NE 806, Neutronics

Homework Set 1 **Fall 2018**

due: 20 September 2018 **Name:** _____

1. For light nuclei, elastic scattering is isotropic in the COM frame; this is called s-wave scattering. For heavier nuclei and at higher neutron energies, elastic scattering is not truly isotropic in the COM frame; this is called p-wave scattering. Assuming rotational invariance, we can write $f(\omega_C,\psi)=\frac{1}{2\pi} f_\omega(\omega_C)$.

(a) (5 points) Write the PDF $f_\omega(\omega_C)$ for s-wave scattering.

(b) (5 points) Assume the joint PDF for a given p-wave scattering case is given by

$$f(\omega_c,\psi)=\frac{K}{2\pi}\left[1+\omega_c\right],\ -1\le\omega_c\le 1,\ 0\le\psi<2\pi\ , \tag{1}$$

What must the value of *K* be?

(c) (5 points) For part (b), plot the PDFs for ω_C and ψ.

(d) (10 points) For s-wave scattering, the the PDF of part (b), what is the PDF for the final neutron energy E' for neutrons of initial energy *E*?

2. Consider the exponential PDF given by

$$f(d)=\Sigma e^{-\Sigma d},\ d\ge 0\ . \tag{2}$$

(a) (5 points) Derive an expression for the mean value of *d*.

(b) (5 points) Derive an expression for the variance of *d*.

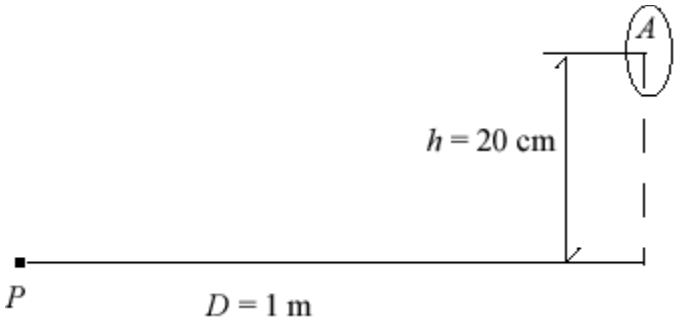
(c) (5 points) What is the probability that a neutron will interact within 0.5 cm in a medium for which the total interaction cross section is $\Sigma = 2$ cm^{-1}?

(d) (5 points) What is the probability a neutron will not interact in the first 5 cm in a medium for which $\Sigma = 2$ cm^{-1}?

3. Consider a circular disk of area A = 64 cm^2 at a distance of D = 100 cm from a point *P*.

(a) (5 points) What is the solid angle of the disk, to four significant figures, if the point *P* and the center of the disk are co-linear.

(b) (25 points) What is the solid angle of the disk, to four significant figures, if the point *P* and the center of the disk are non-colinear, as shown below (h = 20 cm)?



4. Consider the elastic scatter of a 1-MeV neutron with a nucleus of mass $A = 56$ for which the scatter angle in the COM frame is $\theta_C = 45°$.

(a) (5 pts) What is the Q-value of the interaction?

(b) (10 pts) What is the scatter angle in the LAB frame?

(c) (10 points) What is the energy of the scattered neutron?