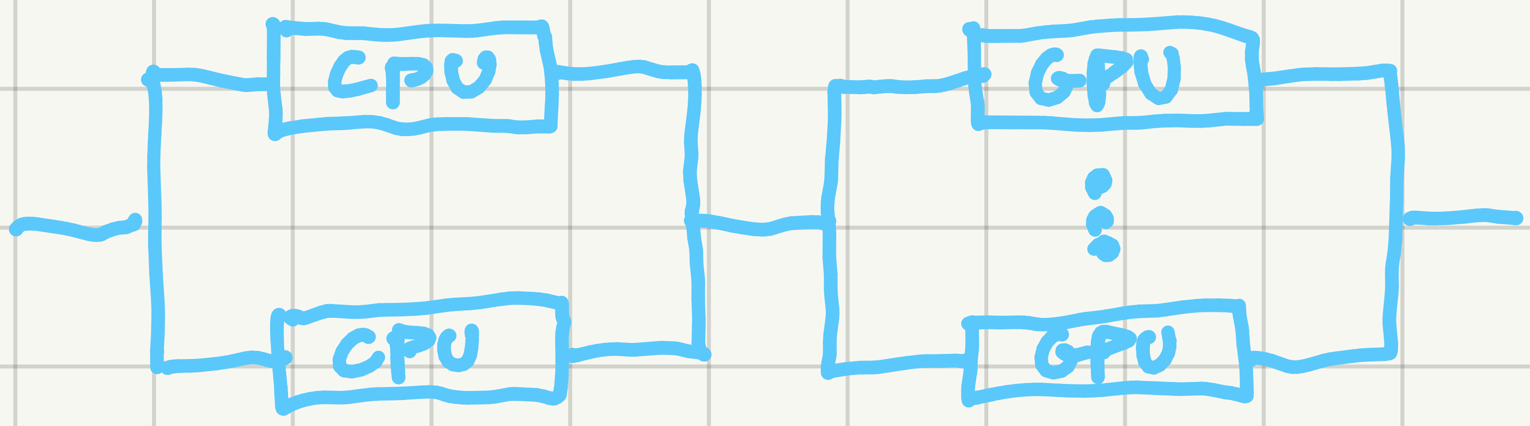
1

$N_{CPU}=2$ $MTTF_{CPU}=350$ DAYS $MTTF_{GPU}=250$ DAYS $t=80$ DAYS

$N_{GPU} \mid R(t)>0,85$?



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

$R(t)=R_{CPU}(t)\cdot R_{GPU}(t)>0,85$

$R_{CPU}(80\ DAYS)=e^{-\frac{80}{350}}=79,57\%$

$R_{CPU}(t)=1-(1-R_{CPU}(80))^2=95,82\%$

$R_{GPU}(80\ DAYS)=e^{-\frac{80}{250}}=72,61\%$

$0,9582\cdot(1-(1-R_{GPU}(80))^{N_{GPU}})>0,85 \Rightarrow N_{GPU}>1,68$ $N_{GPU}=2$

