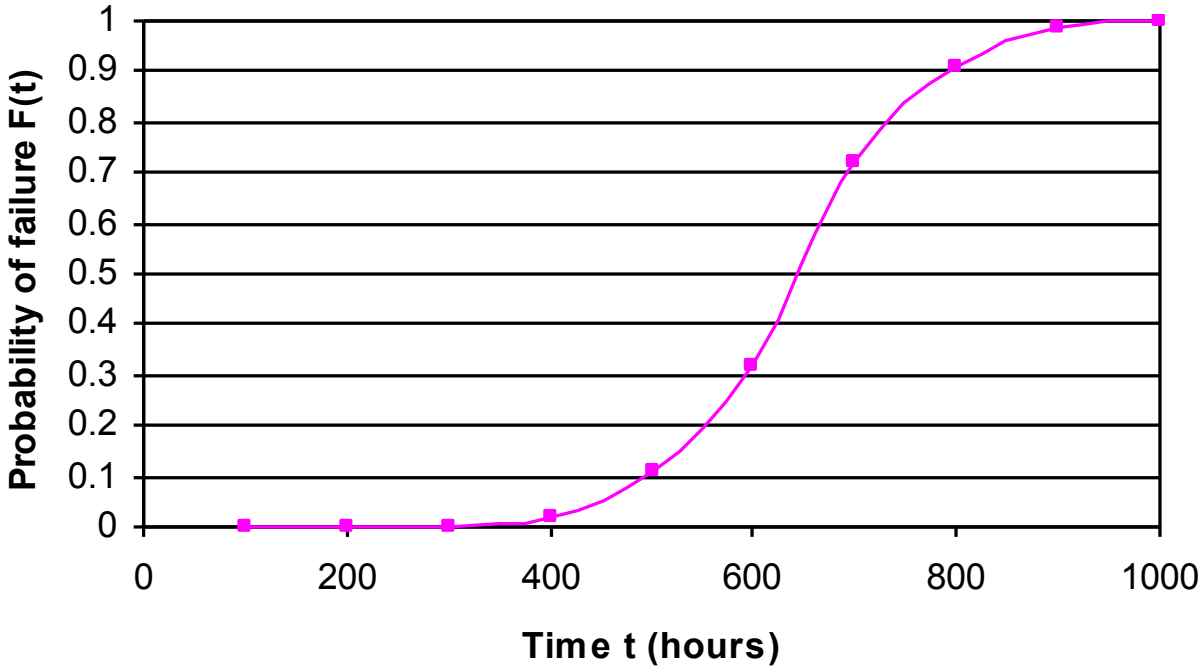
Hazard rate Z(t)

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

Failure Probability F(t)

Time *(h)*	t	0	100	200	300	400	500	600	700	800	900	1000
Total fraction failed	*F(t)*	0	0	0	0	0.02	0.11	0.32	0.72	0.91	0.99	1.00

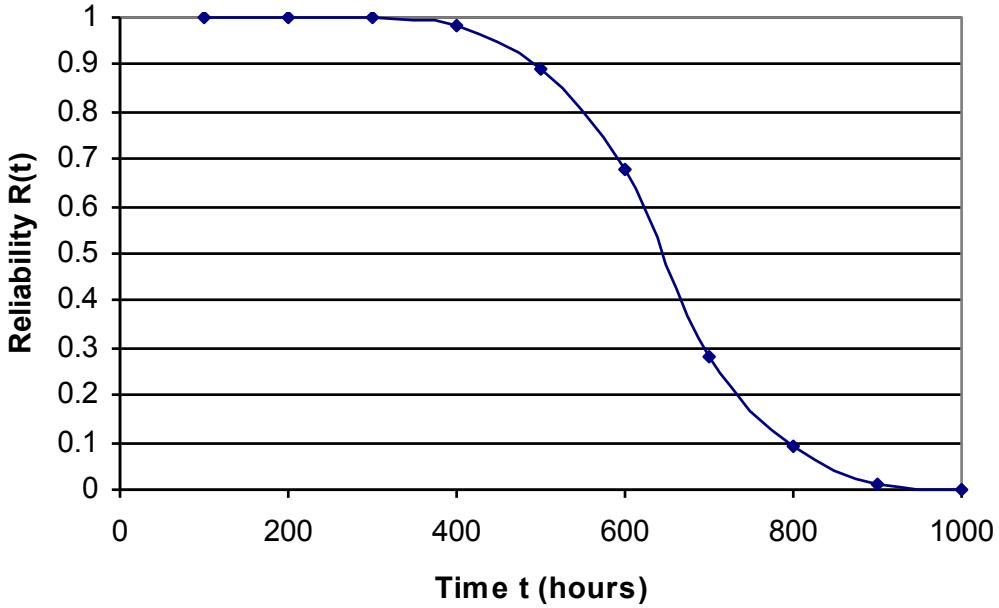
Figure 5. Probability of failure before time t



Reliability R(t)

Time (h)	t	0	100	200	300	400	500	600	700	800	900	1000
Total Fraction failed	R(t)	1	1	1	1	0.98	0.89	0.68	0.28	0.09	0.01	0

Figure 6. Reliability at time t



Hazard Rate Z(t)

- It is defined as the fraction of those items, having survived up to the time t, that is expected to fail in the next unit of time.

