NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics Fall 2025

Problem Set #3

Problem Set Due: Thurs., Sept. 18, 2025
Read Krane Chapter **4.1-4.4**, **6.4-6.5**

There will be a Quiz #1 on Tuesday, September 23

1. **OpenStax University Physics Vol. 3: Section 4.1:** Problem 17
2. **OpenStax University Physics Vol. 3: Section 4.2:** Problem 31
3. **OpenStax University Physics Vol. 3: Section 4.3:** Problem 37

4. **Krane (Note: this is in Chapter 3): Problem 24** **page 90** (draw picture)

   (a) Read **Section 3.4** of Krane on the Compton effect. Draw the scattering diagram for a photon scattering from an electron (you may use Krane's picture, Fig. 3.18).

   (b) Write down the conservation of energy relation for this scattering problem (use the symbols given by Krane in Fig. 3.18).

   (c) Write down the conservation of momentum relation (for the x & y-directions) for this scattering problem.

   (d) Show explicitly, step-by-step, the relation between the energy of the incident and scattered photons follows:

$$\frac{1}{E'} - \frac{1}{E} = \frac{1}{m_e c^2}(1 - \cos\theta)$$

   or, in terms of the wavelengths:

$$\lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

5. Krane (Chapter 4): *Modified Problem 1 below* **page 134** (show derivation)

Find the de Broglie wavelength of

(a) a nitrogen molecule ($m = 28$ u) in air at room temperature (in doing so, show that nonrelativistic mechanics can be used).

(b) a 7 MeV proton in
(i) the relativistic limit
(ii) in the nonrelativistic limit
(iii) Is it ok to use the nonrelativistic limit? (*note*: the kinetic energy is 7 MeV)

(c) a 45 Gev electron in
(i) the relativistic limit and
(ii) (*ii*) in the nonrelativistic limit.
(iii) Is it ok to use the nonrelativistic limit? (*note*: the kinetic energy is 45 GeV)

(d) an electron moving at $v = 1.35 \times 10^6$ m/sec in
(i) the relativistic limit and
(ii) in the nonrelativistic limit.
(iii) Is it ok to use the nonrelativistic limit?

6. Krane (Chapter 4): Problem 20 **page 135** (draw figure and what the electron is doing)

For Part (c), read Section 6.5 (in Chapter 6)—especially examine Figure 6.18.

7. Krane (Chapter 4): Problem 34 **page 136** (draw figure)

8. Krane (Chapter 6): Problem 19 **page 204** (draw figure)

9. Krane (Chapter 6): Problem 22 **page 204** (draw figure)