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NPRE 560 Oleksandr Yardas Fall 2024
HW 1 Due 2024.09.09

- Show your work.
- This work must be submitted online as a `.pdf` through Compass2g.
- Work completed with LaTeX or Jupyter earns 1 extra point. Submit source file (e.g. `.tex` or `.ipynb`) along with the `.pdf` file.

+1

- If this work is completed with the aid of a numerical program (such as Python, Wolfram Alpha, or MATLAB) all scripts and data must be submitted in addition to the `.pdf`.
- If you work with anyone else, document what you worked on together.

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1. (20 points) Review any resource on the use of `git` and GitHub until you feel confident that you will be able to use GitHub Classroom to turn in your three computational projects. Create a GitHub account and provide your GitHub username as an answer to this question.

   Solution: My GithHub username is `yardasol`

2. (10 points) (Ott Review Question 1.1) State three areas of kinetics or dynamics applications.

   Solution: Kinetics refers to time-dependent phenomena over a short time scale, on the order of milliseconds to seconds, without considreing feedback effects. Dynamics is the same but with consideration of feedback effects. Three areas where we apply kinetic theory are:

   1. Reactor stabiltiy analysis w.r.t. neutron flux changes (kinetics and dynamics)
   2. Accident transients (e.g. LOCA) (dynamics)
   3. Time-dependent experiments, such as the Dragon criticality experiment or a neutron pulse.

3. (10 points) (Ott Review Question 1.4) What is the main difference in the balance equations for the neutron flux in reactor dynamics versues fuel cycle analysis?

   Solution: In the balance equation for fuel cycle analysis, we must consider nuclide transmuation, where in the balance equation for reactor dynamics we assume the nuclide composition to be static.

4. (Ott Homework Question 2.1)

(a) (10 points) Calculate the average energy $\bar{E}_k$, of the delayed neutron groups 1 through 4, using the emission spectra $\chi_{dk}(E)$ given in table 2-V.

Solution: I used Python to calculate the average energies:

- $\overline{E}_1 = 10.34$ keV
- $\overline{E}_2 = 18.62$ keV
- $\overline{E}_3 = 15.10$ keV
- $\overline{E}_4 = 17.58$ keV

(b) (10 points) Compare these values with $\bar{E}$ for the total $\chi(E)$ given in the same table and with $\bar{E}_k$ of Table 2-IV.

Solution: I used Python to calculate $\overline{E} = 1641.4$ keV for the total emission spectra from Table 2-V. This is much greater than the average delayed neutron energies for all delayed groups, which is what we expect as the total spectra included prompt neutrons which are emitted at higher energies. The average energies for neutrons from delayed groups 1 through 4 calculated from Table 2-V are roughly half the magnitude of the average energies for the same delayed groups given in Table 2-IV. It's not entirely clear, but I assume this is because the values in Table 2-V are based on theoretical caclulations. It is also unclear which isotopes the given emission spectra are for in Table 2-V.

5. (10 points) (Ott Review Question 2.5) Give approximately the total precursor yields of ^{235}U, ^{238}U, and ^{239}Pu.

Solution: The delayed neutron yield is more or less the same as the precursor yield, so we use the delayed neutron yield to calculate the precursor yield. Based on the yields in Table 2-I, the total precursor yield for ^{235}U is 0.0165, for ^{238}U is 0.0412, and for ^{239}Pu is 0.0063

6. (10 points) (Ott Review Question 2.8) How many delayed neutron groups (families) are generally used per fissioning isotope?

Solution: 6, sometimes 8

7. (10 points) (Ott Review Question 2.9) What is the disadvantage of using isotope-dependent decay constants?

Solution: Isotope-dependent decay constants can be very difficult to measure. Some of them are clustered together very closely, so differentiating the decay of one isotope from another can be challenging. This one of the reasons why we use delay groups in the first place.

also, too many eqns.

8. (10 points) (Ott Review Question 2.12) Give the approximate mean lifetime of the slowest and the fastest decaying precursor group.

Solution: The mean lifetime is simply $T = \frac{1}{\lambda}$. Using values from Table 2-III for a single set of decay constants, the slowest decaying precursor group has $\lambda = 0.0129\ s^{-1}$, so the mean lifetime is $T = 77.5$ s. The fastest decaying precursor group has $\lambda = 3.21\ s^{-1}$, so the mean lifetime is $T = 0.312$ s, and the fastest decaying precursor group