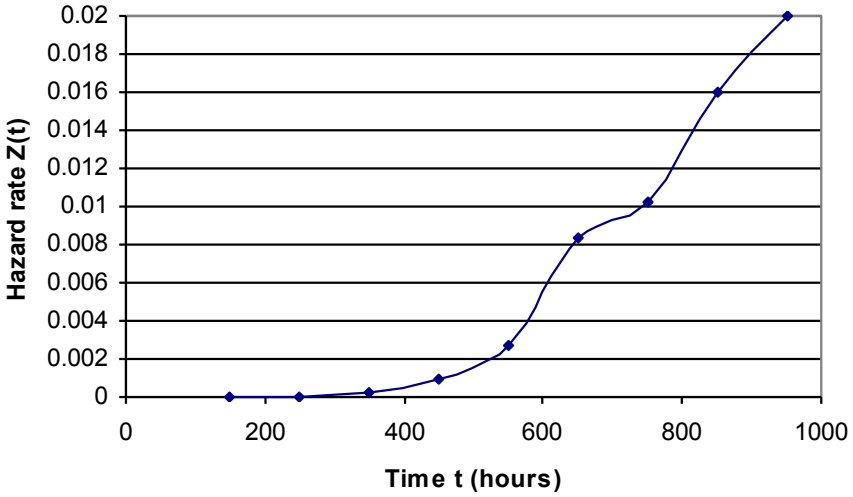
$$Z(t) = \frac{f(t)}{R(t)}$$

where f(t) is the fraction, of original pumps, failing per hour at time t; R(t) is the fraction, of original pumps, still running at time t.

Hazard Rate Calculation

Time (hours)	t	350	450	550	650	750	850	950
Fraction of original pumps) failing per hour, at time t	f(t)	0.0002	0.0009	0.0021	0.004	0.0019	0.0008	0.0001
Fraction surviving at time t (estimated from Fig. 6)	R(t)	0.99	0.94	0.79	0.48	0.18	0.05	0.005
Hazard Rate	Z(t)	0.0002	0.0010	0.0027	0.0083	0.0106	0.0160	0.0200

