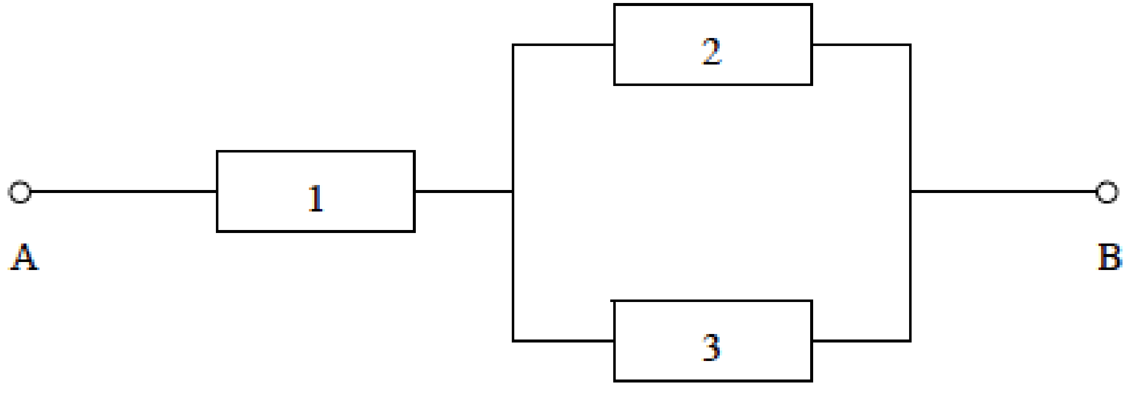
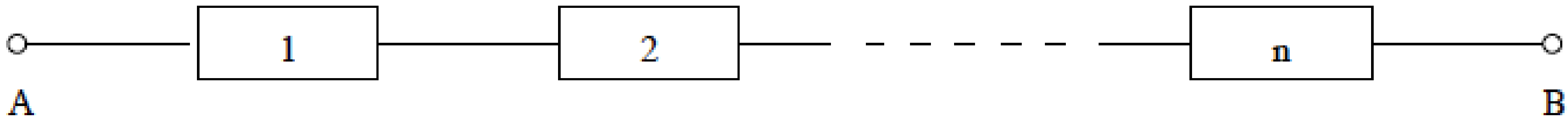
Lab 3, Reliability and survival