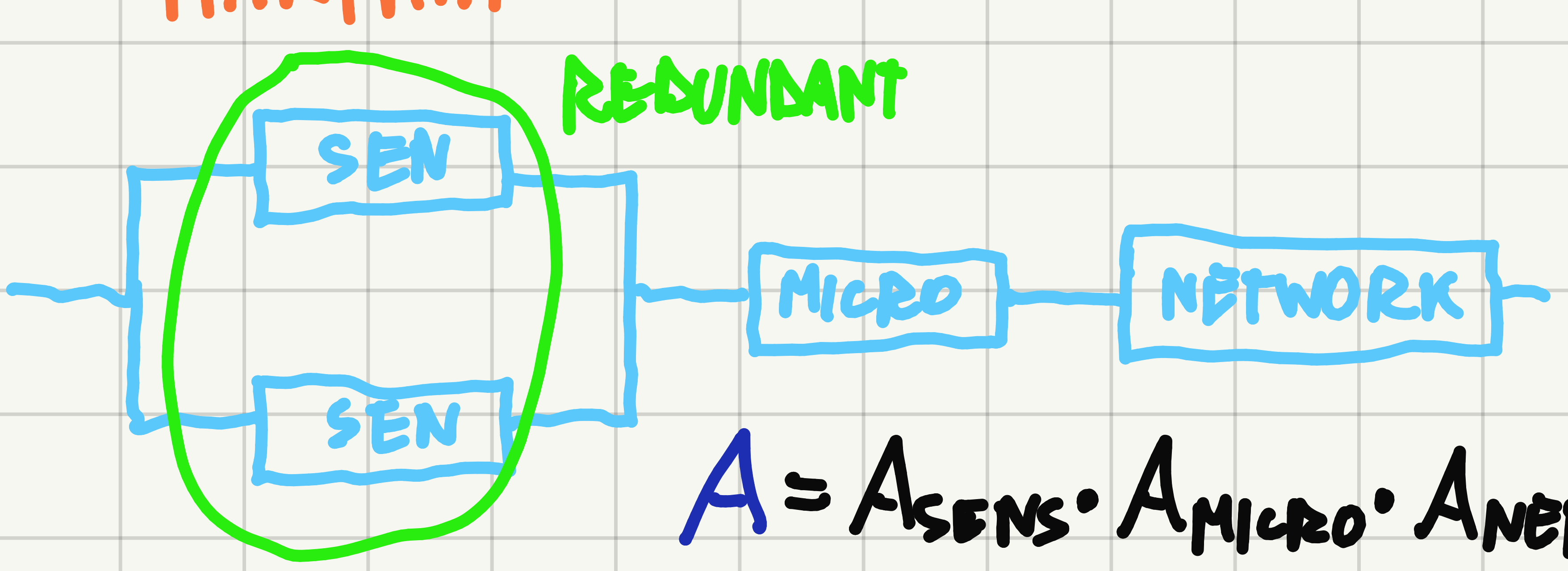
2

A?

$MTTR=3$ DAYS $MTTF_{SEN}=29$ DAYS $MTTF_{MICRO}=MTTF_{NETWORK}=19$ DAYS

$A=\frac{MTTF}{MTTR+MTTF}$

$A_{SEN}=\frac{29}{3+29}=90,63\%$ $A_{MICRO}=A_{NETWORK}=86,37\%$



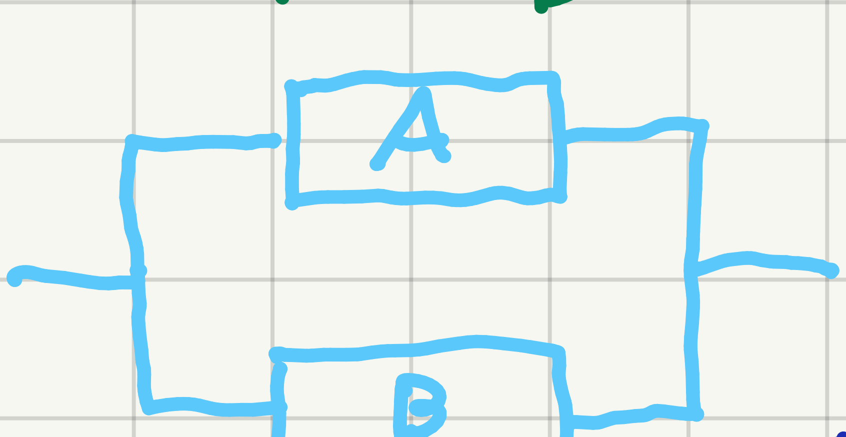
$A_{SENS}=1-(1-A_{SEN})^2=99,12\%$

$A=A_{SENS}\cdot A_{MICRO}\cdot A_{NETWORK}=73,94\%$

3

$MTTF_A=180$ DAYS $MTTR_A=1$ DAY $MTTF_B=12$ DAYS

$MTTR_B=1$ HOUR $=\frac{1}{24}$ DAYS $R(t=8\ DAYS)$?



$R_A=e^{-\frac{8}{180}}=95,65\%$ $R_B=e^{-\frac{8}{12}}=51,34\%$

$R(8\ DAYS)=1-[(1-R_A)(1-R_B)]=97,88\%$

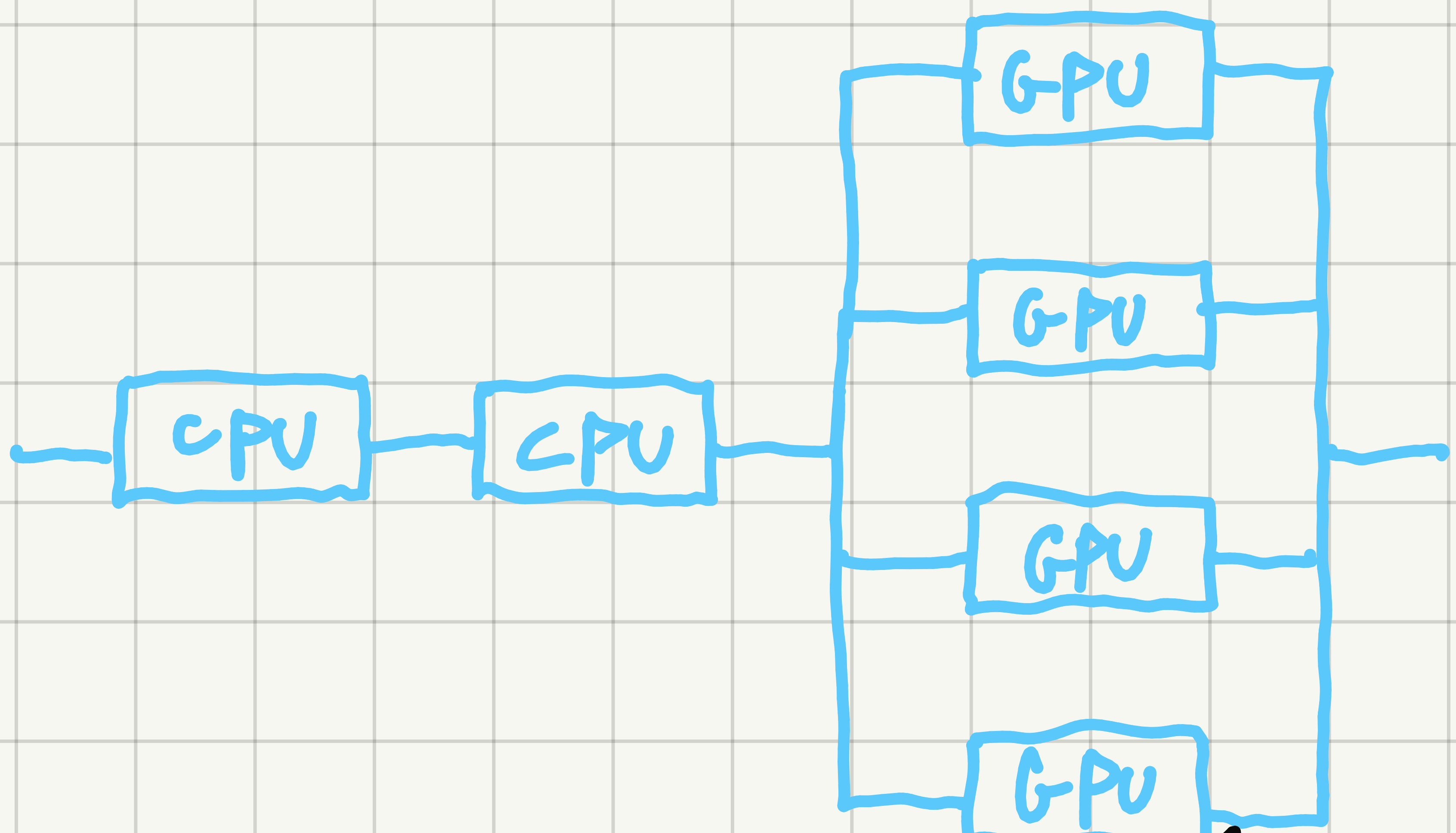
④ $A > 99{,}9999\%$ $MTTF = 800h$ $MTTR = 14\,m$ PARALLEL N?

$$A = \frac{MTTF}{MTTF+MTTR} = \frac{800 \cdot 60}{80060+14} = 99{,}970841\%$$

$$A_{TOT} = 1-(1-A)^N > 0{,}999999$$

$$(1-A)^N < 0{,}000001 \Rightarrow N = 1{,}69 \quad N = 2$$

⑤ $MTTF_{CPU} = 450$ DAYS $MTTF_{GPU} = 310$ DAYS $R(2\text{ YEARS})$?



$$R(t) = e^{-\frac{t}{MTTF}}$$

$$R_{CPU}(2\text{YEARS}) = 19{,}75\%$$

$$R_{GPU}(2\text{YEARS}) = 9{,}491\%$$

$$R(2\text{YEAR}) = R_{CPU}^2 \cdot \left(1-(1-R_{GPU})^4\right) = 1{,}28\%$$

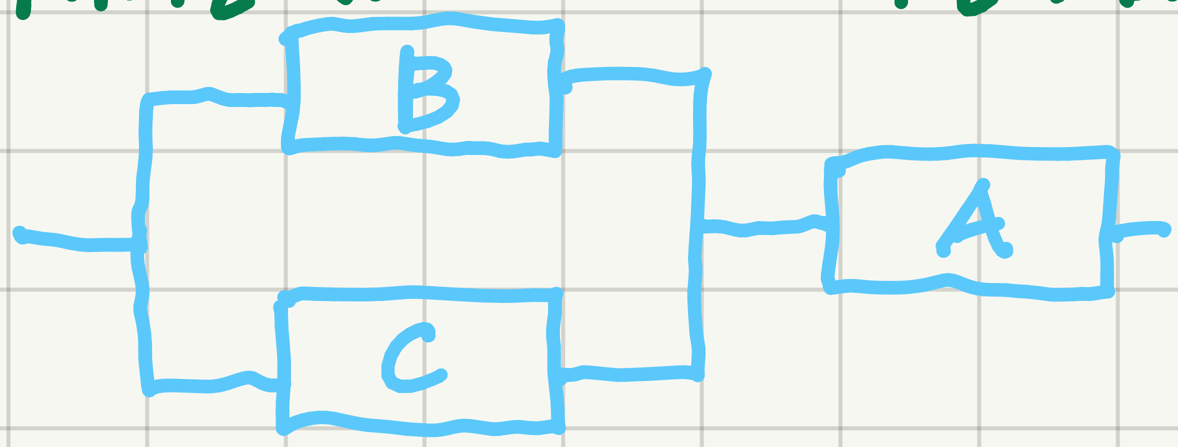
⑥ $N = 500$ IN SERIES $R(4\text{ DAYS}) = 0{,}9$ $MTTF$?

