UNIVERSITY OF REDDIT — Nuclear Reactor Physics : Neutronics

Homework 4: The Diffusion Equation

The number of stars gives the estimated difficulty of an exercise, though I must say they are not a very trustworthy notation system since I do not really know what you will find challenging or not.

You can either write your answer through :

- Google Docs document (insert > Equation... > type your question using LateX-like directives or select manually the formulas you want to introduce).
- Any word processor that supports equations (Word, LibreOffice,...)
- Good ol' paper and pencil, then scan your solutions.
- Virtually any other method you can think of, as long as I can read it

You can then send that to me by:

- Email at NuclearEngineer@ureddit.com
- Dropbox/Google docs link
- Use of the "send your answer" form (select the homework/quiz you are answering to, write your Ureddit username, upload your document and submit !)
- Virtually any other method you can think of, as long as I can receive it

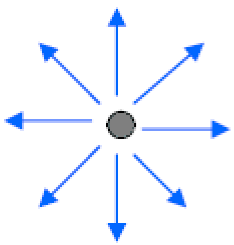
I will acknowledge receipt of your email/message within two days or so, so that you don't worry that it did not reach me.

Please let me know at the end of your homework if you want a partial correction (i.e. hints toward the good answer if your answer is not correct, so that you can try it again if you want), or a total correction (complete solution to the problems).

Once again, I remind you about the discussion platform, if you have any trouble with the math or if you're thinking "how the hell do I answer that ? I'm stuck !"

Exercise n°1: The point Kernel ✪✪

Your objective is to calculate the flux due to a point isotropic source in a homogeneous infinite medium.



$S(r) = S.\delta(r)$

First hint: Write the diffusion equation in 1D spherical geometry.
Second hint: We have one infinite medium. The "boundary" conditions are thus:

$$\lim_{r \to \infty} \phi(r) = 0$$
$$\lim_{r \to 0} 4\pi r^2 J(r) = S$$

The first condition is kind of obvious. The flux is 0 at an infinite distance from the source point. The second condition translates the neutron conservation.

Exercise n°2: k_∞ for a homogeneous medium ✪

In the case of an infinite homogeneous medium, show that:

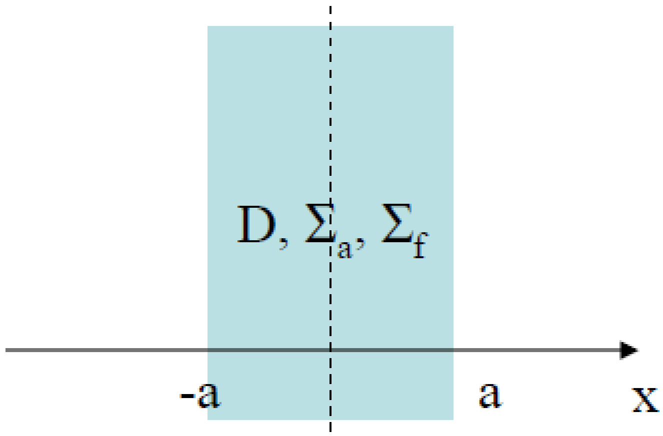
$$k_\infty = \frac{\nu\Sigma_f}{\Sigma_a}$$

$\nu\Sigma_f$ represents the productions (fissions)
Σ_a represents the absorptions

Hint: In an infinite, homogeneous system, we have a flux that does not depend on the space.

Exercise n°3: The critical slab ✪✪

In this exercise, we consider a homogeneous slab that we want to be critical.



1. Show that:

The form of the flux is:

$$\phi(x) = A.\cos\left(\frac{\pi x}{2a}\right)$$

The critical condition is:

$$\frac{k_\infty - 1}{L^2} = \left(\frac{\pi}{2a}\right)^2$$

Where $L^2 = \frac{D}{\Sigma_a}$.

2. You can also obtain the form factor F. That is the ratio between the maximum power $P_{\max}$ (the power is proportional to the flux) and the average power P_{moy}.

If you want more exercises on this subject, do not hesitate to contact me.