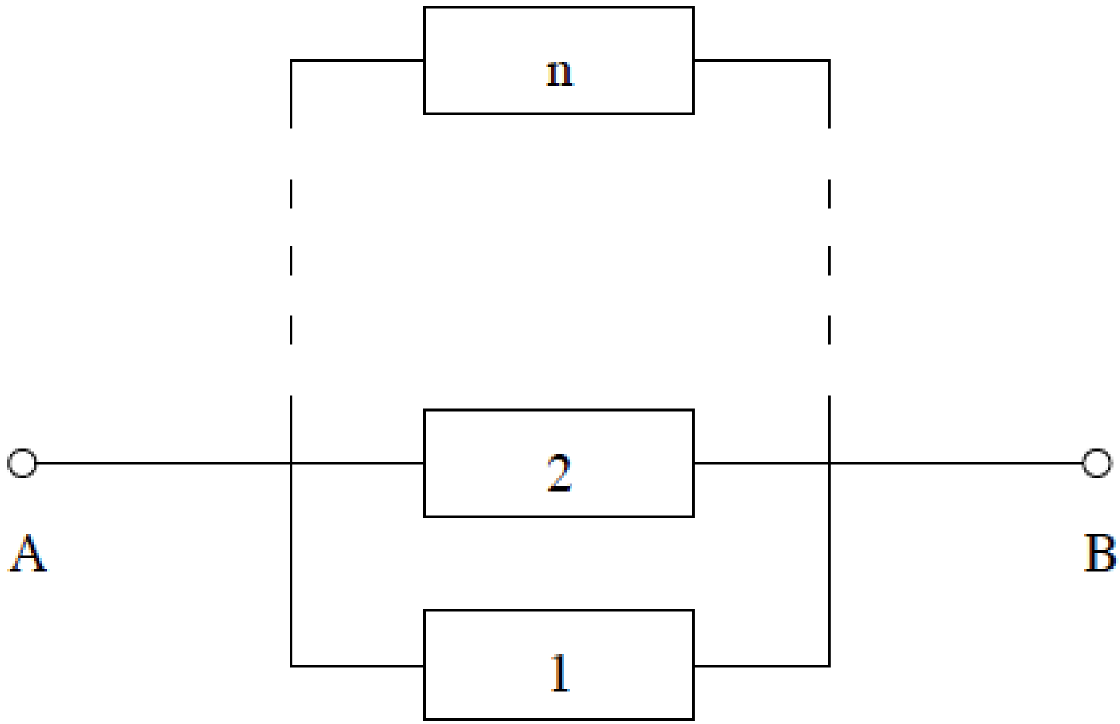
TMS150, MSG400

Lab 3, Reliability and survival

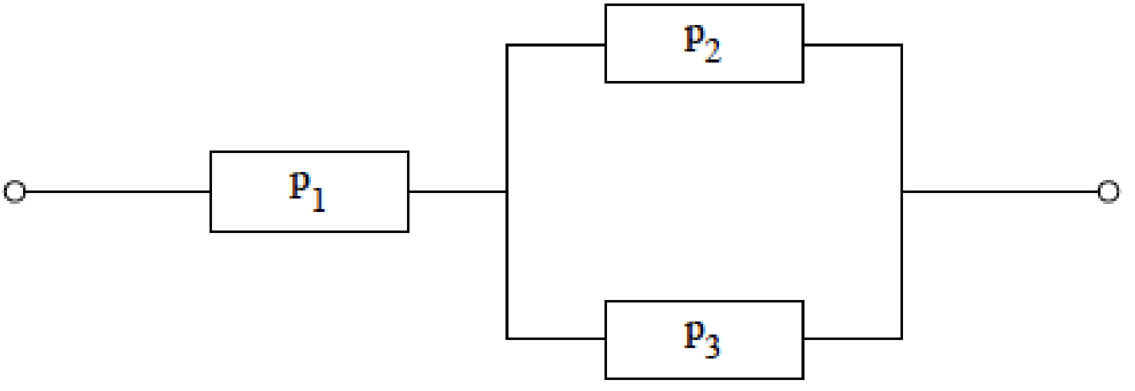
- Study systems of components
- Survival analysis, calculation of expected life lengths
- Applications in industry/technical applications
- Biological applications, e.g. how genetic alterations affect tumor cell survival in cancer

