Problem Set 3a

October 29, 2014

1 Goldstein, Problem 3.10

2 Goldstein, Problem 3.13

Hint: The center of force is in an unexpected place!

3 Goldstein, Problem 3.19

This force is closely related to the Yukawa potential,

$$V_{Yukawa} = -\frac{k}{r}e^{-\mu r}$$

also known as the screened Coulomb potential. It gives a good approximation to the electric field experienced by an outer electron in a multielectron atom, and also describes a solution for a massive scalar particle. The potential is also the solution for the Coulomb potential produced by a massive photon.

Unfortunately, the force given in the problem differs from this one by one term, since

$$\mathbf{F}_{Yukawa} = -\left(\frac{k}{r^2} + \frac{\mu k}{r}\right)e^{-\mu r}\hat{\mathbf{r}}$$

while you are asked to study only the first term,

$$\mathbf{F}_{Goldstein} = -\frac{k}{r^2}e^{-\frac{r}{a}}\hat{\mathbf{r}}$$

However, you are only asked to study the orbits qualitatively, and you can do this from the effective potential using basic properties of the Ei function. For the second part of the problem, the discussion of Bertrand's theorem and the force law are all you will need.

4 Goldstein, Problem 3.20