$$0{,}9 = \left(e^{-\frac{4}{MTTF}}\right)^{500} \qquad \ln(0{,}9) = -\frac{2000}{MTTF} \qquad MTTF = 18982 \text{ DAYS}$$

! EVEN THOUGH THE EXERCISE MENTIONS "COMPUTATION IS EXECUTED IN PARALLEL", WHAT'S IMPORTANT IS THAT "ALL THE SERVERS SHOULD BE UP AND RUNNING..."

⑦ $MTTF_A = 80$ DAYS $MTTR_A = 1$ DAY $MTTF_B = 12$ DAYS $MTTR_B = 12h = 0{,}5$ DAYS

$MTTF_C = 120$ DAYS $MTTR_C = 2$ DAYS A_{TOT}? $A_A = 98{,}77\%$ $A_B = 96\%$ $A_C = 98{,}36\%$



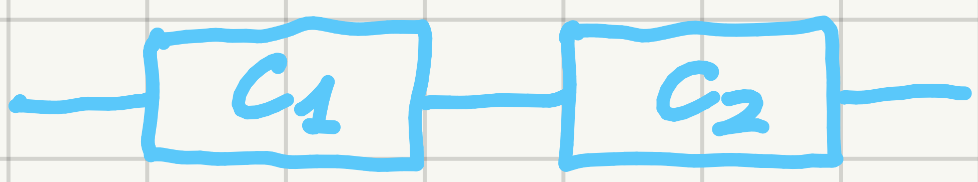
$$A_{TOT} = \left(1-(1-A_B)(1-A_C)\right) \cdot A_A$$

$$= 98{,}70\%$$

8. $R_{c1}=0{,}8$ $R_{c2}=0{,}92$ $t=365$ DAYS MTTR = 1 DAY A? (A) OR (B)?

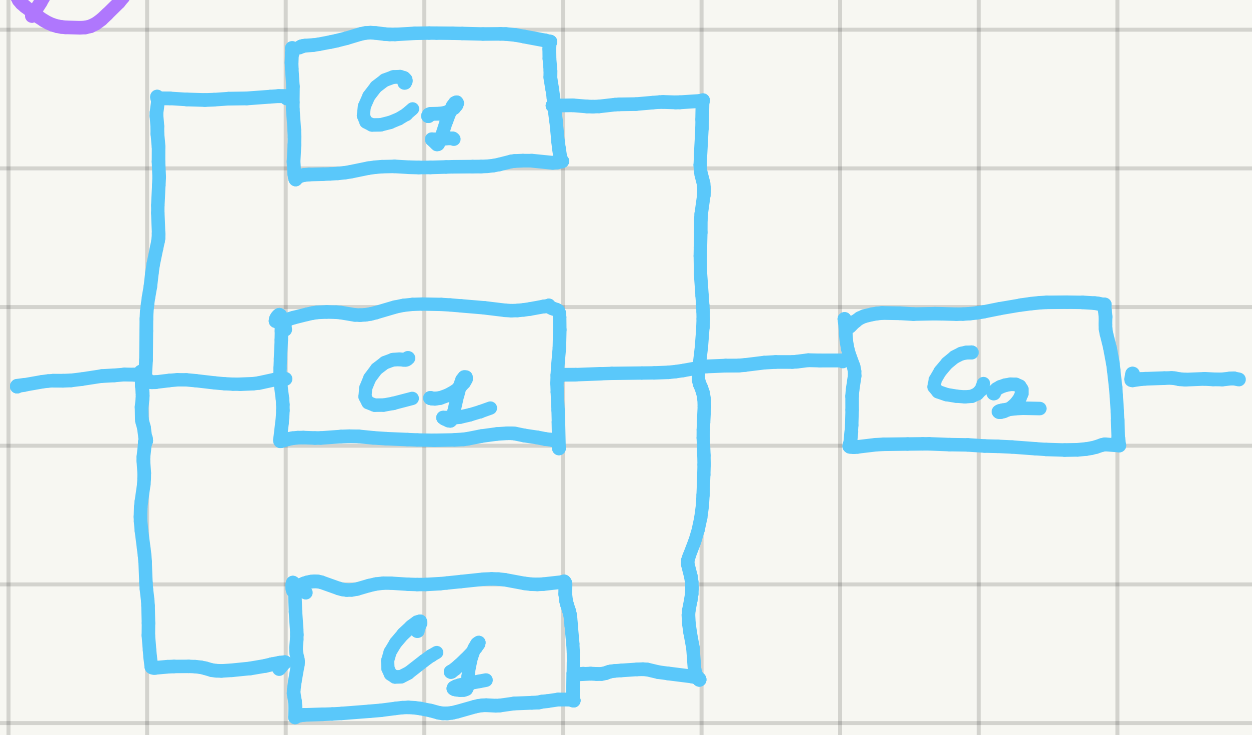
$R(t)=e^{-\frac{t}{MTTF}}$ $0{,}8=e^{-\frac{365}{MTTF_{c1}}}$ $-\frac{365}{MTTF_{c1}}=\ln(0{,}8)\rightarrow MTTF_{c1}=1635$ DAYS

