

NORTHERN ILLINOIS UNIVERSITY
PHYSICS DEPARTMENT

Physics 283 – Modern Physics

Fall 2026

Problem Set #4

Problem Set Due: Thurs., Oct. 1, 2026

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 $d = 0.120 \text{ nm}$**)

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 $135 \text{ MeV}/c^2$. 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 $\pi = \text{pi meson}$). 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.)