NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics Fall 2025

Problem Set #8

Problem Set Due: Thurs., Nov. 6, 2025
Read Krane: Chapter 8.1-8.6

There will be a Quiz #3 on Tuesday, November 11

1. **OpenStax University Physics Vol. 3: Section 2.2:** Problem 37
2. **OpenStax University Physics Vol. 3: Section 2.3:** Problem 45
3. **OpenStax University Physics Vol. 3: Section 2.4:** Problem 55

4. **Krane: Problem 1** **page 266** (just show calculation)

5. **Krane: Problem 6** **page 267** (just show calculation)

6. **Krane: Problem 7** **page 267** (just show calculation)

7. **Krane: Problem 14** **page 267**
   (sketch energy level diagram & transitions for (a) & (c))

8. **Krane: Problem 17** **page 267** (just show calculation)

9. **Krane: Problem 22** **page 267** (just show calculation)

Problem # 10 is on the next page

10. *Selection rules for an infinite square well potential:* Recall in Lecture that the electric dipole is defined as $\vec{\mathbf{p}} = Q\vec{\mathbf{r}}$ where $\vec{\mathbf{r}}$ is the distance between a pair of positive and negative charges $+Q$ and $-Q$. Thus, the average electric dipole, or expectation value of the electric dipole, is $\left\langle \vec{\mathbf{p}} \right\rangle = \left\langle Q\vec{\mathbf{r}} \right\rangle$ which in one-dimensions becomes $\left\langle p_x \right\rangle = \left\langle ex \right\rangle$ for an electron cloud about a nucleus. We can use this to construct a general condition necessary for an atom in an excited state to radiate a photon (electromagnetic waves):

$$\int_{-\infty}^{\infty} x\psi_i\psi_f^* dx \neq 0 \qquad \text{(allowed transitions)}$$

$$\int_{-\infty}^{\infty} x\psi_i\psi_f^* dx = 0 \qquad \text{(forbidden transitions)}$$

where i = initial state, f = final state. The wave function for an infinite square well potential is

$$\psi = A\sin\left(\frac{n\pi x}{L}\right) \qquad (n = 1,2,3,\ldots) \quad \text{and} \quad (0 < x < L)$$

(a) Show whether $\Delta n = \pm 1$ transitions are allowed by examining the $n = 2 \rightarrow n = 1$ transition.

(b) Show whether $\Delta n = \pm 2$ transitions are allowed by examining the $n = 4 \rightarrow n = 2$ transition.

(c) Show whether $\Delta n = \pm 3$ transitions are allowed by examining the $n = 4 \rightarrow n = 1$ transition.

(d) Generalize the selection rules for any Δn, and show all the allowed transitions in the energy level diagram below: