NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics Spring 2026

Problem Set #7

Problem Set Due: Thurs., Mar. 26, 2026
Read Krane: Chapter 7.1-7.8

1. **OpenStax University Physics Vol. 3: Section 1.7:** Problem 64
2. **OpenStax University Physics Vol. 3: Section 1.7:** Problem 65
3. **OpenStax University Physics Vol. 3: Section 2.1:** Problem 26 (see solution to #27)

4. **Krane: Problem 20** **page 234** (just show calculation)
5. **Krane: Problem 21** **page 234** (just show calculation)
6. **Krane: Problem 24** **page 234** (sketch energy level diagram)
7. **Krane: Problem 26** **page 234** (sketch energy level diagram)
8. **Krane: Problem 27** **page 234** (sketch energy level diagram)

Problem # 9 is on the next page

9. *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: