HW problem week 3

Your turned in assignment should be clearly written and easy to follow! Learning how to explain your work in a way that is as easy as possible to follow is an important part of your training as a physicist. An incoherent mess of equations with a correct final answer could receive less points than a solution which is clearly explained at every step but has an algebra mistake somewhere. Once you've solved the problem, you can rewrite it on a new piece of paper for clarity if you need to.

In class we learned about the theory behind Rutherford scattering, in which an alpha particle scatters off of an atomic nucleus due to the repulsive coulomb force. In this problem, we will consider scattering of classical particles obeying newtons law off of a 'hard sphere' potential.

$$V(r) = \begin{cases} \infty & r < a \\ 0 & r > a \end{cases}$$

A potential like this might correspond to, for example, two billiard balls bouncing off of each other. Here we will treat the incident particles as point particles. For scattering off of this potential, the rule is that the angle of 'reflection' is equal to the angle of incidence (from the normal).

1. Determine the relation between the scattering angle θ and the impact parameter b in the form of an equation for $b(\theta)$.

2. By going through the same manipulations that we performed in the Rutherford scattering calculation, obtain the cross section $d\sigma$, and integrate it to obtain the total scattering cross section. Comment on your result: does it make sense? Why or why not?

3. Does this hard sphere potential exhibit the same small angle scattering singularity as the coulomb potential did? Why or why not?

4. To obtain the expression in the book relevant for comparing our calculation to an experiment, we need to think about the statistical description of many incident particles scattering off of many targets. Assume that the targets are far enough apart that the cross section that one target provides for scattering does not overlap with the cross section provided by any other targets. For a target of area A, calculate the fractional area for scattering through an angle θ in terms of the density and thickness of the

target. Use this to determine the fraction of incident particles scattered through angle θ (per unit time per unit solid angle).

5. **Optional, ungraded** Suppose a fraction x of the material you are scattering off of is composed of hard spheres of radius r_a and a fraction $1 - x$ have radius r_b. What is the differential cross section for scattering through angle θ for this material? What if the material is composed of hard spheres of many different radii determined by some distribution $p(r)$?