1 The Bohr Atom

This problem investigates the semi-classical Bohr atom. It can be useful for order-of-magnitude estimates, though, as we will see, it fails dramatically at capturing some essential qualities of quantum mechanics.

A) Write down the Coulomb force for an electron in the field of a nucleus with charge $Zq$. Assuming circular orbits, derive the orbital frequency and velocity of the electron, as a function of orbital radius $R$. Derive the angular momentum of the orbit as a function of orbital radius. You can assume that the mass of the nucleus is infinite for this problem.

B) In Bohr’s quantum description, it is the angular momentum that is quantized. It can only take values of $L = n\hbar$ with integer values of $n \geq 1$. Write down the orbital radius as a function of $n$.

C) Determine the total (kinetic plus Coulomb) energy of the electron as a function of $n$.

D) Determine the total acceleration of the electron at the $n = 1$ orbit. Using the Larmor formula, what would be the expected power radiated by this electron?

E) Determine the orbital decay time $R/\dot{R}$ from the orbital energy of the particle as a function of orbital radius $R$ and the energy loss rate you just calculated. Evaluate this time at the $n = 1$ orbit for hydrogen (i.e., $Z = 1$). Explain why this is a problem.