RELIABILITY - SOME FUNDAMENTALS

N_0 → NUMBER OF PRODUCTS JUST BORN AT TIME T_0
ALL OF THEM IDENTIC.

C → COMPONENT

A → ROOM CONDITIONS

t → TIME (INSTANT OF LIFE OR OF OPERATING LIFE)

RELIABILITY → $R = f(C, A, t)$

USUALLY SIMPLIFYING

$$R = f(t)$$

$N_g(t)$ → NUMBER OF COMPONENTS FAILED AT TIME t

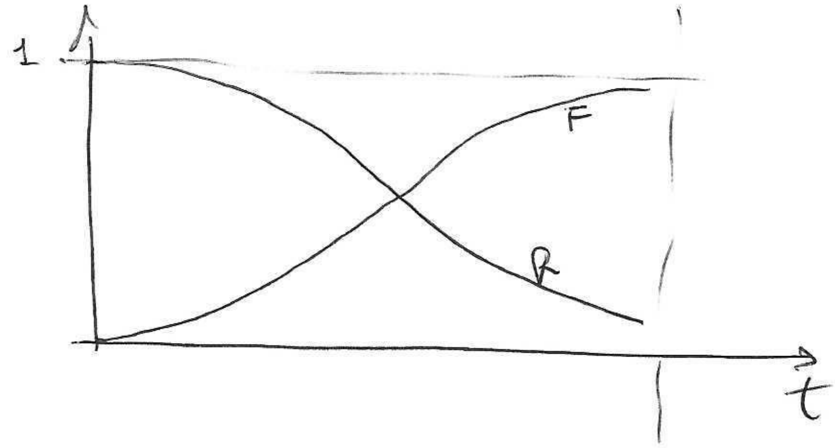
$N_f(t)$ → NUMBER OF COMPONENTS STILL OPERATING AT TIME t

$$\Rightarrow \quad R(t) = \frac{N_f(t)}{N_0}$$

UNRELIABILITY → $F(t)$

$$\Rightarrow \quad F(t) = \frac{N_g(t)}{N_0}$$

$$\Longrightarrow \quad R(t) + F(t) = 1$$



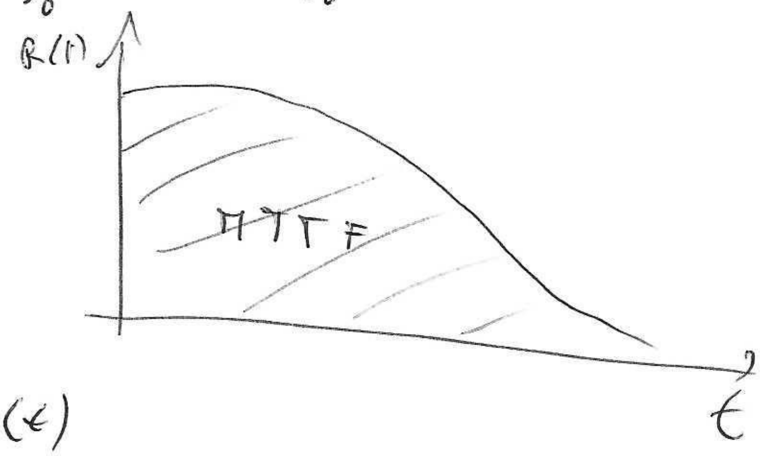
PROBABILITY DENSITY OF UNRELIABILITY $\rightarrow f(t) = \frac{dF}{dt} = \frac{d(1-R)}{dt} = \frac{-dR}{dt}$

MEAN TIME TO FAILURE $\rightarrow$ MTTF

AVERAGE VALUE OF $f(t)$

$$MTTF = \int_0^\infty t \cdot f(t)\, dt = \int_0^\infty t \cdot \left(-\frac{dR}{dt}\right) dt =$$

$$= -\left[t \cdot \frac{dR}{dt} \right]_0^\infty + \int_0^\infty R(t)\, dt = \int_0^\infty R(t)\, dt$$