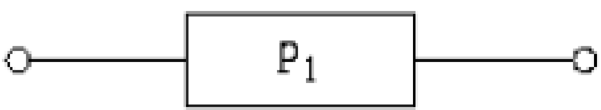



1
2
n
A
B

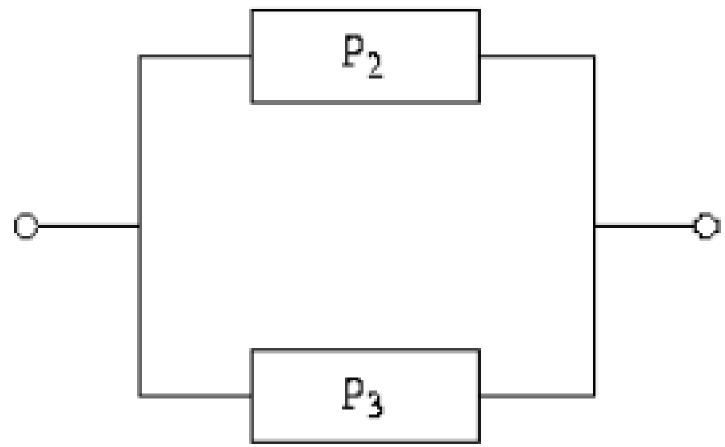

n
2
1
A
B

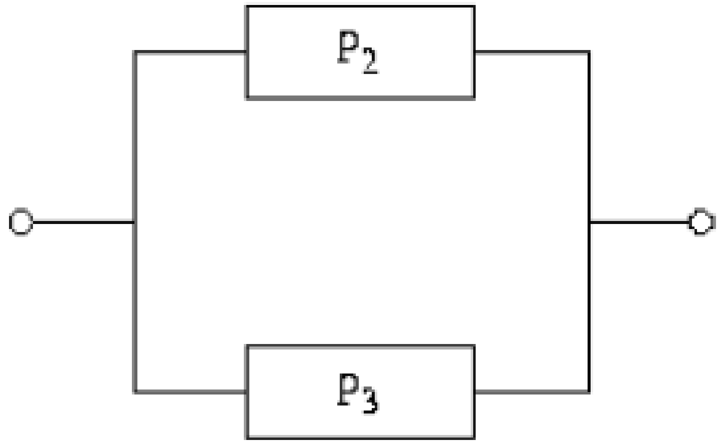
Health probabilities





and





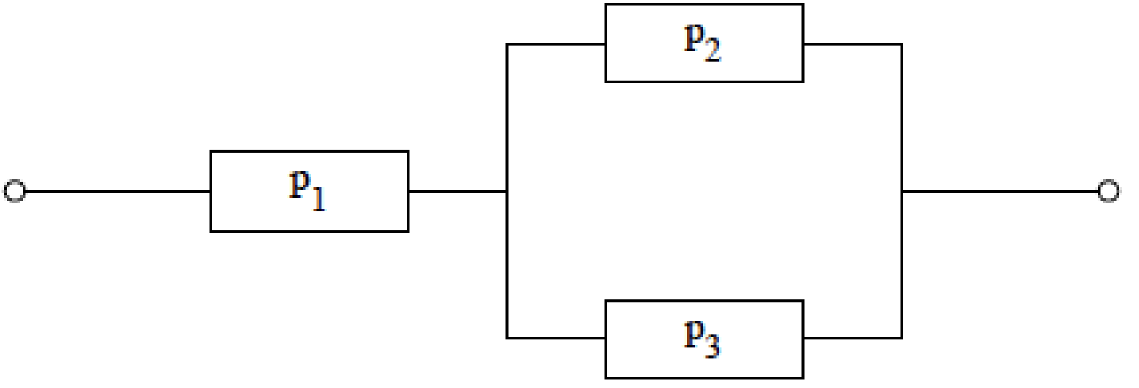
P(at least one is working) = 1 – P(both are not working)

= 1 – P(comp 2 not working)*P(comp 3 not working)

= 1 – (1 – P(comp 2 working))*(1-P(comp 3 working))

= 1 – $(1-p_2)*(1-p_3)$

Health probability whole system



Health probability whole system = $p_1 * (1 – (1-p_2)*(1-p_3))$

Life length, T

- Random variable
- $R_T(t)$ = P(system is working at time t)

  $= P(T>t) = 1 – P(T<t) = 1 – F_T(t)$
- $f_T(t)$

  $F_T(t)$

  $R_T(t)$ survival function$=1-F_T(t)$

  $r_T(t)$ hazard function / death intensity

Survival function

- $R_T(t)$ = P(system is working at time t)

  = P(T>t) = 1 - P(T<t) = 1 – $F_T(t)$

- $$\mathbf{E}\{T\} = \int_0^\infty R_T(t)\,dt$$

- How to find $R_T(t)$?

