

NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 283 – Modern Physics

Spring 2025

Problem Set #3

Problem Set Due: Thurs., Feb. 6, 2025

Read Krane Chapter **4.1-4.4, 6.4-6.5**

There will be a Quiz #1 on Tuesday, February 11

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 ($m = 28 \text{ u}$) 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 and (ii) in the nonrelativistic limit.
(iii) Is it ok to use the nonrelativistic limit? (note: the proton's kinetic energy is 7 MeV)
- (c) a 45 GeV electron in (i) the relativistic limit and (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 $v = 1.35 \times 10^6 \text{ m/sec}$ 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)