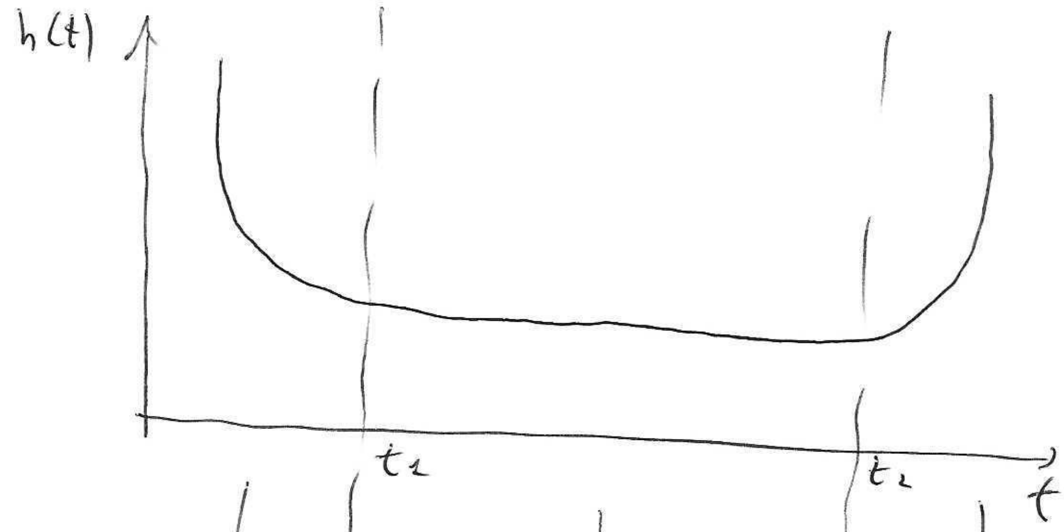
FAILURE RATE $\rightarrow h(t)$

NUMBER OF COMPONENTS FAILING AT TIME t IN RELATION TO THE NUMBER OF COMPONENTS/PRODUCTS STILL WORKING AT TIME t

$$h(t) = \frac{1}{N_f(t)} \cdot \frac{dN_f(t)}{dt} = \frac{1}{N_f(t)} \cdot \frac{N_0}{N_0} \cdot \frac{dN_f(t)}{dt} =$$

$$= \frac{1}{R(t)} \cdot d\left(\frac{N_f(t)}{N_0}\right)/dt = \frac{1}{R(t)} \cdot \frac{dF}{dt} = \frac{f(t)}{R(t)}$$

$$\Rightarrow \quad f(t) = h(t) \cdot R(t)$$



BATH TUBE CURVE

AREA OF CHILD MORTALITY

AREA OF USEFUL LIFE

$h(t) = \text{constant}.$

↓

ELECTRONIC COMPONENTS

AREA OF MECHANICAL WEAR/AGING

↓

MECHANICAL PRODUCTS

CHILD PRODUCTS:

- CHILD MORTALITY OF ELECTRONIC COMPONENTS
- PROJECT ERRORS IN MECHANICAL COMPONENTS

WEIBULL DISTRIBUTION

→ USUALLY EMPLOYED FOR THE THREE TYPICAL LIFE AREAS OF PRODUCTS OR THREE TYPICAL CLASSES OF PRODUCTS

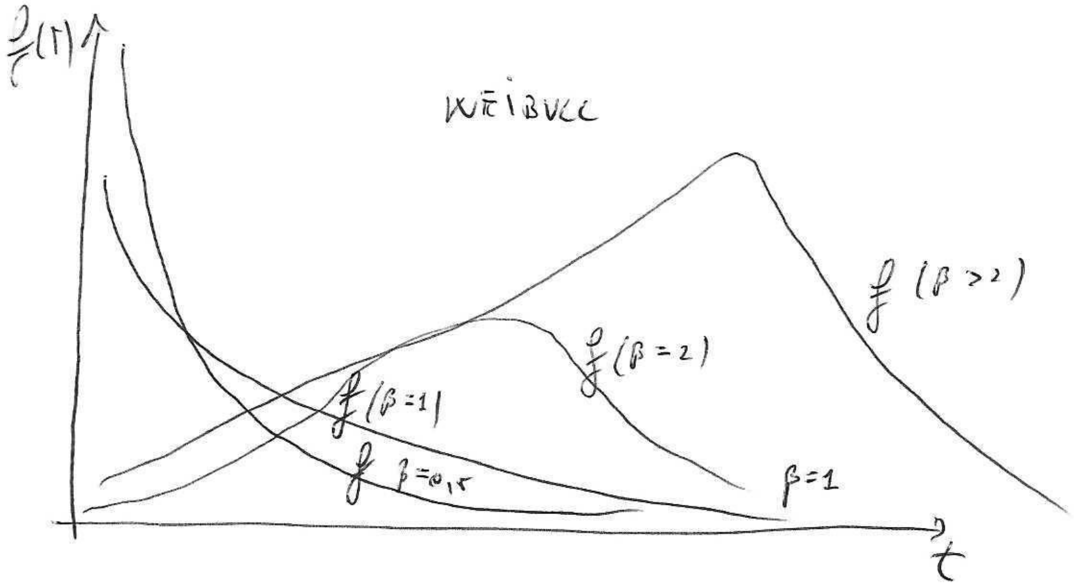
$$\Rightarrow R(t) = e^{-\left(\frac{t}{\alpha}\right)^{\beta}}$$

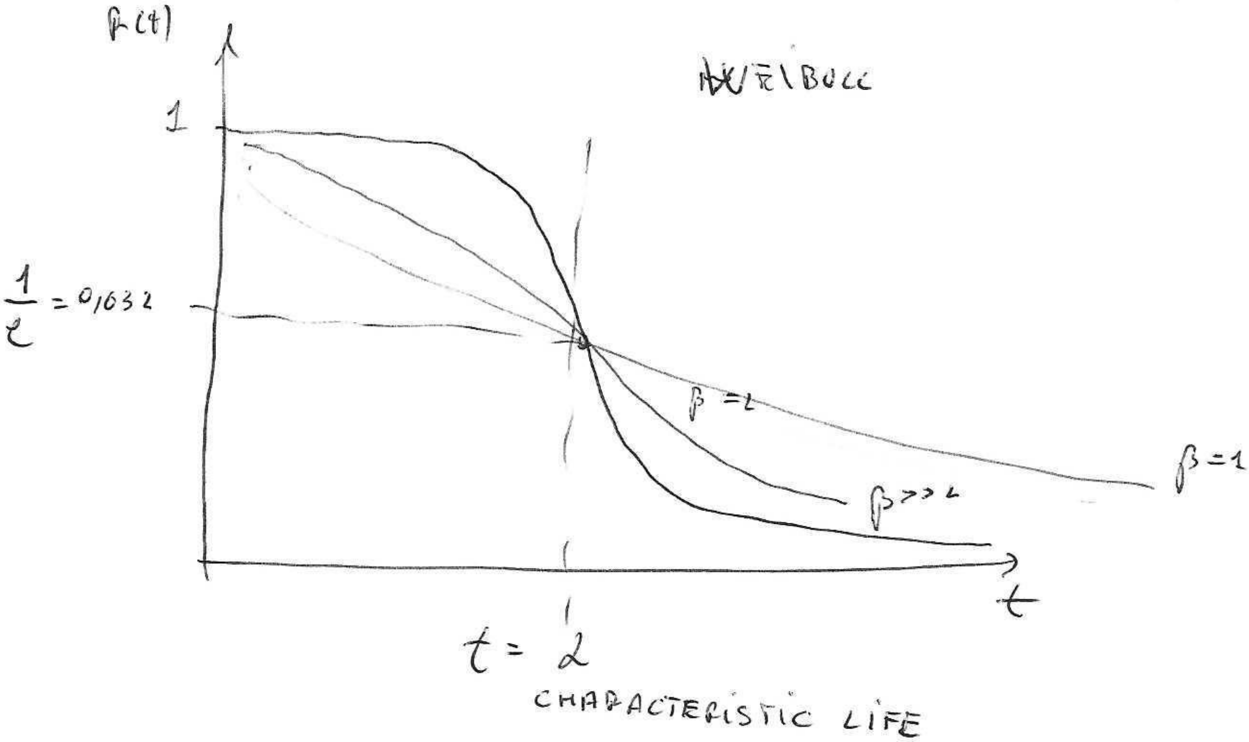
β → SHAPE OF THE GRAPH

α → TIME OF CHARACTERISTIC LIFE

$$f(t) = -\frac{dR}{dt} = e^{-\left(\frac{t}{\alpha}\right)^{\beta}} \cdot +\beta \left(\frac{t}{\alpha}\right)^{\beta-1} \cdot \frac{1}{\alpha} =$$

$$= \underbrace{e^{-\left(\frac{t}{\alpha}\right)^{\beta}}}_{R(t)} \cdot \underbrace{\frac{\beta}{\alpha}\left(\frac{t}{\alpha}\right)^{\beta-1}}_{h(t)}$$



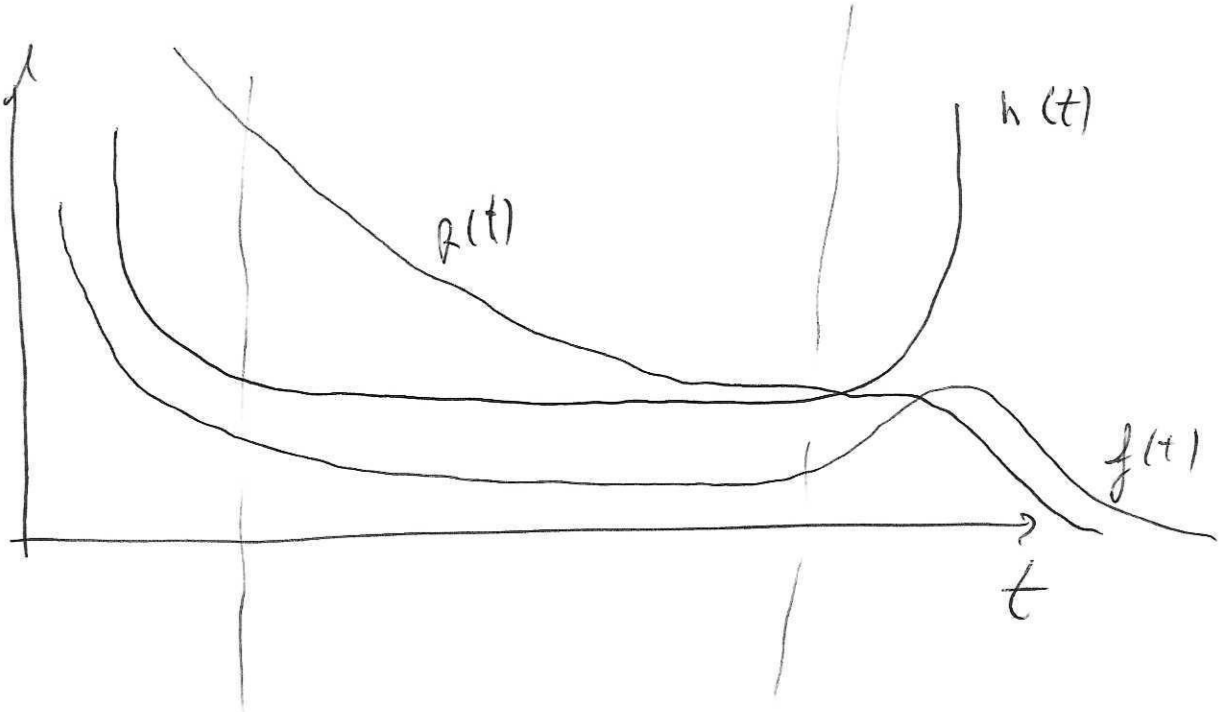


if $h(t) = \text{constant} = \lambda \iff$

AND $h(t) = \frac{\beta}{\alpha}\left(\frac{t}{\alpha}\right)^{\beta-1} \iff \beta = 1, \quad \alpha = \frac{1}{\lambda}$

