

## Homework 06 (21Nov22)

Name: your name

Rubric for each assignment:

Context	Points
Precision of the answer	80%
Answer Markdown readability	10%
Code readability	10%

### Guidance:

- This is an individual homework.
- Upload your answers in the Blackboard submission portal as:  
**lastname-firstname-homework-xx.pdf** or **lastname-firstname-homework-xx.ipynb**

### Table of Problems

- **Problem 1 (20 pts)** Neutron absorption.
- **Problem 2 (20 pts)** Neutron slowing down.
- **Problem 3 (20 pts)** More on neutron slowing down.
- **Problem 4 (10 pts)** Resonance cross section origin.
- **Problem 5 (10 pts)** Neutron energy range.
- **Problem 6 (10 pts)** Neutron spectra.
- **Problem 7 (10 pts)** Properties of neutron moderators.

### Problem 1 (20 pts)

A 5-cm thick layer of purely absorbing material is found to absorb 99.9% of a neutron beam. The material has a nuclide number density of  $4 \times 10^{22}$  nuclei/cm<sup>3</sup>. Calculate the following:

**1.1)(5 pts)** The macroscopic cross section.

Answer:

**1.2)(5 pts)** The mean free path. Explain the formula you used.

Answer:

**1.3)(5 pts)** The microscopic cross section.

Answer:

**1.4)(5 pts)** Is the cross section as big as a barn? Explain.

Answer:

### Problem 2 (20 pts)

What is the minimum number of elastic scattering collisions required to slow a neutron down from 1 MeV to 1 eV in the materials below.

Formulae:

- Head-on energy loss ratio:  $\alpha = \left(\frac{A-1}{A+1}\right)^2$
- Slowing down decrement:  $\xi := \overline{\ln(E/E')} = \int \ln(E/E') p(E \rightarrow E') dE' = 1 + \frac{\alpha}{1-\alpha} \ln \alpha$

- Elastic scattered energy probability distribution function:  $p(E \rightarrow E') = \begin{cases} \frac{1}{(1-\alpha)E} & \text{if } \alpha E \leq E' \leq E \\ 0 & \text{otherwise} \end{cases}$

**2.1)(5 pts) Hydrogen.**

Answer:

**2.2)(5 pts) Deuterium.**

Answer:

**2.3)(5 pts)  $^{12}\text{C}$ .**

Answer:

**2.4)(5 pts)  $^{238}\text{U}$ .**

Answer:

**Problem 3 (20 pts)**

In contrast to Problem 3, assuming that any elastic collision in Problem 2 loses the average value,  $\xi$ , repeat the calculation of the number of elastic collisions for the same materials and compare with the results in Problem 2.

**3.1)(5 pts) Hydrogen.**

Answer:

**3.2)(5 pts) Deuterium.**

Answer:

**3.3)(5 pts)  $^{12}\text{C}$ .**

Answer:

**3.4)(5 pts)  $^{238}\text{U}$ .**

Answer:

**Problem 4 (10 pts)**

Explain the origin of resonance peaks in the scattering cross sections of heavy nuclides.

Answer:

**Problem 5 (10 pts)**

What are the significant neutron energy ranges in nuclear reactors? Provide the bounds and names of the regions.

Answer:

**Problem 6 (10 pts)**

Why all working nuclear reactors either use the thermal or fast neutron spectrum? What is the issue in between these spectra?

Answer:

### Problem 7 (10 pts)

What are the desired properties of a neutron moderator material? List three quantities used to assess the effectiveness of a moderator material and define these quantities?

Answer: