

- Show your work.
- This work must be submitted online as a **single .pdf** file through gradescope.
- If you worked together with another student in the course, please document who you worked with and on what.
- If you used a numerical program (such as Python, Wolfram Alpha, etc.), all scripts must be submitted in addition to the .pdf. You may submit these via email to Sun Myung and myself.

1. (10 points) We have defined the angular neutron density $n(\vec{r}, \hat{\Omega}, E, t)$ in terms of the neutron energy E and the direction of motion $\hat{\Omega}$, but one could define an angular density that depends instead on the neutron velocity \vec{v} , $n(\vec{r}, \vec{v}, t)$. Calculate the relationship between these two dependent variables.
2. Prove the following relationships:
 - (a) (5 points) $n(\vec{r}, \hat{\Omega}, E, t) = \left(\frac{1}{mv}\right) n(\vec{r}, v, \hat{\Omega}, t)$
 - (b) (5 points) $n(\vec{r}, v, \hat{\Omega}, t) = v^2 n(\vec{r}, \vec{v}, t)$
3. Two thermal neutron beams are injected from opposite directions into a thin sample of ^{235}U . At a given point in the sample, the beam intensities are 10^{12} neutrons / $\text{cm}^2\text{-s}$ from the left and $2 * 10^{12}$ neutrons / $\text{cm}^2\text{-s}$ from the right. Compute:
 - (a) (10 points) the neutron flux and current density at this point
 - (b) (10 points) the fission reaction rate density at this point
4. Suppose that the angular neutron density is given by:

$$n(\vec{r}, \hat{\Omega}) = \frac{n_0}{4\pi} (1 - \cos\theta)$$

where θ is the angle between $\hat{\Omega}$ and the z-axis. If A is the area perpendicular to the z-axis, then what is the number of neutrons passing through the area A per second:

- (a) (5 points) per unit solid angle at an angle of 45 degrees with the z-axis,
 - (b) (5 points) from the negative z to the positive z direction,
 - (c) (5 points) net
 - (d) (5 points) total
5. (20 points) A purely absorbing half-plane medium, in which $\Sigma = 1$, contains a source emitting $1 \left[\frac{n}{\text{cm}^3\text{s}} \right]$. Determine the intensity and angular distribution of the flux and the current at the surface. (Bell and Glasstone 1.3)
6. (20 points) Suppose there is a purely absorbing region of finite thickness. It is desired to represent this region as an absorbing region across which the neutron angular density is discontinuous. Derive the discontinuity which is required in the angular density. (Bell and Glasstone 1.10)