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

$$\Rightarrow MTTF = \int_0^\infty R(t)\, dt = \int_0^\infty e^{-\lambda t}\, dt = \frac{1}{\lambda}$$



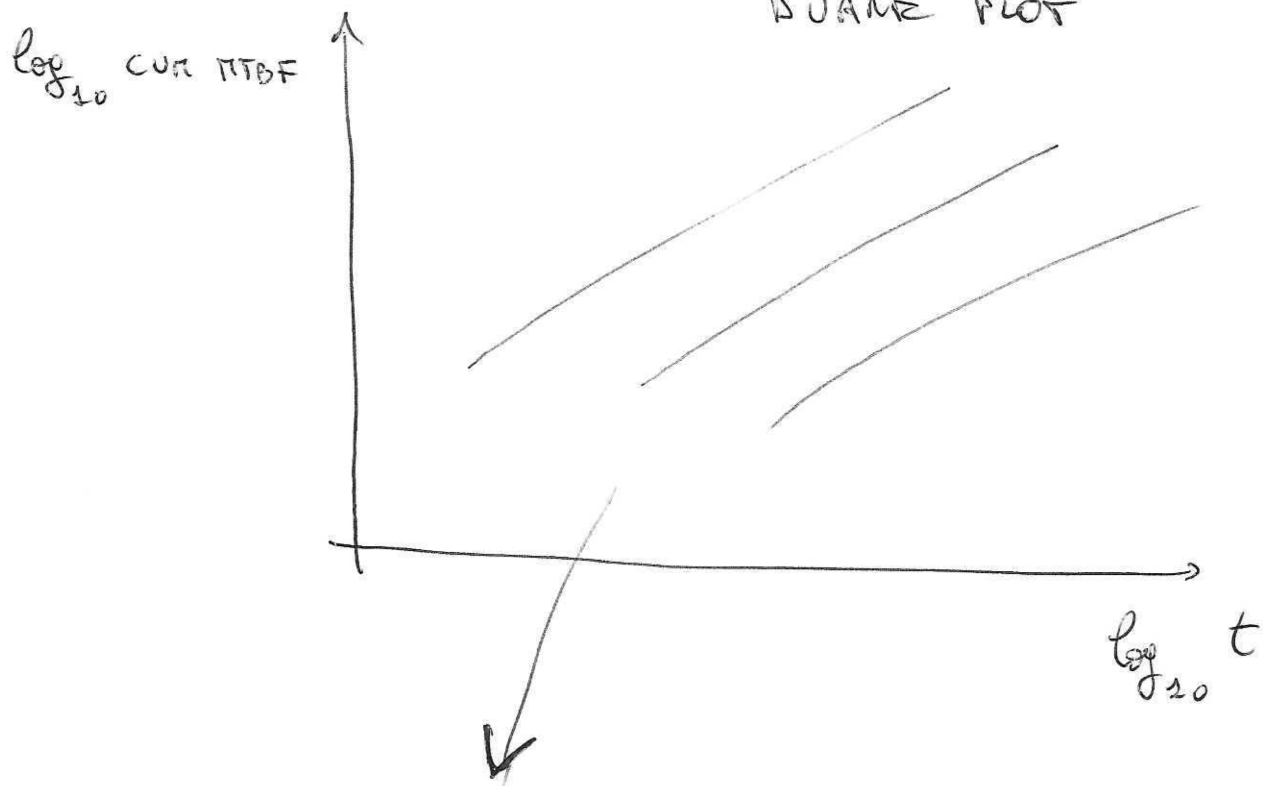
DUANE PLOT EXPERIMENT

CUMULATIVE MEAN TIME BETWEEN FAILURES

NUMERICAL EXAMPLE

m	t	CUM MTBF
0	0	0
	33	
1	33	$\frac{33+0}{1} = 33$
	$\Delta = 43$	
2	76	$\frac{33+43}{2} = \frac{76}{2} = 38$
	$\Delta = 67$	
3	143	$\frac{33+43+67}{3} = 47,6$
⋮	⋮	⋮

DUANE PLOT



DIFFERENT PRODUCTS FOLLOW THE PLOT DISCOVERED BY J.T. DUANE in 1968.