SIMILARLY, $MTTF_{c2}=4377$ DAYS $A=\frac{MTTF}{MTTF+MTTR}$ $A_{c1}=99{,}94\%$



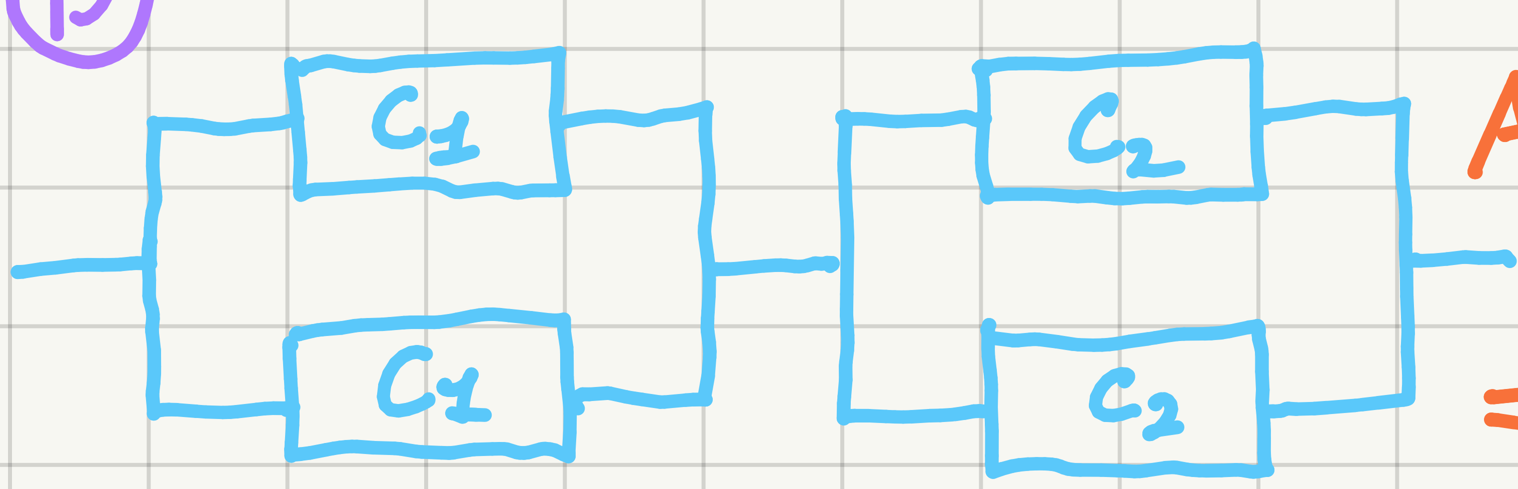
$A_{c2}=99{,}98\%$ $A=A_{c1}\cdot A_{c2}=99{,}92\%$

(A)



$A=(1-(1-A_{c1})^3)\cdot A_{c2}=99{,}979\%$

(B)



$A=(1-(1-A_{c1})^2]\cdot(1-(1-A_{c2})^2]$

$=99{,}9999\% \Rightarrow$ (B)

9. $A=99{,}96\%$ MTTR (SINGLE SYSTEM) = 15 DAYS MTTF?

REDUNDANT = IN PARALLEL

$A=1-\underline{[(1-A_{s1})(1-A_{s2})]}=1-\left(1-\frac{MTTF}{MTTF+MTTR}\right)^2=0{,}9996$

$\left(1-\frac{MTTF}{MTTF+15}\right)^2=0{,}0004$ $1-\frac{MTTF}{MTTF+15}=0{,}02$

$\frac{MTTF}{MTTF+15}=0{,}98$ $MTTF=0{,}98\,MTTF+14{,}7$ $MTTF=\frac{14{,}7}{0{,}02}=735$ DAYS

10. $A=99{,}99\%$ MTTF (SINGLE SYSTEM) = 150 DAYS MTTR?

