Reliability

Reliability

- The ability of a product to perform a required function under stated conditions for a stated period of time
  - ISO 8402-1986

Four requirements

- Quantification through probability
- Statement of successful performance
- Statement of environment / conditions
- Statement of the required operating time

Failure Times

- A repairable equipment
- Place on test
- Run till it fails
- Record failure time
- Repair, run, and record next failure time
- Continue as necessary

Result: Failure Times

Read data

1.0	4.3	7.2	14.4	30.6	51.2
1.2	4.6	7.9	15.6	32.4	52.0
1.3	4.7	8.3	16.2	33.0	53.3
2.0	4.8	8.7	17.0	35.3	54.2
2.4	5.2	9.2	17.5	36.1	55.6
2.9	5.4	9.8	19.2	40.1	56.4
3.0	5.9	10.2	28.1	42.8	58.3
3.1	6.4	10.4	28.2	43.7	
3.3	6.8	11.9	29.0	44.5	
3.8	6.9	13.8	29.9	50.4	

Contd..

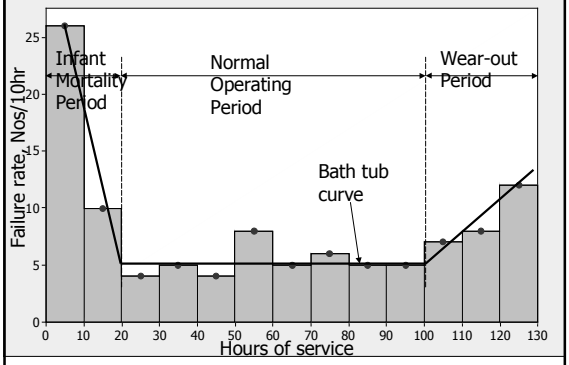
Result: Failure Times ...

60.2	79.2	97.9	113.5	124.5
63.7	84.1	102.6	114.8	125.8
64.6	86.0	103.2	115.1	126.6
65.3	87.9	104.0	117.4	127.7
66.2	88.4	104.3	118.3	128.4
70.1	89.9	105.0	119.7	129.2
71.0	90.8	105.8	120.6	129.5
75.1	91.1	106.5	121.0	129.9
75.6	91.5	110.7	122.9	
78.4	92.1	112.6	123.3	

Make a stem and leaf plot / Histogram

0	11122233334444555666778899
1	0013456779
2	8899
3	02356
4	0234
5	01234568
6	03456
7	015589
8	46789
9	01127
10	2344556
11	02345789
12	012345678999

Neglecting figures after decimal place



Infant Mortality Period

- High failure rate: Congenital defects
  - Missing parts, Substandard material, components out of tolerance, shipping damage
- How to reduce?
- Quality Control to reduce variability
- Debug by simulated use or burn-in
  - Failure takes place before service

Constant Failure Rate Period

- Caused by random events: Accident / Disease
  - Result from limitations inherent in design, changes in environment, accidents caused by use or maintenance
- How to reduce?
- Reduction in failure rate requires design improvement: Make robust

Wear-out period

- Aging: Corrosion, embrittlement, insulation drying out
- How to reduce?
- More durable components
- Preventive maintenance
- Control of environmental stresses

Time Between Failures

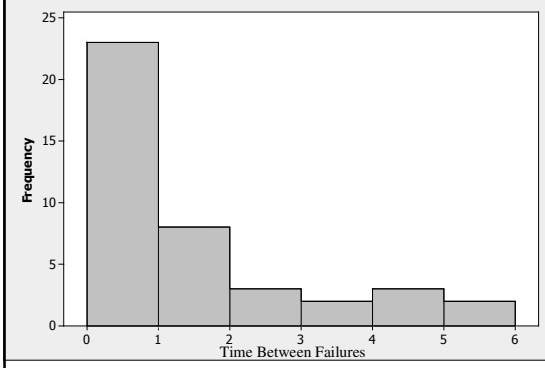
- Length of time without failure
- Determine the time between failures for the constant failure rate period
- Make a stem and leaf plot / histogram

Time Between Failures…

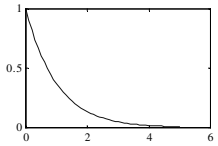
0.1	4.0	0.9	0.9	1.9
0.8	2.7	1.4	3.9	1.9
0.9	0.9	0.8	0.9	0.5
0.7	0.8	1.9	4.1	1.5
1.8	5.9	1.9	0.5	0.9
0.6	0.8	3.5	2.8	0.3
2.3	0.8	0.9	0.8	0.4
0.8	1.3	0.7	4.9	0.6
				5.8

Time Between Failures...

0. 134
0. 55667788888889999999
1. 34
1. 589999
2. 3
2. 78
3.
3. 59
4. 01
4. 9
5.
5. 89



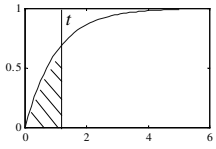
Time Between Failures



$$f(x) = \lambda e^{-\lambda t}$$

- When failure rate is constant,
- time between failures is distributed exponentially
- μ = Mean Time Between Failures
- λ = Mean Failure rate $1/\mu$

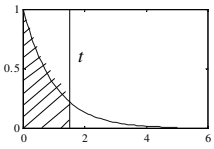
Probability of failure



$$F(x) = 1 - e^{-\lambda t}$$

- Expressing frequencies as relative frequencies converts into probabilities
- The probability of failure before a specified time t is given by the cdf

Probability of survival



- = 1 - Probability of failure
- = Reliability for the time period t

$$R = 1 - \left[1 - e^{-\lambda t}\right]$$

$$R = e^{-\lambda t} = e^{-t/\mu}$$

Problem:

- A washing machine requires 30min to clean a load of clothes. The mean time between failures of the machine is 100h. Assuming a constant failure rate, what is the chance of the machine completing a cycle without failure?

Solution:

$$R = e^{-t/\mu}$$

$$= e^{-0.5/100}$$

$$= 0.995$$

Thus, there is a 99.5% chance of completing a washing cycle

How good: Assumption of constant failure rate?

- Usually, sufficient data not available to test assumption
- Reasonable when
  - Infant mortality eliminated before delivery of product to user
  - User replaces product or specific components before wear-out phase begins

Note about MTBF

- What is the probability that a product will operate without failure for a time equal to or less than its MTBF?
- Answer:
- NOT 50:50
- But 0.37

Increase in MTBF does not result in proportional increase in reliability

For t=1

MTBF	R
5	0.82
10	0.90
20	0.95
100	0.99

System Reliability