[Neutron Flux]
(Chapter 1.4.1 in *Elements*)
Figures a and b illustrate the two ways of interpreting the notion of the flux.

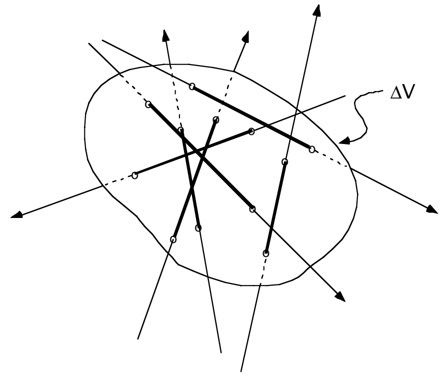


Figure a. The track length view of the definition of the neutron flux. The sum of the lengths of tracks (bold) within the volume ΔV *is the total track length.*

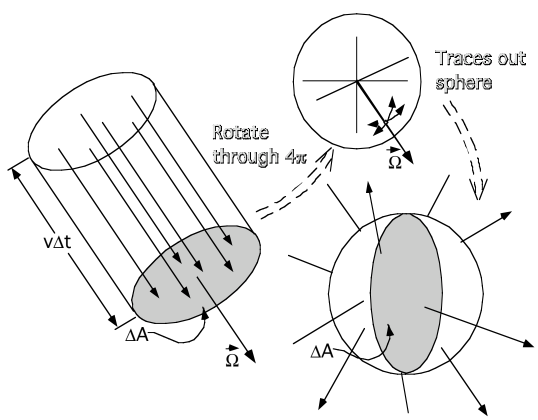


Figure b. The sphere-crossing view of the definition of the neutron flux. Neutrons traveling in any direction at speed v *within a volume* $v\Delta t$ *cross a circular area* ΔA *perpendicular to their direction of travel in the time* Δt*. Considering neutrons of all directions* $\vec{\Omega}$*, the circular areas trace out a sphere whose cross sectional area is* ΔA*. The flux is the total number of neutrons crossing the sphere per unit of cross sectional area* ΔA *per unit time in the interval* Δt*.*

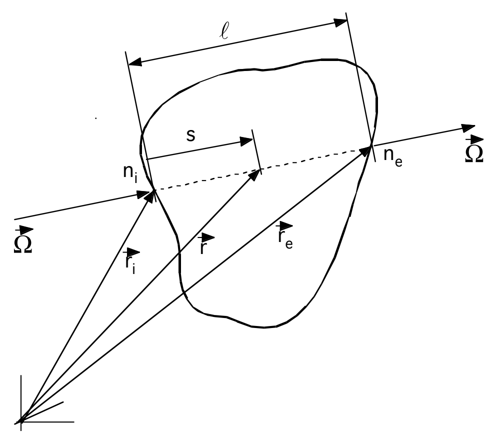
[Transport Equation]
(Chapter 1.5 in *Elements*)
The integral form of transport theory is

$$n\left(\vec{\mathbf{r}},\mathrm{v},\vec{\mathbf{\Omega}},t\right)=\int_0^{\infty}\exp\left(-\int_0^{s}\Sigma_{total}\left(\vec{\mathbf{r}}-s'\vec{\mathbf{\Omega}},\mathrm{v}\right)\right)q\left(\vec{\mathbf{r}}-s\vec{\mathbf{\Omega}},\mathrm{v},\vec{\mathbf{\Omega}},t\text{ - }s/\mathrm{v}\right)ds\ , \tag{1}$$

where

$$q\left(\vec{\mathbf{r}},\mathrm{v},\vec{\mathbf{\Omega}},t\right)=S_{scat}\left(\vec{\mathbf{r}},\mathrm{v},\vec{\mathbf{\Omega}},t\right)+S_{fission}\left(\vec{\mathbf{r}},\mathrm{v},\vec{\mathbf{\Omega}},t\right)+S_{ext}\left(\vec{\mathbf{r}},\mathrm{v},\vec{\mathbf{\Omega}},t\right) \tag{2}$$

is the source at $\vec{\mathbf{r}},\mathrm{v},\vec{\mathbf{\Omega}},t$, provides a simple result for the problem described in the figure. The results apply to neutrons streaming in vacuum or penetrating through a scattering, absorbing body.



Attenuation of a unidirectional beam of neutrons. The shapeless blob could represent a slab of material or a cylindrical detector with neutrons impinging at an arbitrary angle and point.

Neutrons enter the body in direction $\vec{\Omega}$ at position $\vec{r}_i$ at which the area density of neutrons is n_i, measured on an area perpendicular to $\vec{\Omega}$. They stream undeviated ($\frac{\vec{r}-\vec{r}_i}{|\vec{r}-\vec{r}_i|}=\vec{\Omega}$) through the medium where they interact by scattering or absorption with a probability $\Sigma_{total}(v)$ per unit distance and diminish in number by the factor $\exp\left(-s\Sigma_{total}(v)\right)$ in traveling a distance $s=|\vec{r}-\vec{r}_i|$ to a general point $\vec{r}$. The area density of neutrons emerging from the medium at point $\vec{r}_e$ is

$$n_e=n_i\exp\left(-\ell\Sigma_{total}(v)\right). \tag{3}$$

In terms of the incident and emerging currents,

$$\vec{J}_e(\vec{\Omega}) = v\vec{\Omega}n_e = v\vec{\Omega}n_i \exp\left(-\ell\Sigma_{total}(v)\right) = \exp\left(-\ell\Sigma_{total}(v)\right)\vec{J}_i(\vec{\Omega})\,. \tag{4}$$