NE585 – Nuclear fuel cycle analysis
Project 2 – Interaction of radiation with matter

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Total – 200

1 Elastic scattering

(20)

Derive the elastic scattering energy equation for neutrons.

2 Maxima and minima energies

(10)

Based on this, derive the minimum and maximum scattered neutron energies.

3 Average energy

(10)

Derive the average energy of the scattered neutron and the average energy loss.

4 Mass limit

(10)

Find the limit of α with increasing A. What are the implications?

5 Fractional energy loss limit

(10)

Do the same for average fractional energy loss versus α.

6 Materials analysis

(10)

Based on this, what materials are more attractive for slowing down neutrons and why?

7 Lethargy functional behavior

(10)

Plot ξ versus A. What are the major observations and implications?

8 Lethargy derivation

(20)

Derive ξ. Apply the definition of expected value for a continuous random variable and the probability distribution per unit energy loss. *The probability distribution can just be looked up and not derived, but please explain the functional behavior.*

9 Materials functional behavior on collisions

(10)

Plot the average number of collisions versus A for a 2 MeV neutron slowing down to 0.025 eV, for water, boron, carbon, sodium, and uranium. Comment on the results.

10 Inelastic scattering

(10)

Is an inelastic scattering endothermic or exothermic? Please explain why. Similarly, is radiative capture endothermic or exothermic? *Show with math.*

11 Materials for neutron capture

(15)

Why is boron an attractive neutron capture material?

12 Mean free path

(15)

Compute and plot the mean free path for scattering and absorption versus mass for water, boron, carbon, sodium, and uranium and comment on the results. How does this compare to (9)?

13 Maxwell - Most probable energy and velocity

(25)

For thermal $(1/v)$ neutrons derive and compute (produce an actual number) -

(i) the most probable velocity,
(ii) the energy associated with the most probable velocity, and
(iii) the most probable energy.

Why is the energy associated with the most probable velocity not the same as the most probable energy?

14 Maxwell - Mean energy and velocity

(25)

Derive and compute (produce an actual number) mean energy and velocity of thermal ($1/v$) neutrons. How and why do these compare to the most probable velocity and energy?

15 Shielding analysis

(30)

Consider two Ar filled rooms of 10 m wide (x) by 20 m long (y). A neutron source is located at the midpoint of the eastern room. A concrete wall of x thickness separates the two rooms. How thick should the wall be to reduce the flux at the detector on the far western wall to 1%? What would be the thicknesses for a lead-lined, concrete wall? Roughly compare the costs for each shielding material by deriving a cost function. Consider only scattering and absorption. *See Figures* **??** *and* **??**.

Tables

Figures

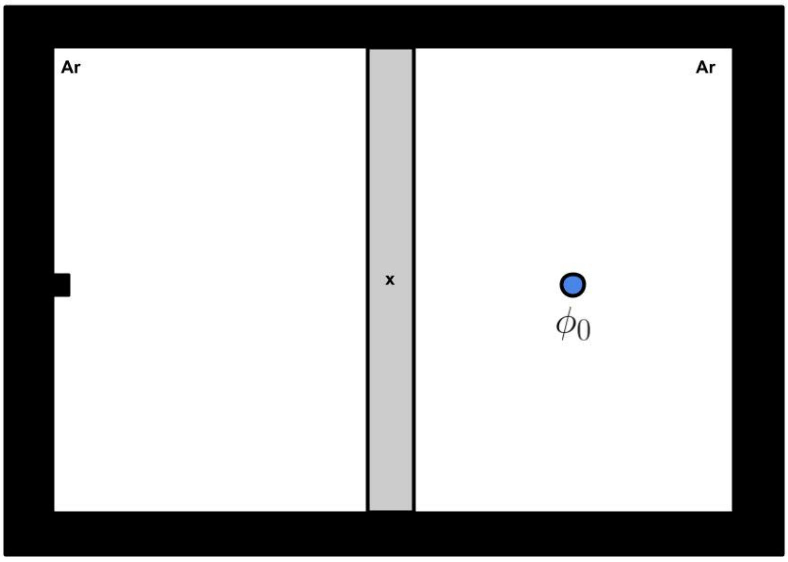

Figure 1. Concrete wall

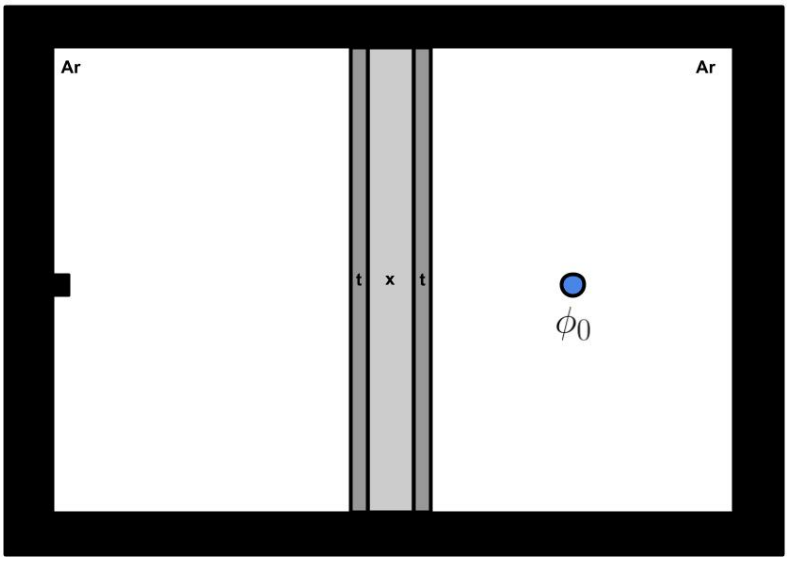

Figure 2. Lead-lined concrete wall