$A=1-[(1-A_{s1})(1-A_{s2})]=1-\left(1-\frac{MTTF}{MTTF+MTTR}\right)^2=0{,}9999$

$\left(1-\frac{150}{150+MTTR}\right)^2=0{,}0001$ $1-\frac{150}{150+MTTR}=0{,}01$ $MTTR=1{,}515$ DAYS

11

$MTTF_{CPU} = 80$ DAYS $MTTF_{TPU} = 40$ DAYS $T = 12$ DAYS $R = 98\%$ N?

$R(T) = e^{-\frac{T}{MTTF}}$

$R_{CPU} = 86,07\%$ $R_{TPU} = 74,08\%$

$R = 54,88\%$ $R = 0,98 = 1 - (1-R)^N = 1 - (1 - 0,5488)^N$

$0,02 = 0,4512^N \Rightarrow N \geq 4,92$ $N = 5$

$-\frac{T}{14Y} = \ln(0,9)$

12

A) $T = 400h$ $MTTF = 1200h$ $MTTR = 3h$
B) $T = 500h$ $MTTF = 1300h$ $MTTR = 4h$
C) $T = 600h$ $MTTR = 5h$ MTTF | HIGHER RELIABILITY?

$R_A = e^{-\frac{400}{1200}} = 71,65\%$ $R_B = e^{-\frac{500}{1300}} = 68,07\%$

$\Rightarrow R_C > R_A \ (> R_B)$ $e^{-\frac{600}{MTTF}} > R_A$ $\frac{1}{12} = \frac{1,47}{x}$

$-\frac{600}{MTTF} > \ln(R_A)$ $MTTF > -\frac{600}{\ln(R_A)} = 1800h$

13 REDUNDANT A (SINGLE MODULE) $= 0,7$ $A_{TOT} \geq 0,98$ N?

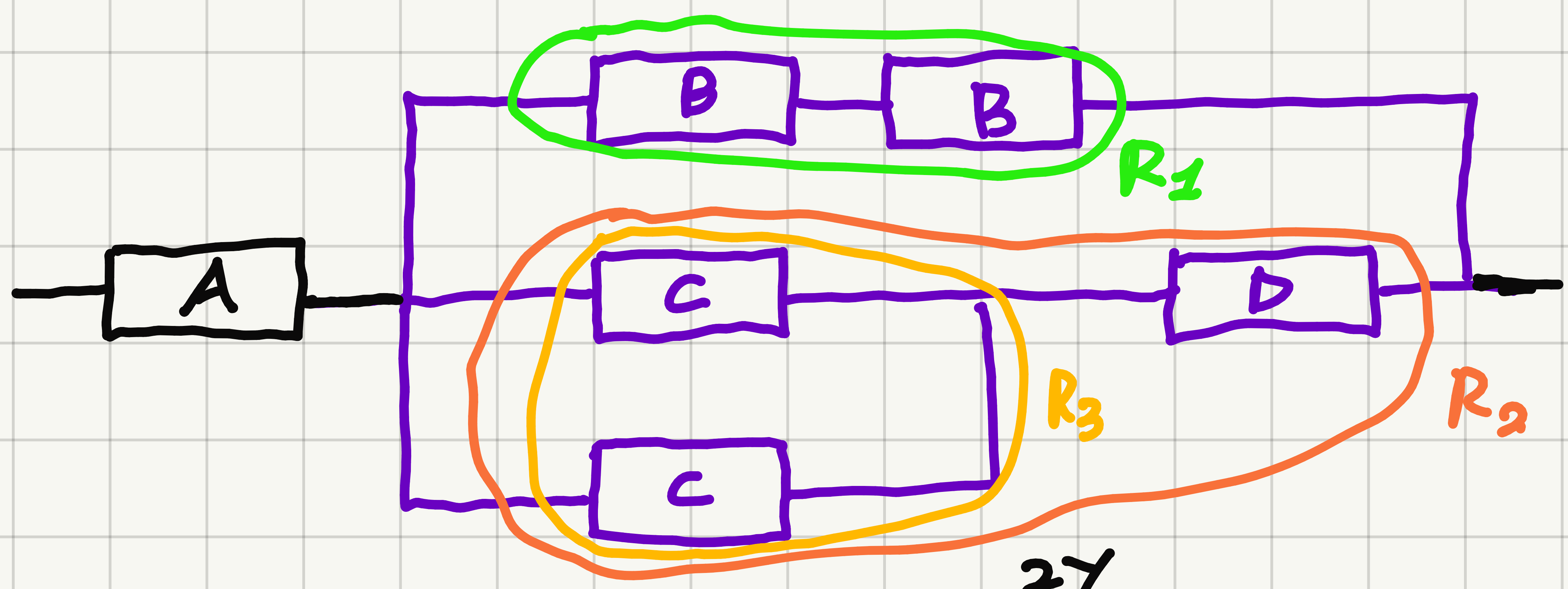
$A_{TOT} \geq 1 - (1 - A(\text{SINGLE MODULE}))^N$ $0.02 \leq 0,3^N$

