H. Hergert
Facility for Rare Isotope Beams
and Department of Physics & Astronomy

MICHIGAN STATE
U N I V E R S I T Y

PHY422/820: Classical Mechanics

FS 2019
Midterm #2 Preparation

November 2, 2019

Problem P11 – Yukawa Potential

[**Goldstein 3.19**] Yukawa potentials

$$V(r) = -\frac{\kappa}{r}e^{-r/a}, \quad a > 0, \kappa \in \mathbb{R}, \tag{1}$$

frequently appear in Quantum Field Theory as the prototypical examples of interactions that are generated by the exchange of massive particles[1]. It can also be viewed as a screened or smoothly regularized version of the Coulomb potential, which is recovered in the limit $a \to \infty$.

1. Derive the equations of motion for $\kappa > 0$. Use the effective potential to discuss the qualitative nature of the orbits for different energies and angular momenta.

2. Show that if the orbit is nearly circular with radius R, the perihelion and aphelion will advance approximately by $\pi R/a$ per revolution.

---

[1]In this context, the range is usually given by the Compton wavelength $\lambda = \hbar/mc$ of the exchange particles: The more massive the exchanged particle, the shorter-ranged the interaction.