Midterm Exam 2

Total Points: 20

Submission deadline: Monday (27.01.2025) at midnight.

Submit your files as a .zip folder with the name of your group.

Each submission should contain the code for Exercises 1 and 2, and a PDF file with the main results and plots.

You can submit directly on Canvas or send the .zip file over email to:

Andrej Stankovski

andrejst@ethz.ch

Exercise 1 (11 points)

One power plant has two identical generators connected in parallel logic. During normal operations, both generators are functioning. When one generator fails, the other must do the whole job alone, with a higher load. The generators are assumed to have exponentially distributed failure times:

$\lambda_H = 1.0 * 10^{-3}\ h^{-1}$ when the generators are bearing 'half load'.

When one of the generators fail, the other bears the full load, which increases its failure rate 5 times.

Additionally, an earthquake may fail both generators at the same time. The failure rate with respect to this common cause failure transition has been estimated to be $\lambda_c = 3.0 * 10^{-4}\ h^{-1}$. This type of external stress may affect the system irrespective of how many generators are functioning when the earthquake occurs.

Repair is initiated as soon as one of the generators fails. The mean time to repair one generator, μ^{-1}, is 10 hours. When both generators are in the failed state, the whole power station has to be shut down. In this case, the power station will not be put into operation again until both generators have been repaired. The mean downtime, μ_B^{-1}, when both generators are failed, has been estimated to be 60 hours.

A) Establish a state-space diagram for the system (label the states as the number of active generators in that state). Determine the steady state probabilities and availability of the system. Comment on the findings. (P: 1)

B) Create an INDIRECT Monte-Carlo simulation to find the time-dependent (un)reliability and (un)availability, assuming a mission time of Tm = 4 years. (P: 6)

C) Calibrate the number of trials N, such that the mean variance of the unavailability from 3 separate estimations is lower than **$5 \cdot 10^{-6}$**. Hint: To speed up the code, use large incremental steps (>300 trials). (P: 2)

D) When can we expect the reliability of the system to reach zero? (P: 1)

E) Plot the (un)availability obtained in B) and compare it to the results from the steady state analysis. Comment on the findings. (P: 1)

Exercise 2 (9 points)

Using the same system as in Exercise 1:

A) Develop a DIRECT Monte-Carlo simulation for a mission time Tm = 4 years and calibrate the number of trials N using the same stopping criterion. (P: 7)

B) Although the failure rate of the two generators is identical, the randomness of the process might result in one of the generators to fail more often. Perform a set of 10 runs and determine which of the generators (on average) failed and was recovered more often. Explain why this is the case. (P: 2)