$\log(0,02) \leq \log(0,3^N) = N\log(0,3)$ $N \geq \frac{\log(0,02)}{\log(0,3)} = 3,52$ $N = 4$

16 $MTTF = 14Y$ $R(T) > 0,9$ T?

$e^{-\frac{T}{MTTF}} > 0,9 \rightarrow T > -\ln(0,9) \cdot MTTF = 1,475Y$

17 $T=2Y \quad R_B=0{,}8 \quad R_C=0{,}6 \quad R_D=0{,}9 \quad R=0{,}82 \quad MTTF_A\,?$



$R = R_A \cdot R = 0{,}82 \qquad R_A = e^{-\frac{2Y}{MTTF_A}}$

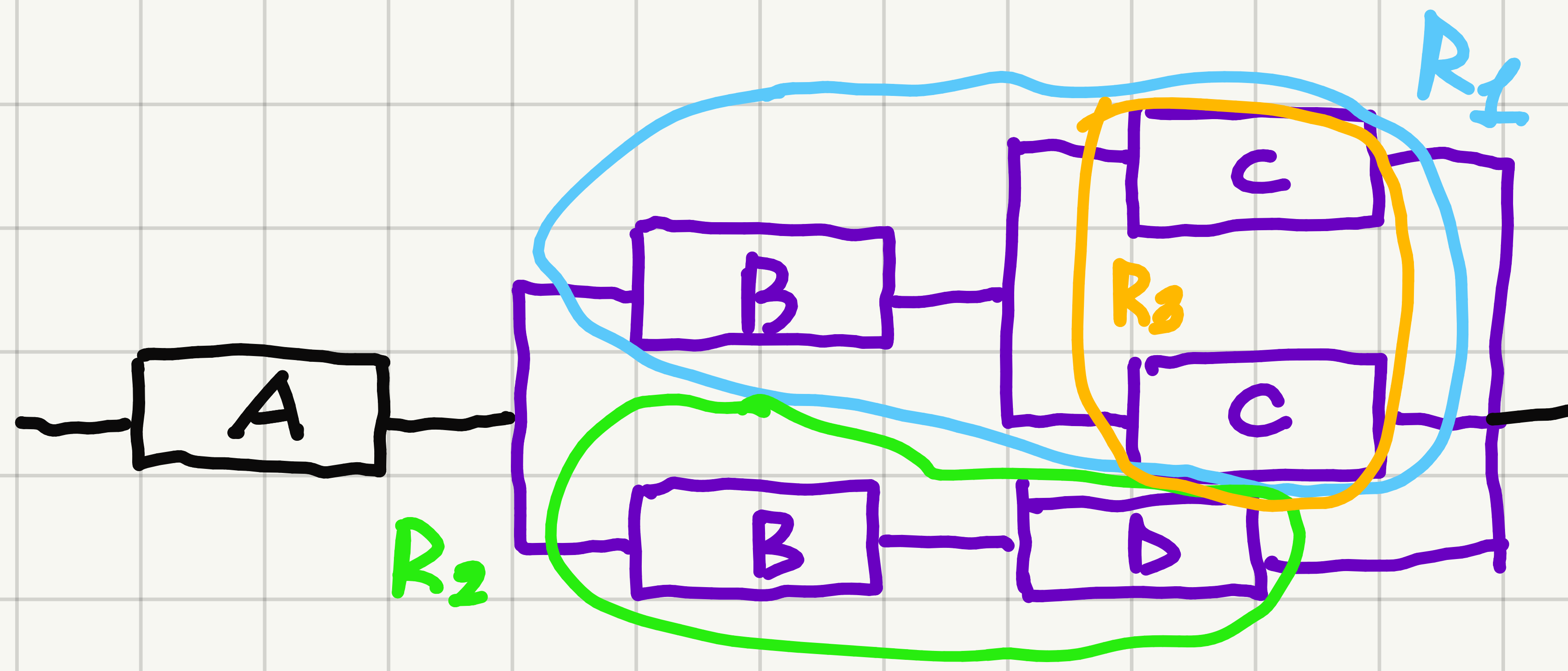
$R = 1-[(1-R_1)(1-R_2)] \qquad R_1 = R_B \cdot R_B \qquad R_2 = R_3 \cdot R_D$

