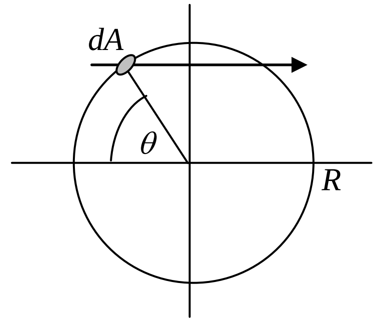
NUCL 510 Nuclear Reactor Theory I
Fall 2011

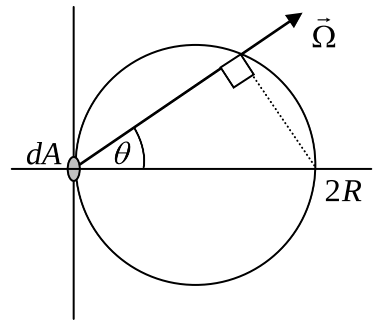
HW#4: Neutron Interactions

Due September 22

1. A spherical target of radius R is placed in a mono-directional beam of neutrons of intensity I. The area of the beam is larger than the cross sectional area of the sphere. Show that the total reaction rate within the sphere in such a beam is equal to the reaction rate when the sphere is completely immersed in an isotropic flux of magnitude equal to I.



   (Hint) For the mono-directional beam, consider the number of neutrons coming into the sphere through an incremental area dA at an angle θ with respect to the beam direction and then the number of interactions made by these neutrons over the traveling path $2R\cos\theta$ within the spherical target. Similarly, for the isotropic flux case, consider the number of neutrons passing through an incremental area dA into an incremental solid angle $d\Omega$ about $\vec{\Omega}$ and then the number of interactions made by these neutrons within the spherical target.



2. Let f_k be an eigenfunction of an operator A corresponding to eigenvalue a_k, and let g_l be an eigenfunction of the adjoint operator A^* with eigenvalue b_l. Show that either b_l is the complex conjugate of a_k the eigenvector g_l is orthogonal to f_k.

3. Represent $x^5 - x^3$ in terms of Legendre polynomials $P_n(x)$.

4. Represent the following functions in terms of spherical harmonics functions $Y_{lk}(\theta,\varphi)$, where θ and φ denote the polar and azimuthal angles, respectively. (a) $\sin\theta\cos\varphi$, (b) $\sin\theta\sin\varphi$ and (c) $\cos\theta$.

5. The angular flux for mono-energetic neutrons at a point $\vec{r}$ is given by $\psi(\vec{r},\vec{\Omega}) = a + b\cos\theta$ where a and b are constants, and θ is the angle between $\vec{\Omega}$ and the z-axis. Compute at $\vec{r}$ (a) the flux, (b) the current, (c) the partial current in the positive z direction, and (d) the partial current in the negative z direction.