Figure 7. Hazard rate plot



Whole Life Picture

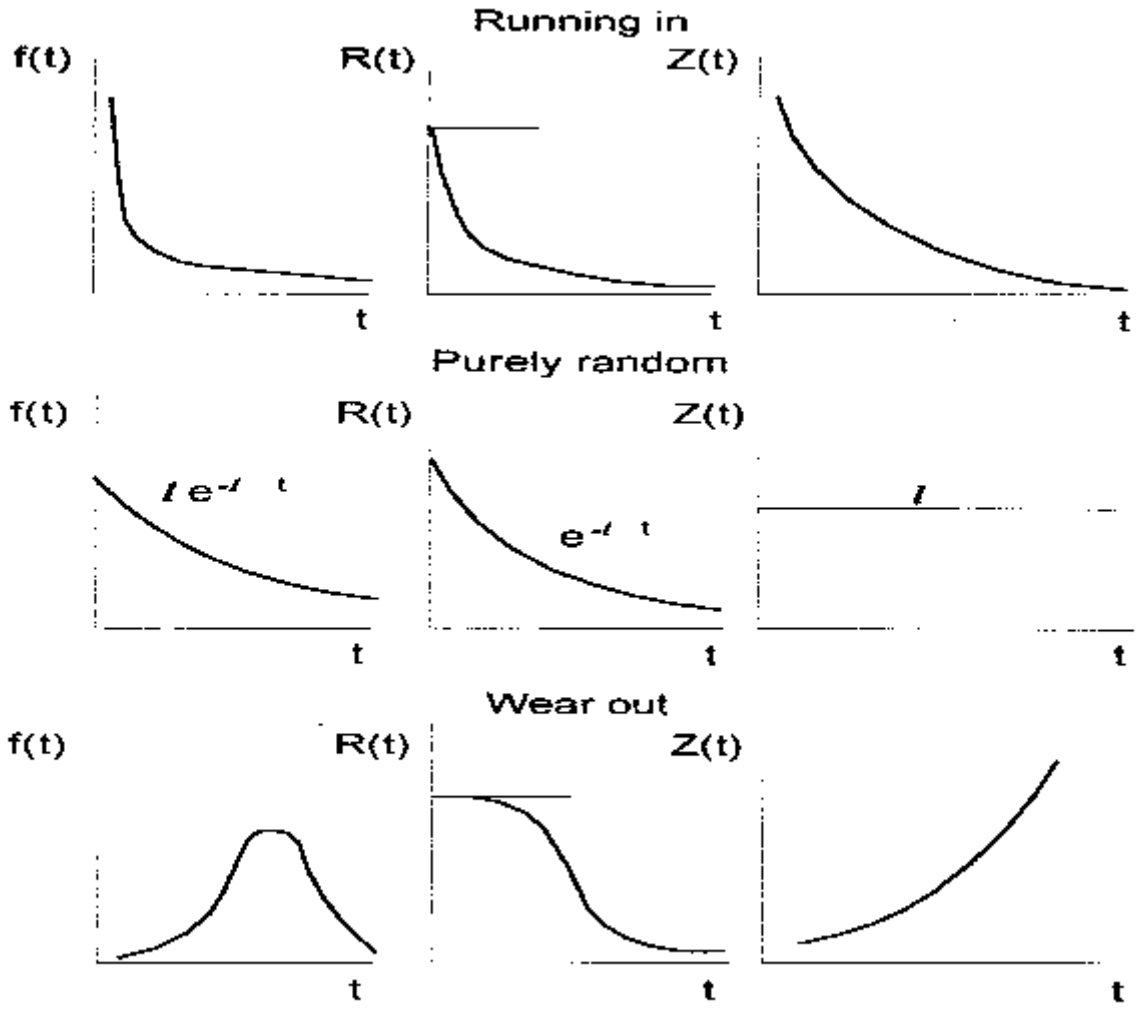


Figure 8: Principal modes of failure

Bath Tub Curve

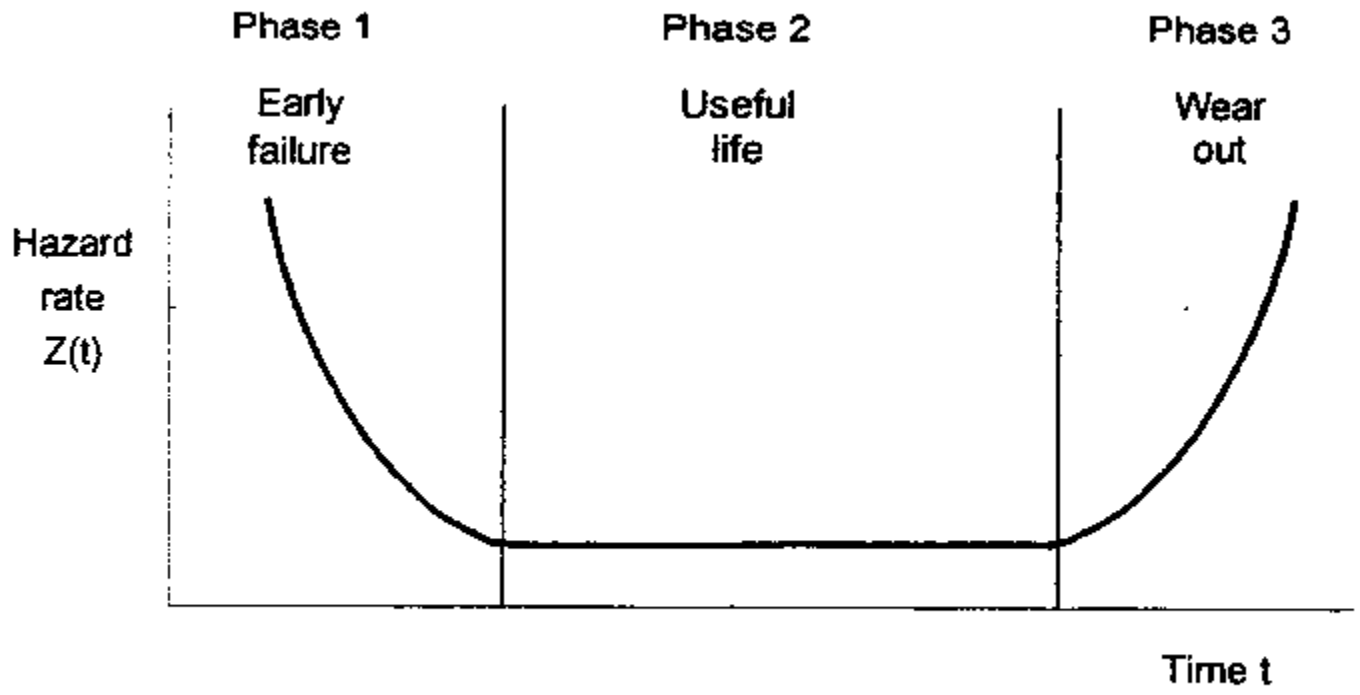


Figure 9: Typical Z(t) characteristic for engineering devices

Topics For Presentations

- Same 4 Groups as DSP project.
- Topic #1: Total Quality Management
- Topic #2: Significance of Six Sigma
- Slides: Note more than 40.
- Presentation Date: 6th June, 2016, Monday.
- Presentation marks= marks of 2 assignments + 2 quizzes

Thankyou

30th May 16