$R_3 = 1-(1-R_C)^2 \Rightarrow R_3 = 0{,}84 \qquad R_2 = 0{,}756 \qquad R_1 = 0{,}64$

$R = 0{,}91216 \qquad R_A = \frac{0{,}82}{0{,}91216} = e^{-\frac{2Y}{MTTF_A}}$

$MTTF_A = \frac{-2Y}{\ln\left(\frac{0{,}82}{0{,}91216}\right)} = 18{,}777\,Y$

18 $T=2Y \quad R_B=0{,}8 \quad R_C=0{,}75 \quad R_D=0{,}9 \quad MTTF_A \mid R=0{,}85?$



$$R = R_A \cdot R = 0{,}85$$

$$R_A = e^{-\frac{2Y}{MTTF_A}}$$

$$R = 1-[(1-R_1)(1-R_2)] \qquad R_2 = R_B R_D = 0{,}72$$

$$R_1 = R_B \cdot R_3 \qquad R_3 = 1-(1-R_C)^2 = 0{,}9375 \Rightarrow R_1 = 0{,}75$$

$$R = 0{,}93 \qquad e^{-\frac{-2Y}{MTTF_A}} = 0{,}91398 \rightarrow MTTF_A = \frac{-2Y}{\ln(0{,}91398)} = 22{,}235Y$$

19 PARALLEL $R(5\ DAYS)=0{,}98 \quad T \mid R>0{,}85?$

$$R = 0{,}98 = e^{-\frac{5\ DAYS}{MTTF}} \Rightarrow MTTF = 247{,}492\ DAYS$$

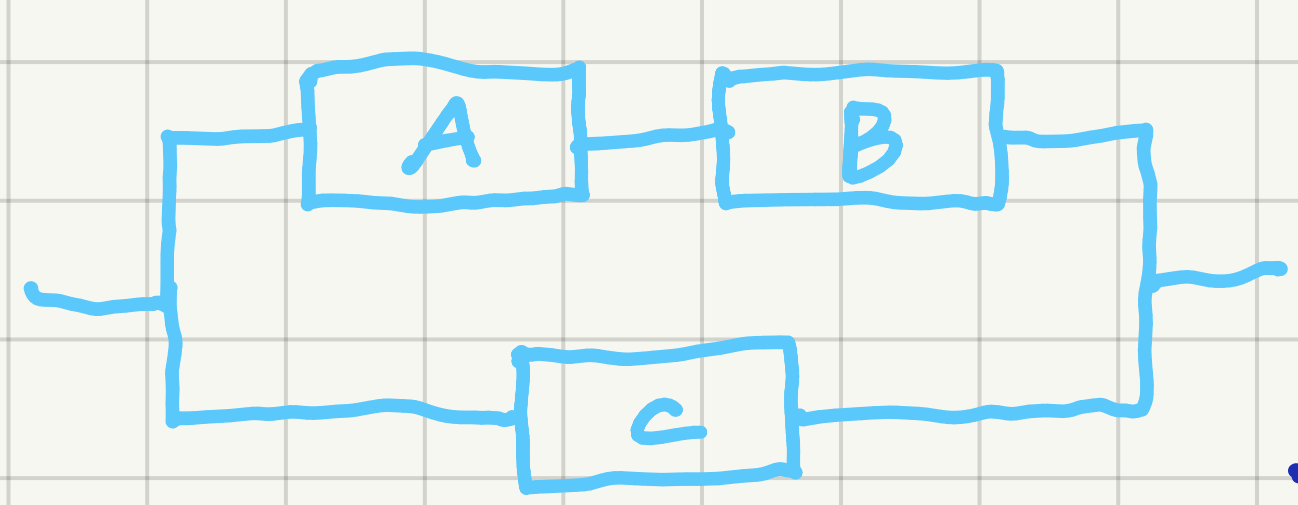
$$1-\left(1-e^{-\frac{T}{247{,}492}}\right)^2 > 0{,}85 \Rightarrow T_{MAX} = 121{,}24\ DAYS$$

20 $MTTF_A = 80\ DAYS \quad MTTR_A = 1\ DAY \quad MTTF_B = 12\ DAYS \quad MTTR_B = 0{,}5\ DAYS$

$MTTF_C = 120\ DAYS \quad MTTR_C = 2{,}5\ DAYS \quad A?$

$$A = \frac{MTTF}{MTTF+MTTR}$$

$= 97{,}96\%$



$A_A = 98{,}77\% \quad A_B = 96\% \quad A_C =$

$$A = 1-[(1-A_A \cdot A_B)(1-A_C)] =$$

$$= 99{,}894\%$$