SH2704 Monte Carlo Methods and Simulations in Nuclear Technology

Oral Exam Questions

Jan Dufek

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- On the next pages you'll find 60 questions split into five sets.
- During the exam, a polyhedral dice (with 12 sides) will be used to select a question from each set.
- You can get up to 6 points for each question (30 points max for all questions).
- We will have about 30 minutes for all questions.

Question Set A:

1. Summarize general advantages and disadvantages of the Monte Carlo method for neutron transport simulations (as compared to deterministic methods).
2. What is the expectation value and the variance of a random variable and how can we compute it?
3. What is the standard deviation of a random variable?
4. What qualities a good RNG should have?
5. How does the linear congruential generator (LCG) work?
6. Describe the inverse transform method.
7. Describe the acceptance-rejection method.
8. What does the central limit theorem say?
9. How can we estimate the variance of the mean value (obtained by the simple sampling method)?
10. How can we estimate the probability that the accurate result lies in some confidence interval around the mean value (computed by the simple sampling method)?
11. How can we measure the efficiency of Monte Carlo simulations? What is the aim of the so-called "variance reduction methods"?
12. What is the principle of the control variate technique?

Question Set B:

1. What is the principle of the correlated sampling method?
2. What is the principle of the stratified sampling?
3. What is the principle of the importance sampling?
4. What procedures are involved in the simulation of a single neutron history?
5. What is the transition kernel?
6. How can we sample the distance to the next collision in a homogeneous system?
7. How can we sample the distance to next collision in inhomogeneous media?
8. How can we select the nuclide on which the neutron collides?
9. How can we select the type of the collision reaction?
10. What are the principle problems in criticality simulations?
11. How are criticality problems simulated by Monte Carlo?
12. How is the multiplication factor calculated in criticality calculations?

Question Set C:

1. What are all the parameters that need to be set by the user in criticality simulations?
2. What is the dominance ratio of a system?
3. How does the convergence rate of criticality simulations relate to the dominance ratio of a system?
4. Which systems have a large (and small) dominance ratio?
5. Is it possible to decrease the dominance ratio of a system in order to accelerate the convergence of the fission source?
6. What is the bias in the fission source and how it differs to the random noise in the source?
7. What effect does the source bias have on the computed multiplication factor in criticality simulations?
8. How can we lower the bias in the fission source and k-eigenvalue?
9. What is the advantage/disadvantage of a small/large neutron batch size in criticality simulations?
10. What should we consider when we optimise the batch size in criticality simulations?
11. Decribe the burnup equation.
12. What is the formal solution of the burnup equation?

Question Set D:

1. What are the common coupling schemes employed in Monte Carlo burnup simulations?
2. Describe the explicit Euler based coupling scheme for MC burnup simualtions.
3. Describe the predictor-corrector based coupling scheme for MC burnup simualtions.
4. Describe the mid-point method based coupling scheme for MC burnup simualtions.
5. Describe the implicit Euler method based coupling scheme for MC burnup simualtions.
6. Comment on the numerical stability of various coupling schemes for MC burnup simualtions.
7. What are the factors affecting the numerical stability of MC burnup simualtions?
8. What is the difference between the calculations of saturated and equilibrium xenon?
9. What are the factors affecting the efficiency of MC burnup simualtions?
10. Describe the idea of the Delta tracking method?
11. What are the advantages/disadvantages of the Delta tracking method?
12. What is the difference between the analog and non-analog Monte Carlo simulations?

Question Set E:

1. Describe the idea of the implicit capture.
2. Describe the Russian roulette method and its purpose.
3. How is the fission source for next cycle sampled in non-analog Monte Carlo simulations?
4. Describe how the neutron flux is computed by the collision estimator.
5. Describe how the neutron flux is computed by the path-length estimator.
6. Describe the principle of the exponential transformation variance reduction method.
7. Describe the principle of the geometry splitting variance reduction method.
8. Describe the principle of the weight-window variance reduction method.
9. Comment on efficiency of parallel fixed-source and criticality Monte Carlo simulations.
10. Describe the master/slave scheme for parallel Monte Carlo criticality simulations.
11. What is the purpose of running independent parallel Monte Carlo criticality simulations.
12. Summarize advantages/disadvantages of the master/slave scheme and the independent parallel simulations.