Problem Set 2

22.211 Fall 2023

Due Date 2/22/2023

Question 1

Write a Monte Carlo code that simulates the slowing down process in an infinite medium of a neutron source at 1 MeV down to 1 eV assuming isotropic elastic scattering in the COM with a constant cross-section (use the potential scattering provided by ENDF/B-VIII for each given nuclide).

For the following nuclides: H-1, H-2 and C-12:

a) Plot the flux spectrum over equal energy bins
b) Plot the flux spectrum over equal lethargy bins
    i. Do you notice any difference between the H-1 and the H-2/C-12 plots? Discuss the cause of these differences.
c) Calculate the number of collisions needed to go from 1 MeV to 1 eV (mean and std. deviation)
    i. Compare to analytical estimates

Question 2

Using the SLBW model with following parameters:

Γ_n = 1.577952E-02 eV
Γ_g = 2.300000E-02 eV
E_0 = 9.251992E+02 eV
a = 0.94800 barns$^{0.5}$
A = 238

a) Calculate analytically the **maximum value** of the absorption cross-section at 0K.
b) Find (analytically) the **two energy points** at which the absorption cross-section is **equal to half its peak at 0K**
c) Calculate analytically the **maximum value** of the scattering cross-section at 0K **and the location** of the scattering peak.
d) Plot the cross-section at 0K, 1000K and 5000K

Question 3

Starting from the following distribution:

$$f(x) = \frac{C}{1+(x-3)^2} \qquad for \quad x \in [-\infty, \infty]$$

a) Calculate the constant C to make f(x) a Probability Distribution Function (PDF).
b) Compute the Cumulative Distribution Function (CDF).
c) Derive a direct sampling scheme using a uniform random number between 0 and 1.
d) Write a rejection sampling scheme in the [-47,53] range (renormalize the pdf) and numerically compute the efficiency of the sampling scheme.