PHYS-3202 Homework 6 Due 10 Nov 2021

This homework is due to `https://uwcloud.uwinnipeg.ca/s/wxqoYpEEa8WT2LX` by 10:59PM on the due date. Your file(s) must be in PDF format; they may be black-and-white scans or photographs of hardcopies (all converted to PDF), PDF prepared by LaTeX, or PDF prepared with a word processor *using an equation editor*.

1. **Collisional Cross Section of the Earth**

   Consider meteoroids approaching the earth with positive asymptotic speed v and impact parameter b. This means the meteoroids have positive total energy. In this problem, ignore friction due to the earth's atmosphere and acceleration around the sun.

   (a) Find the largest impact parameter b_{max} such that the meteoroid will collide with the earth. *Hint:* For a collision to happen, the perigee of the meteoroid's hyperbolic orbit must be less than the earth's radius R.

   (b) Find the total cross section σ for the asteroids to collide with the earth as a function of the asteroid's asymptotic speed.

   (c) How much larger is this cross section than the earth's geometric cross section πR^2? Give your answer as a fractional difference (ie, $(\sigma - \pi R^2)/\pi R^2$) first in terms of the earth mass and radius and the meteoroid's asymptotic speed and then as a dimensionless number for a typical meteoroid speed of $v = 20$ km/s (relative to earth). Does gravity make a significant difference in the likelihood of a meteoroid hitting the earth? You may find astronomical data at the Particle Data Group. Use the nominal equatorial radius for the earth.

2. **Rutherford Experiment** *from Cline*

   In the original series of Rutherford scattering experiments (carried out by Geiger and Marsden), the α particles had initial kinetic energy of 8 MeV. What is the impact parameter for an α particle that has a scattering angle of 90° when scattering from a gold nucleus? Give your answer in femtometers (1 fm$= 10^{-15}$ m) to 1 significant digit. *Hint:* The force constant k in the inverse square law for α particles scattering from gold is $k = 2 \cdot 79e^2/4\pi\epsilon_0 \approx 200$ MeV·fm.