Series coupling, $T = \min(T_1, T_2)$

$$R_T(t) = P(T>t) = P(\min(T_1,T_2)>t)$$

$$= P(T_1>t) * P(T_2>t)$$

$$= R_{T1}(t) * R_{T2}(t)$$

Parallell coupling $T = \max(T_1,T_2)$

$R_T(t) = P(T>t) = P(\max(T_1,T_2)>t)$

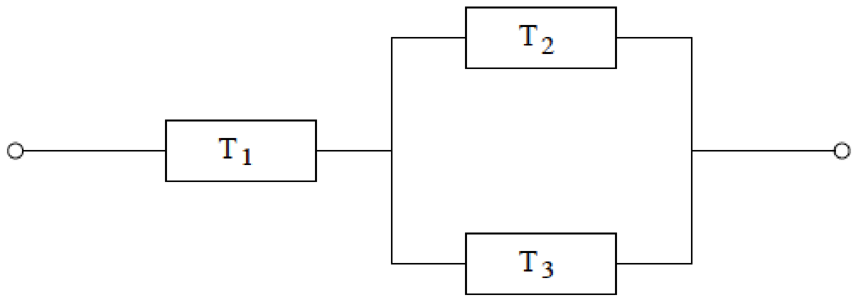
$= 1 - P(\max(T_1,T_2)<t)$

$= 1 - P(T_1<t) * P(T_2<t)$

$= 1 – F_{T1}(t) * F_{T2}(t)$

$= 1 – (1-R_{T1}(t)) * (1-R_{T2}(t))$

$T = \min(T_1, \max(T_2, T_3))$



- $R_T(t) = R_{T1}(t) * [1 – (1-R_{T2}(t)) * (1-R_{T3}(t))]$

  $= [1 – F_{T1}(t)] * [1 – F_{T2}(t) * F_{T3}(t)]$

- Health probability whole system =

  $= p_1 * (1 – (1-p_2)*(1-p_3))$

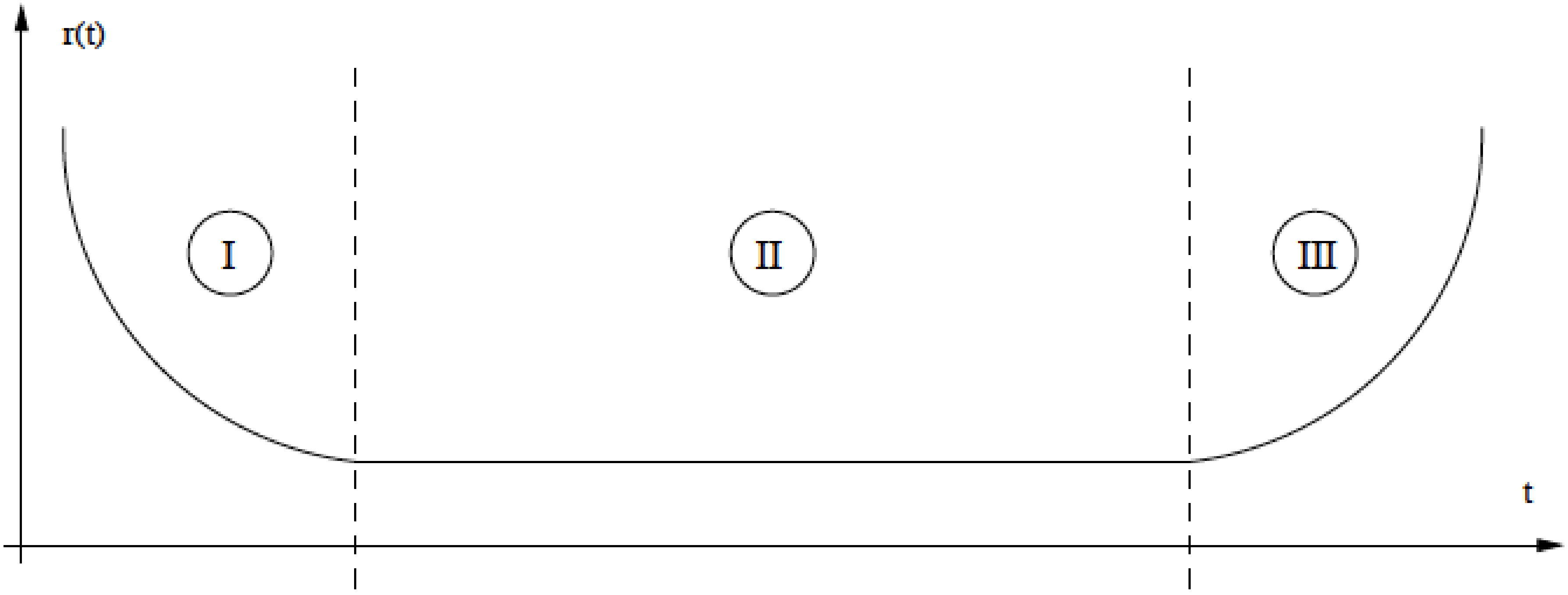
Death intensity, $r_T(t)$

- Instantaneous rate of failure/death

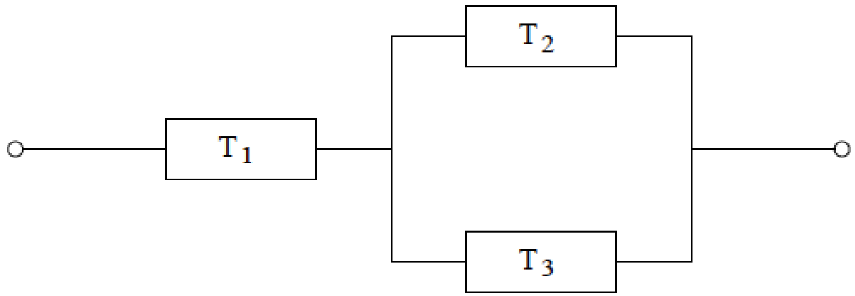
- Hazard function, conditional failure rate, intensity function, age-specific failure rate, force of mortality

