NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics Spring 2025

Problem Set #4

Problem Set Due: Thurs., Feb. 20, 2025
Read Krane: Chapter 5.1-5.4, Lecture Notes #1

1. **OpenStax University Physics Vol. 3: Section 4.4:** Problem 41
2. **OpenStax University Physics Vol. 3: Section 4.5:** Problem 55
3. **OpenStax University Physics Vol. 3: Section 4.6:** Problem 73 **(Let d = 0.120 nm)**

4. **Krane: Problem 2** **page 174**
5. **Krane: Problem 5** **page 174**(draw energy level diagram) (see Fig. 5.13)
6. **Krane: Problem 7** **page 174** (draw figure)
7. **Krane: Problem 9** **page 174** (sketch wavefunction)
8. **Krane: Problem 15** **page 174** (just show calculation)
9. **Krane: Problem 16** **page 174** (just show calculation)

Take home Quiz #1 extension
worth 25 points on Quiz #1
(open book/open internet problem)

See next page:

10. *Nature allows us to "reasonably" violate conservation of energy:* A proton, p, can sometimes "violate" conservation of energy by emitting and then reabsorbing a pi meson, π, which has a mass of 135 MeV/c^2. This is possible as long as the pi meson is reabsorbed within a short enough time Δt consistent with the uncertainty principle.

(a) Consider $p \rightarrow p + \pi$ (where $\pi =$ pi meson). By what amount ΔE is energy conservation violated? (Ignore any kinetic energies.)

(b) For how long a time Δt can the pi meson exist? (give the maximum lifetime of the pi meson)

(c) Assuming the pi meson to travel at very nearly the speed of light, how far from the proton can it go? (This gives us the *range* of the nuclear force, and thus an approximate size of a proton or atomic nucleus.)