- Take on values in $(0,\infty)$

DFR/IFR and bath tub curve



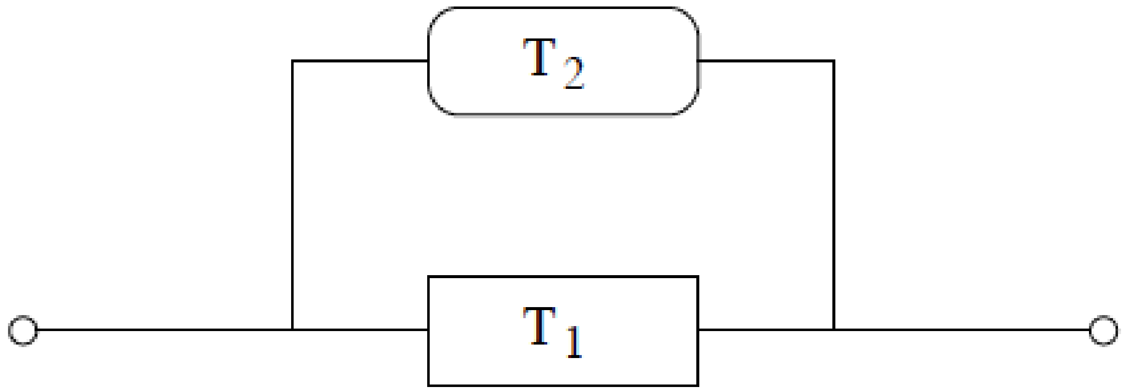
Probability of causing death



- What is the probability that component 1 causes the death of the system?
- P(comp 1 causes failure)

  $= P(T_1 < \max(T_2, T_3))$

Add a redundant component



- Warm: $T_{warm} = \max(T_1,T_2)$ (Comp 2 added at t=0)
- Cold: $T_{cold} = T_1 + T_2$ (Comp 2 added when comp 1 is dead)

Death intensity / hazard function

"The death intensity is such, were that rate to continue for 1 time unit we would expect that number or failures during that time unit."

Death intensity / hazard function

- Gives a nice way of comparing risk between time points and between individuals.

- If the risk is zero…
- If the risk of dying now or tomorrow is the same…
- If the risk is rising/falling with time…